Department of Defense Manufacturing and Quality Management Body of Knowledge

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Office of the Deputy Assistant Secretary of Defense
Systems Engineering

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Department of Defense Manufacturing and Quality Management Body of Knowledge

(DRAFT)

Deputy Assistant Secretary of Defense
Systems Engineering
3030 Defense Pentagon
3C167
Washington, DC 20301-3030
www.acq.osd.mil/se

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Preface

This version of the DoD Manufacturing and Quality Management Body of Knowledge is a working draft for industry and government experts to comment and to make recommended edits and/or corrections. The long-term vision is to provide a practical guide for government manufacturing and quality (M&Q) managers to execute their duties across the DoD acquisition lifecycle. It is further envisioned that this document will be updated on a routine basis to reflect current policy, guidance, tools and best practices. This document does not supersede DoD policy, guidance or law; but is a compilation of best practices, lessons learned (backed by experience, policy and guidance).

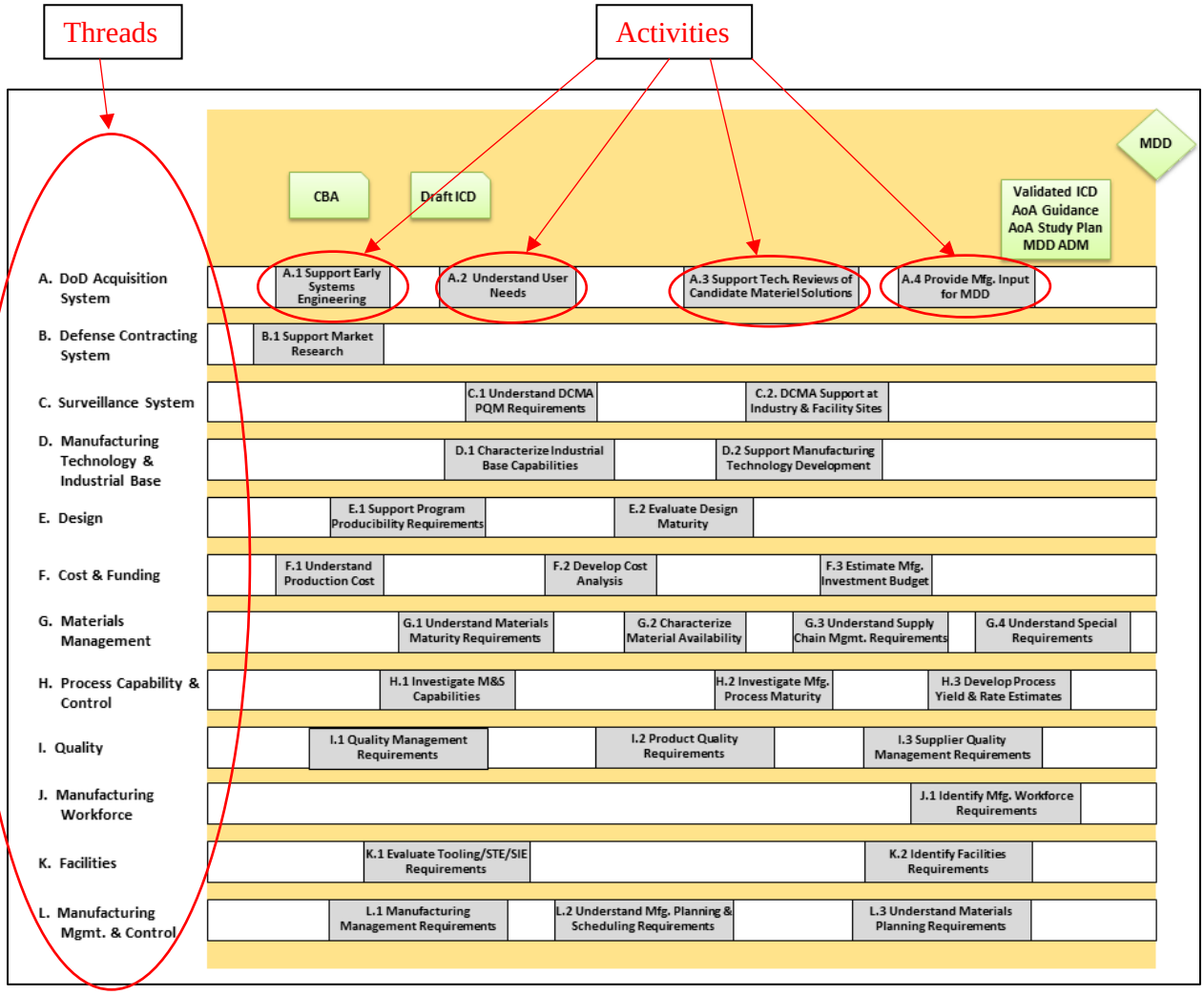
This Body of Knowledge is structured to capture M&Q activities during each phase of the life cycle. The document includes individual chapters to cover M&Q activities and presumptive tasks recommended during each acquisition lifecycle phase to meet DoD Instruction 5000.02, "Operation of the Defense Acquisition System."

The Body of Knowledge includes 6 chapters. DoD PQM managers can use the chapter that reflects the phase of the program that they are working:

- Chapter 1: Pre-Materiel Development Decision (Pre-MDD)
- Chapter 2: Materiel Solution Analysis (MSA)
- Chapter 3: Technology Maturation and Risk Reduction (TMRR)
- Chapter 4: Engineering and Manufacturing Development (EMD)
- Chapter 5: Production and Deployment (P&D)
- Chapter 6: Operations and Support (O&S)

Each chapter breaks down the M&Q related functions for each acquisition phase into major "Threads" and "Activities." Threads include major manufacturing and quality functions based on the "5 Ms" (Machines, Materials, Methods, Manpower, and Measurement); Manufacturing Readiness Level criteria; and DoD unique M&Q related acquisition threads (i.e. DoD acquisition system, defense contracting system, and surveillance system). These Threads are then broken into specific Activities (gray boxes) as indicated on the below figure. Each Activity is numbered (i.e., A.1, A.2, A.3…etc.) and has a corresponding description in each chapter describing presumptive task, metrics, resources and tools associated with this activity.

As an example, Pre-MDD manufacturing and quality activities are displayed in a figure as follows:



The chapter text then includes a description of M&Q objectives for the acquisition phase; and for each activity (A.1, A.2, A.3 …etc.) includes:

- A list of recommended tasks
- Metrics to determine if the task(s) have been accomplished
- Tools (i.e., specific tools and techniques to accomplish tasks)
- Related resources (i.e. law, policy, and guidance applicable to the activity/tasks)

1. Pre-Materiel Development Decision (Pre-MDD)

Introduction

The objectives of the Pre-Materiel Development Decision (Pre-MDD) efforts are to obtain a clear understanding of user needs, identify a range of technically feasible candidate materiel solutions, consider near-term opportunities to provide a more rapid interim response, and develop a plan for the next acquisition phase, including the required resources. This knowledge supports the Milestone Decision Authority's (MDA) decision to authorize entry into the acquisition life cycle and pursue a materiel solution. The Pre-MDD manufacturing and quality activities are displayed below (Figure 1-1).

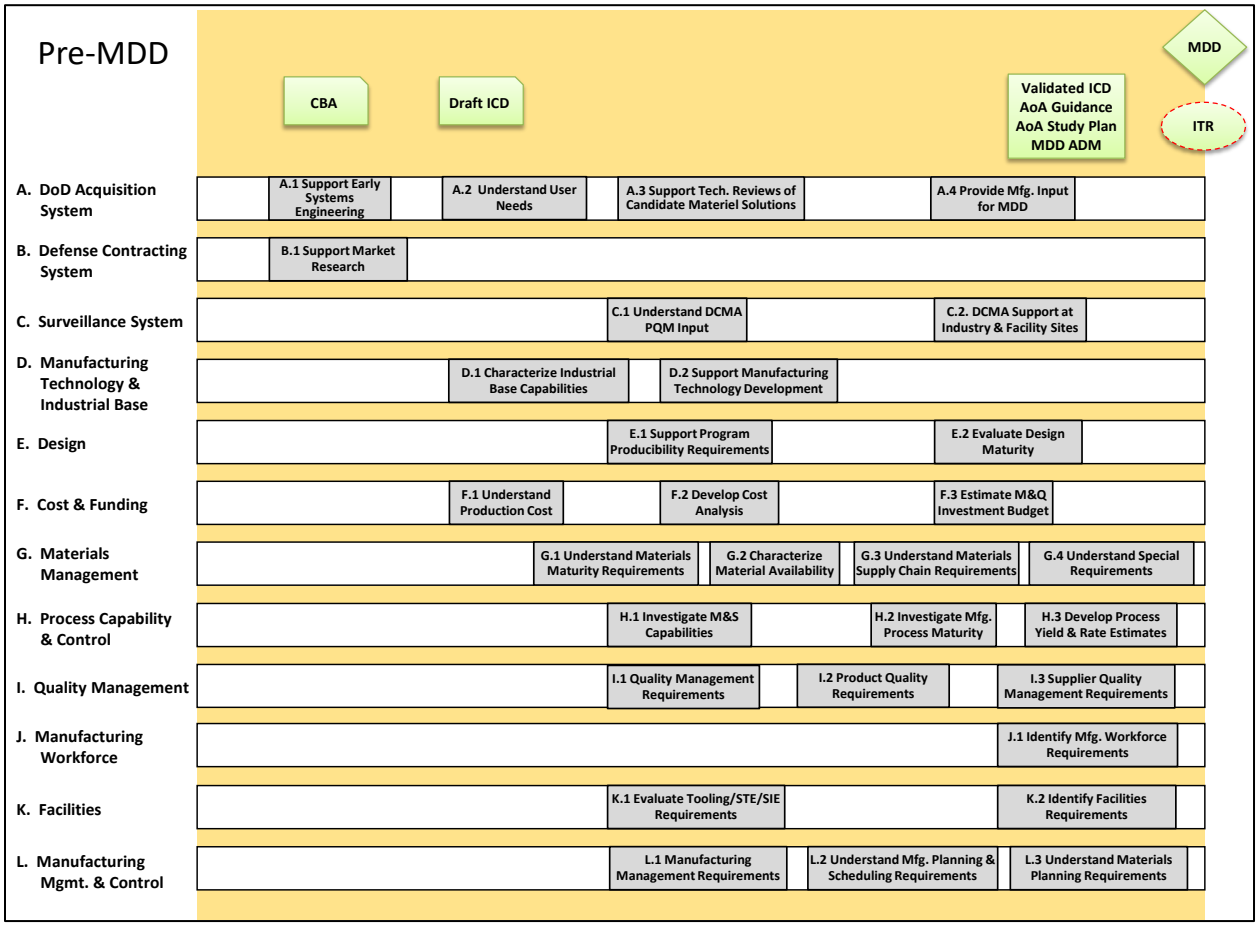


Figure 1-1. Pre-MDD Phase Manufacturing and Quality Activities

An important aspect of the Pre-MDD effort is narrowing the field of possible solutions to a reasonable set that is analyzed in the Analysis of Alternatives (AoA). Early recognition of constraints, combined with analysis of technical feasibility, can eliminate many initial ideas because

they lack the potential to meet the need in a timely, sustainable, and cost-effective manner. Conversely, the range of alternatives analyzed in the AoA need to be chosen from a sufficiently broad solution space.

Studies have found that programs that considered a broad range of alternatives tended to have better cost and schedule outcomes than the programs that looked at a narrow scope of alternatives (citation to come).

Manufacturing and Quality Objectives

Manufacturing is concerned with the conversion of raw materials into products based upon a detailed design. This conversion is accomplished through a series of manufacturing and quality procedures and processes. It includes such major functions as manufacturing planning, cost estimating and scheduling; engineering; fabrication and assembly; installation and checkout; demonstration and testing; and quality assurance. Manufacturing and quality considerations begin before the AoA in Pre-MDD, during which the manufacturing feasibility and quality risks that are associated with each materiel solution must be understood and incorporated into study guidance for the next acquisition phase.

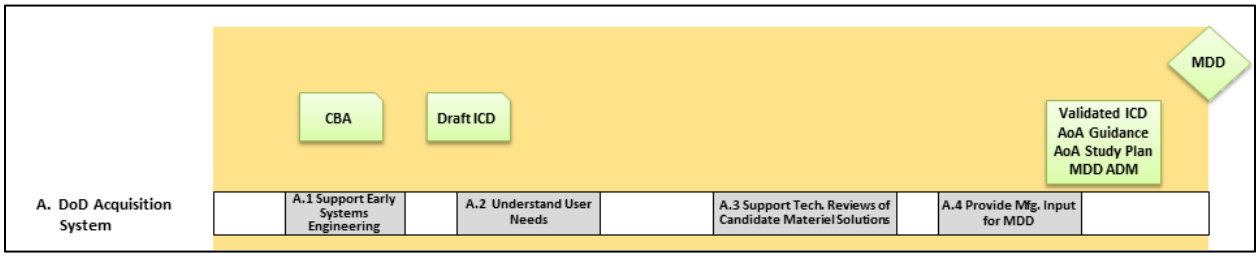
The first objective is to ensure that manufacturing and quality are part of the design process. The role of manufacturing is to influence the design so it is producible. The role of quality is to influence the design so it is reliable and robust, in other words the material attributes, performance features, and characteristics of a product satisfy a given need. The result is a design that is efficient and can be manufactured using existing facilities, tools, equipment and people, and meets quality needs. This role is critical because of the impact design decisions have on life cycle costs.

The second objective is to assess manufacturing feasibility and quality risks for the various materiel solutions identified.

The next objective is to support Knowledge-Based Acquisition to include the reduction of manufacturing and quality risks and demonstration of producibility.

To meet these objectives, manufacturing and quality strategy development must begin during the earliest stages of concept development. The manufacturing and quality strategy should be part of the Capabilities-Based Assessment (CBA) and the draft Initial Capabilities Document (ICD), and should be included in the AoA Study Guidance for the Materiel Development Decision (MDD).

A. DOD ACQUISITION SYSTEM



In order to implement effective early Systems Engineering, the Joint Staff conducts a CBA, and/or other studies as part of the Joint Capabilities Integration and Development System (JCIDS) process, producing a draft Initial Capabilities Document (ICD). The draft ICD contains the initial Key Performance Parameters (KPP), Key System Attributes (KSA), and Additional Performance Attributes (APA). The draft ICD is assigned to a lead Service or Services. Prior to determining if a materiel solution should be developed, the lead Service initiates activities to develop the AoA Study Guidance. These activities include manufacturing feasibility, studies from the science and technology (S&T) community, and other supporting studies (threat analysis, gap studies, etc.) contributing pertinent data and information for the MDD.

Prior to the decision, manufacturing and quality studies are conducted to assist the lead Service activities for each concept to identify potential constraints, risks, and capabilities of the concepts to validate the draft ICD. These studies should be included in the AoA Study Guidance. After the MDD, Department of Defense Instruction (DoDI) 5000.02, Operation of the Defense Acquisition System, specifies that the AoA analyzes cost, schedule, sustainment, and required capabilities associated with each proposed materiel solution, including technology maturity, integration risk, manufacturing feasibility, and, where necessary, technology maturation and demonstration needs.

In addition, the Office of the Secretary of Defense (OSD) Defense Acquisition Program Support (DAPS) Methodology criteria require the study plans address the System Engineering focus areas of maturity, reliability and maintainability, space, weight, power, cooling, and feasibility.

To understand the implications of manufacturing feasibility, studies must address the feasibility, maturity, and quality risks of the proposed alternatives, including the need for:

- Industrial base (IB) development and impacts
- New materials and novel processing methods
- Additional research and development
- Manufacturing technology development and capital equipment
- Special test equipment and environments, special inspection equipment, and tooling
- New or expanded facilities
- New manufacturing skill sets

Development planning activities are initiated before the MDD, continue throughout the Materiel Solution Analysis phase, and eventually transition to the program environment. Development planning encompasses the engineering analysis and technical planning activities that provide the foundation for informed investment decisions that effectively, affordably, and sustainably meet operational needs.

Attention to critical Systems Engineering processes and functions is essential to ensure that programs deliver capabilities on time and on budget. The effective execution of pre-MDD efforts provides technically feasible solution options that satisfy user-driven requirements for the AoA. At the MDD, the MDA not only decides whether an investment is made to fill the capability gap but also determines the fundamental path the materiel development will follow. This decision should be based on effective development planning.

A.1 Support Early Systems Engineering

Manufacturing and Quality Tasks

- Support the MDA MDD process to authorize entry into the acquisition life cycle and pursue a materiel solution.
- As part of a CBA, provide analyze IB capabilities and manufacturing feasibility.
- Identify a range of technically feasible candidate materiel solutions across the entire solution space including user input as appropriate.
- Conduct a gap analysis for manufacturing feasibility to eliminate unfeasible candidate materiel solutions based on factors such as timeliness, sustainability, cost-effectiveness, etc.
    - The gap analysis of manufacturing feasibility includes the use of near-term, commercial, or current systems as a materiel solution for rapid fielding
- Draft a top-level plan that includes scheduling, manpower, and cost projections based on the results of manufacturing feasibility analysis of candidate materiel solutions.
- Develop technical planning with respect to performance characteristics and analysis of capability gaps in manufacturing as part of the analysis of candidate materiel solutions.
- Assess candidate materiel solutions for external dependencies and integration impacts on the industrial base.
- Analyze candidate materiel solutions for reliability, availability, maintainability, and associated costs for the AoA Study Guidance.
- Analyze the potential alternatives that address the feasibility of a rapid interim response to the need.

Metrics

- Analysis and documentation of IB capabilities and manufacturing feasibility provided as part of the CBA.

- Manufacturing feasibility study conducted to identify a range of potential technically feasible candidate materiel solutions across the entire solution space including user input as appropriate; potential solutions are documented, and provided as inputs to the Integrating Integrated Product Team (IIPT), Overarching Integrated Product Team (OIPT), and MDD.
- Gap analysis conducted for manufacturing feasibility to document and eliminate un-feasible candidate materiel solutions based on factors such as timeliness, sustainability, cost-effectiveness, etc.
    - The gap analysis of manufacturing feasibility includes and documents the use of near-term, commercial, or current systems as a materiel solution for rapid fielding, and these are provided as inputs to the IIPT, OIPT, and MDD.
- Draft top-level plan that includes scheduling, manpower, and cost projections based on the results of manufacturing feasibility analysis of candidate materiel solutions completed and documented as an input to the AoA Study Guidance process.
- The analysis of candidate materiel solutions includes documented technical planning with respect to performance characteristics and analysis of capability gaps in manufacturing as an input to the AoA Study Guidance process.
- The analysis of desired materiel solutions includes documented technical planning with respect to external dependencies and integration impacts on the industrial base as an input to the AoA Study Guidance.
- Results of reliability, availability, maintainability, and associated cost analysis have been documented and provided as an input to the AoA Study Guidance.
- Results of analysis of potential alternatives that address the feasibility of a rapid interim response to the need have been documented and provided to the OIPT.

Tools

- Acquisition Decision Memorandum (ADM) Template
- Acquisition Strategy Outline
- AoA Study Plan Template, Sep 2009
- Industrial Base Assessment Survey Form Defense Contract Management Agency (DCMA) Industrial Analysis Center
- Initial Technical Review Checklist
- Integrated Design Exploration and Analysis (IDEA)
- Manufacturing Feasibility Assessment Checklist (no specific tool found)
- Manufacturing Readiness Level (MRL) Assessment Questionnaire
- Market Research Reporting Template
- Multi-Attribute Tradespace Exploration (MATE)
- Pugh Matrix Template
- Quality Function Deployment or House of Quality Matrix
- Quality Function Deployment Excel Spreadsheet

- Requirements Traceability Matrix Template
- Requirements Verification Matrix
- Tailoring Worksheet for Materiel Solution Analysis Phase
- Technology Readiness Level (TRL) Assessment Checklist
- Theory of Inventive Problem Solving (TRIZ) Matrix

Resources

- Air Force AoA Guide, Jun 2013
- Air Force AoA Handbook, Jul 2008
- DoDI 5000.02,
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities
- DoD Market Research Guide, May 2012
- DSMC Acquisition Strategy Guide, Dec 1999
- MRL Deskbook Version 2.5, 2016
- Pre-MDD Analysis Handbook, Jul 2010
- Quality Function Deployment
- Requirements Traceability Matrix Guide, Jan 2012
- Technology Readiness Assessment Guidance, Apr 2011

A.2 Understand User Needs

Manufacturing and Quality Tasks

- In order to obtain a clear understanding of user needs,
    - Participate in development of Draft Initial Capabilities Document (ICD) to provide manufacturing and quality inputs to development of KPPs, KSAs, and APAs, including inputs to Force Protection, System Survivability, Sustainment, and Energy KPPs (four of the six mandatory KPPs)
    - Participate in the CBA or equivalent to provide manufacturing perspective on IB capability and manufacturing feasibility for both processes
- Identify near-term opportunities that address user needs per the draft ICD and the CBA to provide a more rapid interim response.
- Develop understanding of user needs as they relate to candidate materiel solutions and proactively collaborate with the user communities to:
    - Support Technical Reviews of candidate materiel solutions
    - Initiate characterization of trade space, risks, and mission interdependencies as input to support the AoA Study Guidance.

Metrics

- Provide input to the development of the Draft Initial Capabilities Document for a manufacturing and quality perspective on IB capability and manufacturing feasibility.
    - Document manufacturing and quality inputs into the Draft Initial Capabilities Document (ICD) including KPPs, KSAs, and APAs for potential inclusion in the AoA Study Guidance
- Provide input to the CBA or equivalent for a manufacturing and quality perspective on IB capability and manufacturing feasibility.
    - Document manufacturing and quality inputs into the CBA for potential inclusion in the AoA Study Guidance
- Review the User needs and document the manufacturing interpretation of these needs for inclusion in the AoA Study Guidance.
- Document near-term opportunities that address user needs per the draft ICD and the CBA that provide a more rapid interim response for inclusion in the AoA Study Guidance.

Tools

- ICD Template, Oct 2012
- MRL Assessment Questionnaire
- Pugh Matrix Template
- Quality Function Deployment Excel Spreadsheet
- Requirements Roadmap Worksheet
- TRIZ Matrix

Resources

- Capability-Based Assessment Guide, Mar 2009
- Defense Acquisition Guidebook (DAG) Chapter 14.3.1.3, Build Requirements Roadmap
- DoDI 5000.02
- Pre-MDD Analysis Handbook, Jul 2010
- Quality Function Deployment

A.3 Support Technical Reviews of Candidate Materiel Solutions

Manufacturing and Quality Tasks

- Provide manufacturing inputs to support the MDA MDD process to authorize entry into the DoD acquisition process and pursue a materiel solution.

- Identify and provide inputs to the AoA Study Guidance that specify the minimum set of Concept of Operations (CONOPS) and ICD manufacturing and/or quality requirements that must be met for each of the candidate materiel solutions
- Assess each of the candidate materiel solutions for manufacturing feasibility and producibility
- Assess each of the candidate materiel solutions for impacts on reliability and maintainability
- Identify manufacturing and quality risks (technical/engineering) for each candidate materiel solution
  - Identify the capability and capacity risks for rapid fielding of potential solutions.
  - Identify source consideration risks for fragile, single, sole, domestic, and foreign sources.
- Identify manufacturing and quality scheduling impacts and constraints (risks and opportunities) for each candidate materiel solution

- Identify initial manufacturing and quality Measures of Effectiveness for each candidate materiel solution.
- Initiate characterization of trade space, risks, and mission interdependencies of each candidate materiel solution as input to support the AoA Study Guidance.
- Analyze capability and gaps of each candidate materiel solution approach to meet the need in a timely, sustainable, and cost-effective manner.

Metrics

- In support of the MDA MDD process, the manufacturing and quality representatives to the IIPT and the OIPT have:
  - Evaluated the draft ICD to determine relevant manufacturing and quality metrics and values for each of the candidate materiel solutions, and provided these as documented inputs to the AoA Study Guidance and MDD processes.
  - Reviewed the CONOPS and preliminary requirements for each of the candidate materiel solutions to provide documentation for initial definition and assessment of gaps, needs, and new technologies for the AoA Study Guidance and MDD processes.
  - Assessed, evaluated, analyzed, and documented each of the candidate materiel solutions for manufacturing feasibility and producibility.
  - Assessed and documented each of the candidate materiel solutions for impacts on reliability and maintainability.
  - Identified, evaluated, and documented manufacturing and quality risks (technical/engineering) for each candidate materiel solution.
    - Evaluated and documented the capability and capacity for Rapid Fielding of potential solutions for the AoA Study Guidance and MDD processes.

        - Evaluated, assessed, and documented source considerations (sole, domestic, foreign, etc.) for the AoA Study Guidance and MDD processes.
    - Identified, evaluated, and documented manufacturing and quality scheduling impacts and constraints (risks and opportunities) for each candidate materiel solution.
    - Identified and documented initial manufacturing and quality Measures of Effectiveness for each candidate materiel solution.
- Document initial characterization of trade space, risks, and mission interdependencies of each candidate materiel solution as input to the AoA Study Guidance.
- Analyze and document the capability and gaps of each candidate materiel solution approach to meet the need in a timely, sustainable, and cost-effective manner for as input to the AoA Study Guidance.

Tools

- AoA Study Plan Template
- Critical to Customer/Critical to Quality Tree Template
- Manufacturing Capability Assessment Worksheet
- MRL Assessment Checklist
- MDD Development Planning Templates
- MSA Template
- Producibility Assessment Worksheet (PAW)
- TRIZ Matrix

Resources

- Air Force AoA Guide, Jun 2013
- Air Force AoA Handbook, Jul 2008
- DAG Chapter 14.4.2, Performance Management
- Defense Manufacturing Management Guide for Program Managers, Chapter 1.3 and 2.6 Industrial and Manufacturing Capability Assessments in the Acquisition Lifecycle
- DoDI 5000.02
- MRL Deskbook Version 2.5, 2016
- MSA Guide, DAG Chapter 4.2.3 , also see Air Force and Navy Guides

A.4 Provide Manufacturing Input for the Materiel Development Decision

Manufacturing and Quality Tasks

- Support the MDA MDD process to authorize entry into the acquisition life cycle and pursue a materiel solution.

- Identify a range of technically feasible candidate materiel solution approaches that address considerations of industrial, production, manufacturing, and quality constraints.
- Develop manufacturing inputs for the AoA Study Guidance and Study Plan planning for the next acquisition phase, including the required resources.
- Develop draft guidance on the application and use of assessments of manufacturing readiness on the concepts under consideration
    - Identify target Manufacturing Readiness Levels (MRL) that should be achieved at key milestones and decision points for Major Defense Acquisition Programs (MDAP)
    - Identify tools and models that may be used to assess, manage, and reduce risks that are identified in the course of MRL assessments
- Initiate characterization of trade space, risks, and mission interdependencies as input to support the AoA Study Guidance.
- Conduct a complete and rigorous manufacturing analysis/assessment of alternatives and their non-materiel implications as part of a Systems Engineering analysis.
- Assess alternatives for manufacturing and their non-materiel implications (cost, staffing, contracting, etc.) as an input to the MDD.
- Assess the industrial base for production capability and capacity, and manufacturing and quality constraints to eliminate non-supportable candidate materiel solutions (i.e., those that are not timely, sustainable, or affordable) as an input to the AoA Study Guidance.
- Collaborate with the User communities to understand system performance requirements and with the S&T community to identify candidate materiel solutions and potential manufacturing issues as an input to the AoA Study Guidance.
- Support the Initial Technical Review (ITR)
    - Assess the draft ICD, the AoA Study Guidance, and preliminary CONOPS for manufacturing and quality analysis of materiel solution alternatives.
    - Support the ITR to provide detailed manufacturing and quality information and understanding of each concept or alternative for:
        - Engineering trades
        - Development of a Cost Analysis Requirements Description (CARD)
        - Cost drivers, material, and process risks

Metrics

- In support of the MDA MDD process, the manufacturing and quality representatives are included as active contributing members of the IIPT and the Overarching Integrated Product Team (OIPT).
- A rigorous Systems Engineering analysis has been conducted and documented to support the MDD process for entry into the next phase.

  - Alternatives have been assessed and analyzed for manufacturing and their non-materiel implications (cost, staffing, contracting, etc.) and are documented and provided as an input to the MDD
  - Assessment of the industrial base for production capability and capacity, and manufacturing and quality constraints to eliminate non-supportable candidate materiel solutions (i.e., those that are not timely, sustainable, or affordable) are documented and provided as an input to the AoA Study Guidance.
  - Results of collaboration with User community's requirements for system performance and capabilities and the S&T Community for candidate materiel solutions and potential manufacturing issues are documented and provided as an input to the AoA Study Guidance.

- Draft guidance on the application and use of assessments of manufacturing readiness on the concepts under consideration has been developed and documented and includes:

  - Initial identification of target MRLs that should be achieved at key milestones and decision points for Major Defense Acquisition Programs
  - Initial identification of tools and models that may be used to assess, manage, and reduce risks that are identified in the course of manufacturing readiness assessments

- The designated manufacturing and quality support to the Initial Technical Review (ITR) has been specified.

  - Assessment of the draft ICD, the AoA Study Guidance, and preliminary CONOPS for manufacturing and quality analysis of materiel solution alternatives has been conducted and results documented
  - Detailed manufacturing and quality information has been provided to support the Initial Technical Review (ITR) and includes documentation of each concept or alternative for:

    - Engineering trades
    - Development of a CARD
    - Cost drivers, material, and process risks

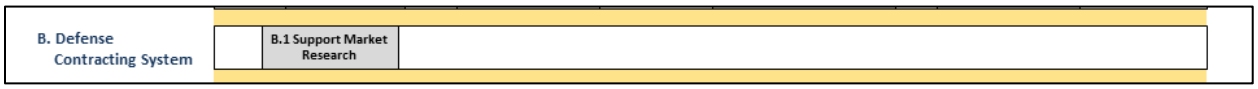
Tools

- Acquisition Decision Memorandum (ADM) Template
- AoA Study Plan Template
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Initial Technical Review Checklist
- Manufacturing Readiness Level (MRL) Assessment Questionnaire
- Multi-Attribute Tradespace Exploration (MATE)
- Pugh Matrix Template
- Quality Function Deployment in excel
- TRIZ Matrix Template

Resources

- Air Force AoA Handbook, Jul 2008
- Defense Manufacturing Management Guide for Program Managers Chapter 12.5.1 Initial Technical Review
- DoDI 5000.02
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- MRL Deskbook Version 2.5, 2016
- Pre-MDD Analysis Handbook, Jul 2010
- Quality Function Deployment

B. DEFENSE CONTRACTING SYSTEM



Manufacturing and quality resources should be focused on the entire acquisition cycle including areas such as production planning, transition to production, concurrent engineering, quality management, continuous improvement, could cost, and manufacturing technology. A clear understanding of these focus areas is key during Pre-MDD for contracting activities in the following acquisition phases. These activities include proactively collaborating with the S&T and user communities to develop understanding of candidate materiel solutions to make necessary and substantive inputs to future contracts and acquisition planning.

B.1 Support Market Research

Manufacturing and Quality Tasks

- Work with the S&T community (across government, industry, and academia) as well as other collaborators to build the technical knowledge base for potential candidate materiel solutions.
- Survey the Industrial Base for necessary resources for the potential candidate materiel solutions and the current state industrial practices.
- Support requests for information and solicit industry and academia responses to warfighter needs.
    - Provide manufacturing and quality inputs for sources sought activity, as appropriate
- Identify and characterize candidate materiel solutions resulting from the Sources Sought to support Requests for Information (RFI) activities and Industry Day events.
    - Ensure the RFI is open to alternative solutions
- Analyze potential trade space to identify performance versus cost benefits discriminators for potential candidate materiel solutions.

- Initiate planning for the manufacturing and quality efforts required during the next phase.

Metrics

- Results of working with the S&T community, as well as other collaborators, technical knowledge base for each candidate materiel solution is documented in the AoA Study Guidance.
- Documentation of the availability of necessary resources for the potential candidate materiel solutions and the current state industrial practices as a basis for the Sources Sought and the Requests for Information.
- Manufacturing and quality inputs for Sources Sought activities are documented and provided, as appropriate.
- Information from the Sources Sought documented and used to support RFI activities and Industry Day events for the potential candidate materiel solutions.
    - Documentation recognizes alternative solutions in the RFI
- Potential trade space identifying performance versus cost benefit discriminators for potential candidate materiel solutions have been analyzed developed and documented for subsequent acquisition phases.
- Planning for the manufacturing and quality efforts required during the next phase initiated and documented for the future Acquisition Strategy (AS).

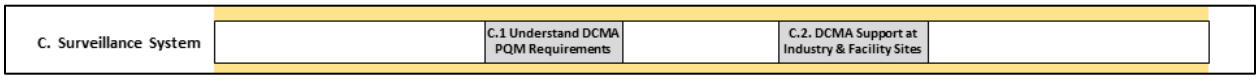
Tools

- AoA Study Plan Template
- Market Research Reporting Template
- Pugh Matrix Template
- Systems Engineering Plan (SEP) Outline

Resources

- Air Force AoA Handbook, Jul 2008
- DAG Chapter 14
- DoD Market Research Guide, May 2012
- SEP Outline, Jun 2015

C. SURVEILLANCE SYSTEM



The activity managing the concept or the Program Manager should maximize the use of DCMA personnel at contractor facilities where there is delegation of authority and expertise available. Request DCMA Contract Management Offices jointly support development of program support plans

for all Acquisition Category I program contracts to ensure agreement on contract oversight needs and perspectives.

C.1 Understand DCMA PQM Data Inputs

Manufacturing and Quality Tasks

- Ensure quality and manufacturing requirements are included in contracts and in appropriate agreements with other agencies (e.g., DCMA).
    - Request DCMA recommend the appropriate quality (i.e., ISO 9001 or AS9100) and manufacturing management program requirements (i.e., AS6500 or contractual) requirements language to be included in solicitations, requests for proposals, and contracts and in appropriate agreements with other agencies (e.g., DCMA).
    - Request DCMA provide supporting rationale for recommendations on the emerging technology maturity.
- As part of manufacturing feasibility assessments of each concept being considered, request information and data input for similar products and manufacturing processes from DCMA on:
    - Manufacturing maturity of similar products and processes
    - Status and readiness of industrial capabilities
    - Current available facilities and equipment
    - Workforce availability and training
    - Quality system processes and results
- Identify the manufacturing and/or production, quality, engineering and software development risks for similar products and processes relevant to each concept being considered for the AoA Study.
    - Request DCMA to provide data to support analysis of the identified risks including lessons learned.

Metrics

- Quality and manufacturing requirements have been documented and included in contracts and in appropriate agreements with other agencies (e.g., DCMA).
- Supporting rationale for recommendations on the emerging technology maturity has been provided by DCMA and incorporated into the manufacturing feasibility assessment.
- In support of and documented in the manufacturing feasibility assessments of each concept being considered, DCMA has provided information and data input for similar products and manufacturing processes for:
    - Manufacturing maturity of similar products and processes
    - Status and readiness of industrial capabilities

- Current available facilities and equipment
- Workforce availability and training
- Quality system processes and results

- Manufacturing and/or production, quality, engineering, and software development risks for similar products and processes relevant to each concept being considered for the AoA Study have been provided by DCMA, including lessons learned, and documented in the analysis of the identified risks.

Tools

- AoA Study Plan Template
- DCMA Pre-Award Survey
- DCMA Program Support Plan
- Industrial Base Capabilities Assessment Questionnaire
- Manufacturing Readiness Level (MRL) Assessment Questionnaire
- Risk Assessment Template
- TRL Assessment Checklist

Resources

- Air Force AoA Handbook, Jul 2008
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, Jan 2017
- MRL Deskbook Version 2.5, 2016
- Technology Readiness Assessment Guidance, Apr 2011

C.2 DCMA Support at Industry and Facility Sites

Manufacturing and Quality Tasks

- Based on DCMA (when requested and agreed to by DCMA) inputs, sponsor manufacturing investment programs that support:
  - Development and management of industrial base investment programs that create, expand, or preserve assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense
  - Assessment and evaluation of candidate programs
- Based on DCMA (when requested and agreed to by DCMA) inputs, develop recommendations to program and contracting personnel on manufacturing technology investments and Title III initiatives.

- Based on DCMA (when requested and agreed to by DCMA) information, develop assistance requests to DoD and/or component manufacturing technology programs that support:
  - Identification of new manufacturing processes associated with the program and candidate components for the identified processes
  - Identification of low-yield processes and components
  - Request for manufacturing technology (ManTech) assistance for identified processes and components
  - Development of requests for information and academia responses to warfighter needs
- Based on DCMA (when requested and agreed to by DCMA) information, evaluate and submit recommendations on an emerging manufacturing technology maturity.
  - Conduct manufacturing technology assessments to evaluate an emerging manufacturing technology to determine feasibility for production
  - Assess the emerging manufacturing technology to ensure it meets production requirements
    - Develop recommendations on the emerging manufacturing technology maturity
    - Document assessment of industrial capabilities and recommendations for applicability of emerging manufacturing technology, and provide to decision maker

Metrics

- Based on DCMA inputs, manufacturing investment programs have/are being sponsored that support for:
  - Development and management of industrial base investment programs that create, expand or preserve assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense have been conducted and the results documented for inclusion in the AoA Study guidance
  - Assessment and evaluation of candidate programs with results documented for inclusion in the AoA Study Guidance
- Based on DCMA inputs, development and documentation of recommendations for program and contracting personnel on manufacturing technology investments and Title III initiatives for the AoA Study Guidance have been completed based on DCMA inputs.
- Based on DCMA information, assistance requests to DoD and/or component manufacturing technology programs have been developed and documented that support:
  - Identification of new manufacturing processes associated with the program and candidate components for the identified processes
  - Identification of low-yield processes and components
  - Request ManTech assistance for identified processes and components
  - Requests for information from industry and academia have been developed and the responses documented to address warfighter needs in the AoA Study Guidance

- Based on DCMA information, evaluate and submit recommendations on an emerging manufacturing technology maturity
    - Manufacturing technology assessments to evaluate an emerging manufacturing technology to determine its feasibility for production have been conducted and the results documented for inclusion in the AoA Study Guidance
    - Emerging manufacturing technology has been assessed to ensure it meets production requirements and the results documented for inclusion in the AoA Study Guidance
    - Prepare an assessment summary on the feasibility of the manufacturing technology to meet production requirements

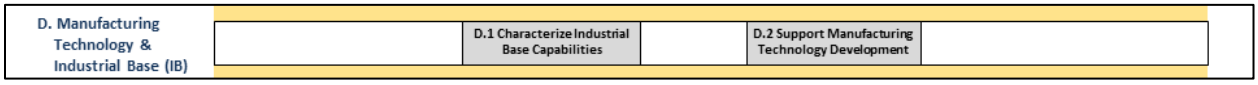
Tools

- Army Manufacturing Technology (ManTech) Proposal Rating Template
- ManTech Phase I Questions
- Pugh Matrix Template

Resources

- DoD Directive 4200.15, DoD ManTech Program
- ManTech Strategic Plan, Mar 2009
- See Service-specific ManTech requirements

D. MANUFACTURING TECHNOLOGY AND INDUSTRIAL BASE



Title 10 U.S.C, Section 2440, Technology and the Industrial Base, requires the "Secretary of Defense to prescribe regulations requiring consideration of the national technology and industrial base in the development and implementation of acquisition plans for each major defense acquisition program." If programs are to be successful and meet the intent of the law, manufacturing and quality need to be a major consideration in all phases of acquisition. For example, the National Environmental Policy Act (NEPA) requires Federal agencies to consider the environmental impacts of proposed actions, including actions within acquisition programs, before they are implemented.

The 5000.02 guidance provides for manufacturing assessments throughout the entire acquisition cycle and includes such areas as production planning, transition to production, concurrent engineering, quality management, continuous improvement, could cost, and manufacturing technology. The Defense Acquisition Executive (DAE) passes this policy through the respective SAEs who are the senior acquisition executives within the DoD Component having cognizance and management. Planning and effective investments in industrial base capabilities allow for a smooth transition from development to production and sustainment.

D.1 Characterize Industrial Base Capabilities

Manufacturing and Quality Tasks

- Conduct industrial base sector studies (i.e., capabilities and capacities) relevant to potential and future needs inclusive of design, development, production, operation, and sustainment, and eventual disposal.
    - Identify and understand potential industrial base sources and needs.
- Conduct an Industrial Base assessment to identify sources relevant to the concepts being considered for the ICD, AoA Study Guidance, and the MDD.
    - Include identification of unique manufacturing capabilities that are not readily accessible (i.e., require regeneration).
    - Include DCMA (when requested and agreed to by DCMA) data that supports the following:
        - Industrial Capability Assessments
        - Analytical Products
        - Defense Business and Economic Analysis
        - Acquisition Planning Support
- Analyze the capabilities of the identified Industrial Base sources to develop, produce, maintain, and support the concepts being considered for inclusion in the ICD, AoA Study Guidance, and the MDD:
    - Identify the external dependencies and integration impacts.
    - Identify the availability of essential raw materials, special alloys, composite materials, components, tooling, and manufacturing and quality test equipment required to support the concepts being considered.
    - Identify items that are sole or single sourced, fragile source, or available only from sources outside the National Technology Industrial Base (NTIB).
        - Analyze the effects on the sources for the concepts being considered that result from foreign acquisition of firms in the United States.
    - Identify the availability of alternatives for obtaining such items from within the NTIB
        - Analyze the military vulnerability that could result from the lack of alternatives, if such items become unavailable from sources outside the NTIB.
- Use appropriate models and simulations to develop required documentation for the MDD.

Metrics

- As a result of industrial base sector studies, potential sources that could address potential and future needs have been identified and documented.

- Includes design, development, production, operation, and sustainment, and eventual disposal.

- An assessment has been conducted and identifies sources relevant to the concepts being considered documented in the ICD, the AoA Study Guidance, and the MDD and includes:
  - Identification of unique manufacturing capabilities that are not readily accessible (i.e., require regeneration)
  - DCMA data on:
    - Industrial Capability Assessments
    - Analytical Products
    - Defense Business and Economic Analysis
    - Acquisition Planning Support
- Capability analysis of the identified Industrial Base sources to support the design, development, production, operation, and sustainment, and eventual disposal have been conducted on the concepts being considered and provided for inclusion in the AoA Study Guidance and the MDD.
  - The analysis identifies the external dependencies and integration impacts.
  - Analysis identifies and documents the availability of essential raw materials, special alloys, composite materials, components, tooling, and manufacturing and quality test equipment required to support the concepts being considered
  - The analysis identifies items that are sole or single sourced, fragile source, or available only from sources outside the NTIB.
    - Analysis also identifies the effects on the sources for the concepts being considered that result from foreign acquisition of firms in the United States.
    - Analyze the military vulnerability that could result from the lack of alternatives, if such items become unavailable from sources outside the NTIB.
- Evidence that appropriate models and simulations have been utilized and the results have been provided as input to the AoA Study Guidance and the MDD.

Tools

- AoA Study Plan Template
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- MRL Assessment Checklist for Technology and Industrial Base thread
- Army ManTech Proposal Rating Template
- Numerous M&S models are available that the contractor may use, we (government) should be familiar with these tools

Resources

- Air Force AoA Handbook, Jul 2008
- DoDD 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.02
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- Industrial Base Capabilities Assessment
- MRL Deskbook Version 2.5, 2016
- M&S Guidance for the Acquisition Workforce, Oct 2008

D.2 Support Manufacturing Technology Development

Manufacturing and Quality Tasks

- As part of industrial base sector studies, survey manufacturing and quality technologies and capabilities relevant to potential and future needs.
    - Identify and understand potential industrial base investment needs.
- Identify the requirement for the use of advanced manufacturing and quality technology and processes for the concepts being considered.
- Conduct a survey of ManTech Program technology concepts that are ongoing, in development, and support the concepts being considered.
    - Based on survey needs for Manufacturing Technology assistance identified.
    - Based on survey provide recommendations on manufacturing and quality technology investments and Title III initiatives.
- Provide input to contract solicitations (sources sought, RFIs, etc.) that encourage acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life-cycle costs.
    - Methods to encourage investment by U.S. domestic sources in advanced manufacturing and quality technology production equipment and processes.

Metrics

- A survey of manufacturing and quality technologies and capabilities relevant to potential and future needs has been conducted and the results documented and included as part of industrial base sector studies.
- Potential industrial base investment needs have been identified, their impact understood and documented.
- The requirements for the use of advanced manufacturing and quality technology and processes for the concepts being considered have been documented for the AoA Study Guidance and the MDD.

- Analysis of ongoing ManTech Program technology concepts that support the concepts being considered completed and documented.
  - Needs for Manufacturing Technology assistance documented AoA Study Guidance.
  - Recommendations on manufacturing and quality technology investments and Title III initiatives have been documented and provided to the appropriate Service or Agency.
- Draft language written for the future AS, sources sought, RFIs, etc. has been provided as input to AoA Study Guidance.

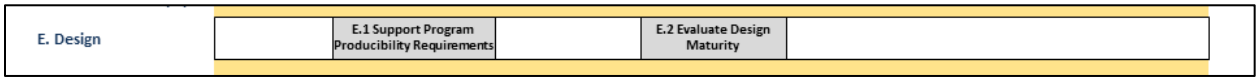
Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- TRL Assessment Checklist

Resources

- Air Force Technology Development and Transition Strategy Guidebook, Nov 2010
- Defense Manufacturing Management Guide for Program Managers, Chapter 8, *Technology Development and Investments*
- DoDI 5000.02
- DoD Directive 4200.15, ManTech
- MRL Deskbook Version 2.5, 2016
- Technology Readiness Assessment Guidance, Apr 2011

E. DESIGN



One of the major objectives is to evaluate manufacturing feasibility, or to answer the question "can you build it?" Producibility is an engineering function directed toward generating a design which is compatible with manufacturing capability and quality processes. It is often considered the most important determinant of product cost, due to the effect on both production and sustainment costs.

Proposed materiel solutions should be assessed for manufacturability and producibility to ensure that one or more candidate materiel solutions have the potential to be affordable, effective, suitable, and can be developed to provide a timely solution to a need at an acceptable level of risk. This presents the first real opportunity to influence systems design and begin planning for production by balancing technology opportunities and current practices against cost, schedule and performance. User needs should be expressed in terms of quantifiable parameters. The intent is to reduce technical risk, evaluate design concepts, support cost estimates, evaluate manufacturing processes, and refine design requirements.

Quality requirements are integral to design and development efforts as specified in industry best practice standards for quality management systems (ISO 9001, AS9100, etc.). These standards for systems engineering processes emphasize the importance of quality as part of program requirements in early design. The typical processes included in the QMS and included in this document are:

- Design and Development Planning (e.g., Engineering Management, FMECA, Safety, etc.)
- Design and Development Inputs/Outputs and Reviews (e.g., Verification and Validation (V&V), Test and Evaluation (T&E) Management, reviews and audits, etc.)
- Risk and Configuration Management

DoD acquisition programs may face a high risk of failure at the outset of the design process based on the maturity of the design. Some level of risk associated with new concepts may be unavoidable, historically this risk has been magnified by a misunderstanding of the efforts necessary to mature the concept into a mature product. The government and its contractors must share equal responsibility for this misunderstanding. The contractor's proposal and the government's source selection process provide the most cost-effective opportunity to ensure application of these critical efforts during design maturation.

A mature design in pre-MDD phase should begin to show these characteristics: the design meets requirements and overcomes shortfalls, the design is experiencing minimal changes, and initial testing and experiments indicate performance can be met. However, final design will be determined at Critical Design Review (CDR), much later in the program.

E.1 Support Program Producibility Requirements

Manufacturing and Quality Tasks

- Assess the manufacturing producibility and feasibility of the concepts being considered as materiel solutions to ensure that one or more concepts have the potential to be affordable, effective, suitable, and can be developed to provide a timely solution to a need at an acceptable level of risk. The assessment should include:
    - Evaluation of design concepts
    - Identification and determination of costs, cost drivers, and potential risks
    - Identification of manufacturing and quality processes needed and requirements
    - Identification of design requirements
    - Identification of technical risks
- Additional analysis of the following areas should be conducted as the concepts mature:
    - Technology maturity
    - Industrial Base capability
    - Manufacturability
    - Funding required for maturing the manufacturing and quality processes

  - Materials availability
  - Tests and demonstrations for new materials and processes
  - Environmental impacts
  - Anticipated manufacturing and quality risks including potential cost and schedule impacts

- Conduct trade studies that consider and incorporate alternative system designs and other technical considerations.

Metrics

- Concepts being considered as materiel solutions have been assessed and documented in the AoA Study Guidance for producibility and feasibility, including:

  - Affordability
  - Effectiveness
  - Suitability
  - Timeliness (including rapid deployment)
  - Manufacturing and quality requirements and processes
  - Design requirements
  - Technical risks
  - Costs, cost drivers, and potential risks

- Concepts analysis has been conducted and documented as an input to the AoA Study Guidance for the following:

  - Technology maturity
  - Industrial Base capability
  - Manufacturability
  - Funding required for maturing the manufacturing and quality processes
  - Materials availability
  - Tests and demonstrations for new materials and processes
  - Environmental impacts
  - Anticipated manufacturing and quality risks including potential cost and schedule impacts

- Trade studies have been conducted to document alternative designs considered and other technical considerations and provide as input to the AoA Study Guidance.

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Manufacturing Producibility Assessment Worksheet (PAW)
- Market Research Reporting Template
- MRL Assessment Checklist for Design thread

- Preliminary Hazards List Developed
- Pugh Matrix
- TRL Assessment Checklist
- TRIZ Matrix

Resources

- ESOH in Acquisition Guide, Apr 2009
- DoDI 5000.02
- MRL Deskbook Version 2.5, 2016
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
- Technology Readiness Assessment Guidance, Apr 2011

E.2 Evaluate Design Maturity

Manufacturing and Quality Tasks

- Identify the manufacturing industrial base capabilities and the manufacturing technologies required by candidate materiel solution approaches to evaluate the respective design maturities.
- Identify broad performance requirements of candidate materiel solution approaches that may drive manufacturing and quality options.
- Assess the maturity of each candidate materiel solution's design options based on experiments.
- Identify and evaluate candidate materiel solution approaches lifecycle and technical requirements.
- Identify and evaluate reasonable technologies that can be available in the timeframe available.

Metrics

- Manufacturing industrial base capabilities and the manufacturing technologies applications required by candidate materiel solution approaches and the impact on respective design maturities have been documented for the AoA Study Guidance.
- Broad performance requirements for candidate materiel solution approaches that may drive manufacturing and quality options have been identified and documented for the AoA Study Guidance.
- Designs have been evaluated for the efforts necessary to mature the concepts into a mature product from immature technologies for inclusion in the AoA Study Guidance.
    - Trade-offs to candidate materiel solution approaches to design have been assessed based on experiments and results documented.

  - Affordability, producibility, sustainability, and other appropriate "ilities" are documented.
  - Analysis results document the necessary steps to mature the concept sufficiently to meet initial manufacturing and quality needs.

- Maturity is demonstrated and documented with a "bread-board" model, trade-off studies, and experiments as appropriate.
- Life-cycle sustainability has been evaluated and documented for the AoA Study Guidance.
- Technologies that can be available in the recommended timeframe have been identified and evaluated for the AoA Study Guidance.

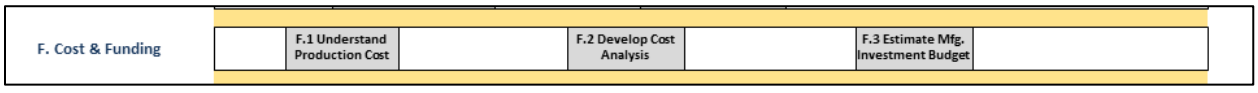
Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Market Research Reporting Template
- MRL Assessment Questionnaire using design thread
- Producibility Assessment Worksheet (PAW)
- Pugh Matrix Template
- TRL Assessment Checklist
- TRIZ Matrix

Resources

- AS9100, Quality Management Systems - Requirements for Aviation, Space and Defense Organizations
- DoD 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.60, Assessing Defense Industrial Capabilities
- ISO 9001, Quality Management Systems
- DoD Market Research Guide, May 2012
- MRL Deskbook Version 2.5, 2016
- Producibility System Guidelines, NAVSO P-3687, Dec 1999
- Technology Readiness Assessment Guidance, Apr 2011

F. COST/FUNDING



Throughout the acquisition process, systems engineering provides the technical foundation for the acquisition program. In the early stages of an acquisition, systems engineering analysis and products are vital to the ability to assess appropriately the feasibility of addressing user needs, technology needs of potential solutions, and robust estimates of cost, schedule, and risk, all leading to predictable, disciplined acquisition.

The government's objective is to determine the costs to develop, execute, field, and maintain each candidate materiel solution. Implementation of processes and systems that consider manufacturing, quality, and design functions in achieving a product design which meets cost, schedule, and performance requirements with acceptable risk is required.

Appropriate practices for implementation will include parametric and production cost modeling estimates. Parametric cost modeling requires identification of similar systems, products, components, and manufacturing processes, and other factors. Production cost modeling includes identification of critical characteristics and Key Characteristics (KC) and critical and key manufacturing and test processes; variability reduction; simulations of the manufacturing environment; cost/performance trade studies; manufacturing capability assessments; product and process validation; and key supplier relationships. Depending on the candidate materiel solution, production cost modeling may have limited application in this phase.

Part of the task or role for manufacturing and quality is to identify investments needed in the industrial base or infrastructure for each candidate materiel solution. The needed investments may include: additional industrial capacity, test equipment, workforce training, special materials handling, transportation, etc.

Additionally, investments in processes and systems to assure program affordability, through product quality and manufacturing efficiency, may include for implementation: product improvement initiatives, variability reduction on product and process, manufacturing process control and continuous improvement, key supplier relationships, and investments in manufacturing technology. To that end, ongoing and future ManTech, Title III, etc., program investments need to be considered to achieve the desired performance while controlling or meeting acquisition cost objectives. This accomplished by developing, maturing, and transitioning advanced manufacturing technologies.

F.1 Understand Production Cost

Manufacturing and Quality Tasks

- Evaluate the Cost Analysis and Program Assessment (CAPE) parametric costs estimates for appropriateness and completeness of manufacturing considerations.
    - Identify similar systems, products, components, and manufacturing and quality processes with established Average Procurement Unit Cost or Average Manufacturing Unit Cost (if available) for input to the parametric cost analysis and the study guidance.
- Support the development of cost estimates for each of the candidate materiel solutions for inclusion in the AoA Study Guidance.
    - Cost estimates should include:

    - Identification of critical and key/critical product characteristics/features and critical and key/critical manufacturing and test processes
    - Identification of variability reduction needs
    - Simulations of the manufacturing environment
    - Trade studies of cost/performance
    - Capability assessments of manufacturing and quality, product and process validation, and key supplier relationships
- Provide manufacturing and quality input to initial cost targets and error bands for candidate materiel solutions.

Metrics

- Analysis of CAPE parametric costs for manufacturing and quality cost estimates have been completed and documented with recommendations for the AoA Study Guidance.
- Manufacturing and quality cost estimates for the candidate materiel solutions have been evaluated and results provided for inclusion in the AoA Study Guidance.
    - Cost estimates include documentation for:
        - Critical and key product characteristics/features and critical and key manufacturing processes
        - Variability reduction needs
        - Manufacturing environment simulation results
        - Trade study cost/performance results
        - Capability assessment results of manufacturing and quality, product and process validation, and key supplier relationships
- Initial cost targets and error bands reviewed and results documented for inclusion in the AoA Study Guidance.

Tools

- Analogy and Parametric Estimating Techniques
- Cost Analysis Requirements Description Template (CARD) (see CAPE website for tools)
- Manufacturing Readiness Level (MRL) Assessment Questionnaire, Cost Thread
- Cost and Lead Time Estimating Worksheet
- Manufacturing Cost Estimating Worksheet

Resources

- Cost Analysis Requirements Description (CARD) Template (See CAPE website for guidance)
- DAG Chapter 3.4, “Cost Estimation for MDAPs”

- Defense Manufacturing Management Guide for Program Managers, Chapter 9, Manufacturing Cost Estimating
- DoDI 5000.73, Cost Analysis Guidance and Procedures, Jun 2015
- MRL Deskbook Version 2.5, 2016
- MIL-HDBK 766, Design to Cost, 1989
- Parametric Estimating Handbook, Apr 2008

F.2 Develop Cost Analysis

Manufacturing and Quality Tasks

- Identify the applicable guidance for developing manufacturing and quality cost estimates
- Identify investments needed in the industrial base or infrastructure for each candidate materiel solution
- Support initial document development of the CARD with the manufacturing and quality inputs for the appropriate cost categories (e.g., producibility study costs).
- Identify any manufacturing and quality cost implications for candidate materiel solutions.
- Identify manufacturing and quality cost drivers of candidate materiel solutions (e.g., proposed materials and process selections that may be inherent).
- Conduct manufacturing and quality cost sensitivity analysis where appropriate if possible.
- Identify manufacturing and quality workforce and integration cost requirement implications.
- Part of the task or role for manufacturing and quality is to identify investments needed in the industrial base or infrastructure for each candidate materiel solution. The needed investments may include: additional industrial capacity, test equipment, workforce training, special materials handling, transportation, etc.

Metrics

- Guidance for developing manufacturing and quality cost estimates has been documented and included in the AoA Study Guidance.
    - Manufacturing and quality cost sensitivity analysis (where appropriate) has been conducted
    - Manufacturing and quality workforce and integration cost requirement implications
    - Process for estimating life cycle costs
- Manufacturing and quality inputs for the appropriate cost categories for the CARD have been developed and provided.
- Manufacturing and quality cost implications for candidate materiel solutions have been documented in the AoA Study Guidance.
- Manufacturing and quality cost drivers of candidate materiel solutions (e.g., proposed materials and process selections that may be inherent) have been documented in the AoA Study Guidance.

Tools

- Cost/Schedule Control System Criteria (widely replaced by Earned Value Management, but could use on a small project)
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Readiness Level Assessment (MRL) Questionnaire using the Cost Thread
- See CAPE website for tools

Resources

- Cost/Schedule Control System Criteria Reference Guide, Sep 1992
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- See CAPE website for guidance

F.3 Estimate Manufacturing and Quality Investment Budget

Manufacturing and Quality Tasks

- Estimate investments required for candidate materiel solution approach
  - Capital equipment (tooling, machines, structures, etc.)
  - Test equipment (specialized, environmental, etc.)
  - Facilities and modifications/expansion (handling, storage, transportation, disposal)
  - Government-furnished equipment (GFE)
- Identify new or high risk manufacturing and quality processes that require investments as part of a manufacturing feasibility assessment to meet concept needs
  - Assess ongoing ManTech, Title III, etc. program investments
  - Identify future ManTech, Title III, etc. program investments

Metrics

- Manufacturing and quality investments for the candidate materiel solutions have been developed and evaluated with results provided for inclusion in the AoA Study Guidance. Including:
  - Capital equipment (tooling, machines, structures, etc.)
  - Test equipment (specialized, environmental, etc.)
  - Facilities and modifications/expansion (handling, storage, transportation, disposal)
  - GFE
- New or high-risk manufacturing and quality processes have been identified, documented, and addressed in either an ongoing or future ManTech or other program budget request.

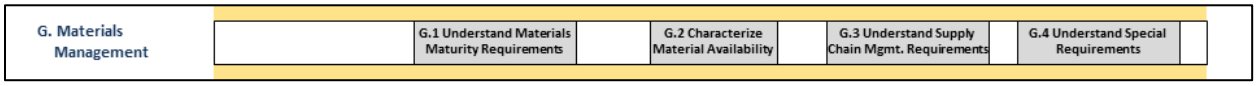
Tools

- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Readiness Level (MRL) Assessment Questionnaire using the Cost Thread
- See CAPE website for tools http://www.cape.osd.mil/

Resources

- MRL Deskbook Version 2.5, 2016
- See CAPE website for guidance http://www.cape.osd.mil/

G. MATERIALS MANAGEMENT



Materials management is a key focus area of manufacturing and quality tasks for the concepts being considered for development. Material management will require assessment of the maturity, the materials availability, the capability and capacity of the proposed supply chain to provide the materials, and the potential need for special handling, government-furnished property (GFP), shelf life, security, storage, environmental, etc. requirements.

The assessment will identify the need for any additional research to mature materials and identify the properties, characteristics, and quality deemed necessary to support the concepts being considered. Material properties, characteristics, and quality will require experiments for validation and assessment for basic manufacturability.

The assessment will also identify materials that are available to support the concepts being considered, as well as the manufacturing, quality, and scale-up risks and issues. It will also identify those materials that are not readily available and will include identification of sources of material (from the NTIB or foreign sources).

The complexity of the DoD supply chain for a weapon system is staggering with a supply chain that often encompasses hundreds of vendors and subcontractors. Adding to the complexity is the fact that on many large weapon system programs the prime contractor is often the integrator, with much of the program content coming from subcontractor, government, and other vendors or suppliers. Thus managing the supply chain, which includes the materials and the associated schedules, becomes a key and critical management function.

G.1 Understand Materials Maturity Requirements

Manufacturing and Quality Tasks

- Identify needed material properties, characteristics, and quality for each candidate materiel solution.
    - Identify and document appropriate metrics for evaluating materials against requirements.
- Identify additional research and development (R&D) and experiments required for immature materials for validation and assessment of basic manufacturability
- Investigate ongoing programs (DoD, science and technology (S&T), commercial, government, etc.) to identify materials that address each candidate materiel solution needs.
    - Assess materials manufacturing maturity
- Perform volatility assessments for each candidate materiel solution:
    - Potential supply chain sources for critical materials
    - Hazardous materials
    - Special handling procedures that were applied in the lab and include in lead time estimates

Metrics

- Material properties for candidate materiel solution approaches have been identified and documented for the AoA Study Guidance.
    - Identified metrics for evaluating materials have been specified and documented.
- Required R&D and experiments for immature materials that have been developed and tested in a lab environment have been investigated and assessed and results documented.
- Ongoing programs (DoD, S&T, commercial, government, etc.) have been investigated and assessed for materials that support candidate materiel solution and results documented.
    - Documentation includes assessments of material maturity for each candidate materiel solution
- Volatility assessments for each candidate materiel solution were conducted and document:
    - Potential supply chain sources for critical materials
    - Hazardous materials
    - Special handling procedures that were applied in the lab and include in lead time estimates

Tools

- Market Research Reporting Template
- MRL Questionnaire for Material Management thread

- Design for Six Sigma (Tools)
- Design of Experiments Analysis
- Taguchi Loss Function Analysis

Resources

- MRL Deskbook Version 2.5, 2016

G.2 Characterize Materiel Availability

Manufacturing and Quality Tasks

- Identify the availability of essential raw materials, special alloys, composite materials, and components, required to support the concepts being considered.
- Assess material requirements, external dependencies, and availability for candidate materiel solutions.
    - Identify materials that are:
        - Developed in a lab environment, but are not immediately available
        - Readily available within near term (i.e., commodities)
        - Commercially available, but have long lead times
        - Readily available, but have environmental or health concerns
- Assess material scale-up issues for candidate materiel solutions.
- Identify items that are sole or single sourced, fragile source, or available only from sources outside the NTIB.
    - Assess the availability and lead time for of alternatives for obtaining such items from within the NTIB
    - Conduct an analysis of any military vulnerability or gaps that could result from the lack of reasonable alternatives.
- Assess the effects on the NTIB that result from foreign acquisition of firms in the United States.

Metrics

- Assessment of material requirements, external dependencies, and availability for candidate materiel solutions has been conducted and documented and identifies materials, special alloys, composite materials, and components that are:
    - Developed in a lab environment, but are not immediately available
    - Readily available within near term (i.e., commodities)
    - Commercially available, but have long lead times
    - Readily available, but have environmental or health concerns

- Assessment of material scale-up issues for candidate materiel solutions has been conducted and documented.
- Items that are sole or single sourced, fragile source, or available only from sources outside the NTIB have been identified and documented.
    - Availability and lead time for of alternatives for obtaining such items from within the NTIB have been identified and documented
    - Analysis of any military vulnerability or gaps that could result from the lack of reasonable alternatives has been completed and documented
- Any domestic sources that are vulnerable to foreign acquisition have been identified and documented.

Tools

- Cost and Lead Time Estimating Worksheet
- Diminishing Manufacturing Sources and Material Sources (DMSMS) Product Life Cycle Assessment (Consult Defense Logistics Agency (DLA))
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- MRL Assessment Questionnaire for Material Management thread
- Market Research Reporting Template
- Technology Readiness Level Assessment Checklist

Resources

- DMSMS Guidebook, SD-22, Sep 2009
- MRL Deskbook Version 2.5, 2016

G.3 Understand Materials Supply Chain Requirements

Manufacturing and Quality Tasks

- Conduct an initial assessment of potential supply chain capability and capacity for candidate materiel solution approaches.
- Recommend industry best practices to be followed for management of the materials supply chain for the concepts being considered.
    - Include industry best practices for manufacturing and quality to be followed in the supply chain for the concepts being considered.
- Recommend manufacturing and quality processes or standards for the procurement team to follow to provide a basis for the team to work together and add value.
- Establish a threshold and objective requirements for flow down of realistic and attainable requirements for a new concept to the supply chain as appropriate.

- Identify realistic material estimates (time, material, manpower, etc.) to be provided to the entire supply chain
- Evaluate the flow down process for gaps throughout the entire supply chain

Metrics

- An initial assessment of potential supply chain capability and capacity for candidate materiel solution approaches has been conducted and documented.
- Documentation of industry best practices for management of the materials supply chain for the concepts being considered has been included in the AoA Study Guidance.
  - Documentation includes recommendations for manufacturing and quality best practices to be followed by the supply chain
- Supplier management manufacturing and quality processes or standards based on industry best practices have been flowed to the entire procurement team and documented in the AoA Study Guidance.
- Threshold and objective requirements for flow down of realistic and attainable requirements for a new concept has been developed and documented.
  - Realistic material estimates (time, material, manpower, etc.) have been developed to be provided to the entire supply chain.
  - Gaps in the flow down process throughout the supply chain with recommended alternatives have been documented.

Tools

- Manufacturing Readiness Level (MRL) Assessment Questionnaire using materials thread
- Supply Chain Management Risk Assessment Checklist

Resources

- DoD Market Research Guide, May 2012
- MRL Deskbook Version 2.5, 2016
- DoD 4140.1-R, Supply Chain Management Regulation, May 2003
- DoDM 4140.1, DoD Supply Chain Management Procedures, Feb 2014

G.4 Understand Special Requirements (e.g., Government-Furnished Property (GFP), Shelf Life, Security, Hazardous Materials, Storage Environment)

Manufacturing and Quality Tasks

- Identify the special requirements in the manufacturing processes which will be utilized to build the candidate materiel solution approaches.
  - Hazardous materials and handling procedures

- Security requirements
- Storage and shelf life
- GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
- Disposal

- Identify potential regulatory requirements, handling concerns, transportation, etc. for candidate materiel solution approaches.

Metrics

- The special requirements in the manufacturing processes which will be utilized to build the candidate materiel solution approaches have been identified and documented
  - Hazardous materials and handling
  - Security requirements
  - Storage and shelf life
  - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
  - Disposal
- Potential regulatory requirements, handling concerns, transportation, etc. for candidate materiel solution approaches have been identified and documented.

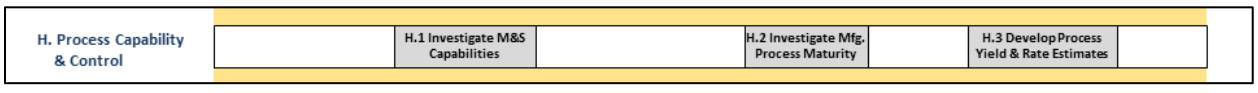
Tools

- Cyber Security Assessment
- DMSMS Product Life Cycle Assessment
- Hazardous Material Assessment Template
- ISO 9001, Checklist Section 7.5.5, Preservation (Handling, Storage, Packaging and Delivery)
- ITAR Compliance Checklist
- Preliminary Hazard List (PHL) See PHA checklist
- Shelf Life Calculator for Composite Materials
- MRL Assessment Checklist for Material Management Thread

Resources

- ISO 9001, Quality Management Systems
- MRL Deskbook Version 2.5, 2016
- ESOH in Acquisition Guide, Apr 2009
- AS9100 Supply Chain Management (SCM) Model

H. PROCESS CAPABILITY AND CONTROL



Advances in digital engineering; modeling and simulation (M&S) along with continual improvements in computer performance have made it possible to perform comprehensive analysis of virtual parts and to test and assess the capability of processes before actual manufacturing begins. Through the use of solid modeling, finite element analysis, multi-paradigm numerical computing environments, and simulation software analysis tools, users are able to simulate different conditions that are likely to occur during manufacturing processes and model the behavior of systems under real-world conditions. An understanding of the capabilities to model products and processes for each of the concepts under consideration can be a valuable discriminator.

The goal of manufacturing and quality is to achieve uniform, defect-free products, and it is the job of the manufacturing and quality team to reduce or eliminate the sources of variation and uncertainty to meet this goal. For each concept being considered, a determination of the manufacturing processes (possibly at a high level) will be completed. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Critical and key manufacturing processes can also be identified during the assessment and analysis either through M&S or experimentation.

The activities managing the concept and program offices must understand the “manufacturing feasibility” (i.e., manufacturing risks) that are associated with each potential materiel solution. For example, many managers are under the false perception that identical production facilities will experience identical problems, this is almost always not the case. Another assumption that may also be made is when a facility that has operated smoothly in one location, it will again operate smoothly if moved to another location. Again, this is almost always not the case, even if the same workforce is utilized; variability due to disassembly, movement, and reassembly will occur. A source of information for these feasibility risks comes from the “lessons learned” data captured by contractors as part of their systems to capture their overall capabilities, knowledge, and best manufacturing practices. Incorporating lessons learned from investigations of similar manufacturing processes maturity into the models and simulations may also increase fidelity of results and characterization of the items being analyzed.

Most companies use M&S and other data analysis tools to help identify, analyze, and remove bottlenecks in the production process, improve yields, reduce costs, and improve quality. By collecting and analyzing the manufacturing and quality data, one is able to get a realistic picture of the entire process. A process has three features: how much variation (spread), where (centering), and shape (normal, skewed, bimodal, etc.). If processes are stable, then the process features, spread, centering, and shape, will remain constant and predictable over time. If the process is unstable, then these features will change, and the product output will become unpredictable. Data and information from similar manufacturing processes, as well as M&S processes, should be utilized to develop estimates of potential yields and rates of production of each concept under consideration as a discriminator as to which has the greatest potential to meet manufacturing and quality requirements.

H.1 Investigate Modeling and Simulation (Product and Process) Capabilities

Manufacturing and Quality Tasks

- Investigate initial product and or process models in development for candidate materiel solution approaches.
- Investigate manufacturing concepts or producibility modeling and simulation needs of candidate materiel solution approaches.
- Identify modeling and simulation tools that make it possible to perform a comprehensive analysis of virtual parts and to assess the capability of processes before actual manufacturing begins.
- Utilize modeling and simulation software to model the behavior of candidate materiel solutions under simulated “real-world” conditions.
- Establish requirements and data needs for the learning curve (cost improvement curve, or experience curve).

Metrics

- Initial product and or process models in development for candidate materiel solution approaches have been identified, assessed, and documented.
- Manufacturing concepts or producibility modeling and simulation needs of candidate materiel solution approaches have been identified, assessed, and documented.
- Modeling and simulation tools that make it possible to perform a comprehensive analysis of virtual parts and to assess the capability of processes before actual manufacturing begins have been identified, evaluated, and documented.
- Identify and document the tools and simulation software being utilized to model the behavior of candidate materiel solutions under simulated “real-world” conditions and the results (i.e., FEA).
- Planned learning curve and data requirements (cost improvement curve, or experience curve) have been developed and documented.

Tools

- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)
- Learning Curve Analysis Spreadsheet
- MRL Assessment Checklist for the Process Capability and Control Thread

Resources

- Modeling and Simulation Guidance for the Acquisition Workforce, Oct 2008

- MRL Deskbook Version 2.5, 2016
- Manufacturing Simulation Applications

H.2 Investigate Manufacturing Process Maturity

Manufacturing and Quality Tasks

- Assess feasibility of similar materials and/or similar manufacturing process approaches, and the projected gaps based on the data collected for each concept under consideration for the AoA Study Guidance.
- Conduct a manufacturing feasibility assessment that identifies the manufacturing and quality risks incurred for each concept under consideration, which should include:
    - Producibility of the potential design concepts
    - Critical and key manufacturing processes
    - Special tooling development required
    - Demonstration, test, and qualification required for new materials, to include items, parts and components
    - Alternate design approaches within the individual concepts
    - Lessons learned from similar approaches
    - Anticipated manufacturing and quality risks and potential cost and schedule impacts

Metrics

- A feasibility assessment of similar material and/or similar manufacturing process approaches for the AoA Study Guidance has been conducted and documented for each concept under consideration.
    - Collect data and document the data results for the AoA Study Guidance
- A feasibility assessment that identifies the manufacturing and quality risks incurred for each concept under consideration has been conducted and documents the following:
    - Producibility of the potential concepts
    - Critical and key manufacturing processes
    - Special tooling development required
    - Demonstration, test, and qualification required for new materials, to include items, parts and components
    - Alternate design approaches within the individual concepts
    - Lessons learned from similar approaches
    - Anticipated manufacturing and quality risks and potential cost and schedule impacts

Tools

- Feasibility Study Checklist

- MRL Assessment using Process Capability and Control Thread
- Process Capability Studies (Cp and Cpk assessment)
- Producibility Assessment Worksheet (PAW)
- Six Sigma Worksheet
- First Pass Yield Estimates Worksheet

Resources

- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999

H.3 Develop Process Yield and Rate Estimates

Manufacturing and Quality Tasks

- Develop and estimate yields and rates of candidate materiel solution approaches.
- Conduct a manufacturing and quality study of existing processes and the need for new processes for each concept under consideration to determine if the yield meets the requirements.
- Identify the sources of variations and plans to address for each concept under consideration.

Metrics

- Estimated yields and rates for each candidate materiel solution approach have been developed, evaluated, and documented.
- A manufacturing and quality study of existing processes and the need for new processes, and corresponding process yields to meet the requirements has been conducted and documented.
- Sources of variations and plans to address have been identified and recommended actions to be taken documented for each concept under consideration.

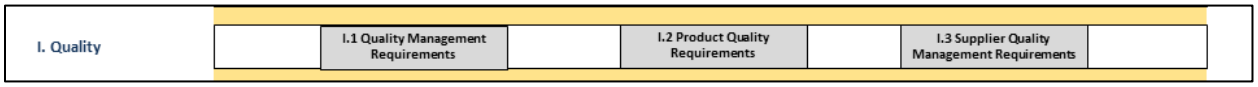
Tools

- Cause and Effect Diagram
- First Pass Yield Estimates Worksheet
- Histograms
- Pareto Analysis
- Process Capability Study Worksheet (Cp and Cpk Assessment)
- Six Sigma Worksheet

Resources

- DoD-Wide Continuous Process Improvement (CPI/Lean Six Sigma) Program, may 2008
- DoD Continuous Process Improvement Transformation Guide, May, 2006

I. QUALITY MANAGEMENT



DoD has increased management focus on manufacturing and quality management during early program phases. Quality is the degree to which material attributes, performance features, and characteristics of a product satisfy a given need. Quality may apply to a product, process, or system and may be physical, sensory, behavioral, temporal, ergonomic, or functional.

Quality management is the coordinated activities to direct and control an organization with regard to quality policy, quality objectives, quality planning, quality assurance and quality improvement. The quality of systems is significantly influenced by design and manufacturing processes and disciplines. These activities are performed as part of the Quality Management System (QMS), which is that part of the organization's management system that focuses on the results, in relation to the quality objectives, to satisfy the needs, expectations and requirements. In turn, Quality Assurance is that part of quality management focused on providing confidence that quality requirements will be fulfilled.

Quality management is an integral part of design and development efforts. QMS standards include industry best practices such as ISO 9001, *Quality Management Systems–Requirements;* and AS9100, *Quality Management Systems - Requirements for Aviation, Space and Defense Organizations*, Product Realization (clause 7) includes typical Systems Engineering tasks under sub-clause 7.3, Design and Development. The typical systems engineering processes included in the QMS are:

- Design and Development Planning – SE Management, Failure Modes, Effects, and Criticality Analysis (FMECA), System Safety, etc.
- Design and Development Inputs/Outputs – T&E, Reviews, and Audits.
- Design and Development Review, Verification and Validation.
- Control of Design and Development Changes – hardware and software Configuration Management.
- Hardware and Software Configuration Management.
- Risk, Issue, and Opportunity Management.
- Corrective Action System.

DoDI 5000.02 guidance provides for manufacturing assessments through the entire acquisition cycle and includes quality management and continuous improvement requirements. There are costs associated with a manufacturing effort and meeting the quality levels required. These costs, to a great degree, are inherent in and become essentially fixed as the design evolves. Given the objective of minimizing cost, quality is a key element and needs to be instituted early, and is integral to planning for the concepts being considered.

The initial AS, developed in the next phase, will address the approach to quality, quality management, and quality assurance. Consideration of these items and their impact on the quality requirements should be an integral part of the in AoA Study Guidance and the final AoA.

I.1 Quality Management Requirements

Manufacturing and Quality Tasks

- Specify the quality management requirements to be met by the contractor or government entity as appropriate.
- Evaluate each concept being considered and identify the capability to meet quality management needs.
    - Evaluate each concept being considered and identify the need for focused manufacturing or quality plans (e.g., a program Quality Assurance Plan) to guide the approach.
    - Evaluate each concept being considered and identify the need for a standalone government manufacturing or quality assurance plan.
- Understand the impact of technology and process state of the art on the concepts being considered and the impacts on quality management.
- Identify and understand potential solutions or systems that could address quality management needs.
    - Identify and understand manufacturing and quality management lessons-learned and best practices among programs and across centers
    - Assess and evaluate quality technologies that could assist on candidate materiel solution programs
- Identify potential solutions or systems to improve low-yield processes and components.
- Establish quality management metrics for each of the concepts being considered
    - Determine the frequency that the metrics should be reviewed, commensurate with manufacturing and quality risks.
- Evaluate potential QMSs for each of the concepts being considered.
    - The QMS should include:
        - Management responsibility
        - Resource management
        - Quality System
        - Contract Review
        - Product Realization
        - Design Control
        - Document Control
        - Purchasing

        - Purchaser-Supplied Product
        - Product Identification and Traceability
        - Process Control
        - Measurement, Analysis, and Improvement
    - Assess QMS audit records for frequency, compliance, and responsiveness
- Ensure quality and manufacturing requirements are included in contracts and in appropriate agreements with other agencies, e.g., the DCMA.
- Contact DCMA for input on QMS evaluation of potential contractors and suppliers for each concept being considered.

Metrics

- Document the quality management requirements to be met by the contractor or government entity as appropriate for the AoA Study Guidance.
- Analyze and document the capability to meet quality management needs for each concept being considered, and
    - Analyze and document the need for focused manufacturing or quality plans (e.g., a program Quality Assurance Plan) to guide the approach for each concept being considered and provide as input to the AoA Study Guidance.
    - Analyze and document the need for a standalone government manufacturing or quality assurance plan for each concept being considered and provide as input to the AoA Study Guidance.
- Document the impact of quality technology and process state of the art on the concepts being considered and the impacts on quality management.
- Identify and document potential solutions or systems to be included in the AoA Study Guidance that could address quality management needs to include:
    - An assessment of manufacturing and quality management lessons-learned and best practices among programs and across centers
    - An assessment of quality technologies that could assist on candidate solution programs
    - Potential solutions to improve low-yield processes and components and lower variability to meet quality management requirements
- Identify and document quality management metrics for each of the concepts being considered
    - The frequency that the metrics should be reviewed has been established, commensurate with manufacturing and quality risks.
- Assess, analyze and document for each concept being considered, the potential QMS for inclusion in the AoA Study Guidance.
    - The QMS is established, based on industry best practices, and should include:

- Management responsibility
- Resource management
- Quality System
- Contract Review
- Product Realization
- Design Control
- Document Control
- Purchasing
- Purchaser-Supplied Product
- Product Identification and Traceability
- Process Control
- Measurement, Analysis, and Improvement

  - QMS audit records for frequency, compliance, and responsiveness

- Quality and manufacturing requirements have been documented and included in contracts and in appropriate agreements with other agencies, e.g., the DCMA.
- DCMA inputs on evaluation of contractor's and supplier's QMS documented and incorporated into QMS analysis for AoA Study Guidance.

Tools

- AS9100 Quality Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- ISO 9001, Quality Management Systems, Quality Audit Checklist
- Manufacturing Readiness Level (MRL) Assessment Questionnaire for the Quality Thread
- Quality Management Plan (Sample)

Resources

- AFMC Instruction 63-145 Manufacturing and Quality
- AS9100 Quality Management System - Aerospace
- DAG Chapter 14.3.1.3.6, Quality Plans
- DoDI 5000.02
- ISO 9001, Quality Management Systems
- MRL Deskbook Version 2.5, 2016

I.2 Product Quality Requirements

Manufacturing and Quality Tasks

- Evaluate product quality requirements for each concept being considered:

- Identify product quality metrics and the frequency that the metrics should be reviewed, commensurate with manufacturing and quality risks.
- Identify the need for focused product quality requirements (i.e., specific product characteristics) to guide the approach.
- Identify the need for a standalone government product quality requirements.

- Identify and understand potential solutions that could address product quality needs.
  - Assess and evaluate quality technologies (e.g., metrology technologies) that could improve the candidate materiel solution's product quality.
  - Identify potential solutions to improve low-yield processes and components for each candidate materiel solution's product quality.
- Understand the impact of quality technology and process state of the art on the product quality requirements of the concepts being considered.
- Contact DCMA for inputs on potential contractor and supplier quality performance against requirements for similar products or processes.

Metrics

- Analyze and document in the AoA Study Guidance for each concept being considered:
  - Product quality requirements
  - Product quality metrics and the frequency that the metrics should be reviewed, commensurate with manufacturing and quality risks that have been determined.
  - The need for focused product quality requirements (i.e., specific product characteristics) to guide the approach for each concept being considered and provide as input.
  - The need for standalone government product quality requirements for each concept being considered and provide as input.
- Identify and document potential solutions that could address product quality needs to include (but not limited to):
  - An assessment of quality technologies that could assist on candidate solution programs
  - Potential solutions to improve low-yield processes and components and lower variability to meet product quality requirements
- Document the impact of quality technology and process state of the art on the concepts being considered and the impacts on product quality requirements for the concepts being considered.
- Inputs on potential contractor and supplier quality performance against requirements for similar products or processes provided by DCMA are incorporated into analysis of potential contractors and suppliers for each concept being considered and provide as input to the AoA Study Guidance.

Tools

- AS9100 Quality Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- ISO 9001, Quality Management Systems, Quality Audit Checklist
- Quality Management Plan (Sample)

Resources

- AS9100
- DAG Chapter 14.3.1.3.6, Quality Plans
- DoDI 5000.02
- ISO 9001, Quality Management Systems

I.3 Supplier Quality Management Requirements

Manufacturing and Quality Tasks

- Understand the impact of quality technology and process state of the art for the concepts being considered and the impacts on the supply chain (i.e., supplier's) quality management.
- Evaluate each concept being considered and identify supply chain quality management needs.
    - Evaluate each concept being considered and identify the need for focused supplier quality management requirements (e.g., a supplier Quality Assurance Plan) to guide the approach.
    - Evaluate each concept being considered and identify the need for a standalone government supplier quality plan for the supply chain.
- Establish supply chain quality management metrics for each of the concepts being considered
    - Determine the frequency that the metrics should be reviewed, commensurate with manufacturing and quality risks.
- Identify and understand potential solutions, tools, and techniques that could address supplier quality management requirements.
    - Assess and evaluate quality technologies (i.e., metrology technologies) that could improve the candidate materiel solution's supply chain programs.
    - Identify potential solutions (e.g., materials, machines, training, etc.) to improve low-yield processes and components and lower variability to meet supplier quality management requirements for each candidate materiel solution.
- Contact DCMA for input on evaluation of potential supplier's quality management (in the lower supply chain) for each concept being considered.

- Ensure quality and manufacturing requirements are included in contracts of proposed suppliers and in appropriate agreements with other agencies, e.g., the DCMA.

Metrics

- Document the impact of quality technology and process state of the art on the concepts being considered and the impacts on supply chain quality management.
- Analyze and document supply chain quality management needs for each concept being considered, and
  - Analyze and document the need for focused supplier quality management requirements (e.g., a supplier Quality Assurance Plan) to guide the approach for each concept being considered and provide as input to the AoA Study Guidance.
  - Analyze and document the need for a standalone government supplier quality plan for the supply chain of each concept being considered and provide as input to the AoA Study Guidance.
- Analyze and document supply chain quality management metrics for each of the concepts being considered
  - The frequency that the metrics are reviewed has been established, commensurate with manufacturing and quality risks.
- Identify and document potential solutions, tools, and techniques that could address supplier quality management needs to include (but not limited to):
  - An assessment of quality technologies (i.e., metrology technologies) that could assist on candidate solution supply chain programs
  - Potential solutions (e.g., materials, machines, training, etc.) to improve low-yield processes and components and lower variability to meet supplier quality management requirements
- DCMA inputs on evaluation of potential supplier's quality management (in the lower supply chain) for each concept being considered documented and incorporated into analysis for AoA Study Guidance.
- Quality and manufacturing requirements have been documented and included in contracts of proposed suppliers and in appropriate agreements with other agencies, e.g., DCMA.

Tools

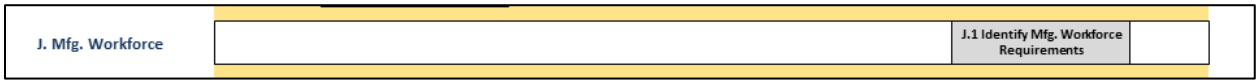
- AS9100 Quality Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- ISO 9001, Quality Management Systems, Quality Audit Checklist
- Supplier Quality Questionnaire

- Quality Management Plan (Sample)

Resources

- AS9100 Quality Management Systems
- DAG Chapter 14.3.1.3.6, Quality Plans
- DoDI 5000.02
- ISO 9001, Quality Management Systems

J. MANUFACTURING WORKFORCE



Manufacturing feasibility and industrial base analyses of the concepts being considered should address the existing skills of the appropriate workforce. The manufacturing and quality workforce has been ageing in recent decades, especially in many key defense sectors. Established manufacturing capabilities are becoming high risks as skills, facilities, equipment, etc. atrophy. Manufacturers have experienced a moderate to severe shortage of available, qualified production workers; a moderate to severe skills shortage in their overall workforce; and anticipate these shortages to grow worse in the coming years; and workforce shortages and skills deficiencies in production roles are having a significant impact on their ability to expand operations or improve productivity.

This trend is being addressed through increased emphasis on Science, Technology, Engineering and Math (STEM) skills to improve the current capabilities and achieve the right levels of skills. Along with education, training of personnel is key, as is having experience in the relevant areas of management. The workforce needs to be continuously improved through training and experience. The lessons learned show that manufacturing drives long-term economic prosperity and growth, and is important to the DoD mission.

J.1 Identify Manufacturing Workforce (Engineering and Production) Requirements

Manufacturing and Quality Tasks

- Identify new manufacturing and quality skills and training requirements for candidate materiel solution approaches.
- Identify planned personnel loadings to ensure that adequate numbers of people with the required skills are made available for each candidate material solution approach
    - Define a profile of the required workforce
    - Identify workforce requirements, special skills and training requirements.
    - Identify sources of personnel and their potential availability
    - Plan for the acquisition and training of new personnel

- Review appropriate workforce lessons learned to initiate development of tools and techniques that can be used to establish a better manufacturing workforce strategy.
- Understand new materials and technologies as they evolve and how the manufacturing and quality workforce will address processing, testing, and acceptance of these materials
- Identify potential regulatory requirements and special handling (e.g., hazardous materials, environmental needs, storage requirements, etc.) impacts to the manufacturing workforce by the candidate materiel solution approaches.

Metrics

- New manufacturing skills for candidate materiel solution approaches have been identified and documented.
- Workforce requirements, including special skills and training requirements have been identified, assessed, documented for the AoA Study Guidance, and includes:
  - Adequacy of the planned personnel loadings, ensuring that the required people with the required skills are available
  - Profile of the workforce required
  - Workforce requirements, special skills, and training requirements
  - Sources of personnel with evidence of their potential availability have been determined
  - A plan for the acquisition and training of new personnel, which is approved by the activity managing the concept or the program office
- Workforce Lessons Learned have been reviewed and documented with appropriate Lessons Learned applied to development of tools and techniques for a better manufacturing workforce strategy.
- Impacts of new materials and technologies on the manufacturing and quality workforce has been assessed and documented for each concept including impacts of processing, testing, and acceptance of these materials and technologies.
- Potential regulatory requirements and special handling (e.g., hazardous materials, environmental needs, storage requirements, etc.) impacts to the manufacturing workforce for each concept has been assessed and documented for the AoA Study Guidance.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)

- MRL Assessment using Manufacturing Management Thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRP II)

Resources

- MRL Deskbook Version 2.5, 2016
- Manufacturing Resource Planning (MRP II)

K. FACILITIES

During Pre-MDD phase, the proposed industrial and manufacturing facilities should be assessed for resources needed by each concept being considered as a materiel solution. Assessment of facility needs for concepts includes real property, factory capacity and storage, special handling and special environmental requirements, storage and handling of hazardous materials, capital equipment, manufacturing processes, tooling, and materiel transportation. Utilization of new materials and technologies will often require concurrent development and procurement of new capital equipment, test equipment and facilities, and development of new quality assurance procedures and equipment. Use of test ranges and special test facilities should be listed and a notional schedule of when those government assets will be needed. Many government facilities are becoming increasingly obsolete and constantly undergoing consolidation. The manufacturing and quality representatives should also identify any requirement for reconstitution or investment in government facilities, labs, ranges, etc. for each concept being considered.

The facility includes the plant, production equipment, and waste handling and storage equipment which is to be made available to accomplish the production task. In developing the facility plan, both the quantitative and qualitative demands of the product must be considered. The quantitative analysis will determine the size of the processing departments within the facility. This analysis should consider the number of units to be delivered, and the rate of delivery. For example, the information collected in the analysis will provide a measure of the work stations, plant layout, and the floor space required. The qualitative analysis determines the types of processes which will be required. The contractor then has the option of utilizing currently existing facilities, acquiring new facilities, requesting government-furnished facilities (must be requested in the proposal), or subcontracting a portion of the effort.

Funding profiles for all of the aspects of each concept being considered must provide for up front development of capital equipment, manufacturing processes, tooling, and verification that new components can be produced at production rates. A top level schedule and target costs should be developed. Development for each concept and installation of tooling, test equipment, and facilities are necessary drivers of each concept's costs and development schedule. The overall results of these assessments, estimates, and evaluations should be included in the AoA Study Guidance.

K.1 Evaluate Tooling/Special Test and Inspection Equipment (STE/SIE) Requirements

Manufacturing and Quality Tasks

- Identify new capital equipment and tooling required for new technology and material manufacturing and quality processes for each concept being considered.
    - Assess new tooling requirements for capability to produce at planned production rates and target unit costs
    - Assess needs for soft tooling vs. hard tooling for facility and funding impacts
    - Assess supplier and sub-tier capabilities and investment incentives
    - Assess the funding requirements and develop appropriate funding profiles
- Evaluate each concept being considered to include alternative designs for GFE/STE/SIE
    - Assess the requirements for GFE/STE/SIE
    - Assess the capabilities of GFE/STE/SIE to meet needs
- Identify requirements for unique or special transportation, handling, and storage equipment to be manufactured for each candidate materiel solution.
- Identify the funding required for capital equipment, manufacturing and quality processes, tooling, and test equipment for each concept being considered.

Metrics

- New manufacturing and quality processes requiring capital equipment and/or tooling for new technology and materials have been identified and documented.
    - Capital equipment and tooling requirements have been documented for inclusion in the funding profiles
    - Capital equipment and tooling have been assessed for the capability to produce at planned production rates and target unit costs and results documented
- Each concept being considered including alternative designs has been assessed for STE/SIE
    - The requirements for STE/SIE have been evaluated and documented
    - The capabilities of STE/SIE to meet needs have been evaluated and documented

- Requirements for unique or special transportation, handling, and storage equipment to be manufactured for each candidate materiel solution have been identified and included in the AoA Study Guidance.
- Funding required for capital equipment, manufacturing and quality processes, tooling, and test equipment for each concept being considered has been estimated and documented for the AoA Study Guidance.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Manufacturing Resource Planning (MRPII)
- MRL Assessment using Facilities Thread

Resources

- MRL Deskbook Version 2.5, 2016
- Manufacturing Resource Planning (MRP II)

K.2 Identify Facilities Requirements

Manufacturing and Quality Tasks

- Identify the facilities and capital equipment required by each of the concepts being considered
- Identify the quantitative and qualitative demands of the each of the concepts being considered
    - Identify the availability, design, rate and capacity capabilities of the facilities under consideration (existing, new, or redeveloped)
    - Identify the types of processes required and the resulting impacts on facilities by each of the concepts being considered (e.g., specialized fixtures, test chambers, laboratories, clean rooms, waste storage and disposal, etc.)
    - Identify the unique or special facility requirements for transportation, handling, and storage equipment being manufactured for each candidate materiel solution
- Identify the funding required for facilities and capital equipment for each concept being considered.

Metrics

- The facilities and capital equipment required by each of the concepts being considered has been identified and documented.
- The quantitative and qualitative demands of the each of the concepts being considered has been identified and documented

- The availability, design, rate and capacity capabilities of the facilities under consideration (existing, new, or redeveloped) have been evaluated and documented
- The types of processes required and the resulting impacts on facilities by each of the concepts being considered (e.g., specialized fixtures, test chambers, laboratories, clean rooms, waste storage and disposal, etc.) have been evaluated and documented
- Unique or special facility requirements for transportation, handling, and storage equipment being manufactured for each candidate materiel solution have been identified and documented

- Funding required for facilities and capital equipment for each concept being considered has been estimated and documented for the AoA Study Guidance.

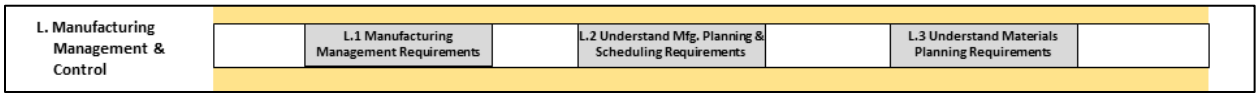
Tools

- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Manufacturing Resource Planning (MRPII)
- MRL Assessment using Facilities Thread
- Manufacturing Resource Planning (MRP II)
- MRL Assessment using Facilities Thread
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- MRL Deskbook Version 2.5, 2016
- Manufacturing Resource Planning (MRP II)

L. MANUFACTURING MANAGEMENT AND CONTROL



Programs with any manufacturing aspects will require a manufacturing management system. The timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risks and issues throughout the program lifecycle will only be met by a comprehensive system. Meeting this objective is best accomplished by including best practices and standards (i.e., AS6500, Manufacturing Management Program) in the contracts with industry.

Beginning in this phase, the activities managing the concept (or program office) should begin the planning for manufacturing management and control of the concepts under consideration. This planning will be evolving and should be updated during the subsequent acquisition phases. The purpose of manufacturing planning is the identification of resources and integration into a structure that provides the capability to achieve production objectives. Manufacturing planning should include:

- Manufacturing requirements in contracts and in appropriate agreements with other agencies (e.g., DCMA)
- Manufacturing assessments to support program Milestone decision points and major design reviews
- Manufacturing metrics and reviews at a frequency commensurate with manufacturing risks

L.1 Manufacturing Management Requirements

Manufacturing and Quality Tasks

- Identify the manufacturing management system requirements (i.e., AS6500) to be met by the contractor or government entity during subsequent phases as appropriate in the areas of:
    - Design analysis for manufacturing
    - Manufacturing risk identification
    - Manufacturing planning
    - Manufacturing operations management
- Evaluate each concept being considered and identify the capability to meet manufacturing management needs.
    - Evaluate each concept being considered and identify the need for focused manufacturing or quality plans (e.g., a program Manufacturing Management Plan) to guide the approach.
    - Evaluate each concept being considered and identify the need for a standalone government manufacturing or quality assurance plan.
- Understand the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- Identify and understand potential sources that could address manufacturing management needs.
    - Identify and understand manufacturing and quality management lessons-learned and best practices among programs and across centers
    - Assess and evaluate manufacturing technologies that could assist on candidate materiel solution programs.
- Establish manufacturing management metrics for each of the concepts being considered
    - Determine the frequency that the metrics should be reviewed, commensurate with manufacturing and quality risks.
- Contact DCMA for input on manufacturing management system evaluation of potential contractor and suppliers for each concept being considered.

Metrics

- The manufacturing management requirements (i.e., AS6500) to be met by the contractor or government entity as appropriate have been identified and documented.
- Each concept being considered has been evaluated and the capability to meet manufacturing management needs has been identified and documented.
    - Each concept being considered has been evaluated and the need for focused manufacturing plans (e.g., a program Manufacturing Management Plan) to guide the approach identified
    - Each concept being considered has been evaluated and the need for a standalone government manufacturing plan identified
- The impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management have been evaluated and documented.
- Potential sources that could address manufacturing management needs are understood and documented.
    - Manufacturing and quality management lessons-learned and best practices among programs and across centers have been evaluated, are understood, and documented
    - Manufacturing technologies that could assist on candidate materiel solution programs have been assessed and documented.
- Manufacturing management metrics for each of the concepts being considered have been established and documented.
    - The frequency that the metrics should be reviewed, commensurate with manufacturing and quality risks, has been determined.
- Potential manufacturing management systems (i.e., AS6500) to be used in subsequent phases for each of the concepts being considered have been identified and documented.
    - The manufacturing management program should include:
        - Manufacturing management system
        - Design analysis for manufacturing
        - Manufacturing risk identification
        - Manufacturing planning
        - Manufacturing operations management
- Availability of DCMA personnel has been determined for input on manufacturing management systems of potential contractors and suppliers for each concept being considered with inputs collected and documented.

Tools

- MRL Assessment Questionnaire using Manufacturing Management and Control Thread

- Manufacturing Resource Planning (MRP II)

Resources

- AS6500, Manufacturing Management Program
- MRL Deskbook Version 2.5, 2016
- Manufacturing Resource Planning (MRP II)

L.2 Understand Manufacturing Planning and Scheduling Requirements

Manufacturing and Quality Tasks

- Initiate planning for each candidate materiel solution approach to include, as a minimum:
  - Description of the manufacturing and quality organization
  - Describe the make or buy plan
  - Description and initial identification of resources and manufacturing and quality capabilities
  - Identification of manufacturing and quality data requirements for facilities, processing, and scheduling
- Evaluate the overall manufacturing feasibility analysis for inputs to planning and scheduling. The analysis should have included:
  - Producibility
  - Critical and key manufacturing and quality processes
  - Special tooling requirements
  - Test and demonstration requirements for new materials and processes
  - Alternate design approaches
  - Anticipated manufacturing and quality risks and potential cost impacts and identify the needed actions to be incorporated into the initial manufacturing and quality plan.
- Ensure manufacturing planning addresses transition considerations that may be impacted by:
  - Funding constraints and phasing of money
  - Design considerations, goals and risks
  - Test and evaluation methods and approaches along with success criteria
  - Production processes, methods, workforce, facilities, equipment and capabilities
  - Life cycle logistics and sustainment criteria, approach and goals
  - Management approach to transition risks

Metrics

- Inputs to be included in the AoA Study Guidance for the initial manufacturing and quality plan document the following:

  - A description of the type of manufacturing and quality organization that could produce the concept
  - General parameters for a make or buy plan
  - A description of the type of resources and manufacturing and quality capabilities needed for the concepts being considered
  - Manufacturing and quality planning data for the quantitative and qualitative demands of the facilities and capital equipment required by each of the concepts being considered

- Appropriate initial manufacturing and quality planning inputs are documented from overall feasibility analysis. These planning and scheduling inputs will include requirements from the evaluations of:

  - Producibility
  - Critical and key manufacturing and quality processes
  - Special tooling
  - Test and demonstration of new materials and processes
  - Alternate design approaches within each concept
  - Potential manufacturing and quality risks and costs impacts

- Initial Manufacturing and quality planning documents, in AoA Study Guidance, address transition considerations that may be impacted by:

  - Funding constraints and phasing of money
  - Design considerations, goals and risks
  - Test and evaluation methods and approaches along with success criteria
  - Production processes, methods, workforce, facilities, equipment and capabilities
  - Life cycle logistics and sustainment criteria, approach and goals
  - Management approach to transition risks

Tools

- Assembly Chart
- Line of Balance Assessment
- MRL Assessment Questionnaire using Manufacturing Management and Control Thread
- Operations Process Chart
- Route Sheet
- Work Breakdown Structure
- Manufacturing Resource Planning (MRP II)

Resources

- AS6500, Manufacturing Management Program
- MRL Deskbook Version 2.5, 2016
- Manufacturing Resource Planning (MRP II)

L.3 Understand Materials Planning Requirements

Manufacturing and Quality Tasks

- Understand feasibility and quality of materials to be used for each candidate materiel solution approach.
    - Understand the maturity (technical and characterization) of material sources, essential raw materials, special alloys, composite materials, etc.
    - Understand alternatives to preferred materials for each candidate materiel solution
- Understanding of all aspects of tasks in materiel availability (See Section G.2)
    - Understand of quality, processing, ageing, handling, and transit times, etc. as an impact to lead times to include alternative materials
    - Evaluate and assess source considerations such as quality, fragility, sole source, domestic vs. foreign, etc. for the AoA Study Guidance and MDD processes
    - The military vulnerability that could result from the lack of alternatives

Metrics

- Analyze and document the feasibility of materials and alternative materials to be used for each candidate materiel solution.
- Analyze the maturity both technical and characterization of material sources, essential raw materials, special alloys, composite materials, etc. and document for the AoA Study Guidance
- Analysis of materials availability tasks documents the impact of quality, processing, ageing, handling, and transit times, etc. to lead times including alternative materials
- Assessment and evaluations of source considerations for quality, fragility, sole source, domestic vs. foreign, etc. are documented and included in the AoA Study Guidance and MDD processes
    - The above assessment includes the military vulnerability that could result from the lack of alternatives

Tools

- MRL Assessment Questionnaire using Manufacturing Management Thread
- Production Plan (schedule)
- Bill of Material Assessment
- Make/Buy Decision
- Parts List

Resources

- AS6500, MANUFACTURING MANAGEMENT PROGRAM
- MRL Deskbook Version 2.5, 2016
- Manufacturing Resource Planning (MRP II)

2. Materiel Solution Analysis (MSA) Phase

Introduction

As stated in Department of Defense Instruction (DoDI) 5000.02, Operation of the Defense Acquisition System, the purpose of MSA phase is to "conduct the analysis and other activities needed to choose the concept for the product that will be acquired . . ." This phase culminates in a risk reduction decision, Milestone A, which is an investment decision to pursue specific product or design concept, and to commit the resources required to mature technology and/or reduce any risks that must be mitigated prior to decisions committing the resources for development. This phase also is an opportunity for manufacturing and quality to influence chosen system design by balancing requirements against producibility, manufacturability, quality, and affordability. To support the MSA phase and the Milestone Decision Authority (MDA) decision process, manufacturing and quality should perform and/or support activities during the phase including:

- Conduct and complete the Analysis of Alternatives (AoA) with manufacturing and quality inputs needed to enable selection of a preferred materiel solution
- Translate validated Key Performance Parameters (KPP) and Key System Attributes (KSA) into Key Characteristics (KC) for manufacturing and quality
- Conducting manufacturing and quality key trades for feasibility and affordability analyses, risks, issues, and opportunities analyses, and plan for mitigations that impact cost, schedule, and performance
- Develop manufacturing and quality goals for any needed development of critical enabling technologies
- Translate the Initial Capabilities Document (ICD) with manufacturing and quality validation and verification analyses results into a draft Capability Development Document (CDD)
- Initiation of the Test and Evaluation Master Plan (TEMP), the Systems Engineering Plan (SEP), and the Acquisition Strategy (AS) with inclusion of manufacturing and quality requirements

Figure 2-1 shows the manufacturing and quality management activities typical of the MSA phase.

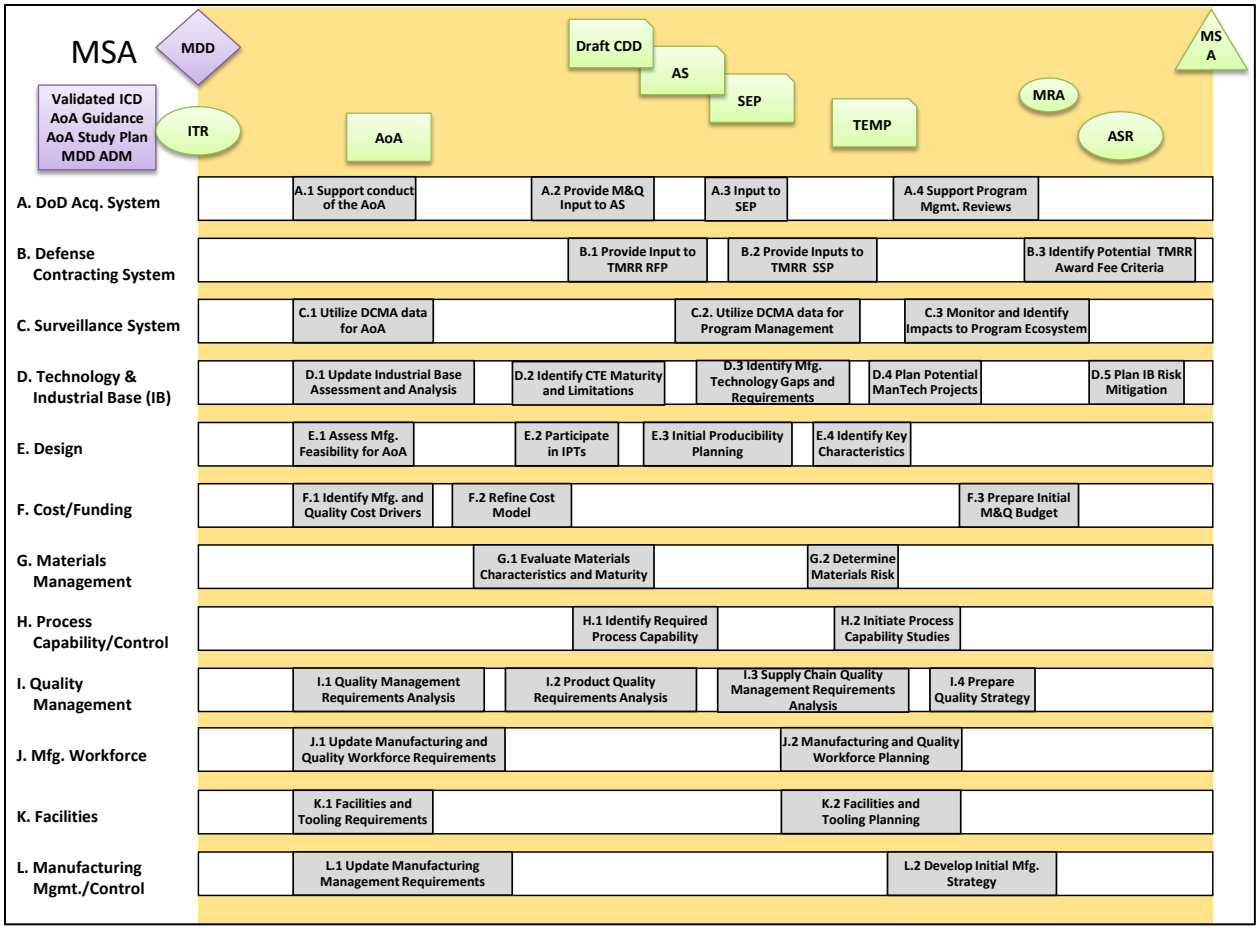


Figure 2-1. MSA Phase Manufacturing and Quality Activities

Phase Description

In conducting and completing the AoA, the various alternative solutions are analyzed for key trades among affordability analyses, risk analyses, and planning for risk mitigations that impact cost, schedule, and performance. It is the role of manufacturing and quality to provide inputs to the AoA process with respect to feasibility and industrial base (IB) analyses, performed as part of the AoA Study Guidance, the validated ICD, and the AoA Study Plan, which guide the AoA and MSA phase activities. The analyses focus on identification and analysis of alternatives; measures of effectiveness; key trades between cost and capability; life-cycle cost, including sustainment; schedule; concepts of operations; and overall risk. The AoA will include affordability analyses, cost analyses, early systems engineering analyses, threat projections, and market research. Minimum funding required for this phase includes all funding and staffing plans for the AoA and the engineering analysis and planning for the next milestone including the milestone certification requirements.

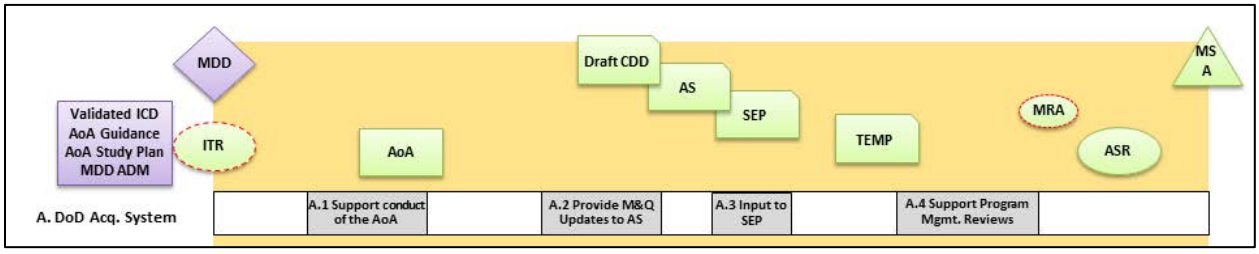
The AoA will address the manufacturing and quality feasibility and technology maturity of the proposed alternatives including the risks, issues, and opportunities associated with varying

production rates; IB health and needs; manufacturing technology research; facilities and tooling, special test equipment, and special inspection equipment; manufacturing skill sets; and maturity of new materials and novel processing methods.

Prior to the completion of this phase, the DoD Component combat developer will prepare a Concept of Operations/Operational Mode Summary/Mission Profile (CONOPS/OMS/MP) that will include the operational tasks, events, durations, frequency, operating conditions and environment in which the recommended materiel solution is to perform each mission and each phase of a mission. The Systems Engineering (SE) IPT uses the outputs of the CONOPS/OMS/MP to identify and validate capability gaps and risks, and translate these into system-specific requirements. These KPPs and KSAs are translated by manufacturing and quality into identified system, product, and component manufacturing and quality KCs. In addition, these outputs are utilized to provide manufacturing and quality inputs to the AS, TEMP, and SEP, and ultimately the Milestone A decision. During the MSA phase, the Component Acquisition Executive (CAE) will select a Program Manager (PM) and establish a program office to complete the necessary actions associated with planning the acquisition program with emphasis on the next phase.

The MSA phase ends when a DoD Component has completed the necessary analysis and the activities necessary to support a decision to proceed to an acquisition phase. The next phase can be Technology Maturation and Risk Reduction (TMRR), Engineering and Manufacturing Development (EMD), or Production and Deployment (P&D), depending on the actions needed to mature the product being acquired. Each of these phases has associated decision points to authorize entry.

A. DOD ACQUISITION SYSTEM



During the MSA phase, trade studies are conducted to identify materiel solutions and address gaps in capability based on an AoA. At the close of the AoA, a program office is assigned ownership of the approach. At this point, program management establishes the appropriate Integrated Product Team (IPT) structure to support program execution. The IPT conducts systems engineering analysis to support the development of the AS, the SEP, and the draft CDD. The MSA phase also provides the opportunity to influence system design and plan for production by evaluating technology opportunities and current practices against cost, schedule, and performance. The intent is to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements. The PM will ensure manufacturing, quality, and producibility risks are identified and

managed throughout the program life cycle. Assessments of manufacturing and quality readiness, risks, and mitigation plans will be developed and documented in the SEP and the AS.

Analysis of Alternatives (AoA)

From a manufacturing and quality perspective during the AoA, each competing alternative under consideration is analyzed for its impact to industrial and manufacturing capabilities. The analysis uses the IB assessments performed previously to determine the likelihood that a proposed solution can be produced using existing manufacturing capabilities while meeting quality, rate, cost, and schedule requirements. The AoA also identifies new or high-risk manufacturing capability or capacity requirements, if they are needed. The AoA should also identify critical technologies and the associated manufacturing process areas in each alternative requiring risk-reduction efforts. The results of the analyses are used to quantify the differences between alternatives and select a preferred solution. At the close of the AoA, the program office takes ownership of the approach and conducts additional engineering analyses to support the development of the Acquisition Strategy and the SEP.

Acquisition Strategy (AS)

Early systems engineering provides the foundation for the development of the AS. It is based on engineering analyses, trade studies, and preliminary system functional and performance requirements to meet a capability need. Critical thinking is required for an evaluation that focuses on determining the correct requirements, and rigorously and objectively considers the risks, issues, and opportunities. This requires an Acquisition Strategy that addresses all of the following program objectives:

- The likely outcome is worth the investment in both resources (real costs) and schedule (opportunity costs)
- The end item meets required performance objectives
- All risks, issues, and opportunities are identified, managed, and mitigated to an acceptable level
- The business strategy effectively executes the program

In addition, an Acquisition Strategy should emphasize and provide incentives for the important aspects of the program. The Acquisition Strategy should include:

- A market analysis and associated acquisition planning
- An assessment of the IB to support design, development, production, sustainment, or restart of an acquisition program
- An assessment of manufacturing feasibility (to answer the question “Can you build it?”
- An initial manufacturing and quality strategy

The initial manufacturing and quality strategy as an integral part of the overall Acquisition Strategy should include considerations such as:

- Competition – Competition can be a major contributor to reducing weapon system costs, however, can also be a major contributor to manufacturing and quality complexity and must be carefully planned.
- New manufacturing technologies – If required by the system concept, new manufacturing technologies will require specific plans for development, proofing, and transition of the technology to the eventual producer.
- Production rates and quantities – These can also play a major role in driving manufacturing cost as they will drive decisions on what production processes to use, types of tooling required, make-buy decisions, etc.
- Materials sourcing – Sources that are sole, single, fragile, or foreign sources, and those domestic sources that are vulnerable to foreign acquisition introduce risks to manufacturing.
- Contracting strategies – Strategies should include manufacturing and quality technologies, facilities, investment incentives, risk mitigation efforts, etc.

Other manufacturing and quality considerations that should be addressed in the manufacturing and quality strategy as part of the AS:

- The Acquisition Strategy should highlight how risk areas will be addressed and minimized in the TMRR phase, on the path to full manufacturing capability in the P&D phase.
- The Acquisition Strategy should highlight how new manufacturing capabilities with a beneficial impact to the program will be addressed.
- The Acquisition Strategy should summarize the technical or manufacturing risks associated with the program, and identify any critical technologies or manufacturing processes that need to be matured and demonstrated in a manufacturing-relevant environment during the TMRR phase.

Systems Engineering Plan (SEP)

Manufacturing and quality input to critical systems engineering processes and functions is essential to ensure that programs deliver capabilities on time and on budget. The effective execution of MSA efforts provides a feasible, producible, and effective solution that satisfies user requirements. The intent is to reduce manufacturing and quality risks, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements. Per DoDI 5000.02, “Program Managers will prepare a SEP as a management tool to guide the systems engineering activities on the program. The SEP will be submitted for approval for each milestone review, beginning with Milestone A.” At each milestone and at the Development Request for Proposal (RFP) Release Decision Point, manufacturing and quality will support the Acquisition Strategy and SEP, including input for interdependencies, and overall manufacturing approach to balance system performance, life-cycle costs, and risks. The SEP should include:

- Description of the program overall technical approach, including manufacturing and quality inputs for key risks, processes, resources, organization, metrics, and design considerations

- Details of the timing and manufacturing and quality criteria for the conduct of technical reviews
- Details for manufacturing and quality planning in order to provide effective management and control of the progress and the execution of risk mitigation activities
- Plans for addressing manufacturing and quality integration with existing and approved architectures and capabilities
- Identification of manufacturing and quality risks from external dependencies (outside the span of control)
- Guidance on the manufacturing and quality details in the program schedule with documentation of the planning

Finally, the SEP should be included in the RFP with an approved plan or a draft plan as either guidance or a compliance document and will be synchronized with the AS.

Program Management Reviews

Management reviews are a major part of the systems engineering process and are conducted by members of the IPT. Reviews serve to confirm:

- Major systems engineering efforts have been conducted and completed
- The program is ready to proceed to the next major schedule event

Technical reviews are also an important tool for program management, independent assessors, and subject matter experts including manufacturing and quality, to identify and evaluate risks early and throughout the program. If conducted in conjunction with the Materiel Development Decision (MDD), manufacturing and quality should support the Initial Technical Review (ITR), which should assess the draft ICD, the AoA Study Guidance, and preliminary CONOPS for manufacturing and quality analyses of the materiel solution alternatives. Support of the ITR will provide detailed manufacturing and quality information and understanding of each concept or alternative for:

- Engineering trades
- Development of a Cost Analysis Requirements Description (CARD)
- Cost drivers, material, and process risks

The primary review during MSA is the Alternative Systems Review (ASR), which is conducted by the program office prior to the Milestone A decision and entry into TMRR phase. The ASR assesses the preferred materiel solution to ensure it has the potential to be affordable, producible, operationally effective, and suitable, and can be developed to provide a timely solution to a need at an acceptable level of risk. The ASR helps ensure that sufficient effort has been given to conducting trade studies that consider and incorporate alternative system designs, manufacturing and quality alternatives, and other technical considerations. The technical understanding, assessed at the ASR, is sufficient and rigorous enough to support a valid cost estimate (CARD, or CARD-like Document).

A.1 Support Conduct of the AoA

Manufacturing and Quality Tasks

- Provide analyses of the manufacturing and quality requirements and feasibility contained in the draft ICD, the AoA Study Guidance, and the preliminary CONOPS for the AoA.
    - Analyses should verify adequacy, relevance, and completeness
    - Analyses should identify and quantify manufacturing and quality risks
- Ensure IB assessments and market analyses are updated for concepts included in the AoA (conduct if not previously accomplished).
    - IB analyses should illustrate the differences between alternatives based on the industrial and manufacturing capabilities and the required resources during the AoA
    - Manufacturing feasibility should answer the question “Can you build it?”
- Ensure assessments of manufacturing feasibility for the AoA preferred concepts are up-to-date including engineering trade studies, early prototypes, models or data, and the industrial capabilities required to design, develop, manufacture, and maintain each (conduct if not previously accomplished).
    - Identify manufacturing and quality risks
        - Include materials, processes, and technology
        - Identify new or high-risk manufacturing processes or capacity requirements
    - Identify manufacturing, quality, materials, and unique requirements that are cost drivers for the AoA
    - Ensure the phase-by-phase requirements for manufacturing and quality skills and training are updated for the AoA preferred materiel solutions
    - Ensure the facilities and capital equipment requirements for each AoA preferred concept are updated
    - Ensure that each AoA preferred concept includes and is analyzed for quality management requirements
    - Ensure each AoA preferred concept includes and is analyzed for manufacturing management requirements

Metrics

- Analyses of the manufacturing and quality requirements and feasibility for were conducted and the results included in the AoA.
    - Analyses addressed, quantified, and documented adequacy, relevance, and completeness of manufacturing and quality risks
    - Assessments of IB and market analyses have been updated and include:

        - The preferred concepts for the AoA, trade studies, early prototypes, models or data, and the industrial capabilities required to design, develop, manufacture, and maintain each
        - Quantification of the differences between alternatives based on the industrial and manufacturing capabilities and the required resources
    - Manufacturing feasibility analyses specifically addressed and answered the question "Can you build it?"
- Assessments of manufacturing feasibility for the AoA preferred concepts are updated and include:
    - Manufacturing and quality risks for materials, processes, and technology identified and documented
    - Analyses that identified and documented new or high-risk manufacturing processes or capacity requirements
    - Manufacturing, quality, materials, and unique requirements that are cost drivers identified and specified for the AoA
    - Manufacturing and quality skills requirements (phase by phase) for training updated and documented for the AoA preferred solutions
    - Facilities and capital equipment requirements for the preferred concepts updated and documented
    - Preferred concept analyses for quality management and manufacturing management requirements are documented

Tools

- Acquisition Decision Memorandum (MDD) Template
- Acquisition Strategy (AS) Outline
- AS6500 Manufacturing Management Program Checklist
- ISO 9000 Quality Management System Checklist
- AS9100 Quality Management System Checklist
- Alternative System Review Checklist
- AoA Study Plan Template, Sep 2009
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Manufacturing Feasibility Assessment Checklist (no specific tool found)
- Manufacturing Readiness Level MRL) Assessment (Questionnaire
- Market Research Reporting Template
- Multi-Attribute Tradespace Exploration (MATE)
- Pugh Matrix Template
- Quality Function Deployment or House of Quality Matrix
- Quality Function Deployment Excel Spreadsheet
- Requirements Traceability Matrix Template
- Requirements Verification Matrix

- Tailoring Worksheet for Materiel Solution Analysis Phase
- Technology Readiness Level (TRL) Assessment Checklist
- TRIZ Matrix

Resources

- Air Force AoA Guide, June 2013
- Air Force AoA Handbook, July 2008
- AS6500, Manufacturing Management Program, Nov 2014
- ISO 9000:2015, Quality Management Systems, Sep 2015
- AS9100, Quality Management Systems, Sep 2016
- Defense Acquisition Guidebook (DAG), Chapter 3-3.3.1 Alternative System Review
- DoDI 5000.02, Change 1, Jan 2017
- DoDI 5000.60, Defense Industrial Capabilities Assessments, Oct 2009
- DoD 5000.60H, Assessing Defense Industrial Capabilities, Apr 1996
- DoD Market Research Guide May 2012
- DSMC Acquisition Strategy Guide, Dec 1999
- MRL Deskbook Version 2016
- National Defense Authorization Act for FY 2017 (PL 114-328 Sect. 807) (assigns program cost and fielding targets and to conduct independent technical risk assessments)
- MDD Analysis Handbook, July 2010
- Quality Function Deployment, Akao 2004
- Requirements Traceability Matrix Guide, Jan 2012
- Technology Readiness Assessment Guidance, Apr 2011

A.2 Provide Manufacturing and Quality Input to the Acquisition Strategy

Manufacturing and Quality Tasks

- Provide a summary of an updated manufacturing and quality IB capability analysis for the AS, as required by DoDI 5000.02.
    - Provide inputs on the capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
    - Provide inputs on IB capabilities, fragility, gaps, and risks for the Acquisition Strategy (e.g., key technologies, processes, components, etc.)
    - Provide the impacts and interdependencies of this acquisition on the National Technology Industrial Base (NTIB) and the analyses used to make this determination
    - Summarize manufacturing and quality impacts, how they will be managed, and the plan for future assessment, including frequency
    - Provide inputs for the government strategy and actions necessary to preserve the IB capabilities (e.g., incentivizing the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)

- Develop and provide a Manufacturing Strategy and a Quality Strategy to address the question "Can you build it?" The strategy should support the AS development and include considerations of:
  - Competition and contracting strategies
  - New manufacturing technologies
  - Design (feasibility, producibility, KCs, risks, etc.)
  - Materials (characteristics, sourcing, risks, etc.)
  - Process, rates, and quantities (capabilities, control, risks, etc.)
  - Facilities, tooling, and workforce (including government-furnished equipment (GFE), government-furnished information (GFI), special test equipment (STE), special inspection equipment (SIE), special requirements, etc.)
  - Management (quality, manufacturing, supply chain, risks, etc.)
- Based on IB capabilities analyses, provide manufacturing and quality inputs to Acquisition Strategy contracting strategy to support selection of a competitive award, a sole source award, or multiple source development (with down select for production contract) as the best course of action.
  - Include manufacturing and quality metrics to differentiate the value of each contract type to include performance, capacity, functional, economic, etc.
  - Include impacts on IB capabilities and risks that may result from different contract types (firm fixed price (FFP), fixed price incentive fee (FPIF), cost plus fixed fee (CPFF), etc.)
  - Determine prototyping approach for TMRR, either competitive, single, or prototyping of critical subsystems (statutory requirement for Major Defense Acquisition Program (MDAP) AS, regulatory requirement for all other programs)
- Develop manufacturing and quality inputs to the Acquisition Strategy for the source selection approach that establishes and maintains access to competitive suppliers at the system, subsystem, and component level (e.g., requiring an modular open systems approach, alternative sources of supplies or services, etc.).
- Develop manufacturing and quality inputs for the Acquisition Strategy that identify and address the sustainment of industrial capabilities, including manufacturing technologies and capabilities, and the maturation required during the TMRR and subsequent phases.
  - Provide manufacturing and quality inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystems, item, and component levels.
  - Provide manufacturing and quality inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
    - Domestic alternatives through regeneration of prior capability
    - Creation of new capability for manufacturing products and processes
    - Lifetime buy of items at the subsystems, and component levels

- Develop plans for new or high-risk manufacturing capabilities and processes Manufacturing Technology ManTech for the Acquisition Strategy that address risks, issues, and opportunities.
    - Specify how this new capability will be demonstrated in a relevant manufacturing environment for the TMRR phase
- Provide manufacturing and quality inputs for required technical reviews, production decisions, events, prototypes, and deliveries, including sub-tier subsystem, item, and components, to be included in the Acquisition Strategy based on:
    - Requested inputs from Defense Contract Management Agency (DCMA)
    - Materials availability (lead-time and scale-up) and maturity (characterization)
    - Achievable rates and yields for manufacturing and quality
        - Provide methodologies for determining rates and schedules (e.g., Economic Order Quantities, affordability goals, etc.)
    - Manufacturing and quality maturity
    - Facilities, tooling, and workforce considerations
    - Capital equipment requirements
- Based on inputs to Acquisition Strategy on required technical reviews, production decisions, events, prototypes, and deliveries, provide manufacturing and quality inputs to the initial Integrated Master Schedule including:
    - Schedule for any planned use of government-furnished special test equipment, government facilities/ranges, unique tooling, or other similar requirements (specific modeling and simulation (M&S), communications, restricted environment, etc.).
    - Schedule impacts from the requirements for special materials and allotments, and the reasons for them if applicable
    - Manufacturing and quality internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
- Develop the government manufacturing and quality management approach to:
    - Manufacturing and quality requirements for program plans
    - Manufacturing and quality contributions to resource management (minimizing cost, schedule, and performance risks for the product life cycle)
    - Manufacturing and quality organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
    - Manufacturing and quality support organization required to meet program projected needs for TMRR and subsequent phases including:
        - Earned Value Management requirements
        - Cost control requirements
        - Data collection, reporting, and management

- Identify the manufacturing and quality requirements for the TMRR contractor's Manufacturing Management System (MMS) and Quality Management System (QMS).
    - Specify the standards to be used to promote industry best practices (e.g., Society of Automotive Engineers (SAE) AS6500, International Organization for Standardization (ISO) ISO 9000, SAE AS9100, IEEE 15288.0, -.1, -.2, etc.)
    - If manufacturing and quality standards are not specified, develop requirements for program specific manufacturing management plan and quality management plan.
    - Identify manufacturing and quality opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- Identify and assess manufacturing and quality risks, issues, and opportunities, and associated plans with key risk reduction events specified as inputs for the TMRR Acquisition Strategy and subsequent phases on the path to full capability.
    - Identify risks from the IB, materials, facilities, workforce, interdependencies with other programs, manufacturing technology voids, quality, software and engineering-related risks etc.
    - Identify required maturation of critical technologies and manufacturing processes to the required level
    - Assess manufacturing and quality cost and schedule impacts from these identified risks
- Specify the ongoing requirements for identification, analysis, mitigation, tracking, and control of manufacturing and quality risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program.
- Develop as inputs to the Acquisition Strategy specific and detailed manufacturing and quality exit criteria metrics for MSA, TMRR, and subsequent phase decision points.
    - Metrics should include current and projected manufacturing and quality maturity of identified critical technologies and manufacturing processes
    - Metrics should also include the planned Manufacturing Readiness Level (MRL) target for system, subsystems, components, and items
- For the Acquisition Strategy develop the manufacturing and quality support plan for the mandated independent assessment.
- Request DCMA inputs on strategies for quality, manufacturing, production, engineering, software development, configuration management, testing and quality.

Metrics

- Manufacturing and quality IB capability analysis updated, summarized, and documented for inclusion in the AS.
    - Analyses of the capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate, have been provided as input for the AS

- IB capabilities, fragility, gaps, and risks (e.g., key technologies, components, key processes, etc.) have been provided as input for the AS
- Impacts and interdependencies of this acquisition on the NTIB and the analyses used to make this determination have been specified and provided as input to the AS
- Inputs summarize the manufacturing and quality impacts, how they will be managed, and the plan for future assessment, including frequency
- Inputs for the government strategy and the actions necessary to preserve the IB capabilities have been identified and documented to include actions to support IB capability preservation

- Detailed Manufacturing and Quality Strategies to address the question "Can you build it?" have been developed and are included in the AS addressing considerations of:
  - Competition and contracting strategies
  - New manufacturing technologies
  - Design (feasibility, producibility, KCs, risks, etc.)
  - Materials (characteristics, sourcing, risks, etc.)
  - Process, rates, and quantities (capabilities, control, risks, etc.)
  - Facilities, Tooling, and Workforce (including GFE/GFI, STE/SIE, special requirements, etc.)
  - Management (quality, manufacturing, supply chain, risks, etc.)
- Based on IB capabilities analyses, manufacturing and quality inputs to the contracting strategy have been provided that support selection of a competitive award, a sole source award, or multiple source development (with down select for production contract) as the best course of action.
  - Inputs include manufacturing and quality metrics to differentiate the value of each contract type to include performance, capacity, functional, economic, etc.
  - Inputs include impacts on IB capabilities and risks that may result from different contract types (Firm Fixed Price (FFP), Fixed Price Incentive Fee (FPIF), Cost Plus Fixed Fee (CPFF), etc.)
  - Inputs include prototyping recommendations for TMRR
- Manufacturing and quality inputs for the source selection approach have been developed and documented in the Acquisition Strategy that establish and maintain access to competitive suppliers at the system, subsystem, and component levels (e.g., requiring an modular open systems approach, alternative sources of supplies or services, etc.).
- Manufacturing and quality inputs have been developed and documented in the Acquisition Strategy that incorporate sustainment of industrial capabilities, including manufacturing technologies and capabilities, and including the maturation required during the TMRR and subsequent phases.
  - Manufacturing and quality inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-

shelf items to required specifications at the subsystems, item, and component levels have been documented.
    - Manufacturing and quality inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources have been documented including options for:
        - Domestic alternatives
        - Creation of new capability for manufacturing products and processes
        - Lifetime buy of items at the subsystems, and component levels
- Plans for new or high-risk manufacturing capabilities and processes (i.e., ManTech) have been developed and documented in the Acquisition Strategy that address risks, issues, and opportunities.
    - Plans include demonstration of the new capability in a relevant manufacturing environment during the TMRR phase
- Manufacturing and quality requirements and metrics for required technical reviews, production decisions, events, prototypes, and deliveries, including sub-tier subsystem, item, and components, have been developed and documented and provided as input to the Acquisition Strategy and incorporate:
    - Inputs from DCMA
    - Materials data including availability and maturity
    - Estimates of achievable rates and yields including methodologies for determining
    - Summaries of manufacturing and quality maturity assessment analyses
    - Initial analyses of facilities, tooling, and workforce requirements
    - Analyses of capital equipment requirements
- Manufacturing and quality inputs to the initial Integrated Master Schedule have been provided based on required technical reviews, production decisions, events, prototypes, and deliveries, and included:
    - Planned use of government-furnished special test equipment, government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.)
    - Impacts to schedule from special materials
    - Impact of internal and external interdependencies, and integration with existing programs, systems, and other programs in development
- The government manufacturing and quality management approach has been developed and documented for:
    - Manufacturing and quality requirements for program plans
    - Manufacturing and quality contributions to resource management (minimizing cost, schedule, and performance risks for the product life cycle)
    - Manufacturing and quality organization and staffing with KLPs and necessary skilled manpower

- Manufacturing and quality support organization required to meet projected program needs for TMRR and subsequent phases including:
  - Earned Value Management requirements
  - Cost control requirements
  - Data collection, reporting, and management

- Manufacturing and quality requirements for the TMRR contractor's MMS and QMS have been identified and documented in the AS.
  - The industry standards to be used, or the requirements for program specific manufacturing and quality management, have been specified and documented (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - Manufacturing and quality management opportunities, initiatives, or systems that contribute to minimizing cost, schedule, and performance risks throughout the product life cycle have been identified and documented

- Manufacturing and quality risks, issues, and opportunities, and associated plans with key risk reduction events have been identified, assessed, and specified as inputs for the TMRR Acquisition Strategy and subsequent phases on the path to full capability.
  - Risks, issues, and opportunities from the IB, materials, facilities, workforce, interdependencies with other programs, manufacturing technology voids, quality, software and engineering related risks,/issues etc. have been included
  - Required maturation of critical technologies and manufacturing processes to the required level has been included
  - Manufacturing and quality cost and schedule impacts from the identified risks have been assessed and included

- The ongoing requirements for identification, analysis, mitigation, tracking, and control of manufacturing and quality risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program have been specified and documented in the AS.
- Detailed manufacturing and quality exit criteria metrics for MSA, TMRR, and subsequent phase decision points have been developed and documented as inputs to the Acquisition Strategy and include:
  - Current and projected manufacturing quality maturity of identified critical technologies and manufacturing processes
  - Planned MRL targets for system, subsystems, components, and items

- Manufacturing and quality support plans for the mandated independent assessment have been developed, documented, and included in the AS.
- DCMA inputs on strategies for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality have been included.

Tools

- Acquisition Strategy Outline
- ICD Template, Oct 2012
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Manufacturing Readiness Level Assessment Questionnaire
- Pugh Matrix Template
- Quality Function Deployment Excel Spreadsheet
- Requirements Roadmap Worksheet
- TRIZ Matrix
- SAE AS6500 Manufacturing Management System Checklist
- ISO 9000 Quality Management System Checklist
- SAE AS9100 Advanced Quality Management System Checklist

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Management Systems, Sep 2016
- IEEE 15288-2014, Systems and Software Engineering
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- ISO 9000:2015, Quality Management Systems, Sep 2015
- MRL Deskbook Version 2016
- PL114-328 and subsequent guidance (TBD)
- Acquisition Plan Preparation Guide, Jan **2009**
- Capability Based Assessment Guide March 2009
- DoDI 5000.02, Change 1, Jan 2017
- DoDI 5000.60, Defense Industrial Capabilities Assessments, Oct 2009
- DoD 5000.60H, Assessing Defense Industrial Capabilities, Apr 1996
- DSMC Acquisition Strategy Guide, Dec 1999
- Pre-Materiel Development Decision Analysis Handbook, July 2010
- Quality Function Deployment (Reference Books)

A.3 Input to the Systems Engineering Plan (SEP)

Manufacturing and Quality Tasks

- Update the assessment of manufacturing feasibility for the preferred concept, if not completed; conduct an assessment, for inclusion in the SEP.
- Provide manufacturing and quality inputs to the SEP on all IB, design, manufacturing, production, and quality risks and risk reduction and mitigation efforts.

559 - Identify critical technologies and manufacturing and quality process areas requiring risk
560 reduction and mitigation efforts for the SEP, including the following activities:
561 - Initial manufacturing and quality approaches for system requirements and system
562 design concepts
563 - Manufacturing and quality trade studies
564 - Potential manufacturing and quality solutions
565 - Identify manufacturing and quality risks, issues and opportunities from existing
566 architectures, capabilities, and external dependencies
567 - Maintain up-to-date status on all key manufacturing and quality inputs to the SEP
568 • Based on the Manufacturing and Quality Strategies in the AS, provide manufacturing and
569 quality plans and support to assist in development of the SEP and the program schedule
570 including:
571 - Inputs on required manufacturing and quality products (e.g., assessment, metrics, etc.) for
572 all SE reviews
573 - Inputs on specific and detailed manufacturing and quality entry and exit criteria metrics
574 for technical reviews and MSA, TMRR, and subsequent phase decision points
575 - Metrics should include current and projected manufacturing and quality maturity of
576 identified critical technologies and manufacturing processes
577 - Metrics should also include the planned Manufacturing Readiness Level (MRL)
578 target for system, subsystems, components, and items
579 - Manufacturing and quality criteria, metrics, and frequency for SE reviews
580 - Planned significant manufacturing and quality activities and tools (i.e. modeling and
581 simulations, manufacturing and quality assessments, long lead or advanced procurements,
582 prototype builds, production lots/phases, etc.)
583 - Specifications for the manufacturing and quality organization, billets, and Key
584 Leadership Positions
585 - Specification of the roles, responsibilities, and organization of the Manufacturing
586 Working Group to support SE
587 - Manufacturing and quality roles and responsibilities within other program IPTs (e.g.,
588 Design, Risk Management, Systems Engineering, Test and Evaluation (T&E),
589 Sustainment, Facilities, etc.)
590 • Provide manufacturing and quality requirements, risks, issues, and opportunities (e.g., design,
591 producibility, manufacturing technology, facilities, sustainment, cost and schedule, etc. for
592 the SEP to be addressed by all IPTs.
593 • Identify manufacturing and quality inputs on required technical reviews/audits (e.g.,
594 Preliminary Design Review, Critical Design Review, Production Readiness Reviews, etc.) to
595 be conducted at the sub-tier level on Configuration Items to be designed and developed by a
596 sub-tier suppliers.
597 • Planned manufacturing and quality activities for the next phase

- Summarize key manufacturing and quality systems engineering, integration, and verification processes and activities established or modified since the previous phase, including updated
  - Risk and risk mitigation strategies
  - Technical and manufacturing maturity
  - Manufacturing and quality metrics to support key management focus areas

Metrics

- The assessment of manufacturing feasibility for the preferred concept for inclusion in the SEP is up-to-date and reflects current program status. If not completed, conduct an assessment.
- Up-to-date manufacturing and quality inputs to the SEP on all IB, design, manufacturing, production, and quality risks and risk reduction and mitigation efforts have been documented and provided.
  - Critical technologies and manufacturing and quality process areas requiring risk reduction and mitigation efforts for the SEP have been identified, developed and documented, including the following activities:
    - Initial manufacturing and quality approaches for system requirements and system design concepts
    - Manufacturing and quality trade studies results
    - Potential manufacturing and quality solutions
  - Manufacturing and quality risks, issues and opportunities from existing architectures, capabilities, and external dependencies requiring risk reduction and mitigation efforts have been identified, developed, and documented
  - A process to maintain up-to-date status on all key manufacturing and quality inputs to the SEP has been developed and is in place.
- Based on the Manufacturing and Quality Strategies in the AS, manufacturing and quality inputs have been documented in the SEP and include:
  - Inputs on manufacturing and quality products (e.g., assessment, metrics, etc.) required for all SE reviews developed and documented
  - Inputs on specific and detailed manufacturing and quality exit criteria metrics for technical reviews and MSA, TMRR, and subsequent phase decision points developed and documented
    - Metrics should include current and projected manufacturing and quality maturity of identified critical technologies and manufacturing processes
    - Metrics should also include the planned MRL target for system, subsystems, components, and items
  - Manufacturing and quality criteria, metrics, and frequency for all SE reviews have been established and documented

- Planned significant manufacturing and quality activities and tools (i.e. modeling and simulations, manufacturing and quality assessments, long lead or advanced procurements, prototype builds, production lots/phases, etc.) have been identified and are documented in the SEP and the program schedule
- Manufacturing and quality organization, billets, and Key Leadership Positions have been identified and documented
- Specification of the roles, responsibilities, and organization of the Manufacturing Working Group to support SE have been specified and documented
- Manufacturing and quality roles and responsibilities within other IPTs (Design, Risk Management, Systems Engineering, T&E, Sustainment, Facilities, etc.) have been specified and documented
    - Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics

- Manufacturing and quality requirements, risks, issues, and opportunities (e.g., design, producibility, manufacturing technology, facilities, sustainment, cost and schedule, etc. have been provided and documented in the SEP to be addressed by all IPTs.
- Manufacturing and quality inputs on required technical reviews/audits (e.g., Preliminary Design Review, Critical Design Review, Production Readiness Reviews, etc.) to be conducted at the sub-tier level on Configuration Items to be designed and developed by a sub-tier suppliers are included and documented in the SEP and the Integrated Master Schedule.
- Planned manufacturing and quality SE activities for the next phase have been documented along with the appropriate metrics
    - Key manufacturing and quality systems engineering, integration, and verification processes and activities established or modified since the previous phase, including updates have been summarized
        - Risk and risk mitigation strategies are documented
        - Technical and manufacturing maturity requirements are developed and documented with threshold and objectives established
        - Manufacturing and quality metrics to support key management focus areas are established and documented

Tools

- Systems Engineering Plan (SEP) Outline
- AoA Study Plan Template
- Critical to Customer/Critical to Quality Tree Template
- Manufacturing Capability Assessment Worksheet
- Manufacturing Readiness Level Questionnaire (Part of MRL Users Guide)
- MDD Development Planning Templates
- MSA Template

- Producibility Assessment Worksheet (PAWs)
- Triz Matrix

Resources

- IEEE 15288-2014, Systems and Software Engineering
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- SEP Outline, Jun 2015
- Air Force AoA Guide, June 2013
- Air Force AoA Handbook, Jul 2008
- DMMG for PMs, Chapter 1.3 and 2.6 Industrial and Manufacturing Capability Assessments in the Acquisition Lifecycle
- DoDI 5000.02, Change 1, Jan 2017
- MRL Deskbook Version 2016
- MRL Users Guide Version 2016
- MSA Guide, DAG Chapter 4.2.3 , also see Air Force and Navy Guides

A.4 Support Program Management Reviews

Manufacturing and Quality Tasks

- Support the ITR (Initial Technical Review) (accomplish prior to AoA, if required).
    - Perform manufacturing and quality analyses of the draft ICD, the AoA Study Guidance, and the preliminary CONOPS of the materiel solution alternatives
    - Provide detailed manufacturing and quality information to promote an understanding of each concept or alternative for:
        - Engineering trades
        - Cost drivers, material, and process risks, issues, and opportunities
        - Development of a CARD
- Manufacturing and quality provides inputs and analyses to the ASR to support that the preferred materiel solution(s) resulting from the AoA has the best potential to be cost effective, affordable, operationally effective and suitable, and can be developed to provide a timely solution to the need at an acceptable level of risk. Manufacturing and quality representatives supporting program IPTs will:
    - Review, evaluate, and update the manufacturing and quality producibility assessments for the preferred system concept(s) for adequacy
    - Review, evaluate, and update the comprehensive risk, issue, and opportunity assessment for completeness and adequacy of all manufacturing and quality risks and update mitigation plans (develop if not initiated)

        - Complete trade studies or technical demonstrations for manufacturing concept risk reduction
        - Incorporate producibility and manufacturing considerations which could impact program decisions (e.g., critical components, materials and processes, tooling and test equipment development, production testing methods, long lead items, and facilities/personnel/skills requirements)
    - Review and evaluate the risks to manufacturing and quality associated with the use of a commercial off-the-shelf (COTS)/ government off-the-shelf (GOTS)/non-developmental items (NDI) solution versus a new design
    - Complete the manufacturing and quality input to the initial hazard analysis and/or the system safety analysis for the preferred solution(s)
    - Assess the manufacturing and quality requirements of the draft CDD to verify that all KCs are traceable to user needs through preliminary system specifications, key assumptions, and constraints back to KPPs and KSAs (from JCIDS)
    - Assess the results of the AoA materiel solution(s) to meet manufacturing and quality cost, schedule, and performance objectives
    - Review, evaluate, and update the comprehensive manufacturing and quality plans that address critical items, parts, components, and prototypes to be developed and demonstrated, along with their cost, and critical path drivers
    - Provide manufacturing and quality inputs on the scope and planning of competitive prototyping of the materiel solution systems, subsystems, and components
    - Provide manufacturing and quality inputs on the scope, planning, and resources needed for the initial end-item development
    - Review Lessons Learned for manufacturing and quality drivers of system life-cycle cost
    - Provide inputs to the CARD that reflect realistic materiel solutions that meet the draft CDD within manufacturing and quality IB constraints including workforce estimates
    - Review and update manufacturing and quality inputs to the SEP and the AS, if necessary

Metrics

- If required prior to AoA, detailed manufacturing and quality information has been documented to support the Initial Technical Review (ITR) and documents each concept or alternative for:
    - Engineering trades
    - Cost drivers, material, and process risks, issues, and opportunities
    - Development of a CARD
- Assessments of the draft ICD, the AoA Study Guidance, and preliminary CONOPS by manufacturing and quality analyses for materiel solution alternatives have been conducted and results documented for the AoA.
- Manufacturing and quality representatives designated to support the ASR have:

- Reviewed, evaluated, and documented the updated producibility assessments for the preferred system concept(s) for adequacy with any shortfalls identified
- Reviewed, evaluated, and documented the updated comprehensive risk, issue, and opportunity assessment for completeness and adequacy of all manufacturing and quality risks and that updated mitigation plans are documented and underway
    - Completed trade studies or technical demonstrations for manufacturing concept risk reduction have been documented
    - Producibility and manufacturing considerations which could impact program decisions (e.g., critical items, parts, components, materials and processes, tooling and test equipment development, production testing methods, long lead items, and facilities/personnel/skills requirements) have been identified and documented in appropriate plans
- Reviewed, evaluated, and documented the relative risk(s) to manufacturing and quality associated with the use of a COTS/GOTS/NDI solution versus a new design
- Completed and documented the manufacturing and quality inputs to the initial hazard analysis and/or the system safety analysis for the preferred solution(s)
- Assessed, verified, and documented that the KCs are traceable to user needs through preliminary system specifications, key assumptions, constraints back to KPPs and KSAs in the draft CDD
- Analyzed and assessed the results of the AoA materiel solutions to meet manufacturing and quality cost, schedule, and performance objectives and have documented the results including shortfalls
- Reviewed, evaluated, and documented the updated the comprehensive manufacturing and quality plans for critical items, parts, components, and prototypes to be developed and demonstrated, including cost, critical path drivers, and any shortfalls identified
- Documented and provided manufacturing and quality inputs on competitive prototyping (scope and planning) for the materiel solution systems, subsystems, and components
- Documented and provided manufacturing and quality inputs on the scope, planning, and resources needed for the initial end-item development
- Reviewed and applied appropriate Lessons Learned for manufacturing and quality drivers of system life-cycle cost
- Developed and provided CARD inputs that reflect realistic materiel solutions that meet the draft CDD requirements within manufacturing and quality IB constraints (including workforce estimates)
- Reviewed and updated manufacturing and quality inputs to the SEP and the AS

Tools

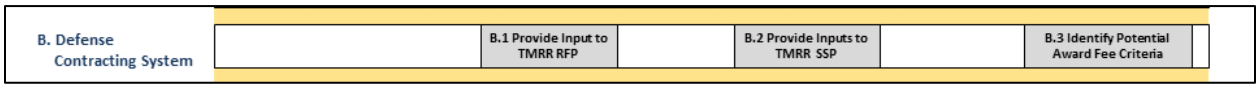
- Alternative System Review Checklist

Resources

- DAG, Chapter 3-3.3.1 Alternative System Review

- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs

B. DEFENSE CONTRACTING SYSTEM



Manufacturing and quality program office personnel will participate in all phases of the development of Technology Maturation and Risk Reduction (TMRR) Request for Proposal (RFP), Source Selection Plan (SSP), and Award Fee incentive criteria. Many programs do not consider manufacturing and quality management requirements until the later stages of the EMD phase and beyond, however, there is a need to manage and control the emerging manufacturing and quality risks in the early acquisition phases.

Manufacturing and quality inputs to the RFP for TMRR should be based on the manufacturing and quality inputs to the AoA in order to successfully develop and deliver the preferred solution and to provide a mature product with reduced risks that meet schedule and cost. These inputs will require specifying the use of best practices in the area of manufacturing management and quality management. As part of the RFP, the contractor will be required to identify and to describe their proposed processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks associated with the proposed materiel solution. The RFP will require these “ilities,” risks, and other requirements to be appropriately documented in Contract Data Requirements List (CDRL), Data Item Description (DIDs), and other deliverables subject to a specified approval and acceptance process.

Each of the manufacturing and quality inputs to the RFP should have appropriate criteria and metrics to be met included in the SSP to ensure a fair and equitable source selection. The manufacturing and quality criteria and metrics should be coupled with appropriate award fee incentives, with processes, and procedures to reward successful management and execution, including incremental achievements of program goals. The criteria and metrics should also be used to incentivize domestic manufacturing and technology capability improvements that contribute to performance enhancement, schedule improvement, cost savings, etc.

The early inclusion of manufacturing and quality inputs into the RFP, SSP, and other program processes will help guide the future development program success and help minimize risk.

B.1 Provide Input to TMRR RFP

Manufacturing and Quality Tasks

- Ensure that manufacturing and quality personnel are included in the TMRR Request for Proposals (RFPs) writing and review teams.

- Analyze the manufacturing and quality results from the AoA Study Guidance and the AoA as a basis for RFP requirements.
    - Results from other relevant manufacturing and quality feasibility and Industrial Base studies to be used as additional data for RFP requirements
- Specify appropriate requirements for CDRLs, DIDs, etc. to support manufacturing and quality processes and the requisite approval process.
    - Include requirements for reporting of manufacturing, quality, and supplier management metrics
- Specify the requirements for best practices for the Contractor's Manufacturing Management System (per Section L.1) and Quality Management System (per Section I.1)to be used (e.g., AS6500, ISO 9000, AS9100, etc.).
    - Specify the requirements for the contractors to identify and to describe their proposed specific processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks associated with the proposed solutions
- If AS6500 is not invoked in the contract(s), the manufacturing management requirements cited in AS6500 should be the basis for specific contractual requirements for a contractor plan. The requirements, at a minimum, should specify that the contractor addresses:
    - Manufacturing Management System:
        - Documenting how, when, and by whom each requirement of their system is to be accomplished, and define the authority and responsibility for each.
    - Design Analysis for Manufacturing:
        - Conducting producibility analyses
        - Identifying and managing key and critical characteristics in the Technical Data Package (TDP)
        - Implementing Variability Reduction (VR) to reduce part to part variation of key and critical characteristics
        - Identifying and managing key and critical manufacturing processes
        - Conducting Process Failure Modes and Effects Analysis (PFMEA) on critical manufacturing processes
    - Manufacturing Risk Identification:
        - Integrating manufacturing risk management activities into the program risk, issue and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
        - Conducting and documenting manufacturing feasibility assessments for each competing design alternative under consideration

856 ▪ Identifying MRL targets and documenting manufacturing risks through the MRL
857 assessments

858 o Manufacturing Planning:

859 ▪ Establishing and maintaining a manufacturing plan that includes supply chain and
860 material management, manufacturing technology development, manufacturing
861 modeling and simulation, manufacturing costs, manufacturing system verification,
862 manufacturing workforce, and tooling, test equipment, and facilities.

863 o Manufacturing Operations Management including:

864 ▪ Production Scheduling and Control
865 ▪ Manufacturing Surveillance
866 ▪ Continuous Improvement
867 ▪ Process Control Plans
868 ▪ Process Capabilities
869 ▪ Production Process Verification
870 ▪ First Article Inspections and First Article Tests
871 ▪ Supplier Management and Quality

872 • Specify industry best practices for Systems Engineering to be used (e.g., IEEE 15288, -1, -2,
873 etc.) in the RFP.

874 o Include requirements for the contractors to identify and to describe their proposed
875 processes, methods, and actions to address technical processes, technical management
876 processes, and essential specialty engineering

877 • Specify contractual manufacturing and quality requirements for:

878 o Conducting manufacturing and quality reviews of engineering and software (with
879 frequency of reviews)
880 o Providing manufacturing and quality information for cost models
881 o Implementing a risk, issue, and opportunity management and mitigation program that
882 includes manufacturing and quality (including IB risks)
883 o Implementing a manufacturing and quality variability reduction program
884 o Managing materials and subcontractors
885 o Utilizing Commercial Off The Shelf (COTS), Government Off The Shelf (GOTS), and
886 Non-Developmental Items (NDIs)

887 • Specify manufacturing and quality:

888 o Content for Statement of Work (SOW) and contract sections C, L, M, and H
889 o Metrics to be met as exit criteria for TMRR phase
890 o Requirements for cost estimates that include rate, alternate materials, quantity, etc.
891 (including Cost of Quality data, if available).
892 o Requirements for identification and description of manufacturing technology capability
893 improvement efforts

- Requirements for identification and description of producibility efforts
  - Include cost sharing and incentive plans relevant to the solution
- Requirements for identification and description of contractor cost sharing and incentive initiatives
  - Requirements that encourage acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life-cycle costs
  - Requirements that encourage investment in U.S. domestic sources
- Requirements for facilities, tooling, and test equipment
- Requirements for workforce (e.g., training, certifications, etc.)
- Requirements for supply chain management

- Specify the requirement that the contractor support conduct of independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment.

Metrics

- Manufacturing and quality personnel have been assigned as designated members of the TMRR Request for Proposals (RFPs) writing and review teams.
- Results of manufacturing and quality inputs to the AoA Study Guidance and the manufacturing and quality outputs from AoA have been used for development of RFP requirements.
  - Results from other relevant manufacturing and quality feasibility and IB studies have been included as additional data for RFP requirements
- Appropriate manufacturing and quality CDRLs, DIDs, etc. or appropriate language and the requisite reporting and approval processes have been included in the RFP.
- Requirements for best practices for the Contractor's Manufacturing Management System (per Section L.1) and Quality Management System (per Section I.1) to be used (e.g., AS6500, ISO 9000, AS9100, etc.) have been specified in the RFP.
  - Requirements for the contractors to identify and to describe their proposed specific processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks associated with the proposed solution(s) have been included
- If AS6500 is not invoked in the contract, the manufacturing management requirements cited in AS6500 have been used as the basis for specific contractual requirements for a contractor plan and have been documented in the RFP. These requirements at a minimum have addressed and documented:
  - The Manufacturing Management System
  - Design Analysis for Manufacturing

        - Producibility analyses
        - Key and critical characteristics
        - Variability reduction
        - Manufacturing process analyses
        - FMEA
    - Manufacturing Risk Identification
        - Feasibility assessments
        - Manufacturing readiness assessments
    - Manufacturing Planning
    - Manufacturing Operations Management
- If an appropriate best practices QMS is not invoked in the contract, the quality management requirements contained in ISO 9000 and/or AS9100 have been used as the basis for specific contractual requirements for a contractor QMS plan and have been documented in the RFP.
- Appropriate standards for Systems Engineering best practices to be used (e.g., IEEE 15288, -1, -2, etc.) have been specified in the RFP.
    - Requirements for the contractors to identify and to describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering are included
- Detailed manufacturing and quality inputs have been specified and documented in the RFP including the requirements and metrics for:
    - Conducting manufacturing, quality, engineering, and software reviews (with frequency of reviews)
    - Cost models information with associated parameters
    - Identification and management of critical characteristics and KCs and the associated manufacturing processes
    - Risk, issue, and opportunity management and mitigation program that includes manufacturing, quality, and IB risks
    - Variability reduction programs
    - Materials management processes
    - Use of COTS, GOTS, and NDIs
- The detailed requirements for manufacturing and quality inputs have been documented in the RFP for:
    - Content for the SOW and contract sections C, L, M, and H
    - Metrics to be met as exit criteria for TMRR phase
    - Cost estimates that include rate, alternate materials, quantity, etc. (includes Cost of Quality data).
    - Identification and description of manufacturing and technology capability improvement efforts

- Cost sharing and incentive plans and initiatives
  - Incentives that encourage acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life-cycle costs
  - Incentives that encourage investment in U.S. domestic sources
- Facilities, tooling, and test equipment
- Workforce planning (training, certifications, etc.)
- Supply chain management

- Requirements contractor support of independent risk assessments have been documented in the RFP to include the requirement for identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment.

Tools

- AS6500 Manufacturing Management Program Checklist
- ISO 9000 Quality Management System Checklist
- AS9100 Quality Management System Checklist
- RFQ Template
- SEP Outline

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- ISO 9000:2015, Quality Management Systems, Sep 2015
- AS9100, Quality Management Systems, Sep 2016
- MIL-HDBK-29612-1A Guidance for Acquisition of Training Data Products and Services, Aug 2001
- MIL-HDBK-245D Handbook for Preparation of Statement of Work, Apr 1996
- SEP Outline, Jun 2015
- 10 USC § 2366b
- FAR 46-202 Types of Contract Quality Requirements
- DAG CH 3-4.3.18 Producibility, Quality and Manufacturing Readiness

B.2 Provide Input to TMRR SSP

Manufacturing and Quality Tasks

- Ensure that manufacturing and quality personnel are included in the drafting of the Source Selection Plan (SSP) and provide inputs and metrics.

  - Analyze the manufacturing and quality results from the AoA Study Guidance and the AoA as a basis for SSP requirements and metrics
  - Results from other relevant manufacturing and quality feasibility and IB studies to be used as additional data for SSP requirements and metrics

- Specify the criteria and metrics for evaluating the contractor's use of best practices for Manufacturing Management, Quality Management (e.g., AS6500, ISO 9000, AS9100, etc.), and Systems Engineering management (i.e., IEEE 15288).
  - Specify the criteria and metrics for evaluating the contractor's proposed processes, methods, and actions to address manufacturing feasibility, producibility, and quality risks associated with the proposed solutions
- Specify the plan with appropriate criteria and metrics for submission, review, revision, and approval of CDRLs, DIDs, etc. to support manufacturing and quality processes.
- Specify manufacturing and quality criteria and appropriate metrics to be met for:
  - All Milestone and technical reviews
  - Manufacturing and quality reviews (including frequency of reviews)
  - Cost models and data (include Cost of Quality data)
  - Management processes for key and critical characteristics
  - Risk, issue, and opportunity identification, management, and mitigation program
  - Variability reduction program
  - Materials management process
  - Supply chain management program
  - Facilities, tooling, and test equipment plan
  - Workforce planning
- Specify the criteria and metrics for evaluating the contractor's:
  - Manufacturing and technology capability improvement plans and efforts.
    - Include cost sharing and incentive plans
  - Producibility efforts relevant to the solution.
    - Include cost sharing and incentive plans
  - Planning for IB risk management and mitigation
  - Plan to meet the exit criteria for TMRR phase.
  - Strategy for acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life-cycle costs
    - Methods to encourage investment U.S. domestic sources
- Specify the criteria and metrics for contractor support of independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment.

Metrics

- Manufacturing and quality personnel have provided criteria and metrics for inclusion in the SSP.
    - Results from the AoA Study Guidance and the AoA (manufacturing and quality inputs) have been analyzed the as a basis for SSP requirements and metrics
    - Other relevant manufacturing and quality feasibility and IB studies results have been documented and used as additional data for SSP requirements and metrics
- Criteria and metrics for evaluating the contractor's use of best practices for Manufacturing Management, Quality Management, and Systems Engineering management (applicable to manufacturing and quality) have been developed and documented for the SSP.
    - Criteria and metrics for evaluating the contractor's proposed processes, methods, and actions that address manufacturing feasibility, producibility, and quality risks associated with the proposed solutions are documented and specified in the SSP.
- Appropriate criteria and metrics for submission, review, revision, and approval of CDRLs, DIDs, etc. to support manufacturing and quality processes have been specified in the SSP.
- Manufacturing and quality criteria and metrics have been specified in the SSP for:
    - All Milestone and technical reviews
    - Conducting manufacturing and quality reviews (with frequency of reviews)
    - Cost models and data including Cost of Quality
    - KC management process
    - Risk, issue, and opportunity identification, management, and mitigation program
    - Variability reduction program
    - Materials management process
    - Supply chain management program
    - Facilities, tooling, and test equipment plan
    - Workforce planning
- Manufacturing and quality criteria and metrics for evaluating the contractor's plan to meet the exit criteria for TMRR phase have been specified
- Specified manufacturing criteria and metrics have been documented in the SSP for evaluating the contractor:
    - Manufacturing and technology capability improvement plans with cost sharing and incentive plans and metrics
    - Producibility efforts with cost sharing and incentive plans and metrics
    - Planning for IB risk management and mitigation
    - Strategy for acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life-cycle costs including methods to encourage investment in U.S. domestic sources

- Criteria and metrics for contractor support of independent risk assessments to include the identification of any critical technologies and manufacturing processes that have not been successfully demonstrated in a relevant environment have been documented in the SSP.

Tools

- Source Selection Plan Template (Navy)
- AS6500 Manufacturing Management Program Checklist
- AS9100 Quality Management System Checklist
- ISO 9001 Quality Management System Checklist

Resources

- Air Force Manufacturing Development Guide, Sep 2012
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Management Systems, Sep 2016
- DAG CH 3-4.3.18 Producibility, Quality and Manufacturing Readiness
- IEEE 15288, Systems and Software Engineering
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- ISO 9000:2015, Quality Management Systems, Sep 2015
- PL 114-328
- Defense Federal Acquisition Regulation Supplement, Procedures, Guidance and Information, Subpart 215.3--Source Selection, March 31, 2016
  Source Selection Plan Guide, Dec 2008

B.3 Identify Potential TMRR Award Fee Criteria

Manufacturing and Quality Tasks

- Develop manufacturing and quality entrance and exit criteria for technical reviews and decision points.
  - Specify metrics for partial achievements, incremental awards, penalties for failure to meet contract requirements, and achievement beyond expectations
- Incentivize early delivery of completed, comprehensive, and acceptable manufacturing and quality CDRLs, DIDs, other program documentation that meet the requirements for timely government approval.
  - Specify metrics for partial achievement and penalties for failure to meet contract requirements
- Provide incentives for achievement of manufacturing and quality specific thresholds, objectives, and sub-goals with respect to rate, schedule, performance, quality, etc.

- Specify metrics for partial achievements, incremental awards, and penalties for failure to meet contract requirements

- Specify thresholds for the adoption and effective implementation of industry best practices in manufacturing and quality (e.g., AS6500, ISO 9000, AS9100. etc.).
  - Develop program specific metrics that measure progress
  - Specify incentives for exceeding thresholds

- Specify thresholds and metrics for comprehensive manufacturing, quality, and subcontracting management plans.
  - Develop metrics for a manufacturing management plan that includes: identifying KCs and critical manufacturing processes; performing variability reduction activities; performing manufacturing capability assessments; and including a producibility program
  - Develop metrics for a quality management plan that implements an effective Quality Management System, focused on defect prevention
  - Develop metrics for a subcontract management plan that implements a comprehensive supplier management organization, promoting exceptional performance

- Develop manufacturing and quality program specific criteria and metrics that include key trades for and among cost, schedule, and performance, affordability analysis, risk analysis, and risk mitigation.
- Develop manufacturing and quality criteria and metrics that incentivize domestic manufacturing capability improvement investments, contributing to enhanced performance, schedule improvement, cost savings, etc. Include as appropriate the following:
  - Continuous Process Improvement (CPI) Program or initiatives
  - Cost sharing, risk reduction, cost recovery, etc.
  - Investments in domestic advanced manufacturing equipment and processes

Metrics

- Manufacturing and quality entrance and exit criteria requirements for technical reviews and decision points within schedule and budget are specified in the contract.
  - Contract specifies metrics for partial achievements, incremental awards, and awards for performance beyond expectations
  - Contract includes penalties for partial and or failure to meet contractual requirements that are definitive and specified in terms of cost to award fee with maximum and minimum penalties

- Contract includes provisions and incentives with metrics for early delivery and approval of complete, comprehensive, and acceptable manufacturing and quality CDRLs, DIDs, other program documentation.
  - Metrics for partial achievements, incremental awards, and penalties for failure to meet contract requirements are included

- Contract includes incentives for achievement of manufacturing and quality specific thresholds, objectives, and sub-goals with respect to rate, schedule, performance, quality, etc.
    - Metrics for partial achievements, incremental awards, and penalties for failure to meet contract requirements are included
- Contract includes appropriate manufacturing and quality criteria and metrics for enhanced performance, schedule improvement, cost savings; and specifies the potential award fee or incentive to be earned.
- Contract includes criteria and metrics for the adoption and implementation of industry best practices in manufacturing and quality (e.g., AS6500, ISO 9000, AS9100. etc.).
    - Contract specifies the metrics for measuring progress and meeting expectations
- Contract includes incentives and metrics for comprehensive manufacturing, quality, and subcontracting management plans.
    - Metrics for a manufacturing management plan have been included that identify: KCs and critical manufacturing processes, performing variability reduction activities, performing manufacturing capability assessments, and including a robust producibility program
    - Metrics for a quality management plan have been included that implement an effective Quality Management System focused on defect prevention
    - Metrics for a subcontract management plan have been included that implement a comprehensive supplier management organization that promotes exceptional performance
- Contract specifies criteria and metrics to evaluate trades among cost, schedule, performance, affordability, risks, risk mitigation for meeting requirements, and incentives for exceeding goals.
- Contract specifies manufacturing and quality criteria and metrics that encourage domestic manufacturing and quality capability improvement investments and includes the following:
    - CPI Program or initiatives
    - Cost savings, recovery, and sharing
    - Risk reduction and mitigation
    - Domestic investment in advanced manufacturing equipment and processes
    - Performance enhancement
    - Schedule improvement

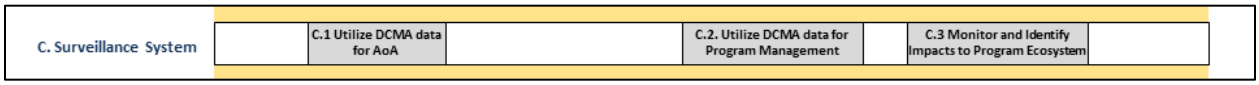
Tools

- Source Selection Plan Template (Navy)
- Award Fee or Incentive Fee Template
- AS6500 Manufacturing Management Program Checklist
- AS9100 Quality Management System Checklist
- ISO 9001 Quality Management System Checklist

Resources

- Award Fee Guide (Army, Navy and Air Force all have one)
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Management Systems, Sep 2016
- Defense Production Act Title III (Manufacturing Technology Programs)
- DODD 4400.01E Defense Production Act Programs, Oct 2001
- ISO 9000:2015, Quality Management Systems, Sep 2015
- Award Fee Guide, (Army, Navy or Air Force)
- MIL-STD-896B Manufacturing and Quality Program

C. SURVEILLANCE SYSTEM



The AoA authority or PM should maximize the use of Defense Contract Management Agency (DCMA) information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. DCMA, utilizing a systematic approach to supplier manufacturing and supply chain evaluation, supply chain improvement initiatives, and best practices, is a valuable resource.

DCMA can provide input into requirements and commitments that enable programs to have current and predictive insight into performance. Access to reliable and accurate data and process information on costs, schedule, and technical performance can assist with objective assessment of supplier plans and the verification of initial and continuing compliance with requirements. The ability to continually analyze risks and identify risk-adjusted solutions to sustain a reliable, technologically superior, efficient, cost-effective, and resilient defense IB mitigates overall program risk.

C.1 Utilize DCMA Data for AoA

Manufacturing and Quality Tasks

- As part of manufacturing feasibility assessments of AoA concepts, request information and data input for similar products and manufacturing processes from DCMA on:
  - Manufacturing maturity
  - Status and readiness of industrial capabilities
  - Current available facilities and equipment
  - Workforce availability and training
  - Quality system processes and results
- Ensure DCMA quality and manufacturing data is utilized in the analysis of the manufacturing and quality requirements and feasibility for the AoA.

- Utilize DCMA manufacturing and quality data relevant for emerging technology maturity to develop and provide recommendations/rationale for the AoA preferred concepts.
- Utilize DCMA data to assist in identifying the manufacturing, quality, and/or supply chain risks for similar products and processes relevant for the AoA.
- Request and utilize DCMA manufacturing and quality data in support of the AoA to include data that supports the following analyses:
  - Manufacturing System Analysis
    - Supplier Surveillance
    - Production Planning and Control System
    - Material Management and Accounting System (MMAS)
  - Manufacturing Program and Product Analysis
    - Development program specific surveillance
    - Industrial Labor Relations
    - Past Performance
  - Manufacturing Continuous Improvement and Analysis
    - Surveillance of Supplier Continuous Improvement System
    - Supplier Performance Measurement
  - Supply Chain System Analysis
    - Materials Planning
    - Supplier/Sub-tier Qualification/Requirements Flow Down
    - Communication/Systems Integration
    - Continuous Improvement
    - Supplier Performance Measurement System and Surveillance Improvement
    - Data Analysis, Statistics, and Sampling
  - Supply Chain Risk Assessment
    - Risk Realization
    - Program/Platform/Sector Analysis and Modeling
    - Critical Item Risk
    - Capacity/Lead Time Analysis

Metrics

- As part of manufacturing feasibility assessments of AoA concepts, DCMA provided information and data on similar products and manufacturing processes has been utilized and included specifics on:
  - Manufacturing maturity
  - Status and readiness of industrial capabilities
  - Current available facilities and equipment
  - Workforce availability and training

- Quality system processes and results

- Quality and manufacturing data provided by DCMA has been utilized in the analysis of the manufacturing and quality requirements and feasibility for the AoA.
- DCMA data relevant emerging technology maturity has been utilized to develop and provide recommendations/rationale for the AoA preferred concept(s).
- DCMA data has been utilized to assist in identifying the manufacturing and/or supply chain risks for similar products and processes relevant for the AoA.
- DCMA data has been utilized to support the AoA to including data that supports the following analyses:
  - Manufacturing System Analysis
    - Supplier Surveillance
    - Production Planning and Control System
    - MMAS
  - Manufacturing Program and Product Analysis
    - Development program specific surveillance
    - Industrial Labor Relations
    - Past Performance
  - Manufacturing Continuous Improvement and Analysis
    - Surveillance of Supplier Continuous Improvement System
    - Supplier Performance Measurement
  - Supply Chain System Analysis
    - Materials Planning
    - Supplier/Sub-tier Qualification/Requirements Flow Down
    - Communication/Systems Integration
    - Continuous Improvement
    - Supplier Performance Measurement System and Surveillance Improvement
    - Data Analysis, Statistics, and Sampling
  - Supply Chain Risk Assessment
    - Risk Realization
    - Program/Platform/Sector Analysis and Modeling
    - Critical Item Risk
    - Capacity/Lead Time Analysis

Tools

- DCMA Pre-Award Survey
- DCMA Program Support Plan
- AS6500 Checklist

- ISO 9000 Checklist
- AS9100 Checklist
- AoA Study Plan Template, Sep 2009
- SF 1404 Preaward Survey – Technical
- SF 1405 Preaward Survey - Production
- SF 1406 Preaward Survey – Quality

Resources

- Air Force AoA Guide, June 2013
- Air Force AoA Handbook, July 2008
- AS6500, Manufacturing Management Program, Nov 2014
- ISO 9000:2015, Quality Management Systems, Sep 2015
- AS9100, Quality Management Systems, Sep 2016
- DCMA Pre-award Survey Guide, (no date)

C.2 Utilize DCMA Data for Program Management

Manufacturing and Quality Tasks

- Utilize the DCMA information and data provided for the AoA to support the development of manufacturing and quality inputs to program documentation, planning, and investments with respect to:
    - Manufacturing maturity
    - Industrial capability status and readiness
    - Facilities and equipment availability
    - Workforce availability and training
    - Quality system processes and results
    - Manufacturing and/or supply chain risks
- Utilize DCMA data to support the manufacturing and quality inputs to systems engineering trade studies, design, analyses, etc. Including information from DCMA reports on:
    - Manufacturing System Analyses
    - Manufacturing Program and Product Analyses
    - Manufacturing Continuous Improvement and Analysis
    - Supply Chain System Analysis
    - Supply Chain Risk Assessment
- Based on DCMA inputs, document and develop recommendations for manufacturing investment programs mature emerging manufacturing technologies and industrial capabilities (see D.3 and D.4).

- Request DCMA Contract Management Offices support development of manufacturing and quality to program support plans for program contracts to ensure agreement on contract oversight needs and perspectives with respect to:
  - Product support analysis
  - Software development
  - Counterfeit parts
  - Cyber security

Metrics

- DCMA information and data provided for the AoA have been utilized to support the development of manufacturing and quality inputs to program documentation, planning, and needed investments with respect to:
  - Manufacturing maturity
  - Industrial capability status and readiness
  - Facilities and equipment availability
  - Workforce availability and training
  - Quality system processes and results
  - Manufacturing and/or supply chain risks
- DCMA analysis data has been utilized to support the manufacturing and quality inputs to systems engineering trade studies, design, analyses, etc., which included information and results from DCMA:
  - Manufacturing System Analyses
  - Manufacturing Program and Product Analyses
  - Manufacturing Continuous Improvement and Analysis
  - Supply Chain System Analysis
  - Supply Chain Risk Assessment
- Based on DCMA inputs, recommendations for manufacturing investment programs mature emerging manufacturing technologies and industrial capabilities have been developed and documented (see D.3 and D.4).
- DCMA Contract Management Offices have been requested to support development of manufacturing and quality inputs to program support plans for program contracts to ensure agreement on contract oversight needs and perspectives.

Tools

- Army Manufacturing Technology (ManTech) Proposal Rating Template
- Industrial Base Capabilities Assessment Questionnaire
- Manufacturing Readiness Level Assessment Questionnaire
- Pugh Matrix template
- Technology Readiness Assessment Checklist

Resources

- DoD Directive 4200.15 DoD ManTech Program
- Counterfeit Parts Prevention Strategy Guide, Jun 2014
- DODI 5000.60 Defense Industrial Capabilities Assessments
- DOD 5000.60H Assessing Defense Industrial Capabilities
- ManTech Strategic Plan, Mar 2009
- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011
- DCMA-INST-204 Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207 Engineering Surveillance
- DCMA-INST-309 Government QA Surveillance Planning
- DCMA-INST-325 Technical Reviews
- DoDI 5000.02, change 1, Jan 2017

C.3 Monitor and Identify Impacts to Program Ecosystem

Manufacturing and Quality Tasks

- Monitor and track external environment for potential impacts to manufacturing and quality for the program.
    - Environmental impacts to supply chain (legal and natural disasters)
    - Strategic and political changes/risks (domestic and foreign)
    - New laws and regulations (state and federal)
    - Obsolescence impacts
    - New industry or updated standards (e.g., AS6500, IEEE 15288, etc.)
- Monitor and track Industrial Base for trends, business startups, technology breakthroughs, etc. for impacts on manufacturing and quality
- Monitor and track economic and business environment developments and impacts on manufacturing and quality with regard to:
    - Acquisitions
    - Mergers
    - Bankruptcies
    - Market changes/disruptions

Metrics

- Changes in the external environment, the economic and business environment, or the Industrial Base that have manufacturing and quality impacts and risks are being monitored and have been documented in the SEP.

- Acquisition Strategy has been updated to reflect changes in the external environment, the economic and business environment, or the Industrial Base that have manufacturing and quality impact.
- Environmental, economic, and business, or Industrial Base changes that have manufacturing and quality impacts on facilities, safety, tooling, etc. have been documented and mitigation planning initiated.

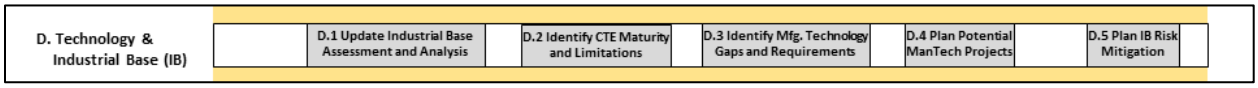
Tools

- Hazardous Material Assessment Template
- ISO 9000 Checklist Section Preservation (Handling, Storage, Packaging and Delivery)
- Preliminary Hazard List (PHL) See PHA checklist

Resources

- ISO 9000:2015, Quality Management System, Sep 2015
- ISO 14001 Environmental Management
- MRL Deskbook Version 2016
- ESHO in Acquisition Guide, Apr 2009
- AS9100, Quality Management Systems, Sep 2016 - SCM Model

D. TECHNOLOGY AND INDUSTRIAL BASE (IB)



The MSA phase identifies materiel solutions to address gaps in capability based on an Analysis of Alternatives (AoA). The AoA is performed independent of the program management office and forms the basis for selecting the recommended approaches for materiel solutions. During the AoA, each competing alternative under consideration is analyzed for its impact to industrial and manufacturing capabilities. The results of the analyses are used to quantify the differences between alternatives based on the industrial and manufacturing capabilities and the resources needed.

The IB assessments performed previously determine the likelihood that a proposed materiel solution can be produced. The assessments identify relevant sources and potential unique manufacturing capabilities, known gaps, risks, and potential sources, technological developments, market trends, processes, environmental factors, and policies, etc. The IB analysis focuses on availability, vulnerability, potential obsolescence, and actions necessary to mitigate.

The IB assessments identify the high-risk manufacturing areas and highlight the need for investments in manufacturing technology improvements. These gaps must be identified early to reduce acquisition costs by providing the required investments in manufacturing capabilities in time to support production. The DoD ManTech program was created to address the concerns for high-risk

manufacturing processes, with the objective of improving performance and reducing cost by developing, maturing, and transitioning advanced manufacturing technologies.

The assessments and analyses also highlight the need to support, maintain, or enhance essential or fragile industrial capabilities. The IB analyses identify the IB risks incurred in selecting a particular design and highlight the need for mitigation of potential product or component obsolescence, supplier fragility, and process economic feasibility.

Note: *When industrial capabilities require an investment greater than $10 million and affect more than one defense program or user, the need to support, maintain, or enhance essential or fragile industrial capabilities the analyses and subsequent decisions must be coordinated within and across the Components per DODI 5000.60.*

D.1 Update Industrial Base Assessment and Analysis

Manufacturing and Quality Tasks

- Manufacturing and quality support the update of the IB assessments for concepts included in the AoA (conduct if not previously accomplished) by:
  - Ensuring identification of relevant sources including identification of unique manufacturing capabilities that are not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
  - Determining the likelihood that a proposed materiel solution can be produced using existing manufacturing capabilities while meeting quality, production rate and cost requirements
  - Ensuring the concept requirements and capabilities assessments are updated to include:
    - Identification of all known gaps, risks, and potential sources for key processes, technologies, and components
    - Identification of all potential and future manufacturing and quality needs inclusive of design, development, production, operation, and sustainment, and eventual disposal
    - All technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact manufacturing and quality of the preferred concepts
- Request updated DCMA industrial analysis data to support manufacturing and quality inputs to the AoA, including data that supports the following analyses:
  - Industrial Capability Assessments
  - Analytical Products
  - Defense Business and Economic Analyses
  - Acquisition Planning Support
- Ensure the manufacturing and quality focus of the IB analyses is on the:

- Capability to cost effectively design, develop, produce, maintain, support and restart the program (if necessary)
- Approach to making production rate and quantity changes that support a response to contingency and support objectives
- Vulnerability of supply chain (to include sole, single, fragile, foreign sources, foreign acquisition of domestic sources, and cybersecurity)
- Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
- Potential obsolescence
- Impact of external dependencies and integration
- New and unique capabilities and processes
- Actions necessary to mitigate existing IB gaps/risks and identifies when a needed industrial capability could be lost

- Prepare the manufacturing and quality inputs to the Industrial Base Capabilities Considerations summary report to summarize the results for inclusion in the AS:
  - Recommend actions or investments that address risks to cost, schedule, performance, and qualitative considerations
  - Define and recommend how and when the actions would be incorporated into the budget and schedule and, if possible, identify budget offsets
  - If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components per DODI 5000.60

Metrics

- The IB assessments for concepts included in the AoA have been updated (conduct if not previously accomplished) and include manufacturing and quality inputs.
  - Relevant sources have been identified and documented including identification of unique manufacturing capabilities that are not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
  - The likelihood that a proposed materiel solution can be produced using existing manufacturing capabilities while meeting quality, production rate and cost requirements has been determined and quantified
    - Identification of all known gaps, risks, and potential sources for key processes, technologies, and components
    - Identification of all potential and future manufacturing and quality needs inclusive of design, development, production, operation, and sustainment, and eventual disposal
    - All technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact manufacturing and quality of the preferred concept

- The IB assessment update included up-to-date DCMA industrial analysis data that supports the following analyses:
  - Industrial Capability Assessments
  - Analytical Products
  - Defense Business and Economic Analyses
  - Acquisition Planning Support
- The IB analyses focused on manufacturing and quality, and documented the following:
  - Capability to cost effectively design, develop, produce, maintain, support and restart the program (if necessary)
  - Approach to making production rate and quantity changes that support a response to contingency and support objectives
  - Vulnerability of supply chain (to include sole, single, fragile, foreign sources, foreign acquisition of domestic sources, and cybersecurity)
  - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
  - Potential obsolescence
  - Impact of external dependencies and integration
  - New and unique capabilities and processes required
  - Actions necessary to mitigate existing IB gaps/risks and identifies when a needed industrial capability could be lost
- The manufacturing and quality inputs to the Industrial Base Capabilities Considerations summary report, summarizing the results, have been prepared for the report and are included in the AS, including:
  - Recommended actions or investments that address risks to cost, schedule, performance, and qualitative considerations
  - Recommendations on actions to be incorporated into the program budget and schedule, and if possible, identify budget offsets (when and how)
  - If the required investment was greater than $10 million and determined to affect more than one defense program or user the following must be accomplished:
    - The need to support, maintain, or enhance essential or fragile industrial capabilities, the analyses, and subsequent decisions must be coordinated within and across the Components per DODI 5000.60.

Tools

- AoA Study Plan Template
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- MRL Assessment Checklist for Technology and Industrial Base thread
- Army ManTech Proposal Rating Template

- Numerous M&S models are available that the contractor may use, we (government) should be familiar with these tools

Resources

- Air Force AoA Handbook, Jul 2008
- DODD 4200.15 Manufacturing Technology (ManTech) Program, Sep 2002
- DoDI 5000.02
- DODI 5000.60 Defense Industrial Assessments, Jul 2014
- DODI 5000.60H Defense Industrial Capabilities Assessments, Apr 1996
- MRL Deskbook Version 2016
- DFARS 207.105
- DoDI 5000.60
- DoDI 5000.02, Change 1, Jan 2017
- 10 USC §2440, Technology and Industrial Base Plans

D.2 Identify Critical Technology Element (CTE) Maturity and Limitations

Manufacturing and Quality Tasks

- Identify the CTEs and assess the manufacturing and quality maturity for the AoA.
    - Include necessary hardware and the associated embedded software maturity
    - Identify mature components, subsystems, manufacturing and quality processes, and alternatives for each immature CTE, and specify a plan for increasing the manufacturing and quality maturity
- Assess the manufacturing feasibility, and manufacturing and quality processes associated with each CTE in the validated ICD, and develop a plan to improve and/or maintain maturity.
    - Include integration risk associated with the CTEs in trade studies and development
    - Include CTE interdependencies and associated risks
- For the ASR, conduct manufacturing and quality analyses to document the likelihood that the CTEs will mature to the required level to meet operational effectiveness and suitability with an acceptable level of risk.
- Ensure that the upcoming phase RFP addresses manufacturing and quality maturation of critical technologies.

Metrics

- As part of the AoA, the CTEs have been identified, assessed, and documented for manufacturing and quality maturity.
    - Necessary hardware and the associated embedded software maturity has been included

- For the AoA preferred concept(s), mature components, subsystems, processes, and alternatives for each immature CTE have been identified and documented as manufacturing and quality inputs in the appropriate program documentation (AS, SEP, etc.).
    - Plans for increasing the manufacturing and quality maturity have been developed and documented
- The manufacturing feasibility, and manufacturing and quality processes associated with each CTEs have been documented in the draft CDD, and have been included in the AS and SEP with the plans to improve and/or maintain maturity documented.
    - Includes manufacturing and quality integration risks associated with the CTEs in trade studies and development
    - Includes CTE manufacturing and quality interdependencies and associated risks
- As part of the ASR, analyses that document the likelihood that the CTE manufacturing and quality maturity will meet the required level of operational effectiveness and suitability with an acceptable level of risk have been provided and included.
- The plan for manufacturing and quality maturation of critical technologies has been documented in the RFP.

Tools

- MRL Assessment Checklist for Technology and Industrial Base thread
- Producibility Assessment Worksheet (PAWs)
- Technology Readiness Assessment
- TRL Calculator

Resources

- Defense Acquisition Program Support Methodology, Ver. 3.0
- MRL Deskbook Version 2016
- NAVSO P-3687Producibility Systems Guidelines, Dec 1999
- **Technology Readiness Assessment Guidance, Apr 2011**

D.3 Identify Manufacturing Technology Gaps and Requirements

Manufacturing and Quality Tasks

- Conduct manufacturing and quality assessments to identify gaps and high-risk in manufacturing processes needed for the preferred concept(s).
    - Analyze identified advanced manufacturing capabilities to definitize requirements
    - Analyze the gaps for potential manufacturing technology solutions that mitigate the risks
    - Estimate manufacturing and quality cost, schedule, and performance impacts

- Identify potential investments in manufacturing and quality technology that address gaps and risks.
- Conduct a survey that includes both DCMA reports and analyses, and the ongoing the DoD ManTech Program projects for potential solutions to manufacturing technology gaps.
    - Request DCMA provide relevant data
    - Request ManTech assistance to identify processes and components
- Identify and develop manufacturing and quality assistance requests to DoD and/or component manufacturing technology programs that support:
    - Identification of new manufacturing processes associated with the program and candidate components for the identified processes
    - Identification of low-yield processes and components
    - Development of requests for information from other government agencies, industry, and academia responses to warfighter needs
- Identify recommendations for program and contracting personnel on emerging manufacturing and quality technology investments and Title III initiatives.

Metrics

- Manufacturing and quality assessments have identified and documented gaps and high-risk manufacturing processes required for the preferred concept(s).
    - Advanced Manufacturing capabilities necessary for the preferred concept have been identified and documented along with associated risks.
    - Gaps have been analyzed and results documented for potential manufacturing technology solutions that mitigate the risks
    - Manufacturing and quality cost, schedule, and performance impacts have been identified and documented
- Potential investments in manufacturing and quality technology that address gaps and risks have been identified and documented.
- DCMA reports and analyses and ongoing ManTech projects have been identified, assessed, and documented for potential solutions that mitigate gaps in the preferred concept.
- Manufacturing and quality assistance requests to DoD and/or component ManTech programs have been developed that support:
    - Identification of new manufacturing processes associated with the program and candidate components
    - Identification of low-yield processes and components
    - Requests for information from other government agencies, industry, and academia
- Recommendations for program and contracting personnel on emerging manufacturing and quality technology investments and Title III initiatives have been identified and documented.

Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- MRL Assessment Checklist for Technology and Industrial Base thread
- Pugh Matrix
- Technology Roadmap
- TRL Assessment Checklist

Resources

- Air Force Technology Development and Transition Strategy Guidebook, Nov 2010
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- DoDI 5000.02, Change 1, Jan 2017
- DoD Directive 4200.15, ManTech, Sep 2002
- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011

D.4 Plan Potential ManTech Projects

Manufacturing and Quality Tasks

- Develop plans for identified gaps and high-risk manufacturing processes that require investments in ManTech or other manufacturing programs.
- Develop a comprehensive plan for each required potential ManTech investment that mitigates manufacturing and quality technology gaps for the preferred concept.
    - Determine potential funding sources for ManTech projects (Program Office, Service, and/or DoD-wide funding)
- Utilize both DCMA reports and analyses and ongoing ManTech projects to support planning for potential solutions to manufacturing and quality technology gaps.
    - Include relevant DCMA and ManTech program data
    - Request manufacturing and quality planning support from DoD and/or component manufacturing technology programs for:
        - Development of new manufacturing processes associated with the program and candidate components for the identified processes
        - Development and maturation of low-yield processes and components
        - Program and contracting personnel supporting manufacturing technology investments and Title III initiatives
        - Evaluating and maturing emerging manufacturing technology maturity

Metrics

- A comprehensive plan for each required potential ManTech investment that mitigates manufacturing and technology gaps for the preferred concept has been developed.
    - Potential budget offsets and/or funding sources for ManTech projects have been determined (Program Office, Service, and/or DoD-wide funding)
- Both DCMA reports and analyses and ongoing ManTech projects have been utilized to support planning for potential solutions to manufacturing and quality technology gaps.
    - Relevant DCMA and ManTech program data has been included
    - Manufacturing and quality planning support has been requested and documented from DoD and/or component manufacturing technology programs for:
        - Development of new manufacturing processes associated with the program and candidate components for the identified processes
        - Development and maturation of low-yield processes and components
        - Program and contracting personnel supporting manufacturing technology investments and Title III initiatives
        - Evaluating and maturing emerging manufacturing technology maturity
- Plans for identified high-risk manufacturing process areas that may require investments in ManTech or other manufacturing programs have been developed with recommendations documented.
- A comprehensive plan for each required investment has been developed for the AS.

Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- MRL Assessment Checklist for Technology and Industrial Base thread
- TRL Assessment Checklist

Resources

- Air Force Technology Development and Transition Strategy Guidebook, Nov 2010
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- DoDI 5000.02, Change 1, Jan 2017
- DoD Directive 4200.15, ManTech, Sep 2002
- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011

D.5 Plan IB Risk Mitigation

Manufacturing and Quality Tasks

- Identify all manufacturing and quality capability risks that impact the preferred concept.
- Develop a mitigation strategy and plan for each manufacturing and quality IB risk.
- Develop an IB capabilities plan with contingencies to identify and mitigate the current and future manufacturing and quality capability risks. Plan should identify and mitigate:
    - All manufacturing and quality capabilities that should be maintained throughout the life of the program
    - Items projected to go out of production and plan for product or technology obsolescence, lifetime replacement, or regeneration
    - Fragility of unique manufacturing and quality capabilities and any facilities or corporations that provide unique services or products
    - The approach to making production rate and quantity changes that support a response to contingency and support objectives
    - Vulnerability of supply chain (to include sole, single, fragile, foreign sources, and foreign acquisition of domestic sources)
    - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
    - Impact of external dependencies and integration
    - New and unique capabilities and processes

Metrics

- All manufacturing and quality capability risks that impact the preferred concept from being produced have been identified and documented.
- A mitigation strategy and plan for each manufacturing and quality IB risk has been developed.
- An IB capabilities plan to address the current and future required manufacturing and quality capabilities has been developed and documented and addresses risk identification and mitigation of:
    - All manufacturing and quality capabilities necessary should be maintained throughout the life of the program
    - All items projected to go out of production and a plan for product or technology obsolescence, lifetime replacement, or regeneration
    - Fragility of unique manufacturing and quality capabilities and any facilities or corporations that provide unique services or products
    - Production rate and quantity changes that support a response to contingency and support objectives
    - Vulnerability of supply chain (to include sole, single, fragile, foreign sources, and foreign acquisition of domestic sources)

  - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
  - Impact of external dependencies and integration
  - New and unique capabilities and processes
- The IB capabilities plan for current and future manufacturing and quality capability risks has been developed and is documented in the AS and SEP.

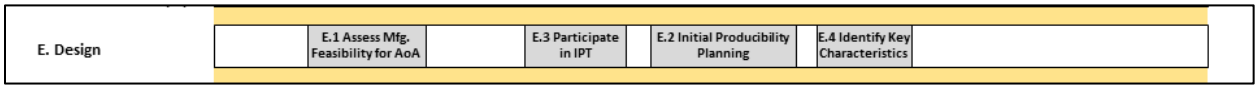
Tools

- Manufacturing/QA Risk Mitigation Plan (no Template available)
- MRL Assessment Checklist for Technology and Industrial Base thread
- Industrial Base Sector Plans (no specific tool)

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions, Apr 1996
- DODI 5000.60 Defense Industrial Assessments, Jul 2014
- MRL Deskbook Version 2016, Chapter 5.2 Development of a Manufacturing Maturation Plan

E. DESIGN



The MSA phase presents the first real opportunity to influence system design and begin planning for production by balancing requirements against producibility, manufacturability, and affordability. The AoA Team should ensure that a manufacturing feasibility assessment is accomplished as a part of the AoA. The feasibility assessment includes:

- Producibility of the potential design concepts
- Critical manufacturing processes and special tooling development which will be required
- Test and demonstration required for new materials
- Alternate design approaches within the individual concepts
- Anticipated manufacturing risks and potential cost and schedule impacts

The feasibility analyses determine the likelihood that a proposed materiel solution(s) can be produced using existing manufacturing capabilities while meeting quality, production rate and cost requirements. The feasibility assessments also identify the manufacturing risks incurred and the manufacturing capability gaps in selecting a particular design. Without these assessments, the PM, once assigned, may find that the program cannot be accomplished within the defined cost and

schedule thresholds as a result of incompatibilities between the system design and the manufacturing capability available to execute it.

At the close of the AoA, a program office is assigned ownership of the approach. At this point, the program management establishes the appropriate IPT structure to support program execution. The IPT structure begins with the Over-arching Program IPT (OIPT). Additional IPTs will be designated as needed to support development of the proposed materiel solution(s). The IPTs may eventually include program activities from the macro to the micro (e.g., Systems Engineering; Design; Risk, Issue, and Opportunity Management; Manufacturing and Quality; Configuration Management; Critical Subsystems, components, and items, etc.). Not all IPTs will be present at all phases of development, however, manufacturing and quality participation and inputs to all program IPTs is essential to program success.

The IPTs conduct systems engineering analyses to support the development of the AS and the SEP. The MSA phase also provides the opportunity to influence system design and plan for production by evaluating technology opportunities and current practices against cost, schedule, and performance. The intent is to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements. The PM is *responsible* for manufacturing, quality, and producibility risk identification and management throughout the program's life cycle. Manufacturing and quality representatives will plan and *conduct* assessments of manufacturing and quality readiness and risk to be documented in the SEP.

As part of the IPTs, manufacturing and quality should conduct analyses that include initial producibility analyses. The IPTs should examine the management of overall requirements and the use of industry best practices, tools, and techniques in development of the established concept. Producibility analyses should include statistical process control, product characterization, modeling and simulations, and lessons learned from similar and/or prior programs.

Systems engineering analyses will also determine the initial KPPs and initial KSAs. User requirements need to be expressed in terms of KPPs and other quantifiable parameters to include:

- System performance requirements to meet mission requirements; and
- The full range of sustainment requirements (materiel availability, production capability, reliability, maintainability, logistics footprint, supportability criteria, etc.) needed to meet system sustainability and affordably over the life cycle.

The KPPs and the KSAs should have threshold values consistent with the requirements specified in the ICD and the performance specified in the preliminary performance specifications. The initial KPPs and KSAs will be documented in the draft CDD. From the initial KPPs and KSAs, manufacturing and quality analyses will determine the features of a material, system, subsystem, item, or component whose variation has significant influence on fit, performance, service life, or manufacturability. These features are the KCs, which will be linked to manufacturing processes with

associated risks, and should be included as manufacturing and quality considerations in the AS and SEP.

E.1 Assess Manufacturing Feasibility for AoA

Manufacturing and Quality Tasks

- Update assessments of manufacturing feasibility for the AoA preferred concepts including the industrial capabilities required to design, develop, manufacture, and maintain each.
    - Update the anticipated manufacturing and quality risks for potential cost and schedule impacts
    - Update the producibility and manufacturability assessments for each concept
    - Analyze each AoA concept for manufacturing and producibility gaps and risks including:
        - Critical and unique manufacturing process requirements
        - Alternate design approaches within the concepts
        - Material requirements
        - Supply chain requirements
        - Production rate requirements
        - Facility requirements
        - Special tooling development requirements
        - Test and demonstration requirements for new materials
        - Manufacturing capability obsolescence
        - Manufacturing capability sustainment
- Ensure assessments provide the data required for the initial manufacturing and producibility inputs to KPPs and KSAs

Metrics

- Manufacturing feasibility assessments for the AoA preferred concepts including the industrial capabilities required to design, develop, manufacture, and maintain each have been updated and documented.
    - Anticipated manufacturing and quality risks for potential cost and schedule impacts have been updated
    - Initial producibility and manufacturability assessment for each of concepts have been updated
    - Each AoA concept has been analyzed for manufacturing and producibility gaps and risks including:
        - Critical and unique manufacturing process requirements
        - Alternate design approaches within the concepts
        - Material requirements
        - Supply chain requirements

- Production rate requirements
- Facility requirements
- Special tooling development requirements
- Test and demonstration requirements for new materials
- Manufacturing capability obsolescence
- Manufacturing capability sustainment

- Data required for the initial manufacturing and producibility inputs to KPPs and KSAs has been documented.

Tools

- Manufacturing Producibility Assessment Worksheet (PAWs)
- MRL Assessment Checklist for Design thread
- TRL Assessment Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Market Research Reporting Template
- Preliminary Hazards List Developed
- Pugh Matrix
- TRIZ Matrix

Resources

- MRL Deskbook Version 2016
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
- Technology Level Assessment Guidance, Apr 2011
- ESOH in Acquisition Guide, Apr 2009
- DODI 5000.60 Defense Industrial Assessments, Jul 2014
- DoD Market Research Guide May 2012
- DoDI 5000.02, Change 1, Jan 2017

E.2 Participate in IPTs

Manufacturing and Quality Tasks

- Manufacturing and quality IPT(s) participants provide design inputs and design support to:
  - Developing initial view of system requirements and system design concepts
  - Formulating initial system solutions
  - Developing a system functional definition that incorporates the user needs
  - Engineering analyses
  - Initial design trade studies including external dependencies
  - Creating a system specification document
  - Developing preliminary system functional and performance requirements
  - Deriving and documenting draft KPPs and KSAs

- Modeling and simulation planning
- Identify critical technologies, and conduct a manufacturing maturity assessments of the hardware and embedded software options
- Identify and assess manufacturing and quality risks as part of identification and assessment of system level risks

- Manufacturing and quality IPT(s) participants provide inputs and support to:
  - Program management reviews
  - Other program IPTs (e.g., Systems Engineering, Configuration Management, Risk Management, Producibility etc.)
  - The AS, SEP, draft CDD, and the TEMP in preparation for and participation in the ASR

Metrics

- Manufacturing and quality IPT(s) participants have provided documented design inputs and design support to:
  - Developing initial view of system requirements and system design concepts
  - Formulating initial system solutions
  - Developing a system functional definition that incorporates the user needs
  - Engineering analyses
  - Initial design trade studies including external dependencies
  - Creating a system specification document
  - Developing preliminary system functional and performance requirements
  - Deriving and documenting draft Key Performance Parameters (KPPs) and Key System Attributes (KSAs)
  - Modeling and simulation planning
  - Identify critical technologies, and conduct a manufacturing maturity assessments of the hardware and embedded software options
  - Identify and assess manufacturing and quality risks as part of identification and assessment of system level risks
- Manufacturing and quality IPT(s) participants have provided documented inputs and support to:
  - Program management reviews
  - Other program IPTs (e.g., Systems Engineering, Configuration Management, Risk Management, etc.)
  - The AS, SEP, draft CDD, and the TEMP which are up-to-date in preparation for and participation in the ASR

Tools

- AS Outline
- Draft CDD Template
- SEP Outline

- TEMP Template
- MRL Assessment Checklist for Design thread
- Technology Readiness Assessment

Resources

- SEP Outline, 2011
- Acquisition Plan Preparation Guide, Jan 2009
- CDD-CPD Writing Guide, Feb 2015
- MRL Deskbook Version 2016
- SEP Outline, Jun 2015
- Technology Level Assessment Guidance, Apr 2011
- Test and Evaluation Management Guide, Dec 2012

E.3 Initial Producibility Planning

Manufacturing and Quality Tasks

- Establish a Producibility sub-IPT.
    - Implement a producibility risk management process
    - Identify and deploy producibility design guidelines
    - Identify producibility best practices to be followed
- Analyze potential manufacturing and quality process risks and capabilities to determine producibility goals to include:
    - Identification and analysis of state of the art manufacturing and production M&S approaches
    - Critical manufacturing and quality processes (yield and rates, if available)
    - Potential cost and schedule impacts
    - Special tooling, testing and qualification
- Provide producibility planning guidance that emphasizes efficient manufacturing and product design and addresses:
    - Industry best practices, tools, and techniques
    - Design analyses that include:
        - Requirements validation analyses
        - FMEA
        - Trade studies on alternative product and process designs
        - Product complexity analyses
        - Manufacturing process analyses
        - Quality and quality process analyses
        - Design for Manufacture and Assembly
        - Tolerance analyses

- Costs, cost drivers, and controls
- Material characterization and goals
- KCs
- Risk and risk mitigation planning
- Prototypes
- Learning curve projections
- Planning for product and process measurements
- Statistical Process Control (SPC)
- Data and database management
- Testing

- Ensure producibility planning is incorporated into the Manufacturing Management Plan.

Metrics

- A Producibility sub-IPT has been established.
  - A producibility risk management process has been established
  - Producibility design guidelines have been identified, documented, and deployed
  - Producibility program best practices have been identified, and followed (e.g., standards from SAE, ISO, ASME, ANSI, etc.)
- Potential manufacturing and quality process risks and capabilities have been analyzed and producibility goals determined and documented. Analyses included:
  - Identification and analysis of state of the art manufacturing and production M&S approaches
  - Critical manufacturing and quality processes
  - Potential cost and schedule impacts
  - Special tooling, testing and qualification
- Producibility planning guidance has been developed and provided as input to the Manufacturing Management Plan, the RFP, the AS, and includes the following:
  - Identification and documentation of required producibility best practices, tools, and techniques
  - Design analyses documentation including:
    - Requirements validation analyses
    - Failure Modes and Effects Analysis
    - Trade studies on alternative product and process designs
    - Product complexity analyses
    - Manufacturing process analyses
    - Quality and quality process analyses
    - Design for Manufacture and Assembly
    - Tolerance analyses
  - Estimates of costs, cost drivers, and controls

- Identification and documentation of materials characterization and goals
- Identification and documentation of KCs
- Identification and documentation of risk and planned risk mitigation
- Requirements and plans for prototypes
- Documentation of learning curve projections
- Documentation of plans for product and process measurements (producibility measurement)
- Requirements and plans for SPC
- Documentation of plans for collection of data and database management
- Requirements and plans for testing (in process and TEMP)

Tools

- Benchmarking
- Quality Functions Deployment (QFD)
- Six Sigma and Lean
- FMEA
- MRL Assessment Checklist for Design thread
- Design Failure Modes and Effects Analysis (DFMEA)
- Process Failure Modes and Effects Analysis (PFMEA)
- Design for Manufacture and Assembly (DFMA)
- Design of Experiments (DOE)
- Producibility Engineering and Planning (PEP) Data Item Description

Resources

- Program Management Guidelines, Jan 1985
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning (PEP)
- MRL Deskbook Version 2016

E.4 Identify Key Characteristics (KC)

Manufacturing and Quality Tasks

- Provide manufacturing and quality inputs and support to deriving and documenting draft KPPs, KSAs, and Additional Performance Attributes (APA).
- Perform analyses of initial KPPs, KSAs, and APAs to determine the features of a material, system, subsystem, item, or component whose variation has significant influence on fit, performance, service life, or manufacturability and develop initial KCs.
  - Provide analysis and quantification of constraints to form, fit, and function for the preferred concept
  - Provide linkage to manufacturing and quality processes and risks

- Provide analyses of draft KPPs, KSAs, and initial determination of KCs as manufacturing and quality inputs to program documentation.

Metrics

- Manufacturing and quality inputs and support to derive and document draft KPPs, KSAs, and APAs has been provided.
- Analyses of KPPs, KSAs, and APAs have been performed and initial KCs have been developed and documented.
  - Analysis and quantification of constraints to form, fit, and function for the preferred concept has been provided
  - Linkage to manufacturing and quality processes and risks has been documented
- Draft KPPs, KSAs, and initial KCs have been provided as manufacturing and quality inputs and documented in the AS, SEP, draft CDD, and the TEMP and maintained up-to-date.

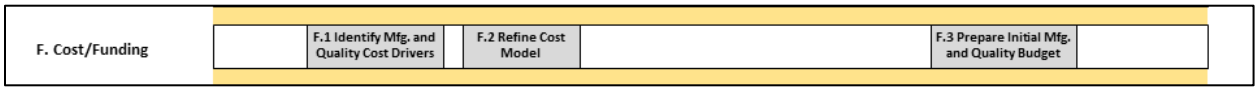
Tools

- MRL Assessment Checklist for Process Capability and Control thread
- Critical to Quality Tree
- FMEA
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- TRL Assessment Checklist

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9103, Variation Management of KCs
- JCIDS Manual
- MRL Deskbook Version 2016
- NAVSO P-3687 Producibility Systems Guidelines, Dec 1999
- Technology Readiness Assessment Guidance, Apr 2011

F. COST/FUNDING



Detailed manufacturing and quality cost estimates cannot be finalized during the MSA phase, but cost drivers can be identified and initial cost estimates developed based on proposed materials and processes that are inherent in the proposed materiel solution(s).

Producibility cost drivers can be assessed and investments in manufacturing technologies can be estimated. These estimates can be used to support development of the program cost estimates and the

initial manufacturing investment budget. Cost estimates will be used to evaluate affordability (a discriminator) and in establishing initial thresholds for the proposed materiel solution(s). In most cases, the estimates will be developed by the use of statistically based cost estimating relationships or by comparison of the proposed systems with similar systems whose costs are known. The cost estimates incorporate the manufacturing and quality risks assessed during the AoA and at the ASR. The cost estimates will be used for evaluating and selecting a preferred system for the Milestone A decision and entry into the TMRR phase.

F.1 Identify Manufacturing and Quality Cost Drivers

Manufacturing and Quality Tasks

- Identify manufacturing, quality, materials, and unique or specialized requirements and associated risks that are cost drivers for the AoA and update for the ASR.
    - Include assumptions on process, materials, rate, supplier quality, workforce, special handling, environmental compliance, security, etc. and quantify the cost driver uncertainties
    - Estimate the cost of quality for each concept
    - Estimate the cost and impact of testing requirements
- Identify producibility cost drivers and associated risks for the AoA and update for the ASR.
    - Estimate impact of producibility opportunities and risks on rates, process, throughput, etc.
    - Estimate cost of implementation for producibility improvements
- Provide updates to the CARD with the manufacturing and quality inputs for the ASR.
    - Provide manufacturing and quality cost sensitivity analyses updates

Metrics

- Manufacturing, quality, materials, and unique or specialized requirements cost drivers and associated risks have been identified and documented for the AoA and updated for the ASR.
    - Assumptions on process, materials, rate, supplier quality, workforce, special handling, environmental compliance, security, etc. are included
    - Cost driver uncertainties for appropriate assumptions have been quantified and documented
    - Cost of quality has been estimated and documented
    - Cost and impact of test requirements have been documented
- Producibility cost drivers and associated risks for the AoA have been identified, documented, and updated for the ASR.
    - Impacts and cost of implementation have been estimated and documented
- Updates to the CARD have been provided with the manufacturing and quality inputs updated.

- Manufacturing and quality cost sensitivity analyses have been updated

Tools

- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- MRL assessment for the Cost Thread
- Cost, Schedule Control Systems Criteria (CSCSC)
- See CAPE website for tools

Resources

- Cost/Schedule Control System Criteria Reference Guide, Dec 1992
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766 Design to Cost, Aug 1998
- MRL Deskbook Version 2016
  - CAPE Website http://www.cape.osd.mil/
  - Guidelines for the Preparation and Maintenance of the Cost Analysis Requirements Description
  - Guidelines for the Preparation and Maintenance of CARD Tables

F.2 Refine Cost Model

Manufacturing and Quality Tasks

- Provide manufacturing and quality inputs to update cost targets and error bands for proposed materiel solutions for the AoA.
  - Review the assumptions behind these targets
  - Prepare detailed manufacturing and quality process charts to ensure the validity behind cost targets
  - Identify and quantify manufacturing and quality cost variables
  - Quantify the uncertainties
- Update the cost estimates for the proposed materiel solutions for the AoA including estimates for:
  - KCs and key processes
  - Variability reduction needs
  - Manufacturing environment simulations
  - Cost/performance trade studies
  - Manufacturing and quality capability requirements

- Product and process validation requirements
- Key supplier management
- Producibility
- Environmental compliance
- Manufacturing systems security (physical, cyber, etc.)

- Upon completion of the AoA, develop manufacturing and quality inputs to initial cost models for the preferred solution.
  - Verify cost models include all manufacturing and quality process variables
  - Provide manufacturing and quality inputs to the CARD for the appropriate cost categories
  - Provide initial manufacturing and quality inputs (cost models estimates) to the ASR

Metrics

- Manufacturing and quality inputs to update cost targets and error bands for proposed materiel solutions have been provided and documented for the AoA.
  - Assumptions supporting these targets are documented
  - Detailed manufacturing and quality process charts have been developed to ensure the validity of cost targets
  - Manufacturing and quality cost variables and uncertainties have been identified, quantified, and documented

- Cost estimates for the proposed materiel solutions have been updated for the AoA and include estimates for:
  - KCs and key processes
  - Variability reduction needs
  - Manufacturing environment simulations
  - Cost/performance trade studies
  - Manufacturing and quality capability requirements
  - Product and process validation requirements
  - Key supplier management
  - Producibility
  - Environmental compliance
  - Manufacturing systems security (physical, cyber, etc.)

- With completion of the AoA, initial cost model manufacturing and quality inputs have been developed and documented for the preferred solution.
  - Cost models verified and documented to include all manufacturing and quality process variables
  - Manufacturing and quality inputs for the appropriate cost categories have been provided for CARD update
  - Initial manufacturing and quality inputs (cost models estimates) provided to the ASR

Tools

- Analogy and Parametric estimating
- CARD - Cost Analysis Requirements Description (see CAPE website for tools)
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding Thread
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Manufacturing Cost Estimating Worksheet

Resources

- Parametric Estimating Handbook, Apr 2008
- CARD - Cost Analysis Requirements Description Template (See CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide, Sep 1992
- DODI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- MRL Deskbook Version 2016
- MIL-HDBK 766 Design to Cost, 1989
- CAPE Website
- Guidelines for the Preparation and Maintenance of the Cost Analysis Requirements Description
- Guidelines for the Preparation and Maintenance of Card Tables

F.3 Prepare Initial Manufacturing and Quality Budget

Manufacturing and Quality Tasks

- Provide manufacturing and quality cost estimates for the TMRR budget.
    - Verify that cost estimates include all manufacturing and quality cost drivers and risk estimates from the updated cost model
    - Provide updated producibility cost drivers and risk estimates to budget process
    - Provide quantified manufacturing and quality cost driver uncertainties and associated budget impact estimates as inputs to the budget process
    - Provide investment estimates in manufacturing and quality technologies, processes, equipment, etc. as inputs to the budget process to include:
        - Capital equipment (tooling, machines, structures, etc.)
        - Test equipment (specialized, environmental, etc.)
        - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
        - GFE
        - Environmental compliance (processes, facilities, equipment, etc.)
        - Manufacturing systems security (physical, cyber, etc.)

- Utilize statistically based cost estimating for comparisons of manufacturing and quality aspects of the proposed system with similar systems whose costs are known

- Verify affordability cost estimates are utilized to establish manufacturing and quality initial thresholds.
- Identify potential ManTech investments that mitigate manufacturing and quality technology gaps.
  - Identify potential funding sources for ManTech projects (program office, Service, and/or DoD-wide funding)

Metrics

- Manufacturing and quality cost estimates have been provided and documented as part of the TMRR budget.
  - Cost estimates have been verified and documented to include all manufacturing and quality cost drivers and risk estimates from the updated cost model
  - Updated producibility cost drivers and risk estimates have been provided to the budget process
  - Quantified manufacturing cost driver uncertainties and associated budget impact estimates have been provided as inputs to the budget process
  - Investment estimates for manufacturing and quality technologies, processes, equipment, etc. have been provided as inputs to the budget process and included:
    - Capital equipment (tooling, machines, structures, etc.)
    - Test equipment (specialized, environmental, etc.)
    - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
    - GFE
    - Environmental compliance (processes, facilities, equipment, etc.)
    - Manufacturing systems security (physical, cyber, etc.)
  - Statistically based cost estimating has been utilized and documents comparisons of manufacturing and quality aspects of the proposed system to similar systems whose costs are known
- Affordability cost estimates have been utilized, verified, and document initial manufacturing and quality thresholds.
- Potential ManTech investments have been identified and documented for mitigation of manufacturing and quality technology gaps.
  - Potential offsets and funding sources determined for ManTech projects (program office, Service, and/or DoD-wide funding)

Tools

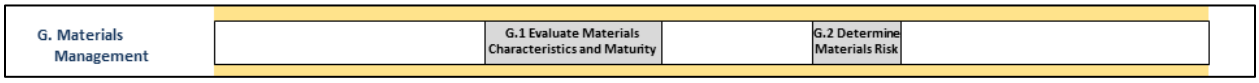
- Manufacturing Feasibility Assessment Checklist?

- See CAPE website for tools
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding Thread

Resources

- See CAPE website for guidance
- MRL Deskbook Version 2016
- CARD - Cost Analysis Requirements Description Template (See CAPE website for guidance)
- DODI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015

G. MATERIALS MANAGEMENT



One of the major tasks of the MSA phase is to answer the question “Can you build it?” (i.e., evaluate manufacturing feasibility). Generally, this task begins with materials; their capability, maturity, availability, and handling characteristics. In early MSA phase, the characteristics of each material must be assessed for each concept chosen in the AoA. Many new and emerging materials are identified during the MSA phase, and each carry potential risks. Material capability, maturity, availability, sources, and handling characteristics are key determinates of manufacturing and quality risks. Thus, the early MSA phase is a series of trade studies to identify materiel solutions and to address gaps in capability.

Inherent in addressing manufacturing and quality risks is an analysis and understanding of the maturity of material properties, characteristics, and quality requirements. This analysis should address scale-up and lead-time requirements, as well as manufacturing and quality processes for all materials, especially those that are hazardous, difficult to obtain, process, and/or handle. Risks from potential counterfeit materials and parts are present at all levels of the supply chain. Additional risks can arise and need to be assessed and understood for materials that are from sole, single, fragile, or foreign sources, and those domestic sources that are vulnerable to foreign acquisition including the entire supply chain.

G.1 Evaluate Materials Characteristics and Maturity

Manufacturing and Quality Tasks

- Update and evaluate material maturity and availability for selected AoA concepts:
  - Determine if the materials have been produced in a laboratory (or more mature) environment

        - Evaluate Research and Development (R&D) and experiments for validation of material manufacturability
        - Evaluate other ongoing programs for prior use of materials under consideration (DoD, Science and Technology (S&T) , commercial, government, etc.)
    - Evaluate material properties, characteristics, and quality requirements for each concept against requirements
    - If new materials emerge or are identified, identify and evaluated needed material properties and characteristics, and quality properties
- Provide manufacturing and quality support to evaluation of the realism of projected lead times for materials (including hazardous) which are difficult to obtain or process.
- Assess manufacturing and quality requirements for material scale-up of selected AoA concepts.
- Perform manufacturing and quality volatility assessments for selected AoA concepts and identify:
    - Potential supply chain sources for critical materials
    - Hazardous materials for each concept
    - Special handling procedures that have been applied
- Determine if all manufacturing and quality special handling requirements have been identified.
    - Evaluate all materials for:
        - Potential regulatory requirements
        - Hazardous materials and handling procedures
        - Security requirements (physical, cyber, etc.)
        - Transportation, storage and shelf life
        - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
        - Disposal

Metrics

- Material maturity and availability has been evaluated and updated for selected AoA concepts:
    - Document the materials production environment
        - R&D and experiments have been evaluated for validation of material manufacturability
        - Other ongoing programs have been evaluated for prior use of materials under consideration (DoD, S&T, commercial, government, etc.)
    - Material properties, characteristics, and quality requirements have been evaluated and documented for each concept against requirements
    - Newly emerging materials have been identified, and needed material properties and characteristics, and quality properties have been evaluated and documented

- Projected lead times for materials (including hazardous) which are difficult to obtain or process have been analyzed and documented with manufacturing and quality support.
- Material scale-up manufacturing and quality requirements for selected AoA concepts have been assessed and documented.
- Manufacturing and quality volatility assessments for selected AoA concepts have been conducted and assessments document:
    - Potential supply chain sources for critical materials
    - Hazardous materials for each concept
    - Special handling procedures that have been applied
- Analysis of manufacturing and quality special handling requirements have been performed and documented, and all requirements have been identified.
    - All materials have been evaluated for:
        - Potential regulatory requirements
        - Hazardous materials and handling procedures
        - Security requirements (physical, cyber, etc.)
        - Transportation, storage and shelf life
        - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
        - Disposal

Tools

- **DMSMS Product Life Cycle Assessment (Consult DLA)**
- Cost and Lead Time Estimating Worksheet
- Design of Experiments Analysis
- Design for Six Sigma
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- ISO 9001 Checklist, Section Preservation (Handling, Storage, Packaging and Delivery)
- MRL Assessment Questionnaire for the Materials Thread
- Rough Cut Capacity Planning
- TRL Assessment Questionnaire

Resources

- DMSMS Guidebook, SD-22, Sep 2009
- DoDI 5000.60 Defense Industrial Capabilities Assessments, Jul 2004
- DOD 5000.60H Assessing Defense Industrial Capabilities, Apr 1996
- ESHO in Acquisition Guide, Apr 2009
- ISO 9001 Quality Management System
- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011

G.2 Determine Materials Risk

Manufacturing and Quality Tasks

- Assess materials maturity and availability manufacturing and quality risks for the AoA preferred solution that are:
  - New or critical materials that are in development
  - Developed in a lab environment, but are not immediately available
  - Readily available within near term (i.e., commodities)
  - Commercially available (long lead, capacity, etc.)
  - Readily available, but have environmental or health concerns
  - Have long lead times
  - Only available from a single or sole source (domestic or foreign)
  - Available within the NTIB
  - Available only from sources that are outside the NTIB
  - Vulnerable to foreign acquisition of domestic sources
  - Hazardous, difficult to obtain, or process
- Assess materials scale-up manufacturing and quality risks for AoA preferred solution.
- Conduct an initial risk assessment of potential supply chain capability and capacity.
  - Include materials risks for delivery times, manpower, quality, fragility, availability, etc. for the entire supply chain
  - Evaluate the materials management processes for gaps throughout the entire supply chain
- Assess materials capability to meet the threshold and objective requirements.
- Assess military vulnerability or gaps that could result from the lack of reasonable materials alternatives.
- Determine if all manufacturing and quality special handling risks have been identified including:
  - Potential regulatory requirements
    - Hazardous materials and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal
- Identify materials risks from counterfeit electronic parts and materials (e.g., end items, components, parts, or assemblies)
- In support of ASR, conduct a comprehensive cost/schedule/technical risk assessment and initiate mitigation plans for each risk.

Metrics

- Materials maturity and availability manufacturing and quality risks for AoA preferred solution have been assessed and documented for materials that are:
    - New or critical materials that are in development
    - Developed in a lab environment, but are not immediately available
    - Readily available within near term (i.e., commodities)
    - Commercially available (long lead, capacity, etc.)
    - Readily available, but have environmental or health concerns
    - Have long lead times
    - Only available from a single or sole source (domestic or foreign)
    - Available within the NTIB
    - Available only from sources that are outside the NTIB
    - Vulnerable to foreign acquisition of domestic sources
    - Hazardous, difficult to obtain, or process
- Materials scale-up manufacturing and quality risks for AoA preferred solution have been assessed and documented.
- An initial risk assessment of potential supply chain capability and capacity has been conducted and documents:
    - Materials risks for delivery times, manpower, quality, availability, etc. for the entire supply chain
    - The material management processes for gaps throughout the entire supply chain
- Materials capability and risks to meeting the threshold and objective requirements has been assessed and documented.
- Military vulnerability or gaps that could result from the lack of reasonable material alternatives has been assessed and documented.
- All manufacturing and quality special handling risks have been identified and documented including:
    - Potential regulatory requirements
        - Hazardous materials and handling procedures
        - Security requirements (physical, cyber, etc.)
        - Transportation, storage and shelf life
        - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
        - Disposal
- Materials risks from counterfeit electronic parts and materials (e.g., end items, components, parts, or assemblies) have been identified and documented.
- In support of ASR, a comprehensive cost/schedule/technical risk assessment has been conducted and mitigation plans for each risk have been documented and provided to the decision maker.

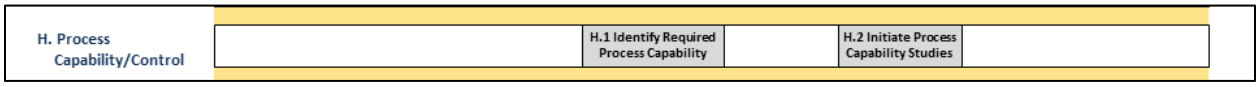
Tools

- Cost and Lead Time Estimating Worksheet
- Design of Experiments Analysis
- DMSMS Product Life Cycle Assessment (Consult DLA)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- ISO 9001 Checklist, Section Preservation (Handling, Storage, Packaging and Delivery)
- Market Research Reporting Template
- MRL Assessment Questionnaire for the Materials Thread
- Supply Chain Management Risk Assessment Checklist
- TRL Assessment Questionnaire

Resources

- DMSMS Guidebook, SD-22, Sep 2009
- DoD Market Research Guide, May 2012
- DoDI 5000.60, Defense Industrial Capabilities Assessments, Jul 2004
- DOD 5000.60H, Assessing Defense Industrial Capabilities, Apr 1996
- DOD 4140.1-R, Supply Chain Management Regulation, May 2003
- DoDM 4140.01, DoD Supply Chain Management Procedures, Feb 2014
- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011
    - DoDI 5000.02, Change 1, Jan 2017
    - IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs, May 2015

H. PROCESS CAPABILITY AND CONTROL



Manufacturing and quality process and control should be a part of any development program and include an assessment of current required capabilities and potential future capabilities. The first task is to identify the process capability required by the preferred concepts for the AoA. This may be accomplished by an analysis of the preferred concept for process capabilities against industry manufacturing and quality standards using manufacturing modeling and simulations.

The next task is to initiate studies to identify any gaps in manufacturing and quality processes. These gaps should include gap in capabilities as a risk and an impact to yields, with time and resources planned to mature these critical capabilities. Manufacturing yields and rates can play a major role in driving manufacturing cost as they will drive decisions on what processes to use, types of tooling required, quantities to be produced, etc. Studies need to include an analysis of the impact of process capability on KCs, and therefore performance, reliability, and affordability.

Many new technologies and emerging manufacturing processes that are identified during the MSA phase carry risks. Failure to demonstrate materials and processes may increase the risk that the material or process may not meet the weapon system design, performance and affordability requirements. When new or high-risk manufacturing capabilities are planned in the AS, it should be specified how this new capability will be demonstrated in a manufacturing environment relevant for the TMRR phase.

H.1 Identify Required Process Capability

Manufacturing and Quality Tasks

- For critical manufacturing and quality processes for the preferred concept, analyze the current state of process capability within industry and identify potential gaps.
- Identify and analyze state of the art manufacturing and production modeling/simulation approaches that support the preferred concept.
- Identify manufacturing and quality process capability risks for the preferred concept from the manufacturing feasibility assessment including risks to:
    - Critical manufacturing and quality processes
    - Potential cost and schedule impacts
    - Producibility
    - Special tooling
    - Testing and qualification
    - Environmental
    - Management (data, security, etc.)

Metrics

- The current state of process capability for the preferred concept has been analyzed and documented with potential gaps for critical manufacturing and quality processes within the industry and included in the AS and the SEP.
- Appropriate manufacturing and production modeling and simulation approaches have been identified, analyzed, and documented in the AS and the SEP.
- Manufacturing and quality process capability risks for the preferred concept have been updated and documented as input to the program risk management system. The updates should include risks to:
    - Critical manufacturing and quality processes
    - Potential cost and schedule impacts
    - Producibility
    - Special tooling
    - Testing and qualification
    - Environmental
    - Management (data, security, etc.)

Tools

- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)
- Learning Curve Analysis Spreadsheet
- MRL Assessment Checklist for the Process Capability and Control Thread

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8 Learning Curve
- Modeling and Simulation Guidance for the Acquisition Workforce, Oct 2008
- MRL Deskbook Version 2016
- Manufacturing Simulation Applications (No Date)
- See Guidance Documents

H.2 Initiate Process Capability Studies

Manufacturing and Quality Tasks

- Initiate manufacturing and quality process capability studies based on the data from the preferred concept.
    - If no data available, conduct necessary studies to generate required data
    - Alternatively, use process capabilities of current or similar products to generate the required data
- Analyze the impact of manufacturing and quality process capability on KCs that impact performance, reliability, and affordability.
- Analyze manufacturing and quality studies of existing processes to determine gaps in manufacturing capabilities as a risk and an impact on yields and rates
    - Utilize modeling and simulation tools to perform an analysis of process capability to support yield and rate estimates, before actual manufacturing begins
    - Determine the need for new processes to meet requirements
    - Include time and resources required to mature these critical manufacturing processes
    - Incorporate sources of variations and plans to address
    - Include additional data from existing, proposed, or similar processes from other projects and programs
- Based on analyses, update yield and rate estimates for the AS and the SEP.

Metrics

- Manufacturing and quality process capability studies have been initiated based on the data from the preferred concept and results documented.
    - If no was data available, the necessary studies were conducted to generate required data
    - Or as an alternative, the process capabilities of current or similar products were used to generate the required data
- The impact of manufacturing and quality process capability on KCs that impact performance, reliability, and affordability has been analyzed and documented including sources of variations with plans to address.
- Manufacturing and quality studies of existing processes have been analyzed to determine and document gaps in manufacturing capabilities as risks and an impacts to yields and rates.
    - Modeling and simulation tools have been utilized to analyze process capability to support yield and rate estimates, before actual manufacturing begins
    - The need for new processes to meet requirements has been determined, documented, and plans initiated
    - Time and resources necessary to mature these critical manufacturing processes and sources of variation have been incorporated in planning
    - Additional data was utilized from existing, proposed, or similar processes from other projects and programs
- Yield and rate estimates for the preferred concept have been updated, and documented in the Quality and Manufacturing Strategies and incorporated in the AS and SEP.

Tools

- Cause and Effect Diagram
- Cost of Quality Estimates
- Feasibility Study Checklist
- First Pass Yield Estimates Worksheet
- Histograms
- MRL Assessment using Process Capability and Control Thread
- Pareto Analysis
- Process Capability Studies (Cp and Cpk assessment)
- Producibility Assessment Worksheet (PAWs)
- Six Sigma Worksheet
- First Pass Yield Estimates Worksheet

Resources

- Defense Management Guide for Program Managers, Chapter 7.6.2 Determine Process Capability

- Defense Manufacturing Guide for Program Managers, Chapter 5.5.4 Seven Quality Control Tools
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program, May 2008
- DoD Continuous Process Improvement Transformation Guide, May 2006
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999

I. QUALITY MANAGEMENT

Quality management is the coordinated activities to direct and control an organization, including the supply chain, with regard to quality policy, quality objectives, quality planning, quality assurance and quality improvement. These activities are performed as part of the Quality Management System (QMS), which is that part of the organization's management system that focuses on the results, in relation to the quality objectives, to satisfy the needs, expectations and requirements. In turn, Quality Assurance is that part of quality management focused on providing confidence that quality requirements will be fulfilled.

There are many opportunities during the MSA phase of the acquisition process for manufacturing and quality personnel to make a positive impact on program execution. Manufacturing and quality considerations should be a major part of a development program. Quality considerations should be an integral part of the AoA. Therefore quality requirements, goals, objectives, responsibilities, and authority should be defined and included in quality strategies and plans. The initial AS will include the approach to quality, quality management, and quality assurance.

I.1 Quality Management Requirements Analysis

Manufacturing and Quality Tasks

- For the AoA, ensure the preferred concepts are analyzed for quality management requirements.
  - The quality management requirements should at a minimum include:
    - Quality management system requirements
    - Management responsibility requirements
    - Resource management requirements
    - Product Realization requirements (e.g., risk management, design and development, purchasing, etc.)
    - Measurement, analysis, and improvement requirements
  - Alternatively, the quality management requirements can be met by adherence to established standards (e.g., AS9100, ISO 9000, etc.)

2605 ▪ Include manufacturing and quality management lessons-learned
2606 ▪ Include industry best practices

2607 • Review, update, and analyze quality management metrics for the preferred concept from the
2608 AoA Study Guidance.

2609 o Verify the frequency that the metrics are reviewed is commensurate with quality risks

2610 • Specify the quality management requirements to be met by the contractor or government
2611 entity as appropriate.

2612 o Provide requirements for quality management responsibilities and personnel within the
2613 IPT
2614 o Provide quality management requirements and metrics

2615 • Contact DCMA for input on QMS evaluation of potential contractor and suppliers for the
2616 preferred concept.

2617 **Metrics**

2618 • The preferred concepts have been analyzed for quality management requirements and
2619 documented in the AoA.

2620 o The documented quality management requirements included at a minimum:

2621 ▪ Quality management system requirements
2622 ▪ Management responsibility requirements
2623 ▪ Resource management requirements
2624 ▪ Product Realization requirements (e.g., risk management, design and development,
2625 purchasing, etc.)
2626 ▪ Measurement, analysis, and improvement requirements

2627 o Alternatively, the documented quality management requirements were met by
2628 conformance to established standards (e.g., AS9100, ISO 9000, etc.)

2629 ▪ Which includes manufacturing and quality management lessons-learned
2630 ▪ Which includes industry best practices

2631 • Quality management metrics for the preferred concept from the AoA Study Guidance have
2632 been reviewed, updated, analyzed, and the results documented.

2633 o Review of quality management metrics is included in all program reviews

2634 • Quality management requirements to be met by the government or contractor entity as
2635 appropriate have been specified for the RFP.

2636 o Quality management responsibilities and personnel have been established for each IPT
2637 o Quality management requirements and metrics have been established and documented

2638 • Where available, DCMA input on QMS evaluation of potential contractor and suppliers for
2639 the preferred concept has been utilized and documented.

Tools

- AS9100, Quality Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- ISO 9001, Quality Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality Thread
- Quality Management Plan (Sample)

Resources

- AFMC Instruction 63-145, Manufacturing and Quality (Draft)
- AS9100, Quality Management Systems, Sep 2016
- DoDI 5000.02, Change 1, Jan 2017
- ISO 9000:2015, Quality Management Systems, Sep 2015
- MRL Deskbook Version 2016

I.2 Product Quality Requirements Analysis

Manufacturing and Quality Tasks

- Analyze product quality requirements for the AoA preferred concept:
    - Incorporate new quality technologies and process state of the art into product quality requirements
    - Analyze the need for unique product quality requirements (i.e., specific product characteristics)
    - Analyze product quality for metrics and the frequency that the metrics should be reviewed, commensurate with manufacturing and quality risks
- Utilize identified potential solutions and processes that could address product quality needs.
    - Analyze identified quality technologies (i.e., metrology technologies) that could improve product quality
    - Analyze identified potential solutions or processes to improve low-yield processes and components product quality
- Contact DCMA personnel for inputs on potential contractor and supplier quality performance against quality requirements for similar products or processes.

Metrics

- Product quality requirements for the AoA preferred concept have been analyzed and document:
    - Incorporation of new quality technologies and process state of the art into product quality requirements

- The need for unique product quality requirements (i.e., specific product characteristics)
- Product quality for metrics and the frequency that the metrics should be reviewed, commensurate with manufacturing and quality risks

- Identified potential solutions and processes that could address product quality needs have been utilized in the analysis and documentation of:
  - Quality technologies (i.e., metrology technologies) that could improve product quality
  - Potential solutions or processes to improve low-yield processes and components product quality
- DCMA inputs on potential contractor and supplier quality performance against quality requirements for similar products or processes have been documented.
- All of the results of product quality requirements analysis has been document in AS and SEP.

Tools

- AS9100 Quality Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- ISO 9001, Quality Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality Thread
- Quality Management Plan (Sample)
- Variability Reduction Plan

Resources

- AAS9100, Quality Management Systems, Sep 2016
- DoDI 5000.02, Change 1, Jan 2017
- ISO 9000:2015, Quality Management Systems, Sep 2015
- MRL Deskbook Version 2016

I.3 Supply Chain Quality Management Requirements Analysis

Manufacturing and Quality Tasks

- Analyze the impact of quality technologies and process state of the art for impacts on the quality management of the supply chain.
- Analyze the supply chain quality management requirements for the preferred concept.
  - Analyze the need for focused supplier quality management requirements (e.g., a supplier Quality Assurance Plan)
  - Analyze the need for a standalone supplier quality management plans for the supply chain
  - The quality management requirements for the supply chain should at a minimum include:
    - Quality management system requirements

        - Management responsibility requirements
        - Resource management requirements
        - Product Realization requirements (e.g., risk management, design and development, purchasing, etc.)
        - Measurement, analysis, and improvement requirements
    - Alternatively, quality management requirements for the supply chain can be met by adherence to established standards (e.g., AS9100, ISO 9000, etc.)
        - Include manufacturing and quality management lessons-learned
        - Include industry best practices
    - Analyze and update supply chain quality management metrics for the preferred concept.
- Analyze potential solutions, tools, and techniques that could address quality management requirements of the supply chain.
    - Incorporate quality technologies (i.e., metrology technologies) that could improve the supply chain quality programs
    - Incorporate potential solutions (e.g., materials, machines, training, etc.) to improve low-yield processes and components and lower variability to meet supply chain quality requirements
- Contact DCMA personnel for input on the analysis of potential supply chain quality management systems.
- Ensure quality and manufacturing requirements are included in contracts of proposed suppliers and in appropriate agreements with other agencies, e.g. the DCMA.

Metrics

- Impact of quality technologies and process state of the art for impacts on the quality management of the supply chain has been analyzed and the results documented.
- The supply chain quality management requirements have been analyzed and document:
    - The need for focused supplier quality management requirements (e.g., a supplier Quality Assurance Plan)
    - The need for a standalone supplier quality management plans for the supply chain
    - The minimum quality management requirements for the supply chain including:
        - Quality management system requirements
        - Management responsibility requirements
        - Resource management requirements
        - Product Realization requirements (e.g., risk management, design and development, purchasing, etc.)
        - Measurement, analysis, and improvement requirements
    - As an alternative, adherence to established standards (e.g., AS9100, ISO 9000, etc.)

        - Inclusive of manufacturing and quality management lessons-learned and industry best practices
    - Supply chain quality management metrics have been analyzed, updated, and documented.
    - Potential solutions, tools, and techniques that could address quality management requirements of the supply chain have been analyzed, documented, and incorporate:
        - Quality technologies (i.e., metrology technologies) that could improve the supply chain quality programs
        - Potential solutions (e.g., materials, machines, training, etc.) to improve low-yield processes and components and lower variability to meet supply chain quality requirements
    - DCMA has been contacted for input on analysis of potential supply chain quality management systems and documented.
    - All of the analyses and results of supply chain quality management requirements have been document in AS and SEP.

Tools

- AS9100, Quality Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- ISO 9001, Quality Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality Thread
- Supplier Quality Questionnaire
- Quality Management Plan
- Variability Reduction Plan

Resources

- AS9100, Quality Management Systems, Sep 2016
- DoDI 5000.02, Change 1, Jan 2017
- ISO 9000:2015, Quality Management Systems, Sep 2015
- MRL Deskbook Version 2016
- MIL-STD-1535B Supplier QA

I.4 Prepare Quality Strategy

Manufacturing and Quality Tasks

- Based on the results of the analyses of quality management, product quality, and supply chain quality management requirements, draft a quality management strategy that specifies:
    - Quality management requirements that address:
        - Management responsibility requirements

2780 ▪ Quality management system requirements
2781 ▪ Resource management requirements
2782 ▪ Product Realization requirements (e.g., risk management, design and development,
2783 purchasing, etc.)
2784 ▪ Risks, Issues and Opportunities
2785 ▪ Measurement, analysis, and improvement requirements

2786 o Alternatively, the quality management requirements met by adherence to established
2787 standards (e.g., AS9100, ISO 9000, etc.)
2788 o Product quality requirements that incorporate new quality technologies and process state
2789 of the art, the need for unique product quality requirements, and metrics and the review
2790 frequency
2791 o Supply chain quality management requirements that include:

2792 ▪ The need for focused supplier quality management requirements
2793 ▪ A supplier quality management plan
2794 ▪ Potential standards (e.g., AS9100, ISO 9000, etc.)
2795 ▪ Metrics
2796 ▪ Potential solutions, tools and techniques

2797 o Planned use of government-furnished quality and testing equipment and assets
2798 o Establishing appropriate agreements, delegations and contracts with other agencies, e.g.
2799 the DCMA

2800 ▪ Solicit inputs to the quality strategy from on-site government personnel

2801 • Provide the Quality Management Strategy with appropriate language and references
2802 for inclusion in the AS and the SEP.
2803 • Draft an initial program Quality Management Plan for incorporation into the SEP that
2804 includes details from the analyses.

2805 **Metrics**

2806 • A program Quality Management Strategy, based on the results of the analyses of quality
2807 management, product quality, and supply chain quality management requirements, has been
2808 drafted that specifies:

2809 o Quality management requirements that address:

2810 ▪ Quality management system requirements
2811 ▪ Management responsibility requirements
2812 ▪ Resource management requirements
2813 ▪ Product Realization requirements (e.g., risk management, design and development,
2814 purchasing, etc.)
2815 ▪ Risks and opportunities
2816 ▪ Measurement, analysis, and improvement requirements

- Alternatively, the quality management requirements met by adherence to established standards (e.g., AS9100, ISO 9000, etc.)
- Product quality requirements that incorporate new quality technologies and process state of the art, the need for unique product quality requirements, and metrics and the review frequency
- Supply chain quality management requirements that include:
  - The need for focused supplier quality management requirements
  - A supplier quality management plan
  - Potential standards (e.g., AS9100, ISO 9000, etc.)
  - Metrics
  - Potential solutions, tools and techniques
- Planned use of government-furnished quality and testing equipment and assets
- Appropriate agreements, delegations and contracts with other agencies, e.g. the DCMA and contains inputs from those agencies

- The Quality Management Strategy with appropriate language and references has been documented in the AS and the SEP.
- An initial program Quality Management Plan has been documented in the SEP that includes details from all of the analyses.

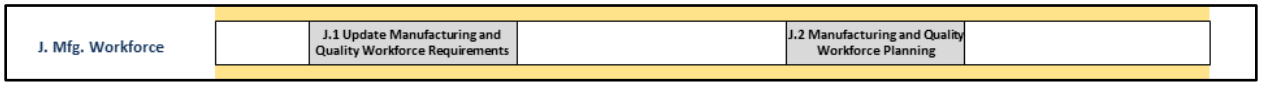
Tools

- AS9100 Quality Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- ISO 9001 Quality Audit Checklist
- Supplier Quality Questionnaire
- Quality Management Plan

Resources

- AS9100, Quality Management Systems, Sep 2016
- DoDI 5000.02, Change 1, Jan 2017
- ISO 9000:2015, Quality Management Systems, Sep 2015

J. MANUFACTURING WORKFORCE



During the MSA phase, it is essential to update the manufacturing and quality workforce requirements and begin planning for future phases. Although trained highly skilled engineers and artisans may be the workforce utilized in the lab environment, they will not be the workforce utilized for production. Identification, planning for, and training of the required production workers with

required skill sets must begin early. In addition to the production workforce, having a technical staff with education and experience in the relevant areas of engineering and management is key to program success.

As part of the evaluations for the AoA, the processes and planning utilized by the preferred concepts to determine workforce requirements need to be examined. The preferred concept(s) manufacturing and quality processes should be evaluated, as well as a forecast of phase-by-phase requirements for manufacturing and quality skills and training.

A Staffing Plan should be initiated early and include personnel skills, experience and education levels, training, ramp-up, and attrition as part of identifying manufacturing and quality skill sets and production workforce requirements. Planning should address risks resulting from shortages of qualified personnel, processes that require certifications, and volatility.

J.1 Update Manufacturing and Quality Workforce Requirements

Manufacturing and Quality Tasks

- Evaluate each AoA concept for appropriate industrial workforce standards.
- Evaluate the workforce processes and planning used to determine personnel skills, experience and education levels, training, ramp-up, and attrition for the preferred concepts.
- Evaluate manufacturing and quality processes for gaps in workforce skill sets, training, and manpower requirements for each AoA concept to include:
    - Workforce requirements (technical and operational)
    - Processes that require certifications (i.e., special skills)
    - Sources and shortages of qualified personnel based on processes, education, location, precision requirements, etc.
- Update requirements by phase for manufacturing and quality skills and training for preferred materiel solutions for the AoA.
    - Identify additional or new skills required
        - Include associated training requirements
    - Determine staffing requirements for skills, experience, certification levels, education levels, ramp-up, and attrition

Metrics

- The workforce processes and planning used to determine personnel skills, experience and education levels, training, ramp-up, and attrition for the preferred concepts have been analyzed and documented with appropriate industrial workforce standards, criteria, and metrics applied for each AoA concept.

- Manufacturing and quality processes have been analyzed and documented for gaps in workforce skill sets, training, and manpower requirements and availability for each AoA concept to include:
  - Production workforce requirements (technical and operational)
  - Processes that require certifications (i.e., special skills)
  - Sources and shortages of qualified personnel based on processes, education, location, precision requirements, etc.
- Workforce requirements by phase for manufacturing and quality skills and training for preferred materiel solutions for the AoA have been analyzed, updated, and documented including:
  - Additional or new skills and associated training requirements
  - Staffing requirements for skills, experience, certification levels, education levels, ramp-up, and attrition
- All of the results of manufacturing and quality workforce requirements analyses have been documented in the AS and the SEP.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- MRL Deskbook Version 2016
- Manufacturing Resource Planning (MRP II)
- Defense Manufacturing Guide for Program Managers (various chapters)

J.2 Manufacturing and Quality Workforce Planning

Manufacturing and Quality Tasks

- Initiate planning, as an input to program management, to address manufacturing and quality skill sets, production workforce availability requirements, and risks for the TMRR phase.
- Planning should address:
  - Mitigation needs for project ramp-up and workforce attrition
  - Mitigation of critical shortages of qualified personnel based on processes, location, precision requirements, etc.
  - Training and/or certification requirements (e.g., certified welders, skilled machine programmers or operators, etc.)
  - Plans for acquisition and training of new personnel
  - Potential impacts from labor relations, surges, competition, etc.
  - Volatility of demand and impact on workforce requirements
  - Impacts on workforce ability to address processing, testing, and acceptance of new materials and technologies
  - Impacts of regulatory requirements (e.g., special handling, security, hazardous materials, environmental needs, storage requirements, etc.) on the workforce
  - Incorporation of appropriate workforce lessons learned for processes, tools, and techniques for manufacturing workforce strategy

Metrics

- Planning, as input to program management, is underway that addresses manufacturing and quality skill sets, production workforce availability requirements, and risks for the TMRR phase and the results have been documented.
- Documented plans address and include metrics for:
  - Mitigation needs for project ramp-up and workforce attrition
  - Mitigation of critical shortages of qualified personnel based on processes, location, precision requirements, etc.
  - Overall training and/or certification requirements (e.g., certified welders, skilled machine programmers or operators, etc.)
  - Acquisition and training of new personnel
  - Potential impacts from labor relations, surges, competition, etc.
  - Volatility of demand and impact on workforce requirements
  - Impacts on workforce ability to address processing, testing, and acceptance of new materials and technologies
  - Impacts of regulatory requirements (e.g., special handling, security, hazardous materials, environmental needs, storage requirements, etc.)
  - Appropriate workforce lessons learned for processes, tools, and techniques for manufacturing workforce strategy

- Workforce planning is documented as part of the SEP and the AS.

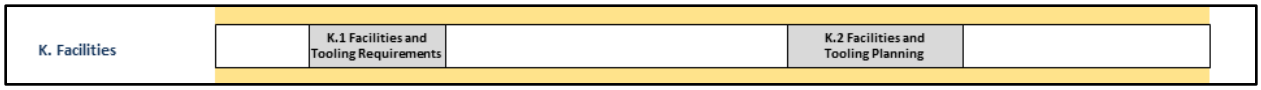
Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- MRL Deskbook Version 2016
- Manufacturing Resource Planning (MRP II)
- Defense Manufacturing Management Guide for Program Managers (various chapters)
- ESHO in Acquisition Guide, April 2009

K. FACILITIES



During the MSA phase, it is essential for the manufacturing and quality representatives to update the facility and tooling requirements for the preferred concepts prior to AoA, and initiate both a facilities plan and a tooling plan for entry into TMRR and future phases. Based on the preferred concepts, new facilities and tools may be required for new materials, new technologies, and new processes. The decision making process will also be impacted by production rates, quantities, and capacities by the types of tooling and facilities required. Therefore, facilities and tooling planning should be integral to planning for development, funding, and scheduling.

Manufacturing and quality planning efforts also define and design the special tooling and test equipment required to execute the effort. Special tooling and test equipment required for a program can be high cost and have a long lead-time to develop and procure. The planning for tooling and test equipment should be initiated during the MSA phase. The planning should include the type of tooling

and test equipment to be utilized, investments, the transition from limited life to rate tools, the need for production and test equipment, and tooling sustainment.

The Facilities and Tooling Plans are subsets of the manufacturing strategy, which is in turn a subset of the overall Acquisition Strategy and the SEP.

K.1 Facilities and Tooling Requirements

Manufacturing and Quality Tasks

- Update the manufacturing and quality facilities and capital equipment requirements for the AoA preferred concepts.
- Analyze the manufacturing and quality quantitative and qualitative facility demands of the preferred concepts for:
    - Availability, design, rate and capacity capabilities of the facilities under consideration (existing, new, or redeveloped)
    - Types of processes required and the resulting impacts on facilities (e.g., specialized fixtures, test chambers, laboratories, clean rooms, waste storage and disposal, etc.)
    - Unique or special facility requirements for transportation, handling, and storage equipment being manufactured
- Update new manufacturing and quality capital equipment, tooling, and Special Test or Inspection Equipment (STE/SIE) requirements for new technology and materials for preferred concepts.
- Update the manufacturing and quality assessments of:
    - Tooling requirements for capability to produce at planned production rates and target unit costs
    - Needs for soft tooling vs. hard tooling
    - Supplier and sub-tier capabilities and investment incentives
    - STE/SIE requirements and capabilities
- Assess manufacturing and quality requirements for unique or special transportation, handling, and storage equipment to be manufactured for preferred concepts.
- Update the manufacturing and quality funding estimates required for capital equipment, tooling, and test equipment for preferred concepts.

Metrics

- The manufacturing and quality facilities and capital equipment requirements for the AoA preferred concepts have been updated and documented in the AoA.
- Quantitative and qualitative manufacturing and quality facility demands of the preferred concepts have been analyzed and documented for:

  - Availability, design, rate and capacity capabilities of the facilities under consideration (existing, new, or redeveloped)
  - Types of processes required and the resulting impacts on facilities (e.g., specialized fixtures, test chambers, laboratories, clean rooms, waste storage and disposal, etc.)
  - Unique or special facility requirements for transportation, handling, and storage equipment being manufactured

- New manufacturing and quality capital equipment, tooling, and Special Test or Inspection Equipment (STE/SIE) requirements have been updated for new technology and materials for AoA preferred concepts.
- The following have been re-analyzed and re-assessed and documented by manufacturing and quality representatives as part of the AoA:
  - Tooling requirements for capability to produce at planned production rates and target unit costs
  - Needs for soft tooling vs. hard tooling
  - Supplier and sub-tier capabilities and investment incentives
  - GFE/STE/SIE requirements and capabilities
- Manufacturing and quality requirements for unique or special transportation, handling, and storage equipment to be manufactured for preferred concepts have been assessed and documented.
- Manufacturing and quality funding estimates required for capital equipment, tooling, and test equipment for preferred concepts have been updated and included in the AoA.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- ISO 9001 Checklist Section Preservation (Handling, Storage, Packaging and Delivery)
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Facilities thread
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- MRL Deskbook Version 2016
- Manufacturing Resource Planning (MRP II)
- ISO 9001:2015, Quality Management System
- Defense Manufacturing Management Guide for Program Managers, Chapter 6, Manufacturing Planning

K.2 Facilities and Tooling Planning

Manufacturing and Quality Tasks

- Initiate a manufacturing and quality Facilities Plan that includes:
  - Requirements for manufacturing and quality facilities for development of technologies, prototypes, and subsequent production within required lead-times (existing, new, or redeveloped)
  - Addressing the rate and capacity capability requirements on the facilities and needed enhancements for manufacturing and quality
  - Mitigation of the impacts on facilities from the types of manufacturing and quality processes required (e.g., acquisition of specialized fixtures, construction of test chambers, upgrading laboratories and clean rooms, upgrading waste storage and disposal equipment, etc.)
  - Addressing unique or specialized manufacturing and quality facility requirements for transportation, handling, and storage equipment
  - New facilities to be constructed to mitigate manufacturing and quality gaps in current facilities
  - Requirements for manufacturing and quality investments and funding with associated schedules
  - Assessment of and mitigation of manufacturing and quality environmental and safety factors and impacts
  - Requirements for security of manufacturing and quality facilities (physical and cyber)
- Initiate a manufacturing and quality Tooling Plan that includes:
  - Tooling requirements to meet production rates, costs, quantities, and schedule
  - Tooling sources, funding, materials impacts, maintenance impacts, etc.
  - Analysis of requirements for soft and/or hard tooling
  - Manufacturing and quality test equipment including STE, SIE, and GFE
- Derive manufacturing and quality funding estimates required for capital equipment, tooling, and test equipment for the preferred concept from the facilities and tooling planning.

Metrics

- A manufacturing and quality Facilities Plan has been initiated and documents the following:
  - Requirements for manufacturing and quality facilities for development of technologies, prototypes, and subsequent production within required lead-times (existing, new, or redeveloped)
  - Addressing the rate and capacity capability requirements on the facilities and needed enhancements for manufacturing and quality
  - Mitigation of the impacts on facilities from the types of manufacturing and quality processes required (e.g., acquisition of specialized fixtures, construction of test chambers,

upgrading laboratories and clean rooms, upgrading waste storage and disposal equipment, etc.)
  - Addressing unique or specialized manufacturing and quality facility requirements for transportation, handling, and storage equipment
  - New facilities to be constructed to mitigate manufacturing and quality gaps in current facilities
  - Requirements for manufacturing and quality investments and funding with associated schedules
  - Assessment of and mitigation of manufacturing and quality environmental and safety factors and impacts
  - Requirements for security of manufacturing and quality facilities (physical and cyber)
- A manufacturing and quality Tooling Plan has been initiated and documents the following:
  - Tooling requirements to meet production rates, costs, quantities, and schedule
  - Tooling sources, funding, materials impacts, maintenance impacts, etc.
  - Analysis of requirements for soft and/or hard tooling
  - Manufacturing and quality test equipment including STE, SIE, and GFE)
- Manufacturing and quality funding estimates required for capital equipment, tooling, and test equipment for the preferred concept have been updated and included in the AS and in the budget process.
- Both the Facilities Plan and the Tooling Plan are incorporated into the Manufacturing and Quality Strategies and have been documented in the AS and the SEP.

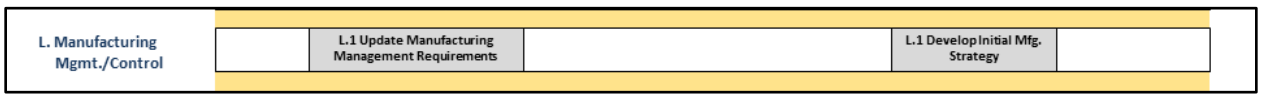
Tools

- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Facilities thread
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- MRL Deskbook Version 2016
- Manufacturing Resource Planning (MRP II)
- Defense Manufacturing Management Guide for Program Managers, Chapter 6, Manufacturing Planning

L. MANUFACTURING MANAGEMENT AND CONTROL



Programs with manufacturing aspects require a manufacturing management system. The timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risks, issues, and opportunities throughout the program lifecycle require a comprehensive manufacturing management system. This is accomplished by including best practices and standards (i.e., AS6500, Manufacturing Management Program) in the contracts with industry.

Beginning in MSA, after the preferred concept is determined, the PM and program office develop the manufacturing strategy and should begin detailed planning for manufacturing. Before the Materiel Development Decision, the activities managing the concept (or the program office) initiated planning for manufacturing management and control. In this phase, manufacturing management planning should be updated for the AoA. The initial manufacturing strategy developed during the MSA phase is a subset of the overall AS and the SEP. The Manufacturing Strategy should address all aspects of manufacturing management and control from design and materials to processes, workforce, and facilities, to transition to TMRR and subsequent phases. For example, competition considerations are a major contributor to reducing weapon system cost. In addition, if a program will be dual sourced, early planning must take into account the strategy required to assure availability of data and data rights for dual sourcing. New manufacturing technologies may require specific plans for development, proofing, and transition to production. Production rates and quantities can also play a major role in driving manufacturing cost as they influence decisions on processes, tooling, make-buy, etc.

The purpose of manufacturing planning is to identify requirements and resources, to manage risk, issues, and opportunities, and to integrate manufacturing processes into a structure that provides the capability to achieve production objectives. This planning should be updated during the subsequent acquisition phases. Manufacturing planning should include:

- Manufacturing management responsibilities as an integral part of the IPT structure with assignment to specific program office personnel
- Manufacturing metrics for the program with a specified review cycle of metrics commensurate with risks
- Manufacturing assessments to identify and quantify risks in support of program Milestone decision points and major design reviews
- Manufacturing requirements and metrics for agreements, delegations, and contracts with other agencies (e.g. DCMA)

The initial Manufacturing Strategy, as an integral part of the AS and SEP, will guide the future development program and help minimize risk.

L.1 Update Manufacturing Management Requirements

Manufacturing and Quality Tasks

- Ensure each AoA preferred concept is analyzed for manufacturing management requirements (to be incorporated into the RFP, per Section B.1):
  - The manufacturing management requirements can be met by adherence to established standards (i.e., AS6500)
  - Alternatively, the manufacturing management requirements should at a minimum include:
    - Manufacturing management system requirements
    - Design analysis for manufacturing requirements
    - Manufacturing risk identification requirements
    - Manufacturing planning requirements (e.g., supply chain, materials, cost, workforce, etc.)
    - Manufacturing operations management requirements
  - Analyze the impacts of technology and process state of the art on manufacturing management
  - Request DCMA inputs on manufacturing management system evaluations of potential contractors and suppliers for the preferred concept(s).
  - Analyze relevant manufacturing management lessons-learned and best practices among programs and across centers
- Review, update, and analyze manufacturing management metrics for the preferred concept from the AoA Study Guidance.
  - Verify the frequency that the metrics are reviewed is commensurate with manufacturing risks
- Specify the manufacturing management requirements to be met by the contractor (in the RFP) or government entity (in the SEP) as appropriate.
  - Provide requirements for manufacturing management responsibilities and personnel within the IPT
  - Provide manufacturing management requirements and metrics
  - Metrics
- Each AoA preferred concept has been analyzed and documented for manufacturing management requirements and results documented for the RFP.
  - The manufacturing management requirements have been met by documented adherence to established standards (i.e., AS6500)
  - If AS6500 is not specified, the manufacturing management requirements have documented the following:
    - Manufacturing management system requirements

        - Design analysis for manufacturing requirements
        - Manufacturing risk identification requirements
        - Manufacturing planning requirements (e.g., supply chain, materials, cost, workforce, etc.)
        - Manufacturing operations management requirements
    - Impacts of technology and process state of the art on manufacturing management have been analyzed and documented
    - DCMA inputs on manufacturing management system evaluations of potential contractors and suppliers for the preferred concept(s) have been included in the AoA.
    - Relevant manufacturing management lessons-learned and best practices among programs and across centers have been analyzed and documented
- Manufacturing management metrics for the AoA preferred concept from the AoA Study Guidance have been updated, analyzed, and documented for inclusion in the AS and the SEP
    - Review of manufacturing management metrics is included in all program reviews
- Manufacturing management requirements to be met by the government or contractor entity as appropriate have been specified and documented.
    - Manufacturing management responsibilities and personnel have been established for each government IPT and documented in the SEP
    - Manufacturing management requirements and metrics for the contractor have been established and documented in the RFP

Tools

- AS6500 Assessment
- Bill of Material Assessment
- Industrial Base Capabilities Assessment Questionnaire
- Line of Balance Assessment
- Materials Requirements Planning (MRP) Assessment
- Manufacturing Resource Planning (MRPII) Assessment
- Make/Buy Decisions
- MRL Assessment Questionnaire for Manufacturing Management and Control Thread
- Systems Engineering Plan (SEP)
    - Manufacturing Plan Inputs
    - Quality Plan Inputs
- Technology Readiness Assessment
- **Work Breakdown Structure**

Resources

- AS6500 Manufacturing Management Program, Nov 2014

- AFI63-145 Manufacturing and Quality Management, Sep 2016
- MIL-HDBK-896B, Manufacturing and Quality Program, Aug 2008
- DODI 5000.60H Defense Industrial Capabilities Assessment, Apr 1996
- Systems Engineering Plan (SEP) Outline, Jun 2015
- Technology Readiness Assessment Guidance, Apr 2011

L.2 Develop Initial Manufacturing Strategy

Manufacturing and Quality Tasks

- Develop appropriate manufacturing management strategy inputs with references based on the best practices from AS6500 for inclusion in the AS and the SEP.
- Develop the initial Manufacturing Strategy, as a subset of the overall Acquisition Strategy, and ensure the Manufacturing Strategy addresses manufacturing and quality considerations for:
    - IB Risk Mitigation
    - Enabling/critical technologies and constraints
    - ManTech projects
    - Design and producibility
    - Rate and schedule (includes processes, tooling, make/buy, etc.)
    - Key and critical characteristics
    - Cost, affordability, and budget
    - Materials management, sourcing, and risks (including counterfeit, obsolescence, etc.)
    - Supply chain management, characteristics and constraints (e.g., sole, single, etc.)
    - Competitive development (e.g., dual source, co-production, etc.)
    - Processes and capability control
    - Workforce Planning
    - Facilities, Tooling, and Test Equipment (including GFE and assets)
    - Environmental, security, and safety
- In addition, the Manufacturing Strategy should address:
    - Manufacturing assessments to support program Milestone decision points and major design reviews with appropriate exit criteria
    - Manufacturing metrics for the program with a specified review cycle of metrics commensurate with risks
- Ensure the Manufacturing Strategy (and AS) includes establishing appropriate agreements, delegations, and contracts with other agencies, e.g. DCMA.
- Draft an initial program Manufacturing Management Plan that addresses each key area of the strategy for incorporation into the SEP that includes details from the analyses. In accordance with AS6500, the plan should address:
    - Manufacturing Management System

- Design Analysis for Manufacturing
- Manufacturing Risk Identification (including mitigation)
- Manufacturing Planning
- Manufacturing Operations Management

Metrics

- Appropriate manufacturing management strategy inputs with references based on AS6500 have been provided for inclusion in the AS and the SEP.
- The initial Manufacturing Strategy, as a subset of the overall Acquisition Strategy, has been developed which includes and documents the considerations for:
  - IB Risk Mitigation
  - Enabling/critical technologies and constraints
  - ManTech projects
  - Design and producibility
  - Rate and schedule (includes processes, tooling, make/buy, etc.)
  - Key and critical characteristics
  - Cost, affordability, and budget
  - Materials management, sourcing, and risks (including counterfeit, obsolescence, etc.)
  - Supply chain management, characteristics and constraints (e.g., sole, single, etc.)
  - Competitive development (e.g., dual source, co-production, etc.)
  - Processes and capability control
  - Workforce Planning
  - Facilities, Tooling, and Test Equipment (including GFE and assets)
  - Environmental, security, and safety
- The Manufacturing Strategy addresses and documents the following:
  - Use of manufacturing assessments to support program Milestone decision points and major design reviews with appropriate exit criteria
  - Manufacturing metrics for the program including a specified review cycle
- The Manufacturing Strategy (and AS) has been established that includes appropriate agreements, delegations, and contracts with other agencies, e.g. DCMA.
- An initial Manufacturing Management Plan has been developed that addresses each key area of the strategy and provided for incorporation into the SEP and includes details in accordance with AS6500 and addresses:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management

Tools

- **Systems Engineering Plan (SEP)**
  - Manufacturing Plan Inputs
  - Quality Plan Inputs

Resources

- MIL-STD-896B, Manufacturing and Quality Program, Aug 2008
- AS6500, Manufacturing Management Program, Nov 2014
- SEP Outline, Jun 2015
- DAG, Chapter 3-4 3.18, Producibility, Quality and Manufacturing Readiness, 2017

3. Technology Maturation and Risk Reduction (TMRR) Phase

Introduction

As stated in Department of Defense Instruction (DoDI) 5000.02, "The purpose of this phase is to reduce technology, engineering, integration, and life cycle cost risk to the point that a decision to contract for EMD can be made with confidence in successful program execution for development, production, and sustainment."

Technology Maturation and Risk Reduction (TMRR) includes a mix of activities intended to reduce the risks associated with the product to be developed. This includes design and requirements trades, maturation and validation of capability requirements, and finalization of affordability caps. The phase normally includes competing sources conducting technology maturation and risk reduction activities. The phase also includes preliminary design activities, including a Preliminary Design Review (PDR), leading to source selection for the Engineering and Manufacturing Development (EMD) phase.

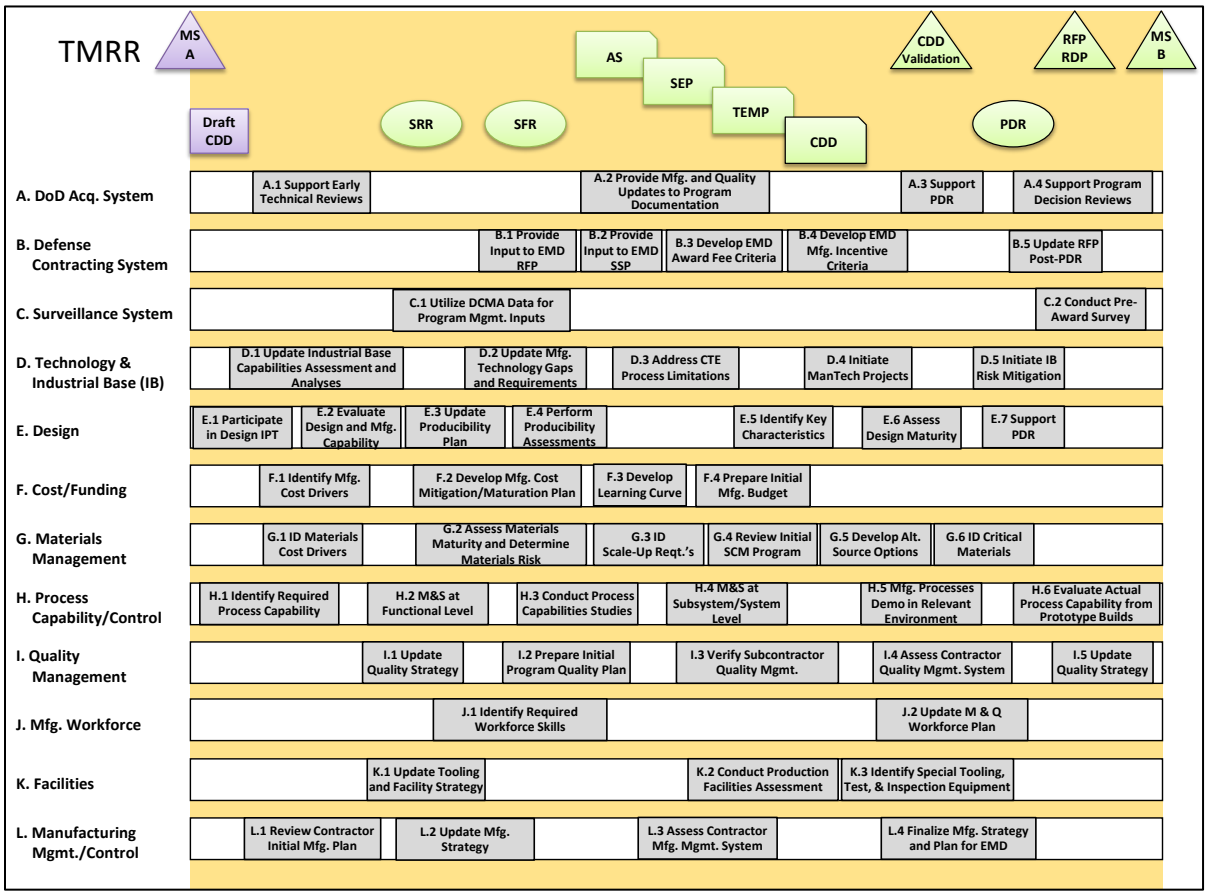


Figure 3-1. TMRR Phase Manufacturing and Quality Activities

The program can exit TMRR when an affordable program or increment of militarily useful capability has been identified, the technology and manufacturing processes for that program or increment have been assessed and demonstrated in a relevant environment and found to be sufficiently mature, manufacturing risks have been identified and assessed, and a system or increment can be developed for production within a short time frame.

Key program phase reviews and documentation include:

- System Requirements Review (SRR)
- System Functional Review (SFR)
- Program Documentation
    - Acquisition Strategy (AS)
    - Systems Engineering Plan (SEP)
    - Test and Evaluation Master Plan (TEMP)
    - Capability Development Document (CDD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)
- Preliminary Design Review (PDR)
- CDD Validation
- Milestone B (MS B) Decision

Manufacturing and Quality Objectives

Manufacturing and quality risks, issues, and opportunities are the most important factors in making the decision to proceed within all phases of development and production. The producibility of the design and risks are reviewed prior to the EMD phase. The TMRR phase requires assessments of the industrial base (IB) and of the contractor(s) selected.

Programs need to specifically assess the capabilities of the industrial base in order to understand if the base can support their program. Multiple technology development demonstrations may be required before the operational user and the contractor can substantiate that the solution is feasible, affordable, and supportable; satisfies capability requirements; and has acceptable risks.

By the end of the TMRR phase, manufacturing and quality processes will be assessed and demonstrated to the extent needed to verify that risks have been reduced to an acceptable level. Some of the mitigations may involve investments in industrial base capabilities (i.e., Title III) as well as investments in advanced manufacturing capabilities (i.e., ManTech).

Program management is responsible for implementing effective risk, issue, and opportunity (RIO) management and tracking to include the identification of all known risks, key assumptions, probability of occurrence, consequences of occurrence (in terms of cost, schedule, and performance) if not handled, analysis of risk handling options, decisions about actions to mitigate risk, and

execution of those actions. Manufacturing and quality personnel are responsible for identification, prioritization, and mitigation of manufacturing and quality risks and issues.

Manufacturing and quality personnel participation in and support to Program Design IPTs are critical to success in producing a manufacturable and affordable system with acceptable risks. In TMRR, costs need to be defined and finalized to include identified manufacturing and quality cost drivers based on contractor-proposed materials and processes, producibility costs, required investments.

Manufacturing and quality personnel should analyze the contractor's processes, materials, make/buy processes (hardware and software), and supply chain for capability and completeness, and identification of single points of failure for mitigation. Process capability and control should be an integral part of any development program and lead to a producible system with effective and efficient manufacturing processes. Workforce skills identification and plans should provide inputs to program planning and should identify the skills required for the scope of the technical effort needed to develop, field, and sustain the system. Also, manufacturing and quality personnel should conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases.

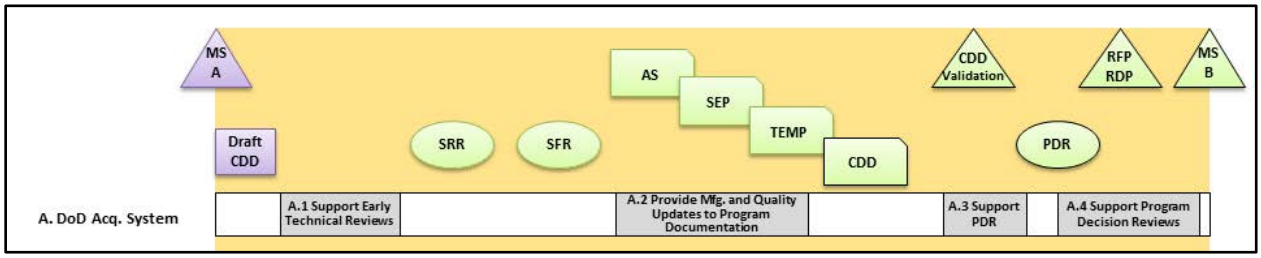
During the TMRR phase the contractor will produce prototypes that will be used during tests to validate that the design meets requirements. These prototypes will be built in a relevant manufacturing environment, meaning that there are some elements of production realism present on the manufacturing line. To the extent practicable, manufacturing and quality personnel will assess the processes used for prototype build and evaluate the tests and demonstrations to better understand the issues that will need to be resolved during the EMD phase.

Contractors must have an effective combination of people and systems in order to plan for, monitor, and control manufacturing and quality resources. To manage these resources, an effective implementation of a manufacturing management system and a quality management system is required during TMRR. A well-structured manufacturing management system generally employs the use of industry best practices. A Quality Management System (QMS) compliant with industry best practices is the foundation for the contractor to deliver a system that meets requirements. Assessment of the contractor's manufacturing management and quality systems should be performed against the recognized industry best practices such as AS6500, ISO 9000, AS9100, etc.

The initial manufacturing and quality strategies should have been developed during the Materiel Solution Analysis (MSA) phase. During TMRR phase, an effective joint government/contractor manufacturing strategy and quality strategy are required if the program is to adequately reduce risks and mature and deliver a design for an operationally safe, suitable, and effective weapon systems. In addition, the program and the contractor should develop a joint government/contractor manufacturing and quality plans that execute the strategy for EMD.

A. DOD ACQUISITION SYSTEM

The TMRR phase objective is to develop and demonstrate competitive sources and prototype designs to reduce technical risk, validate designs and cost estimates, evaluate manufacturing processes, and refine requirements. It is focused on maturing, prototyping, and demonstrating technologies in a relevant environment, resulting in a preferred system concept that achieves acceptable low-risk entry into the EMD phase.



Effective employment of systems engineering will reduce program risk. This is monitored by meaningful technical reviews to reduce program risk, identify potential management issues in a timely manner, and support key program decisions. Manufacturing and quality managers should be making significant inputs into these activities and reviews. Early program reviews include the SRR and SFR. The SRR is conducted to help ensure the level of understanding of top-level system requirements is adequate to support further requirements analysis and design activities, and that the system can proceed into initial system design with acceptable risk. The SFR is conducted to help ensure that the system under review can proceed into preliminary design with acceptable risk and that all system requirements and functional performance requirements derived from the approved preliminary system specification are defined and are consistent with the program budget, program schedule, risk, and other program and system constraints.

The AS developed for the Milestone A (MS A) decision should have addressed the following program objectives:

- Use of industry best practices for manufacturing, quality, and systems engineering management
- The likely outcome is worth the investment in both resources (real costs) and schedule (opportunity costs)
- The end item meets required performance objectives
- All risks, issues, and opportunities are identified, managed, and mitigated to an acceptable level
- The business strategy effectively executes the program

In the TMRR phase, the updated Acquisition Strategy describes the overall approach to acquiring the capability to include the program schedule, risks, funding, and the business strategy.

The pre-MS A initial manufacturing and quality strategies, as an integral part of the AS, includes considerations of:

- Competition
- New manufacturing technologies
- Production rates and quantities
- Materials sourcing
- Contracting strategies

For TMRR, the updated manufacturing and quality strategies are a subset of the program Acquisition Strategy and will include these same considerations. Competition is a major contributor to reducing weapon system cost. If the program will be dual sourced, the early planning must take into account the strategy required to ensure availability of capability and data and data rights for dual sourcing. New manufacturing technologies, if required by the system concept, will require specific plans for development, proofing, and transition of the technology to the eventual producer. This effort will necessitate close coordination with the Service manufacturing technology organization to ensure compatibility of the technology development schedule with the system development schedule. Production rates and quantities also play a major role in driving manufacturing cost as they will drive decisions on what production processes to use, types of tooling required, make-buy decisions, etc.

The Acquisition Strategy provides a master schedule for research, development, test, and production. Manufacturing and quality considerations for inclusion in the strategy should include establishing feasibility, assessing risks, identifying capable manufacturers and suppliers, manufacturing technology maturation, capabilities of the industrial base, availability of critical materials, and the transition from development to production. The Acquisition Strategy and the included Manufacturing and Quality Strategies summarize how the industrial and manufacturing risk will be addressed in the TMRR phase to ensure that manufacturing maturity is appropriate to enter EMD, particularly for new or high risk manufacturing endeavors.

The SEP implements the technical development and engineering aspects of the AS. The Pre-MS A SEP requires updates based on contract award to reflect any changes due to the contractor's technical approach and details not available prior to contract award. Effective employment of systems engineering with competitive prototyping, as applied through the SEP, and monitored with meaningful technical reviews, will reduce program risk, identify potential management issues in a timely manner, and support key program decisions. Manufacturing and quality managers should be making significant inputs into these documents and activities. In addition, manufacturing and quality personnel should provide a manufacturing and quality capability assessment update for the SEP during TMRR. They should assess manufacturing and quality risks for each competing prototype during TMRR and verify risks have been reduced to an acceptable level. Individual risks should be identified and integrated into a cumulative assessment of the production, manufacturing, and quality risks, issues, and opportunities.

As the program matures, it is important to mature the requisite manufacturing requirements and processes needed to build prototypes and production items. The SEP ensures this by providing, updating, and planning for:

- Conducting producibility analyses with consideration of the life cycle costs of proposed manufacturing, assembly, and test processes.
- Significant activities (i.e. manufacturing assessments, long-lead or advanced procurements, prototype builds, production lots/phases, Production Readiness Review (PRR)) indicated on program schedule.
- Industrial, manufacturing, production, engineering, software, firmware, and quality risks and issues, and reduction efforts, as well as opportunities.
- Manufacturing and quality organization, billets, and Production Quality and Manufacturing (PQM) Key Leadership Positions (KLP).
- Manufacturing and Quality Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics).
- Planned activities for the next phase.

Additional considerations for the Acquisition Strategy and the SEP, based on assessments of the contractor's cybersecurity plans, are manufacturing and quality inputs for cybersecurity that include technical risks, processes, industrial control systems, manufacturing and quality resources and organizations, and design considerations. Another consideration is that the updated Program Manufacturing and Quality Strategies include appropriate agreements, delegations, and contracts with other agencies (e.g., Defense Contract Management Agency (DCMA), Defense Logistics Agency (DLA), etc.).

Outputs of the SRR, SFR, and Preliminary Design Review (PDR) will create the need for substantive updates and changes to the SEP. This phase normally includes competitive sources conducting TMRR activities and preliminary design activities up to and including a PDR prior to source selection for the EMD phase. A final revision and re-submission will be required for approval before the EMD Request for Proposal Release Decision Point (RFP RDP) and Milestone B.

The role of manufacturing and quality in the TMRR phase is to influence the design. This is critical because of the impact design decisions have on Life Cycle Cost (LCC). Studies have shown that by the time a PDR is held approximately 80 percent of the program's LCC is determined, even though only a small percentage of the program's cumulative costs have been expended (citation to come). It is also the time when a program or contractor has the most opportunity to impact life cycle cost savings.

The PDR is a technical assessment establishing the allocated baseline to ensure that the system under review has a reasonable expectation of being judged operationally effective and suitable, and has a reasonable expectation of satisfying the requirements within the currently allocated budget and

schedule. A successful PDR includes an assessment of the producibility of the design and an assessment of manufacturing costs and risks.

During this phase, and timed to support CDD validation (or its equivalent), manufacturing and quality will provide support to the Program Manager's conduct of systems engineering trade-off analyses showing how cost and capability vary as a function of the major design parameters. The analyses will support the assessment of refined Key Performance Parameters (KPP), Key System Attributes (KSA)in the CDD. Capability requirements proposed in the CDD (or equivalent requirements document) should be consistent with program affordability goals.

In support of program decision reviews, RFP RDP and Milestone B, manufacturing and quality will have conducted additional requirements analyses and demonstrations including: requirements decomposition and allocation, definition of internal and external interfaces, design activities, and prototypes and process demonstrations that led to a PDR. Milestone B requires final demonstration that all sources of risk have been adequately mitigated to support a commitment to design for production. This includes technology, engineering, integration, manufacturing, sustainment, and cost risks. In addition, pursuant to the NDAA for FY 2017, Sec. 807, before any decision to grant Milestone B approval for the program (pursuant to section 2366b), manufacturing and quality personnel are required to identify manufacturing processes that have not been successfully demonstrated in a relevant environment.

A.1 Support Early Technical Reviews

Manufacturing and Quality Tasks

- Provide manufacturing and quality support to the program's overall risk, issue, and opportunity management processes (e.g., industrial base, manufacturing technology gaps, quality, software, and engineering related risks/issues, etc.).
- Provide manufacturing and quality Program workforce requirements for Program organization, billets, and PQM Key Leadership Positions.
- Provide the manufacturing and quality management requirements (e.g., AS6500, ISO 9000, AS9100, IEEE 15288, etc.) to program management to be used in assessing the contractor's plans to meet Program cost, schedule, and performance requirements throughout the product life cycle (see I.1 and L.1).
    - Ensure the program and contractor have a joint understanding of the system manufacturing and quality requirements and performance that are:
        - Consistent with the preferred materiel solution
        - Consistent with manufacturing and quality budget, schedule, risk, user, and other specific constraints
        - Feasible given available manufacturing technologies for the preferred system solution
        - Adequate and consider the maturity of interdependent system elements

225 - Bidirectional with traceability to the set of source documents (e.g., Key
226 Characteristics (KC) to KPPs
227 - Verifiable with defined and agreed-upon methods
228 - Consistent with program's objectives (with manageable risk)

229 • Provide manufacturing and quality support to the SRR:

230 o Provide requirements that are sufficiently detailed and understood that enable
231 manufacturing and quality functional definitions and functional decompositions
232 o Assess manufacturing and quality feasibility of the contractor(s)' proposed (traceability
233 to the AoA results):

234 - External interface requirements
235 - Alternative and/or competitive architectural concepts
236 - Operational and life cycle sustainment requirements

237 o Provide manufacturing and quality requirements in support of:

238 - Human safety and health
239 - Hazardous materials management and pollution prevention
240 - Environmental (e.g., shock, vibration, thermal, humidity, electromagnetic
241 interference/impact, electrostatic discharge, transport, etc.)
242 - Security (physical and cyber) for both hardware and software
243 - Key Performance Parameters (i.e., KCs)
244 - Data management and software (including collection, analysis, testing, and methods
245 of analysis, storage, retrieval of manufacturing and quality data)
246 - Supportability and sustainment
247 - Use of commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and
248 government-furnished equipment (GFE) (including diminishing manufacturing
249 sources)
250 - Parts, materials, and processes

251 o Provide manufacturing and quality analyses of requirements that potentially impact
252 manufacturing feasibility for:

253 - System Human System Integration/interface requirements
254 - System Safety requirements
255 - System command, control, communication, computer, and intelligence (C4I)
256 requirements
257 - System security requirements (e.g., communications, cyber, program protection, anti-
258 tamper, etc.)
259 - Key Performance Parameters (e.g., mandatory and other)
260 - Interoperability requirements
261 - Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)
262 requirements
263 - Product assurance

264 ▪ Specialized manufacturing requirements (extreme complexity, multiple or very tight
265 tolerances, precision assembly, handling of fragile components, etc.)

266 o Assess and analyze the completeness and adequacy of manufacturing and quality aspects
267 and requirements for:

268 ▪ Contractor's plans for processes and metrics included in the System Engineering
269 Management Plan (SEMP)
270 ▪ Contractor's budget and schedule plans including identification of cost and schedule
271 drivers (with impacts on the critical path)
272 ▪ Contractor's software development strategy and development plans (to include
273 functionality, adequacy, testing, etc.)
274 ▪ Technology maturation plans
275 ▪ Developmental Test and Evaluation (DT&E) approaches
276 ▪ Development, qualification, and acceptance testing approaches including
277 consideration for non-developmental items (NDI), COTS, and reuse items
278 ▪ Modeling and Simulation plans to include design, production, processes, costing, etc.

279 o Provide manufacturing and quality strategies input to:

280 ▪ The joint program/contractor risk, issue, and opportunity management system
281 including hazards, technologies, sources of supply, etc., and mitigating courses of
282 action
283 ▪ The joint program/contractor configuration management system
284 ▪ The joint program/contractor Integrated Master Plan/Integrated Master Schedule
285 ▪ The Cost Analysis Requirements Description (CARD) for manufacturing and quality
286 should-cost inputs (See F.1)

287 • Provide manufacturing and quality analyses and support to the program and systems
288 engineering functions by:

289 o Conducting manufacturing feasibility analyses including cost and schedule
290 o Providing manufacturing and quality requirements mapped to the hardware and software
291 functional baseline
292 o Providing traceability of manufacturing and quality requirements to the draft Capability
293 Development Document (CDD)
294 o Providing results of industrial base capabilities studies
295 o Conducting assessments of risks, issues, and opportunities and associated mitigation
296 planning
297 o Manufacturing and quality inputs to the program PDR planning to include sustainment
298 and life cycle planning
299 o Providing analysis of the contractor's SEMP
300 o Providing inputs to the detailed plan and schedule with inputs on sufficient resources to
301 continue design and development (i.e., Integrated Master Plan (IMP) and Integrated
302 Master Schedule (IMS)

- Providing results of assessments of contractor(s) and supply chain capability to mature the proposed design(s) within the program overall cost, schedule, and performance goals (See E.2)
- Providing results of manufacturing and quality design producibility analyses (See E.2)
- Conducting analyses of materials availability, maturity, and characterization (See G.2)
- Conducting assessments and providing estimates of process maturity and capability for manufacturing and production processes (See H.1)
- Assessing contractor initial Manufacturing Plans for workforce requirements, skills, capabilities, training, and certifications (including for prototypes and system development) (See J.1)
- Providing analyses of the contractor's tooling and facilities strategies (See K.1)
- Assessing the contractor's Manufacturing Management System and plans (See L.1)

Metrics

- Manufacturing and quality support to the program's overall risk, issue, and opportunity management processes have been provided and document the industrial base, manufacturing technology gaps, quality, software, and engineering-related risks/issues, etc.
- Manufacturing and quality Program workforce requirements have been documented and provided to program management delineating manufacturing and quality billets, PQM Key Leadership Positions, IPT membership, etc.
- Documented manufacturing and quality management requirements have been provided to program management for use in assessment of contractor's plans to meet program cost, schedule, and performance requirements throughout the product life cycle. (e.g., AS6500, ISO 9000, AS9100, IEEE 15288, etc.)
  - Program and contractor joint understanding of the system manufacturing and quality requirements and performance have been agreed to and document:
    - Consistency with the preferred materiel solution
    - Consistency with manufacturing and quality budget, schedule, risk, user and other specific constraints
    - Feasibility of given manufacturing technologies for the preferred system solution
    - Adequacy and maturity of interdependent system elements
    - Bi-directional traceability to the set of source documents (e.g., KCs to KPPs)
    - Defined and agreed-upon methods for verification
    - Consistency with program's objectives (with manageable risk)
- Documented manufacturing and quality support has been provided to the SRR to include:
  - Requirements that are sufficiently detailed and understood that enable manufacturing and quality functional definitions and functional decompositions
  - Assessments of manufacturing and quality feasibility including contractor(s) proposed:
    - External interface requirements
    - Alternative and/or competitive architectural concepts

- Operational and life cycle sustainment requirements

- Manufacturing and quality requirements for:
  - Human safety and health
  - Hazardous materials management and pollution prevention
  - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security parameters (physical and cyber) for both hardware and software
  - KPPs (i.e., KCs)
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data)
  - Supportability and sustainment
  - Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
  - Parts, materials, and processes (PM&P)

- Analyses of manufacturing and quality requirements that document the impacts to manufacturing feasibility by:
  - System Human System Integration/interface requirements
  - System Safety requirements
  - System command, control, communication, computer, and intelligence (C4I) requirements
  - System security requirements (e.g., communications, cyber, program protection, anti-tamper, etc.)
  - KPPs (e.g., mandatory and other)
  - Interoperability requirements
  - EMI and EMC requirements
  - Product assurance requirements
  - Specialized manufacturing requirements (extreme complexity, multiple or very tight tolerances, precision assembly, handling of fragile components, etc.)

- Analyses have been accomplished and document the completeness and adequacy of manufacturing and quality aspects and requirements included in contractor's:
  - Plans for processes and metrics included in SEMP
  - Plans for budget and schedule including identification of cost and schedule drivers (with impacts on the critical path)
  - Software development strategy and plans (to include functionality, adequacy, testing, etc.)
  - Technology maturation plans
  - DT&E approaches
  - Development, qualification, and acceptance testing approaches including consideration for NDI, COTS, and reuse items
  - Modeling and Simulation plans to include design, production, processes, costing, etc.

- Documentation of manufacturing and quality strategy inputs to:
  - The joint program/contractor risk, issue, and opportunity management system including hazards, technologies, sources of supply, etc., and mitigating courses of action
  - The joint program/contractor configuration management system
  - The joint program/contractor Integrated Master Plan/Integrated Master Schedule
  - The CARD for manufacturing and quality should-cost inputs (See F.1)

- Manufacturing and quality analyses and support have been provided to the program and Systems Engineering functions and for the SFR document:
  - Manufacturing feasibility analyses to include cost and schedule
  - Mapping of manufacturing and quality requirements to the hardware and software functional baseline
  - Traceability of manufacturing and quality requirements to the draft CDD
  - Results of Industrial Base capabilities studies
  - Assessments of risks, issues, and opportunities and associated mitigation planning
  - Manufacturing and quality inputs for Program PDR planning including sustainment and life cycle planning
  - Analysis and recommendations for the contractor's SEMP
  - Inputs and recommendation on the detailed plan and schedule including inputs on sufficient resources to continue design and development (i.e., IMP/IMS)
  - Results and recommendations from assessments of contractor(s) and supply chain capability to mature the proposed design(s)
  - Results of manufacturing and quality design producibility analyses
  - Analyses of materials availability, maturity, and characterization
  - Results of assessments and estimates of process maturity and capability for manufacturing and production processes
  - Analyses and recommendations for the contractor initial Manufacturing Plans concerning workforce requirements, skills, capabilities, training, and certifications
  - Analyses and recommendations for the contractor's tooling and facilities strategies
  - Analyses and recommendations for the contractor's Manufacturing Management System and plans

Tools

- AS6500 Manufacturing Management System Checklist
- AS9100 Quality Management System Checklist
- Cost Estimating Worksheet, Manufacturing
- ISO 9001 Quality Management System Checklist
- Manufacturing Readiness Level (MRL) Assessment Checklist
- Technology Readiness Level (TRL) Assessment Checklist
- Risk Assessment Tool

- Systems Engineering Plan (SEP) Outline
- System Requirements Review (SRR) Checklist
- System Functional Review (SFR) Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 Quality Systems – Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- Cost Analysis Guide, Nov 1989
- DoD 5000.60-H, DoD Handbook: Assessing Defense Industrial Capabilities, Apr 1996
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- NIST 800-171, Controls for Controlled Unclassified information, June 2015
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017
- MIL-STD-1472, DoD Design Criteria Standard: Human Engineering
- DoD HCI Style Guide, Human Computer Interaction (HCI), 1994
- Technology Readiness Assessment Guidance, Apr 2011
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits, Specifically 12.5.3 System Requirements Review (SRR), 12.5.4 and System Functional Review (SFR)
- Guide to Environment, Safety, and Occupational Health (ESOH) in the Systems Engineering Plan (SEP), no date
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, Jan 2017
- Systems Engineering Plan (SEP) Outline, Jun 2015

A.2 Provide Manufacturing and Quality Updates to Program Documentation

Manufacturing and Quality Tasks

- Based on the results, action items, and resolutions pertaining to manufacturing and quality requirements and concerns from the SRR and the SFR, update the Manufacturing Strategy and Quality Strategies to address development and considerations of:
    - Competition and contracting strategies
    - Management (quality, manufacturing, supply chain, risks, etc.)
    - Design (feasibility, producibility, KCs, risks, etc.)

- New manufacturing technologies
- Modular Open Systems Approach (MOSA)
- Intellectual Property rights (including deliverables and associated license rights over the entire product life cycle)
- Materials (characteristics, sourcing, risks, etc.)
- Cyber threat protection measures (See L.2)
- Integrated Product Support Plan
- Process, rates, and quantities (capabilities, control, risks, etc.) (See H.1)
- Facilities, Tooling, and Workforce (including GFE/GFI, STE/SIE, special requirements, etc.)

- Provide in the Manufacturing and Quality Strategies detailed manufacturing and quality requirements for:
  - Rates, quantities, and schedule (including reference to Economic Order Quantity and the affordability targets)
  - Manufacturing maturity and progress against manufacturing and quality goals required for each technical review (SRRs, PDRs, CDRs, and at other appropriate reviews)
  - Human safety and health
  - Hazardous materials management and pollution prevention
  - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security parameters (physical and cyber) for both hardware and software
  - KPPs (i.e., KCs)
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data)
  - Supportability and sustainment
  - Use of priorities, allocations, and allotments, and justification
  - Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
  - Parts, materials, and processes (PM&P)

- Update the Manufacturing Strategy and Quality Strategy to address the sustainment of industrial capabilities (including manufacturing technologies and capabilities) and the maturation required during the EMD and subsequent phases.
  - Provide manufacturing and quality inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystem, item, and component levels.
  - Provide manufacturing and quality inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
    - Domestic alternatives through regeneration of prior capability
    - Creation of new capability for manufacturing products and processes

497 ▪ Lifetime buy of items at the subsystems, and component levels

498 • Incorporate planning for new or high-risk manufacturing capabilities and processes
499 Manufacturing Technology (ManTech) in the Manufacturing Strategy that addresses risks,
500 issues, and opportunities in the EMD phase. (See D.2)

501 o If this new manufacturing capability can be demonstrated in TMRR phase in a relevant
502 manufacturing environment, specify this demonstration in the plans
503 o Include insertion of the new manufacturing capability in planning for EMD

504 • Initiate the manufacturing and quality Industrial Base (IB) capability analyses updates for
505 inclusion in the Acquisition Strategy and the RFP to include inputs on:

506 o IB capabilities, fragility, gaps, and risks for the Acquisition Strategy (e.g., key
507 technologies and key and critical processes, parts, components, etc.)
508 o Capability of the IB to design, develop, produce, support, and restart the acquisition
509 program, if appropriate
510 o Impacts and interdependencies of this acquisition on the National Technology Industrial
511 Base (NTIB) and the analyses used to make this determination

512 ▪ Include how they will be managed
513 ▪ Include plans for future assessments, including frequency

514 o Government strategy and actions necessary to preserve the IB capabilities (e.g.,
515 incentives for the contractor to support IB capability preservation, ManTech/Title III
516 initiatives, etc.)

517 • Provide manufacturing and quality inputs to Acquisition Strategy for a contracting strategy
518 that supports selection of the best course of action through either a competitive award, a sole
519 source award, or multiple source development to include:

520 o Manufacturing and quality metrics to differentiate the value of each contract type to
521 include performance, capacity, functional, economic, etc.
522 o Impacts and risks, issues, and opportunities that may result from different contract types
523 (Firm Fixed Price (FFP), Fixed Price Incentive Fee (FPIF), Cost Plus Fixed Fee (CPFF),
524 etc.)
525 o Prototyping approach for EMD, either competitive, single, or prototyping of critical
526 subsystems (statutory requirement for Major Defense Acquisition Program (MDAP) AS,
527 regulatory requirement for all other programs)
528 o Potential production approach for EMD and subsequent phases

529 • Update manufacturing and quality inputs to the Acquisition Strategy for EMD with a source
530 selection approach that establishes and maintains access to competitive suppliers at the
531 system, subsystem, and component level (e.g., requiring a modular open systems approach,
532 alternative sources of supplies or services, etc.).

- Provide updated manufacturing and quality requirements as inputs for required technical reviews, production decisions, events, prototypes, and deliveries, including sub-tier subsystem, item, and components, to be included in the Acquisition Strategy based on:
  - Reports and data from Defense Contract Management Agency (DCMA)
  - Analyses materials availability (lead-time and scale-up) and maturity (characterization)
  - Contractor data on rates and yields for manufacturing and quality
  - Analyses of manufacturing and quality maturity and projections
  - Reports on facilities, tooling, and workforce utilization
  - Updated capital equipment requirements
- Provide updated manufacturing and quality inputs and plans to the IMP/IMS including:
  - Schedule for any planned use of government-furnished special test equipment (STE), government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.).
  - Schedule impacts from the requirements for special materials and allotments, and the reasons for them if applicable
  - Manufacturing and quality internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
  - Inputs on reviews down to the sub-tier level (including PDR, CDR, PRR, etc.), documentation inputs (e.g., draft CDD, TEMP, AS, SEP, PDR, etc.), production events, and deliveries
- Update the government Manufacturing Management and Quality Management approach for EMD to include: (See I.1 and L.2)
  - Changes in manufacturing and quality requirements
  - Manufacturing and quality resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to manufacturing and quality organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
  - Changes to manufacturing and quality support organization required to meet program projected needs for EMD and subsequent phases including:
    - Earned Value Management requirements
    - Cost control requirements
    - Data collection, reporting, and management
- Update the manufacturing and quality requirements for the EMD contractor's Manufacturing Management System (MMS) and Quality Management System (QMS).
  - Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - If manufacturing and quality standards are not specified, develop requirements for program specific manufacturing management plan and quality management plan.

572 - Identify manufacturing and quality opportunities, initiatives, and systems that will
573 contribute to minimizing cost, schedule, and performance risks throughout the product
574 life cycle

575 • Update requirements for identification, analysis, mitigation, tracking, and control of
576 manufacturing and quality risks, issues, and opportunities that impact performance, technical,
577 cost, schedule, sustainment, and programmatic areas throughout the life of the program.

578 - Ensure a joint manufacturing and quality comprehensive Risk, Issue, and Opportunity
579 (RIO) Management Process that is capable of identifying and tracking risks and
580 associated mitigation plans is in place

581 • Analyze identified manufacturing and quality risks, issues, and opportunities, and associated
582 mitigation plans for adequacy and completeness, and potential impacts on EMD and
583 subsequent phases to include:

584 - Risk of industry being unable to provide program design or manufacturing capabilities at
585 planned cost and schedule
586 - Materials, facilities, workforce, interdependencies with other programs, manufacturing
587 technology gaps, quality, software and engineering related risks, issues etc.
588 - Required maturation of critical technologies and manufacturing processes to the
589 appropriate level
590 - Manufacturing and quality cost and schedule impacts

591 • Update manufacturing and quality exit criteria metrics for TMRR and subsequent phase
592 decision points.

593 - Metrics should include current and projected manufacturing and quality maturity of
594 identified critical technologies and manufacturing processes
595 - Metrics should also include the planned Manufacturing Readiness Level (MRL) targets
596 for system, subsystems, components, and items

597 • Update the manufacturing and quality support plan for an assessment of manufacturing
598 readiness and the mandated independent assessment.
599 • Ensure other agencies are providing inputs on strategies (e.g., DCMA, Defense Logistics
600 Agency (DLA), etc.) for quality, manufacturing, production, engineering, software
601 development, configuration management, testing and quality.
602 • Manufacturing and quality updated inputs to the SEP and TEMP include the following:

603 - Manufacturing and quality updates and impacts on all KPPs including the mandatory
604 KPPs (Force Protection, System Survivability, Sustainment, and Energy)
605 - Planned significant activities indicated on the up-to-date EMD program schedule

606 ▪ Manufacturing assessments
607 ▪ Long-lead or advanced procurements
608 ▪ Prototype builds
609 ▪ Projected lots or phases

- Production Readiness Review

- Updated inputs to the program Risk, Issue, and Opportunity Management process and plans which include:
  - Industrial risks
  - Manufacturing risks
  - Quality risks
  - Engineering risks
  - Software risks
  - Production risks
  - Risk reduction and mitigation efforts
- Updated Program Manufacturing Management Plan addressing software development and reuse.
- Updated manufacturing and quality inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
  - Compliance with Defense Federal Acquisition Regulation Supplement (DFARS), Program Protection Plan (PPP), International Trafficking in Arms Regulation (ITAR), etc.
  - Management of Controlled Unclassified Information
  - Technical approaches to cybersecurity and related manufacturing and quality security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
- Updated Program Manufacturing Management Plan addressing each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management
- Updated inputs on the manufacturing and quality organization, billets and key assignments including
  - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
- Updated manufacturing and quality planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
- Updated manufacturing and quality inputs to the configuration managed IMP/IMS including critical path

Metrics

- Manufacturing Strategy and Quality Strategies have been updated based outputs from the SRR and SFR pertaining to manufacturing and quality requirements and concerns and address:
  - Competition and contracting strategies
  - Management (quality, manufacturing, supply chain, risks, etc.)
  - Design (feasibility, producibility, KCs, risks, etc.)
  - New manufacturing technologies
  - Modular Open Systems Approach (MOSA)
  - Intellectual Property rights (including deliverables and associated license rights over the entire product life cycle)
  - Materials (characteristics, sourcing, risks, etc.)
  - Cyber threat protection measures (See L.2)
  - Integrated Product Support Plan
  - Process, rates, and quantities (capabilities, control, risks, etc.) (See H.1)
  - Facilities, Tooling, and Workforce (including GFE/GFI, STE/SIE, special requirements, etc.)
- Manufacturing and Quality Strategies contain detailed manufacturing and quality requirements for:
  - Rates, quantities, and schedule (including reference to Economic Order Quantity and the affordability targets)
  - Manufacturing maturity and progress against manufacturing and quality goals required for each technical review (SRRs, PDRs, CDRs, and at other appropriate reviews)
  - Human safety and health requirements
  - Hazardous materials management and pollution prevention
  - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security parameters (physical and cyber) for both hardware and software
  - KPPs and resulting KCs
  - Data management and software which includes collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data
  - Supportability and sustainment requirements
  - Use of priorities, allocations, and allotments, and justification
  - Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
  - Parts, materials, and processes (PM&P)
- Manufacturing Strategy and Quality Strategies have been updated to address the sustainment of industrial capabilities (including manufacturing technologies and capabilities) and the maturation required during the EMD and subsequent phases.
  - Manufacturing and Quality Strategies contain plans for mitigation of product or component obsolescence, use and replacement of limited-life items, unique more efficient

688 manufacturing processes and products (avoidance or regeneration), and converting off-
689 the-shelf items to required specifications at the subsystems, item, and component levels
690 - Manufacturing and Quality Strategies contain plans for mitigation of products or
691 components from sole, single, fragile, or foreign sources including options for:
692 - Domestic alternatives through regeneration of prior capability
693 - Creation of new capability for manufacturing products and processes
694 - Lifetime buy of items at the subsystems, and component levels

695 • Manufacturing Strategy incorporates plans for new or high-risk manufacturing capabilities
696 and processes (ManTech) to be utilized in addressing and mitigating risks, issues, and
697 opportunities in the EMD phase. (See D.2)
698 - Plans specify demonstration of new manufacturing capability TMRR phase in a relevant
699 manufacturing environment
700 - Plans also specify insertion (how and when) of the new manufacturing capability during
701 EMD

702 • Manufacturing and quality Industrial Base (IB) capability analyses have been updated and
703 provided as manufacturing and quality input for the Acquisition Strategy and the RFP and
704 includes inputs on:
705 - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical
706 processes, parts, components, etc.)
707 - Capability of the IB to design, develop, produce, support, and restart the acquisition
708 program, if appropriate
709 - Impacts and interdependencies of this acquisition to the NTIB and the analyses used
710 - Including how they will be managed
711 - Including plans for future assessments, including frequency
712 - Government strategy and actions necessary to preserve the IB capabilities (e.g.,
713 incentivizing the contractor to support IB capability preservation, ManTech/Title III
714 initiatives, etc.)

715 • Manufacturing and quality inputs on a contracting strategy that supports selection of the best
716 course of action through either a competitive award, a sole source award, or multiple source
717 development have been provided as input to the Acquisition Strategy including:
718 - Manufacturing and quality impacts and risks, issues, and opportunities that may result
719 from different contract types (FFP, FPIF, CPFF, etc.)
720 - Manufacturing and quality metrics that differentiate the value of each contract type to
721 include performance, capacity, functional, economic, etc.
722 - Prototyping approach for EMD, either competitive, single, or prototyping of critical
723 subsystems (statutory requirement for MDAP AS, regulatory requirement for all other
724 programs)
725 - Potential production approach for EMD and subsequent phases

- Manufacturing and quality inputs to the EMD source selection approach have been provided as input to the Acquisition Strategy to establish and maintain access to competitive suppliers at the system, subsystem, and component level (e.g., requiring a modular open systems approach, alternative sources of supplies or services, etc.).
- Updated manufacturing and quality requirements have been provided as inputs to both the Acquisition Strategy and the SEP for required technical reviews to be conducted, production decisions, events, prototypes, and deliveries, including sub-tier subsystem, item, and components, based on:
    - DCMA reports and data
    - Results of materials availability (lead-time and scale-up) and maturity (characterization) analyses
    - Contractor data on rates and yields for manufacturing and quality
    - Manufacturing and quality process maturity and projections
    - Reports on utilization of facilities, tooling, and workforce
    - Updated capital equipment requirements
- Updated manufacturing and quality inputs and plans have been provided and incorporated in the IMP/IMS including:
    - Schedule and plans for use of government-furnished STE, government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.).
    - Schedule impacts for special materials and allotments
    - Manufacturing and quality internal and external interdependencies and integration with existing programs, systems, and other programs in development that impact the critical path
    - Inputs on reviews that include the sub-tier level (e.g., PDR, CDR, PRR, etc.), documentation inputs (e.g., draft CDD, TEMP, AS, SEP, PDR, etc.), production events, and deliveries
- Manufacturing Management and Quality Management Strategies for EMD have been updated and include: (See I.1 and L.2)
    - Changes in manufacturing and quality requirements
    - Manufacturing and quality resource management (minimizing cost, schedule, and performance risks for the product life cycle)
    - Changes to manufacturing and quality organization and staffing with KLP and necessary skilled manpower
    - Changes to manufacturing and quality support organization required to meet program projected needs for EMD and subsequent phases including:
        - Earned Value Management requirements
        - Cost control requirements
        - Data collection, reporting, and management

- Requirements for the EMD contractor's Manufacturing Management System and Quality Management System have been updated and provided as inputs for the EMD RFP, SSP, and award fee criteria.
    - Standards have been specified to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
    - If manufacturing and quality standards are not specified, requirements have been developed for program specific manufacturing management plan and quality management plan
    - Manufacturing and quality opportunities, initiatives, and systems have been provided that contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- Requirements for identification, analysis, mitigation, tracking, and control of manufacturing and quality risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program have been updated.
    - A joint manufacturing and quality comprehensive Risk, Issue, and Opportunity Management Process has been established that identifies and tracks risks and associated mitigation plans.
- Manufacturing and quality risks, issues, and opportunities, and associated mitigation plans have been analyzed for adequacy and completeness, and impacts and results documented for EMD and subsequent phases including:
    - Risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule
    - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
    - Maturation of critical technologies and manufacturing processes to the appropriate level
    - Manufacturing and quality cost and schedule impacts
- Manufacturing and quality exit criteria metrics for TMRR and subsequent phase decision points have been documented in the PDR checklist for the Milestone Decision process.
    - Metrics include current and projected manufacturing and quality maturity of identified critical technologies and manufacturing processes
    - Metrics also include the planned MRL targets for system, subsystems, components, and items
- Manufacturing and quality support plan for assessments of manufacturing readiness has been updated and documents the required support for the mandated independent assessment.
- Other agencies' (e.g., DCMA, DLA) support and inputs on strategies for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality have been requested, received, and documented.
- Manufacturing and quality provided updates to the SEP and TEMP document the following:

- Manufacturing and quality updates and impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
- Planned significant activities on the up-to-date EMD IMP/IMS including manufacturing assessments, long-lead or advanced procurements, prototype builds, projected lots or phases, Production Readiness Review, development testing, etc.
- Updated inputs to the program Risk, Issue, and Opportunity Management process and plans including industrial, manufacturing, quality, manufacturing engineering, manufacturing software and firmware, production risks, issues, and opportunities and associated reduction and mitigation efforts
- Updated manufacturing and quality inputs to the Program Manufacturing Management Plan addressing embedded software and firmware development and reuse
- Updated manufacturing and quality inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
  - Compliance with DFARS, PPP, ITAR, etc.
  - Management of Controlled Unclassified Information
  - Technical approaches to cybersecurity and related manufacturing and quality security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
- Updated Program Manufacturing Management Plan that addresses each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management
- Updated inputs on the manufacturing and quality organization, billets and key assignments including roles and responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
- Updated manufacturing and quality plans for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
- Updated manufacturing and quality inputs to the configuration managed IMP/IMS including critical path

Tools

- Acquisition Strategy Outline
- AS6500 Manufacturing Management System Checklist
- AS9100 Quality Management System Checklist
- CDD Template

- ISO 9001 Quality Management System Checklist
- Manufacturing Readiness Level (MRL) Assessment Checklist
- Technology Readiness Level (TRL) Assessment Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center Integrated Master Plan/Integrated Master Schedule use MS Project
- ManTech Proposal Rating Worksheet
- Risk Management Plan Template
- Systems Engineering Plan Outline
- TEMP Outline

Resources

- Acquisition Strategy Guide (DSMC0, Dec 1999)
- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 Quality Systems – Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- CDD Writing Guide, Feb 2015
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- ISO 9001:2015, Quality Management System
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- MRL Deskbook Version 2016
- NIST 800-171, June 2015, Controls for Controlled Unclassified Information
- Risk, Issue, and Opportunity Management Guide, Jan 2017
- RFP Proposal Evaluation Guide,
- Systems Engineering Plan (SEP) Outline, Jun 2015
- Test and Evaluation Management Guide, Dec 2012
- TRA Deskbook, Apr 2012
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017, Enclosure 2, 6.d.
- DoDD 4200.15, Manufacturing Technology (ManTech) Program, Dec 2003
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities, Apr 1996
- subpart 207.106 (S-70) of the Defense Federal Acquisition Regulation Supplement

A.3 Support Preliminary Design Review (PDR)

Manufacturing and Quality Tasks

- Ensure all manufacturing and quality system-level requirements, base-lined at the SRR and the SFR have been correctly decomposed or directly allocated to the appropriate subsystem, item, or component.
- Provide manufacturing and quality system, subsystem, item, and component requirements and inputs for the verification and validation entry/exit criteria required for the PDR process.
- Provide manufacturing and quality support to system (product), subsystem, item, and component design trades to finalize system requirements and configuration.
- Provide a manufacturing and quality assessment of the preliminary system-level design and margins for producibility and costs within the production budget.
- Assess all system (product), subsystem, item, and component physical and functional interfaces and architecture for manufacturing and quality feasibility and producibility (e.g., inspectability, manufacturability, etc.)
    - Include analyses of prototypes
- Assess the design for manufacturing and quality constraints and ensure they have been captured and incorporated into the allocated requirements.
- Provide analyses to identify all preliminary key and critical manufacturing and quality processes and characteristics to show traceability to system-level requirements and technical performance measures (e.g., KPPs, KSAs, TPMs) through the use of Failure Modes and Effects Analysis (FMEA) and similar analyses for design (DFMEA) and process (PFMEA).
    - Ensure all of the preliminary key and critical manufacturing and quality processes are defined and traceable to Critical Safety Items (CSI)and/or Critical Application Items (CAIs)
    - Identify initial process capability indexes for key and critical manufacturing processes
    - Analyze the contractor's identified major/critical sub-tier suppliers for their impact on or responsibility for KCs (and therefore KPPs/KSAs)
- Assess the preliminary system design for impacts on requirements to manufacturing and quality design, processes, and procedures, including:
    - Incomplete specifications of subsystem, items, and components (i.e., TBDs)
    - Change to subsystem, items, and components from re-design based on testing deficiencies or failures
    - Results and data from building and testing prototypes
    - Incorporation of Parts, Materials, and Processes allocated requirements
    - Requirements for computer system Hardware Configuration Items (HWCIs)
    - Analyses of mass properties including growth
    - MOSA requirements
    - Tooling design, testing, and schedule (including special tooling and test equipment)

914 - Security physical and cyber (e.g., processes, industrial control systems, anti-tamper
915 requirements, manufacturing resources and organization, etc.)
916 - Requirements for processes and procedures to control and mitigate EMI
917 - Human Machine Interface requirements
918 - ESOH requirements
919 - System safety requirements
920 - Hazardous materials and environmental controls (e.g., handling, contamination, pollution
921 control, disposal, etc.)
922 - Supportability and maintainability requirements

923 • Provide an assessment of requirements for manufacturing and quality data and data storage
924 including:

925 - Analyses and post processing
926 - Availability, integrity, and maintainability
927 - Communications and processing capacity
928 - User integrity

929 • Provide manufacturing and quality analyses of the Software Development Plan for physical
930 architectures, firmware integration, and physical interfaces that impact manufacturing and
931 quality processes, procedures, and schedule.
932 • Provide an assessment of long-lead materials and production requirements (e.g., components,
933 facilities, equipment, etc.).
934 • Provide an updated analysis of manufacturing and quality inputs to the TEMP include the
935 following:

936 - Manufacturing and quality updates and impacts on all KPPs including the mandatory
937 KPPs (Force Protection, System Survivability, Sustainment, and Energy)
938 - Planned significant activities indicated on the up-to-date EMD program schedule (e.g.,
939 manufacturing assessments, long-lead or advanced procurements, prototype builds,
940 projected lots or phases, PRRs, etc.)
941 - Updated inputs to the program Risk, Issue, and Opportunity Management System and
942 plans including industrial, manufacturing and production, quality, engineering, software
943 (firmware), and risk reduction and/or mitigation efforts
944 - Results of prototype builds, demonstrations, and tests and associated data
945 - Updated manufacturing and quality inputs from the contractor's management of defense
946 information and cyber incident reporting, compliance with DFARS, PPP, ITAR, etc.
947 - Updated planning for manufacturing and quality tests and assessments to be conducted,
948 facilities and test equipment to be used, metrics to be tracked, progress against goals,
949 thresholds and objectives, etc.

950 • Provide an updated assessment and analysis of the manufacturing and quality processes and
951 metrics included in the contractor's SEMP for completeness, adequacy, and alignment with
952 those processes and metrics included in the program SEP, including:

- Integration of any lower-level technical reviews and audits such as SFRs, PDRs, CDRs, PCAs, FCAs, and/or PRRs
- Identified risks and issues to be incorporated into mitigation and/or action plans
- Contractor's plan to CDR

- Provide an updated assessment of Program and contractor manufacturing and quality workforce plans and requirements for adequacy and completeness including:
  - Skills, capabilities, training, and certifications
  - Manufacturing and quality human resources (staffing and staffing plans)
  - Potential changes to organization and KLPs
- Update the Manufacturing and Quality Strategies to include plans for: (See A.1, I.5, and L.4)
  - Manufacturing maturity and progress against manufacturing and quality goals required for each technical review (SRRs, PDRs, CDRs, and at other appropriate reviews)
    - Definition and characterization of all manufacturing and quality processes
    - Manufacturing technology ongoing and future projects (ManTech)
    - Rates, yields, quantities, and schedule (including reference to Economic Order Quantity and the affordability targets)
  - KPPs (i.e., KCs)
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data)
  - Continued manufacturing and quality IB analyses on:
    - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical processes, parts, components, etc.)
    - IB capabilities to design, develop, produce, support, and restart the acquisition program, if appropriate
    - Impacts and interdependencies of this acquisition program to the NTIB
    - Government strategy and actions necessary to preserve the IB
  - Use of priorities, allocations, and allotments, and justification
  - Meeting IMP/IMS with acceptable risk for schedule and budget
  - Impacts and changes, requiring updates to the program's Configuration Items (i.e., GFE, GOTS, etc.) and contractor's supply chain (including COTS)
  - Impacts and changes, requiring updates to Program critical items and Critical Safety Items
  - Support of the failure reporting and corrective action system (FRACAS)
  - Updates and changes to the program Variability Reduction Plans
  - Support and inputs to the Life Cycle Sustainment Plans (LCSP)including Diminishing Manufacturing Sources Materials Sources (DMSMS), PM&P, and counterfeit parts
  - Human safety and health
  - Hazardous materials management and pollution prevention

- Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
- Security parameters (physical and cyber) for both hardware and software
- Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
- Products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
  - Domestic alternatives through regeneration of prior capability
  - Creation of new capability for manufacturing products and processes
  - Lifetime buy of items at the subsystems, and component levels

- Update the plans for a comprehensive joint manufacturing and quality Risk, Issue, and Opportunity Management Process for EMD that has the capacity to identify, monitor, and track risks and associated mitigation plans, including plans for:
  - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software, and engineering related risks and issues
  - Required maturation of critical technologies and manufacturing processes to the appropriate level
  - Manufacturing and quality cost and schedule impacts

- Provide analyses of demonstrations conducted in a production relevant environment to include verification of:
  - Prototypes (e.g., subsystems, items, and components)
  - Manufacturing processes with yield and rate data collected
  - Special Handling procedures
  - Workforce skills
  - Prototype tooling
  - Special test equipment/special inspection equipment (STE/SIE)
  - Acceptance test procedures
  - Modeling and Simulations (M&S)
  - Material maturity
  - Cost models
  - KCs
  - Producibility efforts
  - Manufacturing technology solutions

- Conduct a assessment and an analysis of Program manufacturing maturity against the MRL criteria.

Metrics

- Manufacturing and quality system-level requirements, base-lined at the SRR and the SFR have been verified to be correctly decomposed or directly allocated to the appropriate subsystem, item, or component and documented in the appropriate management system and available as evidence for the PDR.

  - Finalized design trades for manufacturing and quality system requirements and configurations have completed and documented for the PDR for system (product), subsystem, item, and component
  - All manufacturing and quality constraints have been captured, documented, and incorporated into the allocated requirements

- Manufacturing and quality system, subsystem, item, and component requirements and inputs for entry/exit criteria required for PDR have been documented as verified and at a minimum 50 percent have been validated for PDR.
- Manufacturing and quality assessments of the preliminary system-level design and margins for producibility and costs have been completed and documented for the Program Manager to be within the preliminary production budget.
- All system (product), subsystem, item, and component physical and functional interfaces and architecture, including prototypes, for manufacturing and quality feasibility and producibility (e.g., inspectability, manufacturability, etc.) have been assessed with acceptable risk and no TBDs remain.
- Analyses, through use of failure mode effects and criticality, have been conducted that identify all preliminary key and critical manufacturing and quality processes and characteristics. Traceability to system-level requirements and technical performance measures has been demonstrated and documented in the requirements tracking system including:

  - All of the preliminary key and critical manufacturing and quality processes are defined and traceable to Critical Safety Items and/or Critical Application Items
  - Initial process capability indexes for key and critical manufacturing processes have been identified
  - Contractor's identified major/critical sub-tier suppliers have been analyzed for their impact on or responsibility for KCs (ref. E.5)

- The preliminary system design has been assessed for impacts on requirements for manufacturing and quality design (e.g., tooling, equipment, facility layouts, etc.), processes, and procedures, and plans to mitigate and/or resolve have been documented for PDR including:

  - Completed specifications of subsystem, items, and components with no TBDs
  - Completed re-designs or modifications to subsystem, items, and components based on testing deficiencies or failures
  - Prototype results and data
  - Parts, Materials, and Processes allocations completed
  - Requirements for computer system Hardware Configuration Items (HWCI) defined and specified
  - Mass properties analyses completed
  - Modular Open Systems Approach defined

  - Tooling designs with testing and schedule completed (including special tooling and test equipment)
  - Security physical and cyber planning completed (e.g., processes, industrial control systems, anti-tamper requirements, manufacturing resources and organization, etc.)
  - Processes and procedures to control and mitigate EMI defined
  - Human Machine Interface requirements defined
  - Environmental Safety and Occupational Health requirements defined
  - System safety requirements and processes defined
  - Hazardous materials and environmental controls and processes defined and in place (e.g., handling, contamination, pollution control, disposal, etc.)
  - Supportability and maintainability requirements defined

- Manufacturing and quality data and data storage requirements have been assessed and defined and are documented in the PDR documentation and integrated into the Program Management System including:
  - Data analyses and post processing
  - Data availability, integrity, and maintainability
  - Communications and processing capacity
  - User integrity and control
- Manufacturing and quality analyses of the Software Development Plan for physical architectures, firmware integration, and physical interfaces have been conducted to document the impact on manufacturing and quality processes, procedures, and schedule for systems engineering and program management.
- [check] An assessment of long-lead materials and production requirements has been conducted and documents for PDR and in the IMP/IMS ordering requirements, capacity risks, issues, and opportunities (e.g., materials, facilities, and equipment) with the associated EMD budget projections.
- Manufacturing and quality inputs for the TEMP have been provided and include the following:
  - Manufacturing and quality updates and impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Planned significant activities indicated on the up-to-date EMD program schedule (e.g., manufacturing assessments, long-lead or advanced procurements, prototype builds, projected lots or phases, PRRs, etc.)
  - Updated inputs to the program Risk, Issue, and Opportunity Management System and plans including industrial, manufacturing and production, quality, engineering, software (firmware), and risk reduction and/or mitigation efforts
  - Results of prototype builds, demonstrations, and tests and associated data
  - Updated manufacturing and quality inputs from the contractor’s management of defense information and cyber incident reporting, compliance with DFARS, PPP, ITAR, etc.

- Updated planning for manufacturing and quality tests and assessments to be conducted, facilities and test equipment to be used, metrics to be tracked, progress against goals, thresholds and objectives, etc.

- Contractor's SEMP has been assessed and analyzed for PDR to determine completeness, adequacy, and alignment with manufacturing and quality processes and metrics documented in the updated Program SEP and the IMP/IMS. Recommendations provided for any shortfalls, including:
  - Integration of any lower-level technical reviews and audits such as SFRs, PDRs, CDRs, PCAs, FCAs, and/or PRRs
  - Identified risks, issues, and opportunities incorporated into mitigation and/or action plans
  - Contractor's detailed plan to CDR

- Updated assessment of Program and contractor manufacturing and quality workforce plans and requirements for adequacy and completeness has been completed and documents for PDR the required:
  - Skills, capabilities, training, and certifications
  - Manufacturing and quality human resources (staffing and staffing plans)
  - Changes to organization and KLPs

- Manufacturing and Quality Strategies for EMD have been updated for PDR and include plans for: (See A.1, I.5, and L.4)
  - Manufacturing maturity and progress against manufacturing and quality goals required for each technical review (CDRs, PRR, and at other appropriate reviews)
    - All manufacturing and quality processes
    - Ongoing and future manufacturing technology projects (ManTech)
    - Rates, yields, quantities, and schedule (including EOQ and affordability)
  - Managing and achieving KPPs (i.e., KCs)
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data)
  - Continued manufacturing and quality IB analyses on:
    - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical processes, parts, components, etc.)
    - IB capabilities to design, develop, produce, support, and restart the acquisition program, if appropriate
    - Impacts and interdependencies of this acquisition program to the NTIB
    - Government strategy and actions necessary to preserve the IB
  - Use of priorities, allocations, and allotments, and justification
  - Meeting IMP/IMS (critical path) with acceptable risks
  - Impacts, changes, and updates to the program's CIs (i.e., GFE, GOTs, etc.) and contractor's supply chain (including COTs)

- Impacts, changes, and updates to Program critical items and CSIs
- Support of the FRACAS
- Changes and support to the program Variability Reduction Plans
- Inputs and support to the LCSPs including DMSMS, PM&P, and counterfeit parts
- Human safety and health
- Hazardous materials management and pollution prevention
- Mitigation of environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
- Security parameters (physical and cyber) for both hardware and software
- Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
- Products or components from sole, single, fragile, or foreign sources including options for:
  - Domestic alternatives
  - Creation of new capability
  - Lifetime buys

- The comprehensive joint manufacturing and quality Risk, Issue, and Opportunity Management Process for EMD has been updated and documents the capacity to identify, monitor, and track risks, issues, and opportunities, and associated plans.
- Demonstrations have been conducted in a production relevant environment to verify and document manufacturing and quality maturity for PDR, and provide status of:
  - Prototypes (e.g., subsystems, items, and components)
  - Manufacturing processes with yield and rate data collected
  - Special Handling procedures
  - Workforce skills
  - Prototype tooling
  - STE/SIE
  - Acceptance test procedures
  - Modeling and Simulations (M&S)
  - Material maturity
  - Cost models
  - KCs
  - Producibility efforts
  - Manufacturing technology solutions
- MRL assessment has been conducted and an analysis of Program manufacturing maturity provided for PDR and as support to the independent program assessment.

Tools

- Preliminary Design Review Checklist

Resources

- AS6500, Manufacturing Management Program, Nov 2014
    - Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits
- DoDI 5000.02DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017, Jan 2017
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
    - MIL-STD-1521B, Jun 1985 (retired)
- MRL Deskbook Version 2016
    - Preliminary Design Review (PDR) Procedure, Oct 2016
- NDAA FY 2017 (Public Law 114-328)
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA), Jan 2009

A.4 Support Program Decision Reviews

Manufacturing and Quality Tasks

- Provide manufacturing and quality inputs and updates, for both the RFP Development Release Decision and the Milestone B Decision following post-PDR assessment results, the following statutory and regulatory program required updates to:
    - The Acquisition Strategy
        - Acquisition Approach
        - Business Strategy
        - Contracting Strategy (type and termination liability)
        - Cooperative Opportunities (if necessary)
        - General Equipment Valuation
        - Industrial Base Considerations
        - Intellectual Property Considerations
        - Market Research (for RFP DRD)
        - Modular Open Systems Approach
        - Multiyear Procurement
        - Risk, Issue, and Opportunity Management Process
        - Small Business Innovation Research/Small Business Technology Transfer (for RFP RDP)
    - Acquisition Program Baseline
    - Affordability Analysis

- Analysis of Alternatives
- Bandwidth Requirements Review
- Capability Development Document
- Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
- Exit Criteria
- Item Unique Identification Implementation Plan
- Life Cycle Sustainment Plan (LCSP)
- Low-Rate Initial Production (LRIP) Quantity
- PESHE and NEPA Compliance Schedule
- Program Protection Plan (PPP)
- Request for Proposal (RFP)
- Should Cost Target
- Spectrum Supportability Risk Assessment
- Systems Engineering Plan (SEP)
- Technology Readiness Assessment (TRA)
- Test and Evaluation Master Plan (TEMP)

- Provide PDR documentation of conducted demonstrations in a production relevant environment of manufacturing and quality maturity (including risks and mitigation) with status of:
  - Prototypes (e.g., subsystems, items, and components)
  - Manufacturing processes with yield and rate data collected
  - Special Handling procedures
  - Workforce skills
  - Prototype tooling
  - Special Test Equipment/Special Inspection Equipment (STE/SIE)
  - Acceptance test procedures
  - Modeling and Simulations (M&S)
  - Material maturity
  - Cost models
  - KCs
  - Producibility efforts
  - Manufacturing technology solutions
- Provide results of a MRL assessment and analyses that was conducted for PDR.

Metrics

- Manufacturing and quality inputs and updates, for both the RFP Development Release Decision and the Milestone B Decision following post-PDR assessment results, have been documented and provided for the following statutory and regulatory program required updates to:
  - The Acquisition Strategy

        - Acquisition Approach
        - Business Strategy
        - Contracting Strategy (type and termination liability)
        - Cooperative Opportunities (if necessary)
        - General Equipment Valuation
        - Industrial Base Considerations
        - Intellectual Property Considerations
        - Market Research (for RFP RDP)
        - Modular Open Systems Approach
        - Multiyear Procurement
        - Risk, Issue, and Opportunity Management Process
        - Small Business Innovation Research/Small Business Technology Transfer (for RFP RDP)
    - Acquisition Program Baseline
    - Affordability Analysis
    - Analysis of Alternatives
    - Bandwidth Requirements Review
    - Capability Development Document
    - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
    - Exit Criteria
    - Item Unique Identification Implementation Plan
    - Life Cycle Sustainment Plan (LCSP)
    - Low-Rate Initial Production (LRIP) Quantity
    - PESHE and NEPA Compliance Schedule
    - Program Protection Plan (PPP)
    - Request for Proposal (RFP)
    - Should Cost Target
    - Spectrum Supportability Risk Assessment
    - Systems Engineering Plan (SEP)
    - Technology Readiness Assessment (TRA)
    - Test and Evaluation Master Plan (TEMP)
- Documentation of conducted demonstrations for PDR of manufacturing and quality maturity (including risks and mitigation) in a production relevant environment has been provided with status of:
    - Prototypes (e.g., subsystems, items, and components)
    - Manufacturing processes with yield and rate data collected
    - Special Handling procedures
    - Workforce skills
    - Prototype tooling
    - STE/SIE
    - Acceptance test procedures

- Modeling and Simulations (M&S)
- Material maturity
- Cost models
- KCs
- Producibility efforts
- Manufacturing technology solutions

- Results of a MRL assessment and analyses that was conducted for PDR have been provided as input to program management.

Tools

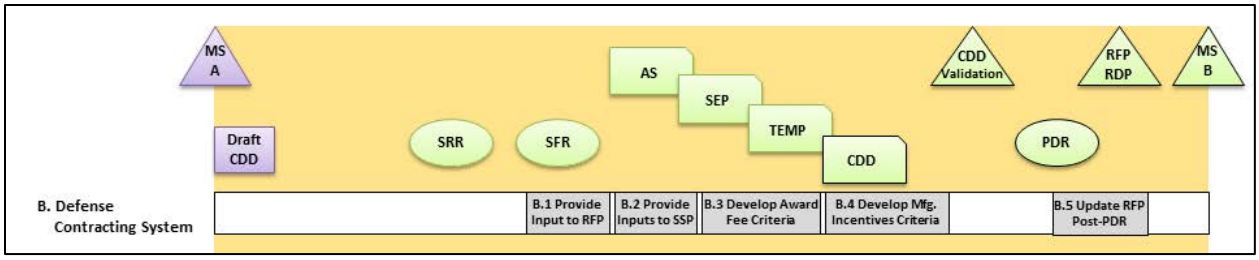
- Market Research using Pugh Template
- CARD use Cost and Lead Time Worksheet
- Life Cycle Sustainment Plan
- Technology Readiness Assessment (TRA)
- Manufacturing Readiness Level (MRL) Assessment
- Test and Evaluation Master Plan
- Integrated Master Plan/Schedule

Resources

- Affordability Analysis Tools, May 2015
- Life Cycle Sustainment Plan, see Product Support Manager Guide, Feb 2017
- DoD Market Research Guide, May 2012
- MRL Deskbook Version 2016
- TRA Deskbook, Apr 2012
- Test and Evaluation Management Guide, Dec 2012
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs

B. DEFENSE CONTRACTING SYSTEM

The contracting process is a partnership between the contracting office and program personnel. Contracting molds and shapes the procurement process and is ultimately responsible for contract award and administration. However, a cohesive effort between the contracts and program management including the participation of both contractual and technical subject matter experts is essential to managing and completing the steps in this phase of the contracting process.



The RFP is the primary opportunity to make inputs to the EMD contract and should be based on manufacturing and quality risks, issues, and opportunities discovered during TMRR. Typical areas to be included in the proposal include industry best practices for manufacturing management, quality management, and systems engineering. Other areas such as design and producibility, trade studies, manufacturing and quality technology investments, competition, materials (availability, counterfeit, and/or long-lead), data management, quality processes (capability studies), manufacturing and quality reporting and control, etc. should be addressed by manufacturing and quality. This list and other details should be addressed in the Statement of Work (SOW) and/or the Statement of Objectives (SOO).

As part of implementing industry best practices and meeting regulatory requirements, certain manufacturing and quality requirements need to be incorporated in the EMD RFP. For example, when the system under development meets the definitions in Federal Acquisition Regulation (FAR) 46.203 (Criteria for Use of Contract Quality Requirements, for Complexity and/or Criticality), FAR 46.202-4 requires supplier compliance with higher-level quality standards that should be addressed in the RFP. This may also require on-site government Quality Assurance personnel to perform source inspections.

Other Program requirements, often neglected during the contracting process, for manufacturing and quality input include:

- Direction for use of COTS items, GOTS items and NDIs.
- Determination of need to develop and maintain a FMECA
- Determination of intellectual property and data rights, maintenance, ownership and access for later phases.
- Direction for incorporation of manufacturing safety into System Safety Analyses.
- Determination of specialized system requirements, such as Flight Operations, Space Operations, etc.
- Determination of appropriate manufacturing and quality physical and cybersecurity requirements (e.g., data, information, control systems and networks, supply chain, etc.)
- Direction for inclusion of DCMA in an appropriate role to support the program

Manufacturing and quality personnel should be making early and significant inputs into EMD RFP documents and activities to ensure manufacturing and quality risks, issues, and opportunities will be considered. Having determined and provided the early and significant requirements for EMD, the

manufacturing and quality objective for the source selection plan is to develop criteria that ensure selection of the proposal that represents the best value to the government. The criteria for source selection should be realistic and address all of the above areas, especially industry best practices.

Award Fees can provide increased interaction of program and contractor manufacturing and quality management and provide the program with increased visibility into the contractor's best practices for manufacturing, quality, and supply chain processes and procedures. Award fees in the contract should be based on contractor performance to industry manufacturing and quality best practices and reward specific accomplishments such as:

- Producibility improvements
- Materials characterization in production relevant environment
- Manufacturing cost reduction efforts
- Manufacturing maturation plan risks burned down
- Variation and variability reduction
- Manufacturing process definition and characterization
- Progress in achieving the targeted Manufacturing Readiness Level
- Progress in maturation and demonstration of KCs (i.e., meeting KPPs/KSAs)
- Progress in achieving specific yield and rate goals
- Progress in meeting the EMD exit criteria

Incentives in the contract should be consistent with the AS and tied to goals for exceeding contract requirements and program expectations. Manufacturing and quality incentives in contracts are designed to obtain specific manufacturing and quality objectives by establishing reasonable and attainable criteria that can meet the goals or targets. These criteria must be clearly communicated to the contractor; and include appropriate incentive arrangements that will motivate contractor efforts that might not otherwise be emphasized and discourage contractor inefficiency and waste.

Important manufacturing and quality management goals and expectations to be exceeded in contract incentives include:

- Cost (e.g., cost reductions, should costs, life cycle costs)
- Schedule (e.g., expedited development or delivery, early delivery, on-time delivery, etc.)
- Technical (e.g., quality, reliability, maintainability, product improvement, etc.)
- Management commitment
- Producibility processes
- Risk, Issue, and Opportunity Management processes
- Commercial best practices

The success of an enterprise's manufacturing and quality system is directly related to the commitment of the enterprise to the quality and producibility elements presented in the contract and the ability of the successful contractor to implement them effectively.

The learning curve (cost improvement curve, or experience curve) is a well-known approach to modeling many effects, such as the effect of quantity on cost. Generally, people and organizations learn to do things more efficiently when performing repetitive tasks. Learning curves are used as a measurement of progress in processes and procedures. Learning curves show that as the number of units produced doubles, the unit cost decreases in a predictable pattern. This technique continues as an industry standard today both in commercial and government applications. Manufacturing and quality should be developing the appropriate learning curves for the system and the plans for data collection to support further development.

Prior to the RFP RDP, but post manufacturing and quality analyses of the PDR, the manufacturing and quality inputs provided to the RFP should be reviewed to include:

- Overall affordability
- Competition strategy and incentive structure
- Provisions for small business utilization
- Source selection criteria
- Manufacturing and quality trades
- Capability requirements
- Security requirements
- Should Cost goals
- Risk, issue, and opportunity management
- Manufacturing and quality schedule

B.1 Provide Input to EMD Request for Proposal (RFP)

Manufacturing and Quality Tasks

- Ensure that manufacturing and quality personnel are included in the EMD Request for Proposals (RFP) writing and review teams.
- Specify the requirements for best practices for the contractor's Manufacturing Management System (MMS) (per Section L.2) and Quality Management System (QMS) (per Section I.1 and per FAR 52.246-11, Higher-Level Contract Quality Requirement) to be used (e.g., AS6500, ISO 9000, AS9100, etc.).
    - Specify the requirements for the contractors to identify and to describe their proposed specific processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks associated with the proposed system
    - Specify a requirement for on-site government Quality Assurance personnel will have access to perform management system audits
    - Specify a requirement for on-site government Quality Assurance personnel to have access to perform source inspections and data monitoring

- If AS6500 is not invoked in the contract(s), the manufacturing management requirements cited in AS6500 should be the basis for specific contractual requirements for a contractor plan. The requirements, at a minimum, should specify that the contractor addresses:
  - Manufacturing Management System:
    - Documenting how, when, and by whom each requirement of their system is to be accomplished, and define the authority and responsibility for each.
  - Design Analysis for Manufacturing:
    - Conducting producibility analyses
    - Identifying and managing key and critical characteristics in the Technical Data Package (TDP)
    - Implementing Variability Reduction (VR) to reduce part to part variation of key and critical characteristics
    - Identifying and managing key and critical manufacturing processes
    - Conducting FMEA on critical manufacturing processes (PFMEA)
  - Manufacturing Risk Identification:
    - Integrating manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
    - Conducting and documenting manufacturing feasibility assessments for a competing design alternative
    - Identifying MRL targets and documenting manufacturing risks through the MRL assessments
  - Manufacturing Planning:
    - Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing modeling and simulation, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities.
  - Manufacturing Operations Management including:
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - Production Process Verification
    - First Article Inspections and First Article Tests
    - Supplier Management and Quality

- If ISO 9000 or AS9100 is not invoked in the contract(s), the quality management requirements cited in the standards should be the basis for specific contractual requirements for a contractor plan. The requirements, at a minimum, should specify that the contractor addresses:
  - Quality Management Leadership
    - Leadership and Commitment
    - Policy
    - Organizational Roles, Responsibilities, and Authorities
  - Quality Planning
    - Actions to Address Risks and Opportunities
    - Quality Objectives and Planning
    - Planning of Changes
  - Quality Support
    - Resources
    - Competence
    - Awareness
    - Communication
    - Documented Information
  - Operation
    - Operational Planning and Control
    - Requirements for Products and Services
    - Design and Development of Products and Services
    - Control of Externally Provided Processes, Products, and Services
    - Production and Service Provision
    - Release of Products and Services
    - Control of Non-conforming Outputs
  - Quality Performance
    - Monitoring, Measurement, Analyses, and Evaluation
    - Internal Audit
  - Quality Improvement
    - Nonconformity and Corrective Actions
    - Continual Improvement
- As a basis for RFP EMD requirements and inputs, analyze the TMRR manufacturing and quality output from:
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, feasibility, and manufacturability studies and analyses
  - Tooling, facility, and workforce analyses

- Prototype demonstrations and development tests
- Materials analyses
- Make/buy processes and analyses
- Costs and budget analyses
- Market research and analyses
- Modeling and simulations analyses
- Process Capability Studies
- Environmental studies and risks (PESHE)
- Manufacturing and quality processes and data
- Work measurement/learning curve analyses
- Industrial Base studies

- Specify appropriate requirements for manufacturing and quality Contract data Requirements List (CDRL), Data Item Description (DID), etc. to support manufacturing and quality processes, include the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.)
  - Specify a requirement for on-site government Quality Assurance personnel will have access to perform source inspection of the plan (include on-site government Quality Assurance personnel in contractual distribution of the program Quality Plan (ref. I.1))
- Specify industry manufacturing and quality best practices for Systems Engineering to be used (e.g., IEEE 15288, -1, -2, etc.) in the EMD RFP.
  - Include requirements for the contractors to identify and to describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specify contractual manufacturing and quality requirements for:
  - Content for SOW, SOO, and contract sections C, L, M, and H
  - Conducting manufacturing and quality reviews of engineering and software (with frequency of reviews)
  - Intellectual property and government technical/manufacturing data rights, maintenance, ownership, and access
  - Identification and description of producibility efforts including cost sharing and incentive plans relevant to the solution
  - Plans for facilities, tooling, test equipment, workforce (e.g., training, certifications, etc.), and supply chain management
  - Plans for material availability including make/buy, long-lead, sources and risks (sole, single, foreign, fragile, and critical)
  - Utilizing analyses of failure mode effects and criticality (e.g., FMECA, DFMEA, PFMEA) from the system level down to the component level (i.e., throughout the supply chain)
  - Definition and traceability of CSI and/or CAIs to all preliminary key and critical manufacturing and quality processes

- Conducting analyses of manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Providing manufacturing and quality information for costs, cost models, and cost estimates that include rate, alternate materials, quantity, etc. (including Cost of Quality data)
- Plans for establishing and meeting EMD required process capability (Cpk) goals
- Identification and description of manufacturing technology capability improvements
- Encouraging investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- Implementing (or continuing) a joint risk, issue, and opportunity management and mitigation program that includes manufacturing and quality (including industrial base risks)
- Implementing (or continuing) a manufacturing and quality variability reduction program
- Appropriate cyber threat protection measures including
  - Safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
  - Compliance with NIST 800-82 Guide to Industrial Control Systems Security
- Managing materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
- Utilizing COTS, GOTS, GFE, and NDIs
- Metrics to be met as exit criteria for EMD phase

- Provide manufacturing and quality inputs and support to specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specify the requirement that the contractor support and/or conduct as required manufacturing and quality:
  - Technical reviews and audits including CDR, TRR, PRR, Physical Configuration Audit (PCA), Functional Configuration Audit (FCA), etc.
  - MRL assessments with trained personnel utilizing the MRL criteria
  - Independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment

- Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
- Joint risk, issue, and opportunity management meetings to manage mitigation activities

Metrics

- Appropriate requirements for best practices for the contractor's MMS (Section L.2) and QMS (Section I.1) (e.g., AS6500, ISO 9000, AS9100, etc.) have been incorporated in the EMD RFP.
  - Requirements specify that the contractors identify and describe their proposed specific processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks associated with the proposed system
  - Requirement specify that on-site government Quality Assurance personnel will have access to perform management system audits and access to perform source inspections and data monitoring
- If AS6500 is not invoked in the contract(s), the manufacturing management requirements cited in AS6500 are the basis for specific contractual requirements. The requirements, at a minimum, should specify that the contractor addresses and documents plans, procedures, and processes for:
  - Manufacturing Management System:
    - Documenting how, when, and by whom each requirement of their system is to be accomplished, and define the authority and responsibility for each.
  - Design Analysis for Manufacturing:
    - Conducting producibility analyses
    - Identifying and managing key and critical characteristics in the Technical Data Package (TDP)
    - Implementing Variability Reduction (VR) to reduce part to part variation of key and critical characteristics
    - Identifying and managing key and critical manufacturing processes
    - Conducting FMEA on critical manufacturing processes (PFMEA)
  - Manufacturing Risk Identification:
    - Integrating manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
    - Conducting and documenting manufacturing feasibility assessments for a competing design alternative
    - Identifying MRL targets and documenting manufacturing risks through the MRL assessments

- Manufacturing Planning:
  - Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing modeling and simulation, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities.
- Manufacturing Operations Management including:
  - Production Scheduling and Control
  - Manufacturing Surveillance
  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - Production Process Verification
  - First Article Inspections and First Article Tests
  - Supplier Management and Quality

- If ISO 9000, AS9100, or other quality best practices standards are not invoked in the contract(s), the quality management requirements cited in the standards are the basis for specific contractual requirements. The requirements, at a minimum, should specify that the contractor addresses and documents plans, procedures, and processes for:
  - Quality Management Leadership
    - Leadership and Commitment
    - Policy
    - Organizational Roles, Responsibilities, and Authorities
  - Quality Planning
    - Actions to Address Risks and Opportunities
    - Quality Objectives and Planning
    - Planning of Changes
  - Quality Support
    - Resources
    - Competence
    - Awareness
    - Communication
    - Documented Information
  - Operation
    - Operational Planning and Control
    - Requirements for Products and Services
    - Design and Development of Products and Services
    - Control of Externally Provided Processes, Products, and Services

        - Production and Service Provision
        - Release of Products and Services
        - Control of Non-conforming Outputs
    - Quality Performance
        - Monitoring, Measurement, Analyses, and Evaluation
        - Internal Audit
    - Quality Improvement
        - Nonconformity and Corrective Actions
        - Continual Improvement
- Manufacturing and quality EMD RFP requirements and inputs have been provided to the proposal team based on TMRR analyses and outputs from:
    - Risk, Issue, and Opportunity Management System and processes
    - Design producibility, feasibility, and manufacturability studies and analyses
    - Tooling, facility, and workforce analyses
    - Prototype demonstrations and development tests
    - Materials analyses
    - Make/buy processes and analyses
    - Costs and budget analyses
    - Market research and analyses
    - Modeling and simulations analyses
    - Process Capability Studies
    - Environmental studies and risks (PESHE)
    - Manufacturing and quality processes and data
    - Work measurement/learning curve analyses
    - Industrial Base studies
- Appropriate manufacturing and quality requirements for CDRLs, DIDs, etc. (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.) to support manufacturing and quality processes, including the corrective action and approval processes have been incorporated in the EMD RFP.
    - Requirements include access for on-site government Quality Assurance personnel to perform source inspection of the plan (ref. I.1)
- Manufacturing and quality best practices for Systems Engineering have been specified in the EMD RFP (e.g., IEEE 15288, -1, -2, etc.).
    - Requirements specify that the contractors identify and describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Contractual requirements for manufacturing and quality have been specified in EMD RFP to include:

- Content for SOW, SOO, and contract sections C, L, M, and H
- Conducting manufacturing and quality reviews of engineering and software (with frequency of reviews)
- Intellectual property and government technical/manufacturing data rights, maintenance, ownership, and access
- Identification and description of producibility efforts including cost sharing and incentive plans relevant to the solution
- Plans for facilities, tooling, test equipment, workforce (e.g., training, certifications, etc.), and supply chain management
- Plans for material availability including make/buy, long-lead, sources and risks (sole, single, foreign, fragile, and critical)
- Utilizing analyses of failure mode effects and criticality (e.g., FMECA, DFMEA, PFMEA) from the system level down to the component level (i.e., throughout the supply chain)
- Definition and traceability of CSIs and/or CAIs to all preliminary key and critical manufacturing and quality processes
- Conducting analyses of manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Manufacturing and quality data for costs, cost models, and cost estimates that include rate, alternate materials, quantity, etc. (including Cost of Quality data)
- Plans to meet required process capability (Cpk) EMD goals
- Identification and description of manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- Implementation of (or continuing) a joint risk, issue, and opportunity management and mitigation program that includes manufacturing and quality (including industrial base risks)
- Implementation of (or continuing) a manufacturing and quality variability reduction program
- Cyber threat protection measures including:
  - Safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper , and security-related activities such as physical security and industrial security
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information by manufacturing information systems.
  - Compliance with NIST 800-82 Guide to Industrial Control Systems Security

  - Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
  - Utilization of COTS, GOTS, GFE, and NDIs
  - Metrics to be met as exit criteria for EMD phase
- Manufacturing and quality inputs and metrics have been provided for the EMD RFP to support specialized system requirements, such as Flight Operations, Space Operations, etc.
- Requirements have been specified in the EMD RFP that the contractor support and/or conduct, as required, manufacturing and quality:
  - Technical reviews and audits including CDR, TRR, PRR, PCA, FCA etc.
  - MRL assessments with trained personnel utilizing the MRL criteria
  - Independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment
  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
  - Joint risk, issue, and opportunity management meetings to manage mitigation activities

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist, Sep 2016
- ISO 9001, Quality Management System Checklist, Sep 2016
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- IG5315.204-5(b) Section L Guide and Template
- IG5315.204-5(c) Section M Guide and Template

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.228-7001, Ground and Flight Risk
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017, Enclosure 14
- IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- MIL-STD-882, Rev. E, System Safety, May 2012
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

B.2 Provide Input to EMD Source Selection Plan (SSP)

Manufacturing and Quality Tasks

- Ensure that manufacturing and quality personnel are included in the EMD Source Selection Plan (SSP) writing and review team.
- Specify in the SSP metrics and scoring for application of manufacturing and quality industry best practices for the contractor's Manufacturing Management System and Quality Management System (e.g., AS6500, ISO 9000, AS9100, etc.).
    - Plan should include metrics and scoring for preferred specific processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks associated with the proposed system
    - Plan should include metrics and scoring for accommodation of on-site government Quality Assurance personnel to complete required management and quality audits and data collection
- If manufacturing management industry best practice requirements (i.e., AS6500) are not invoked in the contract(s), the requirements cited in AS6500 should be the basis for specific SSP metrics and scoring. Specify metrics that, at a minimum, include the contractor plans, processes, and procedures for:
    - Documenting how, when, and by whom each requirement of their manufacturing management system is to be accomplished, and defining the authority and responsibility for each.
    - Conducting producibility design analyses
    - Identification and management of key and critical characteristics in the TDP
    - Implementation of VR to reduce part to part variation of key and critical characteristics
    - Identification and management of key and critical manufacturing processes
    - Conducting Process FMEA on critical manufacturing processes
    - Integration of manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion

- Conducting and documenting manufacturing feasibility assessments for any competing design alternative
- Identification of MRL targets and documenting manufacturing risks through the MRL assessments
- Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing modeling and simulation, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities
- Production Scheduling and Control
- Manufacturing Surveillance
- Continuous Improvement
- Process Control Plans
- Process Capabilities
- Production Process Verification
- First Article Inspections and First Article Tests
- Supplier Management and Quality

- If ISO 9000 or AS9100 quality management industry best practices are not invoked in the contract(s), the requirements cited in the standards should be the basis for specific SSP metrics and scoring. Specify metrics that, at a minimum, include the contractor plans, processes, and procedures for:
  - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
  - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management
  - Quality support with resources, competence, awareness, communication, and documented information
  - Operation including operational planning and control, products and services requirements, and design and development
  - Control of externally provided processes, products, and services
  - Production and service provision
  - Release of products and services
  - Control of non-conforming outputs
  - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
  - Quality improvement including nonconformities and corrective actions, and continual improvement

- Utilizing analyses of TMRR manufacturing and quality outputs, specify metrics and scoring that at a minimum address the contractor(s) plans, processes, and procedures for:
  - Risk, issue, and opportunity management
  - Design producibility, feasibility, and manufacturability
  - Tooling, facility, and workforce

- Prototype demonstrations and development tests
- Materials management
- Make/buy management
- Costs and budgets
- Modeling and simulations
- Process capability management
- Hazardous materials, environmental and safety management
- Manufacturing and quality process and data management
- Work measurement/learning curve management
- Industrial security
- Supply chain management

- Specify metrics and scoring that ranks contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing manufacturing and quality CDRLs, DIDs, etc., including the requisite approval processes.
- Specify in the SSP metrics and scoring for application of manufacturing and quality industry best practices for the contractor's Systems Engineering management (e.g., IEEE 15288, -1, -2, etc.).
  - Include metrics and scoring for the contractors proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specify manufacturing and quality metrics and scoring on timeliness, completeness, accuracy, and alignment (corrective actions, if required) for:
  - Meeting each SOW, SOO requirements, and requirements for contract sections C, L, M, and H
  - Planning of manufacturing and quality reviews of engineering and software (with frequency of reviews)
  - Planning and processes for Intellectual Property management and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Planning and processes for producibility (including cost sharing and incentive plans relevant to the solution)
  - Plans for facilities, tooling, test equipment, workforce (e.g., training, certifications, etc.), and supply chain management
  - Planning and processes for materials including make/buy, long-lead, sources and risks (sole, single, foreign, fragile, and critical)
  - Plans for utilizing failure mode effects and criticality analyses (e.g., FMECA, DFMEA, PFMEA) from the system level down to the component level (i.e., throughout the supply chain)
  - Planning and processes for management of CSIs and/or CAIs, and all preliminary key and critical manufacturing and quality processes

- Planning and processes for manufacturing system safety analyses
- Planning and processes for providing manufacturing and quality information for costs, cost models, and cost estimates that include rate, alternate materials, quantity, etc. (including Cost of Quality data)
- Plans for establishing and processes for meeting EMD required process capability (Cpk) goals
- Planning for manufacturing technology capability improvements
- Plans for investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- Plans for implementing (or continuing) a joint risk, issue, and opportunity management and mitigation program that includes manufacturing and quality (including industrial base risks)
- Plans for implementing (or continuing) a manufacturing and quality variability reduction program
- Planning and processes for cyber-threat protection measures including:
  - Safeguarding manufacturing and quality information including supply chain risks
  - Designed in systems protection, hardware and software manufacturing network assurance (including suppliers), anti-tamper , and security-related activities such as physical security and industrial security
  - Anti-counterfeit practices
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
- Planning and processes for utilization of COTS, GOTS, GFE, NDI items

- Specify metrics and scoring that ranks contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specify manufacturing and quality metrics and scoring on timeliness, completeness, accuracy, and alignment (corrective actions, if required) for contractor planning and processes to support and/or conduct as required manufacturing and quality:
  - Technical reviews and audits including CDR, TRR, PRR, PCA, FCA, etc.
  - MRL assessments with trained personnel utilizing the MRL criteria
  - Independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment
  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions

- Joint risk, issue, and opportunity management meetings to manage mitigation activities

Metrics

- Metrics and scoring have been specified in the SSP for contractor's application of manufacturing and quality industry best practices for the contractor's Manufacturing Management System and Quality Management System (QMS) (e.g., AS6500, ISO 9000, AS9100, etc.).
  - Metrics and scoring include preferred specific processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks
  - Metrics and scoring include provisions for accommodation of on-site government Quality Assurance personnel to complete required management and quality audits and data collection
- If manufacturing management industry best practice requirements (i.e., AS6500) are not invoked in the contract(s), then specific metrics and scoring have been included that rank contractor plans, processes, and procedures for:
  - Documenting how, when, and by whom each requirement of their manufacturing management system is to be accomplished, and defining the authority and responsibility for each.
  - Producibility design analyses
  - Identification and management of key and critical characteristics in the TDP
  - Implementation of VR to reduce part to part variation of key and critical characteristics
  - Identification and management of key and critical manufacturing processes
  - Conducting Process FMEA on critical manufacturing processes
  - Integration of manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
  - Conducting and documenting manufacturing feasibility assessments for any competing design alternative
  - Conducting and documenting manufacturing risks through the MRL assessments with trained SMEs
  - Establishing and maintaining a Manufacturing Plan that includes supply chain and material management, manufacturing technology development, manufacturing modeling and simulation, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities
  - Production Scheduling and Control
  - Manufacturing Surveillance
  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - Production Process Verification
  - First Article Inspections and First Article Tests

- Supplier Management and Quality

- If quality management industry best practice requirements (e.g., ISO 9000, AS9100, etc.) are not invoked in the contract(s), then specific metrics and scoring have been included that rank contractor plans, processes, and procedures for:
  - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
  - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management
  - Quality support with resources, competence, awareness, communication, and documented information
  - Operation including operational planning and control, products and services requirements, and design and development
  - Control of externally provided processes, products, and services
  - Production and service provision
  - Release of products and services
  - Control of non-conforming outputs
  - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
  - Quality improvement including nonconformities and corrective actions, and continual improvement

- Specific metrics and scoring have been documented in the SSP that at a minimum address the contractor(s) plans, processes, and procedures for:
  - Risk, issue, and opportunity management
  - Design producibility, feasibility, and manufacturability
  - Tooling, facility, and workforce
  - Prototype demonstrations and development tests
  - Materials management
  - Make/buy management
  - Costs and budgets
  - Modeling and simulations
  - Process capability management
  - Hazardous materials, environmental and safety management
  - Manufacturing and quality process and data management
  - Work measurement/learning curve management
  - Industrial security
  - Supply chain management

- Specific metrics and scoring have been documented in the SSP that rank contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing manufacturing and quality CDRLs, DIDs, etc., including the requisite approval processes.

- Specific metrics and scoring have been documented in the SSP for application of manufacturing and quality industry best practices for the contractor's Systems Engineering management(e.g., IEEE 15288, -1, -2, etc.).
    - Metrics and scoring include the contractors proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specific manufacturing and quality metrics and scoring have been documented in the SSP for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for:
    - Meeting each SOW, SOO requirements, and requirements for contract sections C, L, M, and H
    - Planning of manufacturing and quality reviews of engineering and software (with frequency of reviews)
    - Planning and processes for intellectual property management and government technical/manufacturing data rights, maintenance, ownership, and access
    - Planning and processes for producibility (including cost sharing and incentive plans relevant to the solution)
    - Plans for facilities, tooling, test equipment, workforce (e.g., training, certifications, etc.), and supply chain management
    - Planning and processes for materials including make/buy, long-lead, sources and risks (sole, single, foreign, fragile, and critical)
    - Plans for utilizing failure mode effects and criticality analyses (e.g., FMECA, DFMEA, PFMEA) from the system level down to the component level (i.e., throughout the supply chain)
    - Planning and processes for management of CSIs and/or CAIs, and all preliminary key and critical manufacturing and quality processes
    - Planning and processes for manufacturing system safety analyses and in support of System Safety Assessments in accordance with MIL-STD-882
    - Planning and processes for providing manufacturing and quality information for costs, cost models, and cost estimates that include rate, alternate materials, quantity, etc. (including Cost of Quality data)
    - Plans for establishing and processes for meeting EMD required process capability (Cpk) goals
    - Planning for manufacturing technology capability improvements
    - Plans for investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
    - Plans for implementing (or continuing) a joint risk, issue, and opportunity management and mitigation program that includes manufacturing and quality (including industrial base risks)
    - Plans for implementing (or continuing) a manufacturing and quality variability reduction program

- Planning and processes for cyber-threat protection measures including:
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Compliance with NIST 800-82 Guide to Industrial Control Systems Security and anti-tamper, and security-related activities such as physical security and industrial security
  - Compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
  - Compliance with NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- Planning and processes for utilization of COTS, GOTS, GFE, and NDIs

- Specific metrics and scoring have been documented in the SSP that rank contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specific manufacturing and quality metrics and scoring have been documented in the SSP for timeliness, completeness, accuracy, and alignment (corrective actions, if required) of contractor planning and processes to support and/or conduct as required manufacturing and quality:
  - Technical reviews and audits including CDR, TRR, PRR, PCA, FCA etc.
  - MRL assessments with trained personnel utilizing the MRL criteria
  - Independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment
  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
  - Joint risk, issue, and opportunity management meetings to manage mitigation activities

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Source Selection Plan Template, USMC, Jan 2014

Resources

- AS6500, Manufacturing Management Program, Nov 2014

- AS9100, Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.228-7001, Ground and Flight Risk
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017, Enclosure 14
- DoD Source Selection Procedures Memo, Mar 2011AS6500, Manufacturing Management System
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016ISO 9001, Quality Management System
- MIL-STD-882, Rev. E, System Safety, May 2012
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

B.3 Develop EMD Award Fee Criteria

Manufacturing and Quality Tasks

Develop and provide manufacturing and quality input to Award Fee Criteria appropriate to the contract type and consistent with the Acquisition Strategy that specify periodic EMD phase goals address the necessary and appropriate manufacturing and quality, including supply chain, cost, schedule, and performance improvements (progress against goals) in the areas of:

- Manufacturing and quality CDRLs, DIDs, etc. submission and approval meet contract requirements (schedule)
- Compliance with cyber-threat protection and industrial security requirements
- Manufacturing, quality, and Industrial Base risk mitigations to schedule goals (#,%, milestones)
- Manufacturing readiness progress (MRL assessments) against targets including risk mitigations
- Manufacturing and producibility projects planned and completed (#/%)
- Initiation, development, and progress of manufacturing and quality learning curves (% to goals) including rates, yields, variability, process times, re-work and repair, etc.

- System design, specifications, and documentation completion, approval, and release for prototyping/manufacturing (progress against schedule)
- Manufacturing and quality systems design (production line, tooling, equipment, ManTech insertion, etc.) completion against plans (%)
- KC development, management, maturation, and demonstration to goals (% to goal and schedule progress)
- Technical Performance Measures (TPMs) (% progress to schedule)
- Manufacturing processes and advanced manufacturing capability development, improvement, and demonstration (#/% to goals)
- Management of CSIs and CAIs to requirements
- Process Capability development and improvement (Cpk value to goals)
- Quality improvement projects planned and completed (#/% to goals)
- Variation and Variability reduction efforts (initial yield rates and trends)
- Manufacturing improvement projects identified, planned, and implemented (#/% to goals)
- Materials characterized in production relevant environment (#/%)
- Materials management, characterization, and analyses completion against appropriate quality goals (#/%)
- Facilities and equipment development, completion, and demonstration (% to plan)
- Workforce development and management to plan (e.g., hiring, training, and reductions) (#/% to plan)
- Development testing completion to schedule (% successfully completed)
- Manufacturing costs and cost reduction with minimum periodic thresholds (#/%)
    - Cost sharing when goals are not met must also be specified.
- Quality costs and cost reduction with minimum periodic thresholds (#/%)
- Manufacturing Plan progress against completion (cost and schedule)
- Quality Plan progress against completion (cost and schedule)
- Manufacturing and quality safety system requirements (% compliance)
- Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
- Quality Management System compliance to best practices and/or contract requirements (# to standard)
- System Engineering management compliance to best practices for manufacturing and quality technical processes, technical management processes, and essential specialty engineering (# to standard)
- Progress toward meeting EMD exit criteria

Metrics

Manufacturing and quality inputs to Award Fee Criteria consistent with the Acquisition Strategy have been documented and specify periodic EMD phase goals that require manufacturing and quality

cost, schedule, and performance improvements including the supply chain, measured as progress against goals, for:

- Manufacturing and quality CDRLs, DIDs, etc., submission, approval, and corrective actions, meeting contract requirements (schedule)
- Compliance with cyber-threat protection and industrial security requirements
- Manufacturing, quality, and Industrial Base risk mitigations (#,%, milestones)
- Manufacturing readiness progress (MRL assessments against targets, including risk mitigations)
- Manufacturing and producibility projects (planned and completed, #/%)
- Manufacturing and quality learning curves (% to goals)
  - Include rates, yields, variability
  - Include process times, re-work and repair, scrap, etc.
- Prototype/manufacturing design specifications, drawings and documents completion, approval, and release (#/%)
- Manufacturing and quality systems design completion (#/%)
  - Production line, tooling, equipment, ManTech insertion, etc.
- Development, management, maturation, and demonstration of manufacturing and quality KCs and processes (#/%)
- TPMs
- Advanced manufacturing capability development, improvement, and demonstration (#/%/schedule)
- Monitoring and management of CSIs and CAIs to requirements (%)
- Development and improvement of manufacturing processes
  - Process Capability development and improvement (Cpks)
  - Quality improvement projects (#/%/schedule)
  - Variation and Variability reduction (yield, rates and trends)
  - Manufacturing improvement projects (#/%/schedule)
- Materials characterized in production relevant environment (#/%)
- Management and characterization of materials completion (rate/#/%)
- Completion and/or demonstration of facilities and equipment (%)
- Plans for, development, and management of the workforce (#/%)
  - Hiring, training, reductions, etc.
- Development testing completion (% successfully completed)
- Manufacturing costs and cost reduction with minimum periodic thresholds (#/%)
  - Cost sharing when goals are not met must also be specified
- Quality costs and cost reduction with minimum periodic thresholds (#/%)
- Manufacturing Plan progress (cost and schedule)
- Quality Plan progress (cost and schedule)

- Manufacturing and quality safety system progress (% compliance and schedule)
- Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
- Quality Management System compliance to best practices and/or contract requirements (# to standard)
- System Engineering management compliance to best practices for manufacturing and quality technical processes, technical management processes, and essential specialty engineering (# to standard)
- Progress toward meeting EMD exit criteria (#/%/schedule/cost)

Tools

- Aware Fee Template, USAF

Resources

- Air Force Award Fee Guide, Oct 2008 (Army and Navy guides available)
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016

B.4 Develop EMD Manufacturing Incentive Criteria

Manufacturing and Quality Tasks

- Develop and provide manufacturing and quality inputs to EMD Incentives Criteria appropriate to the contract type and consistent with the Acquisition Strategy that are tied to early investments with goals of exceeding contract requirements and program expectations. These should address appropriate manufacturing and quality cost, schedule, and performance improvements (including supply chain) in the areas of:
  - Strong management commitment to success through effective communications, team empowerment, and visibility in manufacturing and quality planning, teamwork, and execution
  - Assessments of lower tier supply chain for manufacturing readiness and maturity in advance of the System maturity targets (#/%)
  - Manufacturing cost (Δ$), cost reduction (%/$), and cost avoidance
  - Schedule improvements (such as increased slack time, expedited development, early delivery, or just-in-time implementation, etc.)
  - Technical enhancements beyond contract requirements in quality, reliability, maintainability, product improvement, yield, rates, etc.
  - Testing and reliability improvements positive trends (%)
  - Testing and demonstration beyond contract requirements (include test reductions)

- Quality improvement positive trends (acceleration of improvements %)
- Exceeding quality improvement goals
- Key and critical manufacturing process variation reduction (Cpk improvements on key and critical products beyond contract)
- Investments in modern manufacturing methods, software, and equipment including ManTech (cost share %)
- Materials characterization schedule improvements in additional environments beyond contract requirements (time)
- Variation and Variability reduction efforts exceeding contract requirements (yields, rates, and trends)
- Qualification and investments in additional sources within the U.S. IB ($)

Metrics

- Manufacturing and quality inputs to EMD Incentives Criteria consistent with the Acquisition Strategy have been documented are traceable to early investments that exceed contract requirements and program expectations. These incentives specify manufacturing and quality cost, schedule, and performance improvements (including supply chain) in the areas of:
  - Strong management commitment to success through effective communications, team empowerment, and visibility in manufacturing and quality planning, teamwork, and execution
  - Progress of Manufacturing Maturation Plan for lower tier supply chain manufacturing readiness and maturity against program goals (risk reductions to cost and schedule)
  - Manufacturing cost (Δ$), cost reduction (%/$), and cost avoidance
  - Schedule improvements (such as increased slack time, expedited development, early delivery, or just-in-time implementation, etc.)
  - Technical enhancements beyond contract requirements in quality, reliability, maintainability, product improvement, yield, rates, etc.
  - Testing and reliability improvements positive trends (%)
  - Testing and demonstration beyond contract requirements (include test reductions)
  - Quality improvement positive trends (acceleration of improvements %)
  - Exceeding quality improvement goals
  - Manufacturing processes against process capability (Cpk) (appropriate positive progress)
  - Key and critical manufacturing process variation reduction (Cpk improvements on key and critical products beyond contract)
  - Investments in modern manufacturing methods, software, and equipment including ManTech (cost share %)
  - Producibility enhancement and project completion (#/%) above contract requirements
  - Materials characterization schedule improvements in additional environments beyond contract requirements (time)
  - Variation and Variability reduction efforts exceeding contract requirements (yields, rates, and trends)
  - Qualification and investments in additional sources within the U.S. IB ($)

Tools

- Award Fee/Incentive Fee Plan

Resources

- FAR Subpart 16.4 Incentive Contracts
- DoD/NASA Incentive Contracting Guide
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016

B.5 Update RFP Post-PDR

Manufacturing and Quality Tasks

- If needed, update manufacturing and quality inputs to the RFP based on post-PDR assessment results (see A.3) and updates made to the following (see A.4):
  - The Acquisition Strategy
    - Acquisition Approach
    - Business Strategy
    - Contracting Strategy (type and termination liability)
    - Cooperative Opportunities (if necessary)
    - General Equipment Valuation
    - Industrial Base Considerations
    - Intellectual Property Considerations
    - Market Research (for RFP RDP)
    - Modular Open Systems Approach
    - Multiyear Procurement
    - Risk, Issue, and Opportunity Management Process
    - Small Business Innovation Research/Small Business Technology Transfer (for RFP RDP)
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives
  - Bandwidth Requirements Review
  - Capability Development Document
  - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - Life Cycle Sustainment Plan (LCSP)

- Low-Rate Initial Production (LRIP) Quantity
- PESHE and NEPA Compliance Schedule
- Program Protection Plan (PPP)
- Should Cost Targets
- Spectrum Supportability Risk Assessment
- Systems Engineering Plan (SEP)
- Technology Readiness Assessment (TRA)
- Test and Evaluation Master Plan (TEMP)

Metrics

- Manufacturing and quality updated inputs for changes to the RFP (post-PDR) have been documented and provided to program management for recommended potential changes in following:
  - The Acquisition Strategy
    - Acquisition Approach
    - Business Strategy
    - Contracting Strategy (type and termination liability)
    - Cooperative Opportunities (if necessary)
    - General Equipment Valuation
    - Industrial Base Considerations
    - Intellectual Property Considerations
    - Market Research (for RFP DRD)
    - Modular Open Systems Approach
    - Multiyear Procurement
    - Risk, Issue, and Opportunity Management Process
    - Small Business Innovation Research/Small Business Technology Transfer (for RFP DRD)
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives
  - Bandwidth Requirements Review
  - Capability Development Document
  - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - Life Cycle Sustainment Plan (LCSP)
  - Low-Rate Initial Production (LRIP) Quantity
  - PESHE and NEPA Compliance Schedule
  - Program Protection Plan (PPP)
  - Should Cost Targets
  - Spectrum Supportability Risk Assessment

- Systems Engineering Plan (SEP)
- Technology Readiness Assessment (TRA)
- Test and Evaluation Master Plan (TEMP)
- TBD

Tools

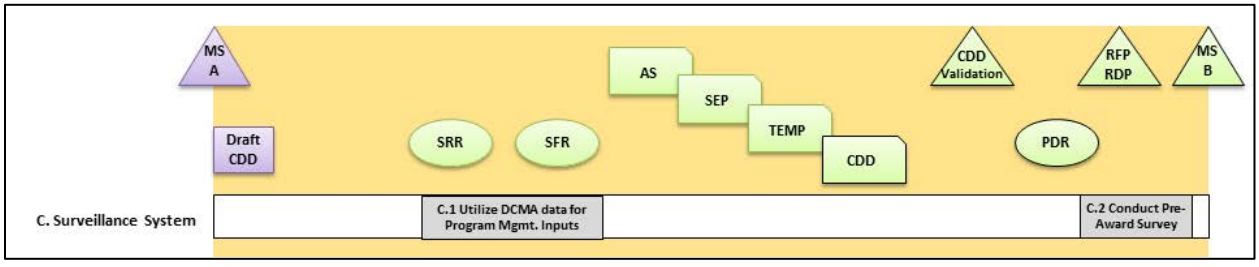
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist, Sep 2016
- ISO 9001, Quality Management System Checklist, Sep 2016
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- IG5315.204-5(b) Section L Guide and Template
- IG5315.204-5(c) Section M Guide and Template

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- ISO 9001, Quality Management System

C. SURVEILLANCE SYSTEM

The Program Manager should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. DCMA, utilizing a systematic approach to supplier manufacturing and supply chain evaluation, supply chain improvement initiatives, and best practices, is a valuable resource.



Effective quality management is required if the contractor is to deliver an operationally safe, suitable and effective system. The Quality Management System (QMS) assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The QMS serves as the control function within the systems engineering process, requiring control over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. The QMS also requires monitoring and measuring of processes and products to ensure they conform to requirements.

DCMA provides access to reliable and accurate QMS data and process information on costs, schedule, and technical performance and can assist with objective assessment of supplier plans and the verification of initial and continuing compliance with requirements. The ability to continually analyze risks and identify risk-adjusted solutions to sustain a reliable, technologically superior, efficient, cost-effective, and resilient defense industrial base mitigates overall program risk.

Manufacturing and quality should provide information, data, plans for the requirement to obtain DCMA analyses, supporting information, and recommendations as inputs to the program management and technical reviews.

A pre-award survey can focus on virtually every facet of the contractor's business operations from technical capability to financial stability, from quality assurance to plant safety. DCMA conducts nearly all pre-award surveys required by government buying activities. Manufacturing and quality should provide recommendations and inputs to program management for the pre-award survey requirements to be addressed by DCMA.

The process begins with a program request for a survey and concludes with a program decision based on a recommendation by a DCMA Contract Management Office (CMO) survey team. A pre-award survey can focus on virtually every facet of the contractor's business operations from technical capability to financial stability, from quality assurance to plant safety. In a sense, the survey process is the contractor's opportunity to provide evidence (i.e., Plan of Performance) that they can successfully fulfill the terms of the contract.

C.1 Utilize DCMA data for Program Management Inputs

Manufacturing and Quality Tasks

- Utilize the DCMA information and data to support manufacturing and quality inputs to the SRR to include:
    - Assessments of manufacturing and quality feasibility
    - Contractor(s) capability to meet manufacturing and quality requirements for:
        - Manufacturing Management System best practices (i.e., AS6500)
        - Quality Management System best practices (e.g., AS9100, ISO 9000, etc.)
        - Risk, Issues, and Opportunities Management System capabilities
        - Human safety and health

- Environmental and hazardous materials management (pollution prevention)
- Security (physical and cyber) for both hardware and software (e.g., communications, cyber, program protection, anti-tamper, etc.)
- Management of KCs
- Management of data and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data)
- Supportability and sustainment
- Use of COTS, GOTS, NDIs, and GFE (including diminishing manufacturing sources)
- Management of parts, materials, and processes (PM&P)
- Configuration Management System capabilities
- Specialized manufacturing requirements (extreme complexity, multiple or very tight tolerances, EMI protection, precision assembly, handling of fragile components and Electrostatic Discharge protection, etc.)
- Process capabilities and manufacturing operations
- Modeling and Simulation tools and capabilities
- Testing processes, equipment, and facilities capabilities
- Earned Value Management System capabilities
- Cost, Scheduling, and Control System capabilities
- Systems Engineering Management capabilities (i.e., IEEE 15288)
- Performance to plans and schedules (IMP/IMS)

- Provide information, data, plans for manufacturing and quality requirements to obtain DCMA analyses, supporting information, and recommendations as inputs to the System Functional Review to include DCMA:
  - Analyses and results of contractor(s) and supply chain capabilities
  - Analyses and results of Industrial Base capability studies
  - Recommendations from assessments of contractor(s) supply chain capability, if available
  - Analyses of contractor(s)' capability to procure, mature, and characterize materials
  - Analyses and recommendations for contractor(s)' producibility and continuous improvement processes
  - Recommendations for the contractor(s) tooling and equipment strategies
  - Recommendations for the Manufacturing and Quality Plans, the TEMP, and the IMP/IMS
  - Analyses and recommendations for the contractor's SEMP
  - Recommendations for the contractor(s) workforce requirements, skills, capabilities, training, and certifications
  - Analyses of contractor(s) manufacturing and production process verifications and Process Capabilities (Cpks)
  - Analyses and recommendations for the contractor(s) Quality Management System and processes

- Based on DCMA inputs, develop recommendations for manufacturing investment programs that mature emerging manufacturing technologies and industrial capabilities (see D.2 and D.4).

Metrics

- DCMA information and data has been utilized to develop and document manufacturing and quality inputs for the SRR, including:
  - Results of manufacturing and quality feasibility assessments
  - Reports on contractor(s) capability to meet manufacturing and quality requirements for:
    - Manufacturing Management System best practices (i.e., AS6500)
    - Quality Management System best practices (e.g., AS9100, ISO 9000, etc.)
    - Risk, Issues, and Opportunities Management System capabilities
    - Human safety and health
    - Environmental and hazardous materials management (pollution prevention)
    - Security (physical and cyber) for both hardware and software (e.g., communications, cyber, program protection, anti-tamper, etc.)
    - Management of KCs
    - Management of data and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data)
    - Supportability and sustainment
    - Use of COTS, GOTS, NDIs, and GFE (including diminishing manufacturing sources)
    - Management of parts, materials, and processes (PM&P)
    - Configuration Management System capabilities
    - Specialized manufacturing requirements (extreme complexity, multiple or very tight tolerances, EMI protection, precision assembly, handling of fragile components and Electrostatic Discharge protection, etc.)
    - Process capabilities and manufacturing operations
    - Modeling and Simulation tools and capabilities
    - Testing processes, equipment, and facilities capabilities
    - Earned Value Management System capabilities
    - Cost, Scheduling, and Control System capabilities
    - Systems Engineering Management capabilities (i.e., IEEE 15288)
    - Performance to plans and schedules: Integrated Master Plan(IMP), Integrated Master Schedule (IMS)
- DCMA analyses, supporting information, and recommendations have been obtained and document inputs to the System Functional Review including the contractor(s):
  - Capabilities including supply chain capabilities and recommendations
  - Capability to procure, mature, and characterize materials
  - Producibility and continuous improvement processes
  - Tooling and equipment strategies

- Manufacturing Plans, Quality Plans, the TEMP, the IMP/IMS, and the SEMP
- Workforce requirements, skills, capabilities, training, and certifications
- Manufacturing and production process verifications and Process Capabilities (CpKs)
- Quality Management System and processes

- DCMA analyses, supporting information, and recommendations have been obtained and document inputs to the System Functional Review for Industrial Base capability studies.
- Recommendations for manufacturing investment programs have been developed and documented based on DCMA recommendations that mature emerging manufacturing technologies and industrial capabilities (see D.2 and D.4).

Tools

- DCMA inputs to the following documents, go/no-go (either is or is not included)
- Manufacturing Readiness Level (MRL) Assessment
- Technology Readiness Assessment (TRA)
- Integrated Master Plan/Schedule (IMP/IMS)
- Test and Evaluation Master Plan (TEMP)
- Systems Engineering Plan (SEP)

Resources

- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-209, Pre-award Surveys
- DCMA-INST-323, Data Collection and Analysis
- DCMA-INST-325, Technical Reviews
- DCMA-INST-1201, Corrective Action

C.2 Conduct Pre-Award Survey

Manufacturing and Quality Tasks

- Develop manufacturing and quality requirements for DCMA pre-award surveys requests.
- Manufacturing and quality provide recommendations and inputs to program management for the pre-award type survey requirements (e.g., formal general purpose, formal on-site with solicitation requirements, or short form).
    - Identify manufacturing and quality management systems (MMS/QMS) specific contract clauses and work statements within the acquisition planning documents
    - Identify MMS/QMS risk areas during pre-award and post-award conferences, and follow-on assessments

- Ensure the following factors are included in the pre-award surveys of the contractor and key and critical suppliers:
  - Technical capability
  - Production capability
  - Quality assurance
  - Risk identification
  - Supply chain management
  - Finance and accounting
  - Government property control
  - Transportation and packaging
  - Security, physical and cyber
  - Plant safety
  - Hazardous materials/environmental/energy/regulatory compliance
  - Flight, space, and/or operations and safety
  - Software capability
  - Technical documentation
  - Configuration management
- Review DCMA audit results for manufacturing and quality impacts and make recommendations to the source selection personnel, the Procurement Contracting Officer (PCO), the program Systems Engineer, and the Program Manager.

Metrics

- Manufacturing and quality requirements for DCMA pre-award surveys requests have been developed, documented, and provided to program management.
- Manufacturing and quality have developed, documented, and provided recommendations to program management for the pre-award type survey requirements (e.g., formal general purpose, formal on-site with solicitation requirements, or short form).
  - Specific contract clauses and work statements within the acquisition planning documents have been identified for formal survey
  - MMS/QMS risk areas have been documented
- The following factors were included and survey results documented for the contractor and key and critical suppliers:
  - Technical Capability (e.g., plans, processes, and systems)
  - Production Capability (e.g., facilities, tooling, rates, etc.)
  - Quality Assurance (e.g., audits, compliance, processes, plans, monitoring, etc.)
  - Risk identification (e.g., processes, plans, monitoring, etc.)
  - Supply Chain Management (i.e., qualification processes)
  - Finance and Accounting
  - Government Property Control
  - Transportation and Packaging

- Security, physical and cyber
  - Security standards including Industrial Control Security
  - ITAR compliance
  - Cyber-security
- Plant Safety (i.e., compliance audits)
- Hazardous Materials/Environmental/Energy/Regulatory Compliance
- Flight, Space, and/or Operations and Safety
  - Airworthiness
  - Seaworthiness
  - Combat operations readiness
  - Space-worthiness
  - Cyber-readiness
- Software Capability
- Technical documentation, status, and reporting (e.g., CDRLs, SEMPs, TEMPs, etc.)
- Configuration Management

- DCMA audit results have been reviewed for manufacturing and quality impacts and recommendations have been documented and provided to the source selection personnel, the PCO, the program Systems Engineer, and the Program Manager.

Tools

- SF 1404 Pre-Award Survey – Technical
- SF 1405 Pre-Award Survey – Production
- SF 1406 Pre-Award Survey – Quality Assurance
- SF 1407 Pre-Award Survey – Financial Capability

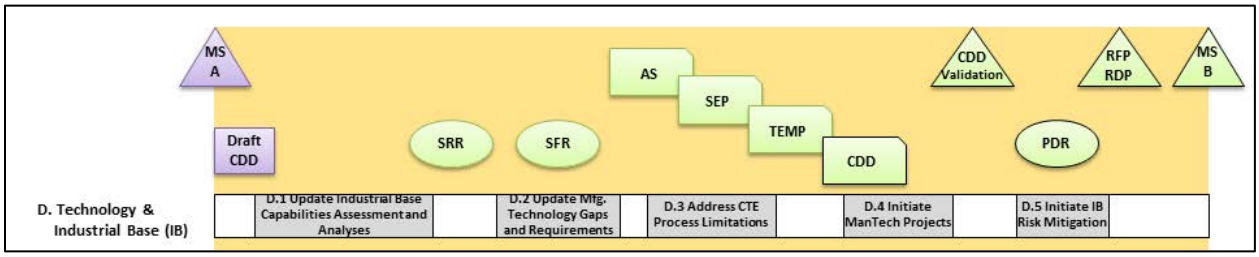
Resources

- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-209, Pre-Award Surveys
- DCMA Pre-Award Survey Guide (old version)

D. TECHNOLOGY AND INDUSTRIAL BASE (IB)

TMRR phase IB considerations should include a thorough evaluation of the IB to understand how the IB capability and availability will impact the program. DoD Directives (DoDD) and Public Law requires each major program to conduct assessments of the IB throughout the acquisition cycle. The phase assessments help determine the capabilities of the IB to develop, produce, maintain, and support all defense acquisition programs. The program will document the source availability,

producibility, supportability, and maintainability risks and technology needs associated with the materials and components needed.



The update of earlier phase assessments will serve as a baseline as the design evolves. It will document the manufacturing capabilities required for the AS and facilitate the updates of manufacturing and quality inputs to the Systems Engineering Plan (SEP) and Request for Proposal (RFP) documents. The IB topic areas that should be assessed include:

- Industrial base sources relevant to the program, the contractor, and the contractor's supply chain
- Manufacturing and quality processes and techniques
- Design producibility risks, issues, and opportunities
- Cyber risks and vulnerabilities to manufacturing and quality information and data
- Impacts of materials (e.g., critical, long-lead, etc.)
- Supply disruption risks, issues, and program impacts from critical and strategic materials
- Availability and capability of production machinery, equipment, and tooling

IB analysis is a continuing process that gathers program specific information and provides feedback throughout the program life cycle. Earlier IB analyses require updating for the following:

- Development requirements and planned production rates
- Industrial capabilities risks, issues and opportunities (e.g., single points of failure, fragile suppliers, sole and single sources, etc.)
- Resilience of critical defense industrial base capabilities
- Procurement surges and contractions

Much of the technology that will be incorporated into the system is matured during phase for inclusion or insertion. Manufacturing and quality should be working closely with the design engineers to evaluate the maturity and feasibility of each new system technology. New system technologies are prone to producibility issues that make them high risk and these technologies may require new manufacturing technologies. Manufacturing technology gaps should be addressed with plans and budget for development, initiation, and insertion points identified along with cost, schedule, and performance impacts. Contractor agreements to utilize completed or successful manufacturing technology projects are essential.

While all new technologies need to be monitored, certain technologies will be critical to the success of the program these critical technologies deserve special considerations. If a system depends on specific technologies to meet operational thresholds in development, production, operation, and sustainment, and if the technology or its application is either new or novel, then that technology is considered a critical or enabling technology. These Critical Technology Elements should have been identified and evaluated in the MSA phase for maturity of the technology, in preparation for a formal Technology Readiness Assessment (TRA).

Additionally, CTEs were identified in the previous phase and assessed for feasibility, affordability, and supportability and for manufacturing and quality maturity. Plans to increase maturity were incorporated into the draft CDD, AS, SEP, and the RFP for the MSA phase. For TMRR, the identified manufacturing and quality process areas and process limitations requiring risk mitigation will be updated, including the hardware and the associated embedded software maturity and the cybersecurity risks and vulnerabilities to software and firmware. Implementation of risk reduction efforts in these areas should be initiated in this phase.

Technology risks that are critical to the success of the program are candidates for new Manufacturing Technology (ManTech) projects. However these types of projects will have their own risks, costs, and schedule impacts that must be factored into the program. The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing and transitioning advanced manufacturing technologies. The ManTech program impacts all phases of acquisition. It aids in achieving reduced acquisition and total ownership costs by developing, maturing, and transitioning key manufacturing technologies in support of new system technologies. Plans from the previous provide the basis for investments and should be initiated in this phase to find and implement affordable, low-risk solutions.

During TMRR phase program management is responsible for incorporating industrial base analyses, to include capacity and capability considerations, into acquisition planning and execution. Having documented industrial base considerations in the Acquisition Strategy and identified industrial capability problems, the program should initiate an IB mitigation plan that addresses current and future manufacturing and quality risks. The plan should address manufacturing and quality capabilities that should be maintained throughout program life cycle; mitigate obsolescence, business fragility, supply chain vulnerability, material availability; and address impacts of external dependencies, new and unique capabilities, military vulnerabilities, and rate and quantity changes.

Additionally, public law requires major defense acquisition programs to conduct an analysis of the capabilities of the national technology and industrial base to develop, produce, maintain, and support the program, including consideration of the following factors related to foreign dependency:

- The availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment for the sustained production of systems fully capable

of meeting the performance objectives established for those systems; the uninterrupted maintenance and repair of such systems; and the sustained operation of such systems.

- The identification of major systems and items available only from sources outside the national technology and industrial base.
- The availability of alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base; and an analysis of any military vulnerability that could result from the lack of reasonable alternatives.
- The effects on the national technology and industrial base that result from foreign acquisition of firms in the United States.

During TMRR, management of industrial base and technology considerations to reduce technology, engineering, integration, and life cycle risks must be an integral part of program management and are key to the success of the program through development, production, and sustainment.

D.1 Update Industrial Base Capabilities Assessment and Analyses

Manufacturing and Quality Tasks

- Update the analyses of Industrial Base Capabilities Considerations (from previous phase or conduct if not previously accomplished) of the national technology and industrial base to develop, produce, maintain, and support the program, including foreign dependency. The updated analyses will consider the following:
    - Identification of relevant sources including identification of:
        - Unique manufacturing capabilities
        - Capabilities not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
        - Major systems and items available only from sources outside the national technology and industrial base
        - Alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base
    - Vulnerabilities of and effect on the supply chain including sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
    - Capability of the materiel solution to be produced using existing manufacturing capabilities and capacities while meeting quality, production rate and cost requirements.
    - Capability of the IB to protect digitized program and system information including system definition, design and test, contracting, and competitive prototyping.
    - Capability to cost effectively design, develop, produce, maintain, and support the program, including:
        - Tooling

        - Production test equipment
        - Operation of systems
        - Maintenance and sustainment of systems
    - Capability to make production rate and quantity changes that support a response to contingency and support objectives (surges and contractions)
    - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
    - Potential obsolescence of components, parts, and materials
    - Impacts of external dependencies and integration
    - New and unique capabilities and processes
    - Assessed requirements and capabilities which include:
        - Identified sources for key technologies, components, and processes, including known gaps and risks
        - Identified needs including design, development, production, operation, and sustainment, and eventual disposal
        - All technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact the program
    - Updated DCMA industrial analysis data and reports to include:
        - Industrial Capability Assessments
        - Appropriate Analytical Products
        - Defense Business and Economic Analysis
        - Acquisition Planning Support
- Prepare the updated Industrial Base Capabilities Considerations summary report for inclusion in the Acquisition Strategy and appropriate updates to the SEP:
    - Include recommended actions or investments that address risks to cost, schedule, performance, and qualitative considerations that define and recommend how and when the actions would be incorporated into the budget and schedule and, if possible, identify budget offsets
        - Note: If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components and approved by the Under Secretary Of Defense For Acquisition, Technology, And Logistics per DODI 5000.60.

Metrics

- Analyses of Industrial Base Capabilities Considerations of the national technology and industrial base to develop, produce, maintain, and support the program, including foreign dependency have been updated or conducted including consideration of the following:
    - Relevant source(s) identification including identification of:

- Unique manufacturing capabilities
- Capabilities not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
- Major systems and items available only from sources outside the national technology and industrial base
- Alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base

- Vulnerabilities and the effect on the supply chain from sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
- Capability to produce the system, subsystem, items, and components using existing manufacturing capabilities and capacities, and meet requirements (e.g., quality, production rate and cost requirements)
- Capability of the IB to protect digitized program and system information (cybersecurity) including system definition, design and test, contracting, and competitive prototyping
- Capability to cost effectively design, develop, produce, maintain, and support the program, including:
  - Tooling
  - Production test equipment
  - Operation of systems
  - Maintenance and sustainment of systems
- Capability to make production rate and quantity changes that support a response to contingency and support objectives (surges and contractions)
- Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
- Potential obsolescence of components, parts, and materials
- Impacts of external dependencies and integration
- New and unique capabilities and processes
- Assessed requirements and capabilities:
  - Sources for key technologies, components, and processes, including known gaps and risks
  - Needs including design, development, production, operation, and sustainment, and eventual disposal
  - Program impacts including technological developments, market trends, processes, environmental factors, and policies, etc.
- Updated DCMA industrial analysis data and reports to include:
  - Industrial Capability Assessments
  - Appropriate Analytical Products
  - Defense Business and Economic Analysis

- Acquisition Planning Support

- The updated Industrial Base Capabilities Considerations Summary Report has been prepared manufacturing and quality input to the Acquisition Strategy and updates for the SEP:
  - Recommended actions or investments to address risks to cost, schedule, performance, and qualitative considerations have been included
    - Note: If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components and approved by the Under Secretary Of Defense For Acquisition, Technology, And Logistics per DOD 5000.60.

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- MRL Assessment Checklist for Technology and Industrial Base thread

Resources

- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017
- DODI 5000.60H, Defense Industrial Capabilities Assessments
- MRL Deskbook Version 2016
- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base

D.2 Update Manufacturing Technology Gaps and Requirements

Manufacturing and Quality Tasks

- Update assessments and analyses of emerging technologies to determine capability of current manufacturing technology, processes, and infrastructure to support system development.
  - Analyze the need (determine gaps) for new manufacturing technologies, processes, and infrastructure
  - Identify required risk mitigation efforts with cost and schedule impacts
- Perform manufacturing technology trade studies that includes an assessment of how new and emerging technology might impact product design requirements, affordability, and manufacturing capabilities.
- Update the assessment of identified high risk manufacturing process areas necessary for the program that require investments in ManTech programs.
  - Estimate cost, schedule, and performance impacts
- Update current ManTech project plans with survey data from ongoing ManTech projects and DCMA reports and analyses for solutions to manufacturing technology gaps.

- Request DCMA provide up-to-date data
- Update the comprehensive plan for each required ManTech investment
  - Ensure the DoD/Service ManTech POC membership in appropriate IPT
  - Request information from other government agencies, industry, and academia responses to needs

Metrics

- Assessments and analyses of emerging technologies to determine capability of current manufacturing technology, processes, and infrastructure to support system development have been updated and documented for program management and reviews (e.g., SFR, AS, budget, PMRs, etc.) including:
  - Gaps requiring new manufacturing technologies, processes, and infrastructure
  - Required risk mitigation planning efforts with cost, budget, and schedule impacts
- Manufacturing technology trade studies have been performed and documented that includes assessment new and emerging technology impacting product design requirements, affordability, and manufacturing capabilities.
- ManTech project plans have been updated based on the assessment of high-risk manufacturing process areas, the ongoing ManTech projects, DCMA inputs from reports and analyses, information from Services and agencies, industry, and academia; and quantify the required investments in ManTech programs including cost, schedule, budget, and performance impacts.

Tools

- MRL Assessment Checklist for Technology and Industrial Base thread
- Producibility Assessment Worksheet (PAWs)
- Pugh Matrix
- Technology Readiness Assessment

Resources

- MRL Deskbook Version 2016
- NAVSO P-3687 Producibility Systems Guidelines, Dec 1999
- Technology Transition Managers Guide, June 2005

D.3 Address Critical Technology Element (CTE) Process Limitations

Manufacturing and Quality Tasks

- Update and assess the identified CTEs for feasibility, affordability, and supportability and for manufacturing and quality maturity.
  - Identify mature alternative components or subsystems for each immature CTE

- Develop plans for increasing CTEs manufacturing and quality maturity and mitigating associated risks and include:
  - Update plans to improve and/or maintain maturity from the draft CDD, AS, and SEP (if available)
  - If manufacturing processes need to be updated or developed, plan and budget for the effort to mitigate manufacturing risk
  - Include integration risks associated with the updated CTEs from trade studies
  - Include updates for CTE interdependencies and associated risks

- Update the identified manufacturing and quality process areas and process limitations requiring risk mitigation
  - Include necessary hardware and the associated embedded software maturity
  - Include cybersecurity risks and vulnerabilities (software and firmware)

- Support the Technology Readiness Assessments that benchmark technology risks.
  - Determine the degree of manufacturing and quality risks in development
  - Conduct in depth analyses of the manufacturing and quality risks associated with the design as needed
  - Develop plans for recommended manufacturing and quality risk mitigations to be conducted
  - Implement plans to improve CTE manufacturing and quality maturity

- Manufacturing and quality support definition of the required Technology Readiness Levels (TRLs) to be achieved for each CTE at each systems engineering milestone (e.g., Systems Requirements Review (SRR), Test Readiness Review (TRR), etc.).

Metrics

- Identified CTEs have been assessed for feasibility, affordability, and supportability and for manufacturing and quality maturity and results documented for:
  - Mature alternative components or subsystems for each immature CTE
  - Plans for increasing CTEs manufacturing and quality maturity and mitigating associated risks which included:
    - Plans to improve and/or maintain maturity from the draft CDD, AS, and SEP (if available) have been updated
    - Budget for the effort to mitigate manufacturing risk has been updated and submitted
    - Integration risks from trade studies
    - Updates for CTE interdependencies and associated risks

- Manufacturing and quality process areas and process limitations requiring risk mitigation have been updated and documented in the SEP to include:
  - Necessary hardware and the associated embedded software maturity
  - Cybersecurity risks and vulnerabilities (software and firmware)

- Technology Readiness Assessments that benchmark technology risks have been conducted.
  - The degree of manufacturing and quality risks in development has been documented
  - In depth analyses of the manufacturing and quality risks associated with the design has been conducted and risks quantified
  - Recommended plans for manufacturing and quality risk mitigations to be conducted has been documented in the SEP, the AS, and the budget and schedule
  - Plans to improve CTE manufacturing and quality maturity have been implemented
- Manufacturing and quality has provided input for determination of the required TRLs to be achieved for each CTE at each systems engineering milestone (e.g., Systems Requirements Review, Test Readiness Review , etc.).

Tools

- MRL Assessment Checklist for Technology and Industrial Base thread
- Producibility Assessment Worksheet
- Technology Readiness Assessment
- TRL Calculator

Resources

- DoDI 5000.02, Feb 2017, 5d(4)(b)3. and 5d(4)(c)
- Defense Acquisition Program Support Methodology, Ver. 3.0
- MRL Deskbook Version 2016
- NAVSO P-3687, Producibility Systems Guidelines, Dec 1999
- Technology Readiness Assessment Deskbook, Jul 2009

D.4 Initiate ManTech Projects

Manufacturing and Quality Tasks

- Review Service ManTech portfolios for projects with potential application to program gaps to:
  - Determine if the program/contractor should participate in the project
  - Determine if the program/contractor should support bridging of the project to the next phase
  - Determine how the results of the project can be implemented in the program
- Review current Title III, IBAS, and other government investment program portfolios for projects with potential application to program gaps.
- Based on Service portfolio reviews, update program ManTech plan and submit proposals for funding, which should include:
  - Identified high-risk manufacturing process areas that require investments in state of the art manufacturing technology

- Identification of manufacturing technology development efforts to be funded by the program or other alternative sources
- Justification of benefit to industry, industry sector, or other DoD systems
- Determination if required manufacture technology efforts will be completed in time to support program needs
- Relevant data from DCMA and other sources to support plan

Metrics

- Service ManTech portfolios for projects with potential application to program gaps have been reviewed and document the need for:
  - Program/contractor participation in the project
  - Program/contractor support to bridge the project to the next phase
  - Project implementation in the program
- Current Title III, IBAS, and other government investment program portfolios have been reviewed for projects and the results document potential application to the program.
- Program ManTech plans have been updated and proposals submitted for funding. Proposals included:
  - Investments in state of the art manufacturing technology
  - Investments efforts to be funded by the program or other alternative sources
  - Justification of benefit to industry, industry sector, or other DoD systems

Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- MRL Assessment Checklist for Technology and Industrial Base thread
- TRL Assessment Checklist

Resources

- Defense Production Act, Title III
- DoDI 5000.02, Feb 2017
- DoDD 4200.15, ManTech
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011
- Service ManTech guidance, e.g. Air Force Technology and Transition Strategy Guidebook, Nov 2010

D.5 Initiate Industrial Base (IB) Risk Mitigation

Manufacturing and Quality Tasks

- Initiate mitigation plans that address current and future manufacturing and quality Industrial Base risks. Plans should:
  - Address all manufacturing and quality capabilities required that should be maintained throughout the life of the program
  - Mitigate product or technology obsolescence, lifetime replacement, or regeneration of items projected to go out of production
  - Mitigate business fragility of any facilities or corporations that provide unique services or products or unique manufacturing and quality capabilities
  - Address the approach to making production rate and quantity changes that support a response to contingency and support requirements including surges
  - Mitigate the vulnerability of the supply chain (to include sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources)
  - Address the availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment (required to include the availability of alternatives for obtaining such items from within the NTIB)
  - Address the impacts of external dependencies and integration
  - Address the risks introduced by new and unique capabilities and processes

Metrics

- Mitigation plans have been initiated that document and address manufacturing and quality Industrial Base risks. Plans should address and mitigate risks to:
  - Manufacturing and quality capabilities that are required throughout the life of the program
  - Product or technology obsolescence including lifetime replacement or regeneration of items projected to go out of production
  - Facilities or corporations that provide unique services or products, or unique manufacturing and quality capabilities
  - Adapting to production rate and quantity changes including surge requirements
  - Supply chain vulnerability to include sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
  - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment
  - Program from the impacts of external dependencies and integration
  - Program by introduction of new and unique capabilities and processes

Tools

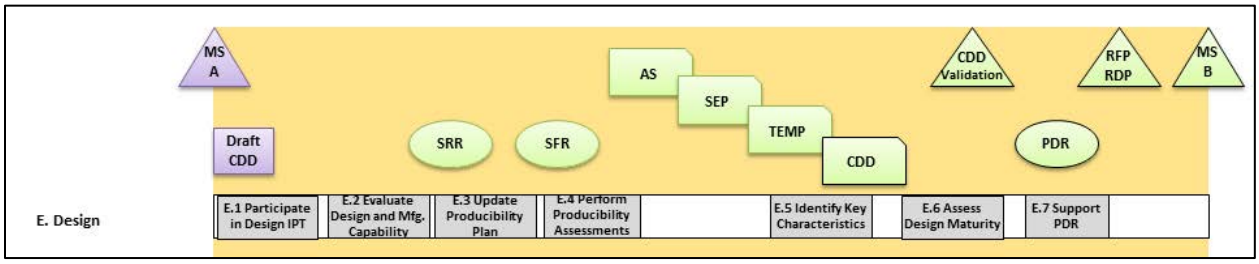
- Manufacturing/QA Risk Mitigation Plan (no Template available)

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions, Apr 1996
- MRL Deskbook Version 2016, Chapter 5.2 Development of a Manufacturing Maturation Plan

E. DESIGN

Manufacturing and quality personnel participation in and support to Program Design IPTs is critical to success in producing a manufacturable and affordable system with acceptable risks. Manufacturing and quality industry best practices are integral to design and development efforts in both Manufacturing Management System (MMS) and Quality Management System (QMS) requirements (e.g., AS6500, ISO 9001, AS9100, etc.). The program should integrate manufacturing and quality into the product design and development process and engage manufacturing and quality expertise as early as possible. Analyses of design alternatives through trade studies, producibility analyses, and manufacturing feasibility based on program requirements need to be conducted with results incorporated into the design. To accomplish program objectives, these need to be performed throughout the supply chain (e.g., failure mode analyses, Key Characteristics (KC), quality capabilities, test processes, etc.), enabling appropriate visibility and accountability through collection, recording, and communication of technical and programmatic data to all levels.



During the TMRR phase, the manufacturing and quality capabilities should be assessed for each competing design under consideration. The assessments should baseline needed industrial, manufacturing, and quality capabilities and identify required investments. While it is not expected that contractors have a complete factory and supply chain established at this point, program understanding of key and critical manufacturing and quality processes, scale-up efforts, and supply chain risks and issues is critical. This understanding for TMRR phase should include:

- Manufacturing processes and techniques not currently available
- Design producibility risks, issues, and opportunities
- Probability of meeting milestones
- Potential impacts of critical, strategic, and long-lead materials including disruptions
- Manufacturing and quality equipment and tooling availability
- Cost models and goals realism
- Estimates for support of management reviews

- Analyses and rationale for manufacturing and quality feasibility, cost, and schedule trade-offs of alternative approaches
- Anticipated manufacturing and quality processes testing and demonstration efforts

Producibility criteria should reflect a blending of general criteria and specific criteria applicable to the system being developed. Producibility analyses will be effective if the design engineers understand and apply the producibility design criteria. Producibility is more than a design engineering function requiring manufacturing and quality engineer participation to generate a design which is compatible with the manufacturing and quality capabilities of the contractors. Producibility is the most important determinant of product cost, due to the impacts on EMD, Production and Deployment (P&D), and Operations and Support (O&S) costs. Ignoring producibility may lock the acquisition program into design solutions which can only be accomplished at unnecessarily high costs and/or designs which can entail substantial technical, cost and schedule risk. The TMRR contract should have required that the contractor develop, execute, and maintain a Producibility Plan and criteria to guide the design and development efforts. The plan should describe specifically what activities will be accomplished in each phase, the responsible organization, and the management controls that will be established to ensure successful accomplishment. Manufacturing and quality should review the plan with a focus on the completeness, clarity, adequacy, and realism of the planning accomplished by the contractor. Results of these analyses will support the development of specific contractual provisions for the EMD phase.

DOD policy on major system acquisitions makes producibility risk considerations a requirement in the Acquisition Program Baseline (APB) prior to the start of technology development. Producibility assessments should be an integral part of the on-going systems engineering process. Design processes should have included producibility assessments as part of the design decisions, however producibility is not limited to design.

Effective measurement is critical to accuracy producibility assessments. Measurement is a tool for evaluating the effectiveness of producibility performance and for determining the degree to which improvements need to be made to ensure that future products are producible. Producibility assessments are conducted on system, subsystem, item, and component levels. Manufacturing and quality processes must be monitored and controlled with measurements, to ensure repeatable and consistent production of accurate, high-quality products. Process variability results in product variability, and product variability, when outside of design limits, means unacceptable quality. As a general rule, reducing process variability improves product quality and, therefore, producibility.

In general, to assess program producibility, the organization must evaluate producibility on a product-by-product basis. Analysis of producibility on a per product basis allows the organization to better understand the strengths and weaknesses of the system, so that enhancements can be identified.

Other producibility considerations include:

- Minimizing costs and schedule while maximizing performance

- Infrastructure – cyber-security, software tools, design guides, training, and policies
- Trade studies for design principles, reducing part counts, using of common parts, ease of assembly, simplicity of fabrication, safety, etc.

Key and critical product characteristics and features are the output of key and critical manufacturing and quality processes. Consequently, to achieve program goals it is important for the contractor to identify and control these characteristics early in the system design and development effort.

According to AS9100D, KCs (Key Characteristics) are defined as an attributes or features whose variation have a significant effect on product fit, form, function, performance, service life or producibility, that require specific actions for the purpose of controlling variation. A critical characteristic is defined by AS6500 as a characteristic that is likely, if defective, to create or increase a hazard to human safety, or to result in failure of a system to perform a required function. Additionally, AS6500 defines a critical manufacturing process as a process that creates or substantially affects a key or critical characteristics. Some KCs and critical characteristics and the associated manufacturing processes may be produced or accomplished at a sub-tier supplier. By the end of the TMRR phase, the contractor and the program office should have a top-level understanding of KCs. Products perform better when there is less variation on the key and critical characteristics.

Based on design and manufacturing feasibility and capability analyses, producibility assessments, and KC identification process, manufacturing and quality will assess design maturity in accordance with industry best practices. It must be economically feasible to manufacture a quality product at a specified rate and to deliver end items capable of achieving the performance and reliability inherent in the design. A strong emphasis early in the design phase on:

- Configuration control,
- Key and critical characteristics processes,
- Risks, issues, and opportunities management,
- Manufacturing and quality capabilities, feasibility, and producibility,

will minimize the time and cost required for successful transition to production.

Design maturity occurs when a product design meets the requirements, as well as cost, schedule, and reliability targets. It is a best practice to achieve design completion at the system-level critical design review in the EMD phase. Consequently design completion should include a ramp-up during TMRR to meet Preliminary Design Review exit criteria.

The PDR is a technical assessment establishing the physically allocated baseline and the functional baseline to ensure that the system under review has a reasonable expectation of being judged operationally effective and suitable, and has a reasonable expectation of satisfying the requirements within the currently allocated budget and schedule. A successful PDR should include an assessment of the producibility of the design and an assessment of manufacturing costs and risks.

Manufacturing and quality is responsible for inputs, per industry best practices, to almost every aspect of PDR. Manufacturing and quality inputs include:

- Entry/exit criteria for the preliminary PDR process
- Results of MRL assessments
- Reviews, analyses, assessments, and contractor deliverables that support sufficient maturity of the allocated baseline
- Results of the assessments establishing the system functional baseline
- Inputs and documentation to the technical planning process
- Manufacturing Plans and Quality Plans
- Inputs to the program risk, issue, and opportunity assessment process for identification and mitigation of manufacturing and quality cost, schedule, and technical risks
- Inputs to the program life cycle cost estimates

E.1 Participate in Design IPT

Manufacturing and Quality Tasks

- Manufacturing and quality Design IPT participants ensure adherence to manufacturing and quality design best practices (e.g., AS6500, AS9100, ISO 9001, etc.).
- Provide manufacturing and quality requirements based on analyses of system requirements and design concepts.
    - Identify capabilities and constraints based on the system specifications
    - Establish the required manufacturing and quality capabilities baseline
    - Identify manufacturing and quality affordability cost drivers and impact on schedule and performance
- Manufacturing and quality provide input to design trade studies (i.e., functional and performance requirements) that include criteria concerning:
    - KPPs, KSAs, APAs, and evolving KCs
    - Manufacturing process capabilities, limitations, and concerns
    - Software and firmware development and re-use
    - Safety, handling, storage, and disposal considerations and restrictions
    - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
    - Manufacturing costs, materials, special tooling, and test equipment
    - Cost-effective and affordable designs to achieve performance and schedule while minimizing cost
    - Manufacturing capacity, workforce, and schedule impacts
- Manufacturing and quality participation in the design producibility process provides:
    - Identification products and processes that would benefit from producibility analyses (i.e., Design for Manufacturing (DFM)/Design for Assembly (DFA)

  - Monitoring and reporting on producibility process activities with respect to risks, issues, and opportunities
  - Integration of producibility with other design activities including software and firmware development and re-use
  - Participation in producibility design trade studies to include process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
  - Identification of innovative manufacturing technology opportunities

- Manufacturing and quality Design Integrated Product Team (IPT)participants provide monitoring, reviewing, analyses, and reporting on multiple analyses as part of the FMECA process (e.g., DFMEA, PFMEA).
- For the Design and Development planning process, manufacturing and quality shall provide:
  - Planning inputs that establish, implement, and maintain appropriate processes to manage key and critical subsystems, components, and items including process controls for KCs
  - Requirements for design, production process verification, test, inspection, verification, and product acceptance (statistical techniques)
  - Inputs for monitoring and managing the development process through frequency, data, and metrics for design reviews
  - Criteria for manufacturing and quality evaluation of design outputs (product)
  - Requirements for manufacturing and quality verification, validation, and change control
- Provide manufacturing and quality impacts and interdependencies of design activities to other functional areas or activities (e.g., engineering, producibility, costs, safety, manpower, schedule, etc.).
- Manufacturing and quality performs assessments and identification of manufacturing and quality risks, issues, and opportunities (e.g., technology, manufacturing, cybersecurity, software development, and sustainment) including mitigation.
- Provide manufacturing and quality support to program reviews (e.g., PMRs, SRR, SFR, and PDR).
- Provide manufacturing and quality support to the program level TRA and MRL assessment (as required).
- Provide manufacturing and quality support to the specified program configuration control process for the design.
- Evaluate the design for the impacts on manufacturing and quality requirements with respect to GFE (e.g., subsystems, components, test ranges, facilities, etc.).
- Provide manufacturing and quality inputs to program documentation (e.g., SEP, TEMP, AS, CDD, etc.)
  - Include inputs and support for CDD validation efforts
  - Include inputs for manufacturing plan updates (including design changes, investments, etc.)

- Provide support to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.)
- Provide manufacturing and quality input in support of congressionally mandated assessments and reports.
    - Inputs on **manufacturing and quality risks** associated with the program
    - Inputs on manufacturing and quality processes that **need to be matured.**

Metrics

- Manufacturing and quality Design IPT participants have documented compliance with manufacturing and quality design best practices (e.g., AS6500, AS9100, ISO 9001, etc.).
    - Documentation includes Lessons Learned
    - Includes DCMA reports, program reviews, and deliverables
- Manufacturing and quality analyses of system requirements, design concepts, and capabilities baseline have been included and documented in the design including:
    - Capabilities and constraints based on the system specifications
    - Required manufacturing and quality capabilities baseline
    - Affordability cost drivers and impact on schedule and performance
- Manufacturing and quality inputs to design trade studies (i.e., functional and performance requirements) have been provided and include criteria for:
    - KPPs, KSAs, APAs, and evolving KCs
    - Manufacturing process capabilities, limitations, risks, issues, and opportunities
    - Software and firmware development and re-use
    - Safety, handling, storage, and disposal requirements
    - Quality requirements and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
    - Manufacturing costs, materials, special tooling, and test equipment requirements
    - Cost-effective and affordable designs to achieve performance and schedule while minimizing cost
    - Manufacturing capacity, workforce, and schedule requirements
- Documented manufacturing and quality support to the design producibility processes include:
    - Products and processes producibility analyses (i.e., DFM/DFA)
    - Producibility process analyses with respect to risks, issues, and opportunities
    - Producibility integration with other design activities including software and firmware development and re-use
    - Design trade studies that have included process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
    - Opportunities for use of innovative manufacturing technology

- Manufacturing and quality Design IPT participants have provided monitoring, reviewing, analyses, and documentation on multiple FMEAs (e.g., DFMEA, PFMEA, etc.) as part of the FMECA process.
- Manufacturing and quality, as part of the Design and Development planning process, has documented and provided:
  - Planning inputs to establish, implement, and maintain appropriate processes and management of key and critical subsystems, components, and items (including process controls for KCs)
  - Requirements for design, production process verification, inspection, verification, product acceptance and test (statistical techniques)
  - Inputs for monitoring and management of the manufacturing and quality development process through the frequency, data, and metrics required for design reviews
  - Manufacturing and quality metrics for the evaluation of design outputs (e.g., verification, validation, change control, etc.)
- Manufacturing and quality design activity impacts and interdependencies to other functional areas or activities (e.g., engineering, producibility, costs, safety, manpower, schedule, etc.) has been documented and provided as inputs to and in support of the Acquisition Strategy and SEP.
- Assessments, identification, tracking, and mitigation of manufacturing and quality risks, issues, and opportunities (e.g., technology, manufacturing, cybersecurity, software development, and sustainment) have been documented as inputs to the SEP.
- Manufacturing and quality participants have documented and provided support to:
  - Program reviews (e.g., PMRs, SRR, SFR, and PDR) to include action items, entry/exit criteria, metrics, documentation, etc.
  - Program configuration control process for the design
  - Program-level TRA and MRL assessment (as required)
- Documentation of the impacts on manufacturing and quality design requirements has been provided for GFE (e.g., subsystems, components, test ranges, facilities, etc.).
- Manufacturing and quality inputs have been documented for inclusion in program documentation (e.g., SEP, TEMP, AS, CDD, etc.), including:
  - Inputs and support for CDD validation efforts
  - Inputs for manufacturing plan updates (including design changes, investments, etc.)
- Manufacturing and quality participants have provided documented support to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.).
- Manufacturing and quality inputs to support of congressionally mandated assessments and reports have been provided.
  - Inputs on manufacturing and quality risks associated with the program
  - Inputs on manufacturing and quality processes that need to be matured

Tools

- Design for Manufacturing and Assembly (DFMA)
- SRR checklist
- SFR checklist
- TRA checklist
- MRL assessment checklist
- PDR checklist
- Acquisition Plan Preparation Guide template
- SEP template
- TEMP template
- Life Cycle Sustainment Plan template
- CDD template

Resources

- 10 USC 144B, Sec 2366 and 2448
- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 Quality Systems – Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- AS 9103, Variation Management of Key Characteristics
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management Program
- Acquisition Strategy Guide, DSMC, Dec 1999
- Systems Engineering Plan (SEP) Outline, Jun 2015
- TEMP Guide, Dec 2012 and DAG Chapter 8-4.1
- LCSP memo, Sep, 2011 and DAG Chapter 4-3.1
- CDD-CPD writing Guide, Feb 2015
- System Requirements Review (SRR), DAG Chapter 3-3.3.2
- System Functional Review (SFR), DAG Chapter 3-3.3.3
- Preliminary Design Review (PDR), DAG Chapter 3-3.3.4
- Technology Readiness Assessment (TRA) Guidance 2011
- Manufacturing Readiness Level (MRL) Deskbook 2016

E.2 Evaluate Design and Manufacturing Capability

Manufacturing and Quality Tasks

- Perform a manufacturing and quality assessments of the contractor(s) and supply chain capability to mature the proposed design(s) within the program overall cost, schedule, and performance goals.

- Identify risks, issues, opportunities and mitigation plans
- Include competing technologies, prototypes, etc.
- Include capabilities with respect to environmental and hazardous processes

- Conduct analyses to:
  - Determine shortfalls (risks) to the required baseline manufacturing and quality capability and mitigation required
  - Identify manufacturing and quality processes and techniques that require development (including for special and hazardous)
  - Identify materials, producibility, equipment, and schedule risks, issues, and opportunities (including availability, hazardous, and long-lead)
  - Develop manufacturing and quality inputs to production unit cost and schedule (realism) estimates
  - Provide manufacturing and quality comparisons of competing and/or alternative approaches
  - Provide manufacturing and quality recommendations for anticipated manufacturing and quality process testing and demonstration efforts for each competing and alternative approach
  - Identify required manufacturing and quality capability investments (e.g., ManTech, GFE, facilities, capital equipment, tooling, test equipment, and processes, Modeling and Simulation (M&S), etc.)

Metrics

- Manufacturing and quality assessments of contractor in-house and supply chain manufacturing maturation processes and capabilities, with risk and issue mitigation plans to meet program cost, schedule, and performance goals have been documented.
  - Include competing technologies, prototypes, etc.
  - Include manufacturing and quality capability investments (e.g., ManTech, GFE, facilities, capital equipment, tooling, test equipment, and processes, M&S, etc.)
  - Include capabilities with respect to environmental and hazardous processes

- Manufacturing and quality analyses have been conducted and documented that:
  - Determine shortfalls (risks) to the required baseline manufacturing and quality capability and mitigation required
  - Identify manufacturing and quality processes and techniques that require development
  - Identify materials, producibility, equipment, and schedule risks, issues, and opportunities (including availability and long-lead)
  - Develop manufacturing and quality inputs to production unit cost and schedule (realism) estimates
  - Provide manufacturing and quality comparisons of competing and/or alternative approaches

- Provide manufacturing and quality recommendations for anticipated process testing and demonstration efforts for each competing and alternative approach

Tools

- MRL assessment
- Quality system audit

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 Quality Systems – Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- MRL Deskbook Version 2016

E.3 Update Producibility Plan

Manufacturing and Quality Tasks

- Review and analyze the contractor(s) plans for specific processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks associated with the proposed solutions.
  - Include schedule, responsibilities, and management controls
  - Review the plan for purpose, realism, completeness, and clarity
  - Identify interdependencies and integration factors
  - Identify risks, issues, and opportunities
  - Identify manufacturing technology requirements
  - Include technology insertion opportunities
- Ensure plan describes how the design engineers apply the producibility design criteria.
  - If a competitive approach is used, describe how each competing design will be evaluated from a producibility standpoint
- Update identified and potential manufacturing and quality process risks, issues, and capabilities to include:
  - Validated and updated producibility goals and metrics
  - Updated Modeling and Simulation (software) approaches (manufacturing and production)
  - Critical manufacturing and quality processes (yield, rates, and variability, if available)
  - Impacts to cost, schedule, and performance
  - Facilities, tooling, testing, and qualification
- Merge the identified contractor and government manufacturing and quality risks, issues, and opportunities into a consolidated government/contractor program plan and process.

- Ensure producibility planning for design includes manufacturing and quality considerations for and/or address the following:
  - Security (physical and cyber)
  - System safety and hazardous materials management criteria
  - Interdependencies and integration
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
  - Benchmarking
  - Costing
  - Data management systems
  - Design for Manufacture/Assembly
  - Design of Experiments (DOE)
  - Failure Modes and Effects Analysis (FMEA)
    - Design Failure Modes and Effects Analysis (DFMEA)
    - System Failure Modes and Effects Analysis (SFMEA)
    - Process Failure Modes and Effects Analysis (PFMEA)
  - Prototyping approaches
  - Design for Six Sigma
  - Tools (Quality Functions Deployment (QFD), Root Cause Analyses, Statistical Process Control (SPC), Tolerance Analyses, etc.)

Metrics

- Contractor(s) plans for processes, methods, and actions to address manufacturing feasibility, producibility, and manufacturing and quality risks associated with the proposed solutions have been reviewed, analyzed for adequacy, and documented for formal IPT/program reviews (PDR, etc.) to include:
  - Contractually required documentation (Contract Data Requirements List (CDRLs), Data Item Description (DIDs), etc.) have been approved or corrective actions initiated
  - Schedule, responsibilities, management controls, and costs
  - Review of purpose, realism, completeness, and clarity
  - Interdependencies and integration factors
  - Risks, issues, and opportunities
  - Manufacturing technology requirements
  - Technology insertion opportunities
- Documented planning describes how producibility is incorporated into the system design.
- In a competitive development approach, competing design plans have been evaluated from a producibility standpoint with comparative planning results documented.
- Identified and potential manufacturing and quality process risks, issues, and capabilities have been documented to include:
  - Validated and updated producibility goals and metrics

- Updated Modeling and Simulation (software) approaches (manufacturing and production)
- Critical manufacturing and quality processes (yield, rates, and variability, if available)
- Impacts to cost, schedule, and performance
- Facilities, tooling, testing, and qualification

- Identified contractor and government manufacturing and quality risks, issues, and opportunities have been documented and incorporated for the consolidated government/contractor program plan and process.
- Producibility planning for design included manufacturing and quality considerations for and/or addressed and documented the following:
  - Security (physical and cyber)
  - System safety and hazardous materials management criteria
  - Interdependencies and integration
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
  - Benchmarking
  - Costing
  - Data management systems
  - Design for Manufacture/Assembly (DFMA)
  - Design of Experiments (DOE)
  - Failure Modes and Effects Analysis (FMEA)
    - DFMEA
    - SFMEA
    - PFMEA
  - Prototyping approaches
  - Design for Six Sigma
  - Tools (Quality Functions Deployment (QFD), Root Cause Analyses, Statistical Process Control (SPC), Tolerance Analyses, etc.)
- Evidence that the producibility plan delineates activities to be accomplished in TMRR phase to include:
  - Organizational responsibilities
  - Specific management controls by function
  - Establishes methodology for application of producibility design criteria
  - Establishes methodology for evaluation of producibility between competing design concepts

Tools

- Producibility Engineering and Planning (PEP) Data Item Description

Resources

- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs

- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MIL-STD-882E DoD Standard Practice: System Safety, May 2012
- NAVSO P-3687 Producibility System Guidelines, Dec 1999
- Producibility System Guidelines, Missile Defense Agency, Apr 2009
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning

E.4 Perform Producibility Assessments

Manufacturing and Quality Tasks

- Manufacturing and quality Design IPT participants perform and/or support producibility assessments utilizing approved contractual documentation (CDRLs, DIDs, etc.) and other programmatic information and data including the following factors in the assessments:
    - Planned producibility goals and metrics
    - Management responsibilities and controls
    - Design analyses (between and among competitive designs)
    - Cost and schedule
    - Key Characteristics
    - Interdependencies and integration
    - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
    - Risks, issues, and opportunities
    - Manufacturing technology requirements (including innovative and advanced)
    - Technology insertion opportunities
    - Review of goals, realism, completeness, and clarity
    - Implementation of industry best practices, tools, and techniques
    - System safety design and hazardous materials management criteria
    - Security (physical and cyber)
    - Facilities, tooling, testing, and qualification
    - Government-furnished equipment (GFE), etc.
- Utilize producibility tools, techniques, procedures, and associated metrics that include:
    - State-of-the-art Modeling and Simulation software
    - Failure Modes and Effects Analyses (FMEA)
        - DFMEA
        - SFMEA
        - PFMEA
    - Design for Manufacture and Assembly (DFMA)
    - Design of Experiments (DOE)
    - Design for Six Sigma
    - Quality Function Deployment (QFD)
    - Benchmarking

- Design guides
- Interdependencies and integration analyses
- Tolerance analyses
- Requirements validation analyses
- Trade studies on alternative product and process designs
- Product complexity analyses
- Safety analyses
- Manufacturing process analyses
- Quality and quality process analyses
- Costs, cost drivers, and controls analyses
- Materials characterization and availability
- Prototyping of component, item, subsystem, competitive, etc.
- Learning curve goals and projections
- Product and process measurements utilizing Statistical Process Control (SPC)
- Data and database management
- Testing

- Provide manufacturing and quality support to design producibility analyses including:
  - Process capabilities
  - Manufacturing costs
  - Tooling and test equipment
  - Materials availability and characterization
  - Manufacturing capacity and capability
  - Workforce availability and training
  - Schedule impacts
  - Manufacturing and quality cybersecurity (including all digital communications and connectivity for design, facilities, equipment, etc.)
  - System safety and vulnerability

Metrics

- Manufacturing and quality Design IPT participants have conducted and/or supported producibility analyses and assessments that have addressed and document the following factors (adequacy, validity, completeness, etc.):
  - Producibility goals and metrics
  - Management responsibilities and controls
  - Design analyses (between and among competitive designs)
  - Cost and schedule
  - Key Characteristics
  - Interdependencies and integration
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
  - Risks, issues, and opportunities
  - Manufacturing technology requirements (including innovative and advanced)

- Technology insertion opportunities
- Review of goals, realism, completeness, and clarity
- Implementation of industry best practices, tools, and techniques
- System safety design and hazardous materials management criteria
- Security (physical and cyber)
- Facilities, tooling, testing, and qualification
- GFE), etc.

- Evidence for use of tools, techniques, procedures, with associated metrics to improve producibility has been documented in assessments and analyses to support program reviews and milestones decisions. These included:
  - State of the art Modeling and Simulation software
  - Failure Mode & Effects Analyses (FMEA)
    - DFMEA
    - SFMEA
    - PFMEA
  - Design for Manufacture and Assembly (DFMA)
  - Design of Experiments (DOE)
  - Design for Six Sigma
  - Quality Function Deployment (QFD)
  - Benchmarking
  - Design guides
  - Interdependencies and integration analyses
  - Tolerance analyses
  - Requirements validation analyses
  - Trade studies on alternative product and process designs
  - Product complexity analyses
  - Safety analyses
  - Manufacturing process analyses
  - Quality and quality process analyses
  - Costs, cost drivers, and controls analyses
  - Materials characterization and availability
  - Prototyping of component, item, subsystem, competitive, etc.
  - Learning curve goals and projections
  - Product and process measurements utilizing Statistical Process Control (SPC)
  - Data and database management
  - Testing

- Manufacturing and quality design producibility analyses and support included and documented:
  - Process capabilities
  - Manufacturing costs

- Tooling and test equipment
- Materials availability and characterization
- Manufacturing capacity and capability
- Workforce availability and training
- Schedule impacts
- Manufacturing and quality cybersecurity (including all digital communications and connectivity for design, facilities, equipment, etc.)
- System safety and vulnerability

Tools

- Producibility Assessment Worksheet
- Taguchi Loss Function Sheet
- Design of Experiments (DOE)
- Quality Function Deployment (QFD) method
- Trade Studies

Resources

- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA), Jan 2009
- MIL-STD-882E DoD Standard Practice: System Safety, May 2012
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center, Sep 1993
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999

E.5 Identify Key Characteristics (KCs)

Manufacturing and Quality Tasks

- Manufacturing and quality Design IPT participants provide monitoring, evaluation and analyses from multiple FMEA activities (e.g., FMECA DFMEA, PFMEA, , etc.) for the derivation of KCs, critical characteristics, and Critical Safety Items (CSIs), where possible.
  - Provide manufacturing and quality support to the System Safety Assessment (SAR) to assist in CSI identification with supporting rationale
- Guide and ensure identification, derivation, and justification of KCs and critical characteristics from identified KPPs, KSAs, and APAs (including all mandatory KPPs).
  - Update initial manufacturing and quality draft KPPs, KSAs, and APAs, and associated CTEs

- Provide manufacturing and quality inputs on development and management processes to establish, implement, and maintain management of key and critical subsystems, components, items, and software including process controls for KCs
  - Provide inputs on development and management processes to be evaluated
  - Include identification of manufacturing and quality processes to be matured
  - Specify, as applicable, specific actions to be taken (e.g., mitigation, investments, etc.)
- Develop a preliminary list, which includes where produced or accomplished and a rationale for inclusion (see G.6), of:
  - Key Characteristics
  - Critical characteristics
  - Critical Application Items (CAIs) (e.g., systems, subsystems, software, materials, components, etc.)
  - Key manufacturing and quality processes
  - Critical Safety Items (CSIs)

- Manufacturing and quality IPT participants provide outputs of and updates to key and critical characteristic identification, derivation, justification, and management processes to the SEP, AS, CDD validation process, RFP development process, TRA, MRL assessment, and PDR entry/exit criteria development process.

Metrics

- Manufacturing and quality Design IPT participants have provided documented evaluations and analyses of multiple FMEA activities (e.g., FMECA, DFMEA, PFMEA,).
  - Manufacturing and quality has provided these as inputs to the derivation processes for KCs, critical characteristics, and CSIs
  - Manufacturing and quality has provided documented input in support of the SAR to assist in CSI identification
- Manufacturing and quality has provided documented guidance to support identification, derivation, and justification of KCs and critical characteristics from identified KPPs, KSAs, and APAs.
  - Draft manufacturing and quality KPPs, KSAs, and APAs (with associated CTEs) have been updated and documented including those with impact on mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy at a minimum)
  - Manufacturing and quality has provided documented inputs for development and management processes that establish, implement, and maintain management of key and critical subsystems, components, items, and software including process controls for KCs
    - Inputs have been provided on those development and management processes requiring evaluation

        - Inputs included identification of manufacturing and quality processes requiring maturation with recommended metrics
        - Specific actions have been documented with recommended metrics (e.g., mitigation, investments, etc.)
    - A preliminary list of KCs and Critical characteristics, CAIs(e.g., systems, subsystems, software, materials, components, etc.), key manufacturing and quality processes, and CSIs has been created and documented, including where produced or accomplished information with supporting rationale

- The program office and the contractor manufacturing and quality IPT participants have jointly identified ninety percent KPPs; and have analyzed, linked, and documented these KPPs to key and critical characteristics in the appropriate management systems for tracking and status.
- Manufacturing and quality IPT participants have documented and provided outputs/updates to key and critical characteristic identification, derivation, justification, and management processes as inputs to the AS, SEP, CDD validation process, RFP development process, TRA, MRL assessment, and PDR entry/exit criteria development process.

Tools

- MRL Matrix Version 2016
    - Critical to Quality Tree
    - Failure Mode and Effects Analysis
    - Process Capability Analysis Worksheet
    - Producibility Assessment Checklist
    - Technology Readiness Level Assessment Checklist

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- DoDI5000.02, change 1,
- IEEE 15288.1, -.2
- JCIDS Manual
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA), Jan 2009
- MIL-STD-882E DoD Standard Practice: System Safety, May 2012
    - MRL Deskbook Version 2016
    - NAVSO P-3687 Producibility System Guidelines, Dec 1999
    - Technology Level Assessment Guidance, April 2011

E.6 Assess Design Maturity

Manufacturing and Quality Tasks

- Based on design and manufacturing feasibility and capability analyses, producibility assessments, and KC identification process, manufacturing and quality will assess design maturity in accordance with industry best practices (e.g., AS6500, AS9100, etc.) and readiness for the PDR (per IEEE 15288).
    - Update prior or conduct manufacturing and quality assessments of capability and feasibility based on contracted system concept(s).
        - Assess lower level performance requirements to determine sufficiency to proceed to preliminary design
        - Assess completeness of product data required for component manufacturing
    - Update the producibility and manufacturability assessments for gaps and risks including:
        - Critical and unique manufacturing process requirements including software
        - Alternate design approaches within the concepts
        - Material requirements
        - Supply chain requirements
        - Production rate and yield requirements
        - Facility requirements
        - Special tooling development requirements
        - Test and demonstration requirements for new materials
        - System safety and hazardous materials management
        - Economic feasibility
        - Manufacturing capability obsolescence
        - Manufacturing capability sustainment
    - Assess adequacy and robustness of the contractor configuration control processes with respect to design, engineering, software changes
    - Assess updates and status of key and critical characteristic processes
        - Assess manufacturing and quality engineering and management activities for adequacy and completeness (e.g., documentation, drawings, data collection and management, etc.)
        - Assess for adequacy and completeness of manufacturing and quality inputs on mandatory KPPs
    - Provide inputs and plans for manufacturing and quality risks, issues, and opportunities to the government/contractor Risk, Issue, and Opportunity (RIO) Management Process
        - Update and status known
        - Identify and develop plans for new
        - Evaluate adequacy and completeness of mitigation activities

- Provide manufacturing and quality inputs for product level engineering/design requirements definition and support the validation activities.
- Assess and validate product requirements and features as well enough defined to support PDR
- Identify manufacturing and quality components of Technical Performance Measures (TPMs) to support tracking of design maturity
- Assess and validate if product data essential for system/subsystem prototyping is ready for release
- Assess completion status of physical and functional interface definitions for the product (system)
- Assess and validate prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software
- Assess percentage completion of subsystem design (with schedule for completion) and component and item maturity (percentage in current production) for PDR

Metrics

- Manufacturing and quality assessments of capability and feasibility based on contracted system concept(s) have been conducted, evaluated, and the results documented for requirements and completeness.
  - Lower level performance requirements have been assessed as sufficient to support required preliminary design activities
  - Product data has been assessed as complete to support component manufacturing
- Producibility and manufacturability assessments have been reviewed, identified and/or updated for gaps and risks with documentation that includes:
  - Critical and unique manufacturing processes including software
  - Alternate design approaches within the concepts
  - Materials
  - Supply chain
  - Production rates and yields
  - Facilities
  - Special tooling
  - Tests and demonstrations
  - System safety and hazardous materials management
  - Economic feasibility
  - Manufacturing obsolescence and sustainment
  - New or emerging risks, issues, or opportunities
- Contractor configuration control processes with respect to design, engineering, software changes has been assessed and validated for adequacy, robustness, accuracy, and compliance with contract.

- Assessments of key and critical characteristic processes have been conducted, updates and status documented, and shortfalls and corrective actions identified.
    - Manufacturing and quality engineering and management activities have been assessed and document adequacy and completeness (e.g., documentation, drawings, data collection and management, etc.)
    - Manufacturing and quality inputs for mandatory KPPs (CDD validation process) have been assessed for adequacy and completeness
- Manufacturing and quality inputs and plans for risks, issues, and opportunities have been assessed and documented in the government/contractor RIO Management Process:
    - Updates and status have been included
    - Plans for new and emerging risks, issues, and opportunities have been identified and developed
    - Adequacy and completeness of mitigation activities has been documented
- Manufacturing and quality inputs for product level engineering/design requirements definition have been provided and support validation activities.
    - Product requirements and features have been defined and documented to support PDR
    - Manufacturing and quality components of Technical Performance Measures have been identified to support tracking of design maturity
    - Product data required for subsystem/system prototype manufacturing is under configuration control and has been documented and released with all enabling/critical items, parts and components prototyped including software
    - Physical and functional interfaces for the product (system) have been eighty percent defined and documented
    - Prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software have been assessed and validated
    - Subsystems designs have been assessed and documented to be seventy-five percent complete and ninety percent of components and items have been assessed and documented as proven designs ready for production
- Based on industry best practices for design and manufacturing feasibility and capability analyses, producibility assessments, and KC identification process, manufacturing and quality has assessed and documented design maturity and readiness (IAW: AS6500, AS9100, etc.).
    - Documented inputs have been provided for the AS, SEP, and other program documentation
    - Appropriate documentation has been provided for CDD validation, TRA and MRL assessment activities, RFP release
    - Documentation has been provided for the PDR entry/exit criteria

Tools

- Design for Six Sigma

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017, Enclosure 2, 6.d., Jan 2017
- JCIDS Manual, Enclosure D, Dec 2015
- MIL-STD-882E DoD Standard Practice: System Safety, May 2012
- References to Public Law, 114-328, etc.
- Risk, Issue, and Opportunity Management Program Guide

E.7 Support Preliminary Design Review (PDR)

Manufacturing and Quality Tasks

- Provide manufacturing and quality inputs to the entry criteria for the preliminary PDR process per industry best practices (i.e., IEEE 15288) including:
    - Acceptability criteria for technical review outputs
    - Preparatory actions for the specific program
    - Inputs to allocated baseline and budget
    - Review of lower level subsystem PDRs
- Provide manufacturing and quality inputs to the exit criteria for the PDR process per industry best practices (i.e., IEEE 15288) that include addressing:
    - Adequacy, accuracy, and completeness of required manufacturing and quality PDR criteria
    - Closure of manufacturing and quality action items with appropriate corrective action plans
    - Risk and issue mitigation and opportunity planning
    - Adequacy of the allocated and functional baselines
- Manufacturing and quality support the PDR to ensure, by inputs provided from results of a MRL assessment(s), that the manufacturing system will meet expectations for effectiveness and suitability (quality) within the allocated budget and schedule includes:
    - Manufacturing equipment, tooling, and software (including ManTech)
    - Processes, process control, and process capabilities (C_{pk}s)
        - Include initial data analyses
    - Interfaces and interface requirements

- Materials management (including hazardous)
- Workforce (personnel, skill sets, training, etc.)
- Supply chain (includes industrial base alternatives)
- Facilities (including GFE)

- Provide manufacturing and quality design inputs for reviews, analyses, assessments, and contractor deliverables that support sufficient maturity of the allocated baseline per contractual requirements to conduct a PDR including:
  - Analyses of system-level performance, producibility, growth allocations, and traceability
  - Design trade studies to the lowest level
  - Software development and re-use
  - Allocation of interoperability performance requirements
  - Preliminary long-lead production requirements
  - Requirements for parts, materials, and processes incorporated in the preliminary design including risks, issues, and opportunities (e.g., obsolescence; fragile, sole, single, foreign sources, hazardous, etc.)
  - Manufacturing and quality control processes and procedures (e.g., Electromagnetic Interference, hazardous, environmental, etc.)
  - Meeting the Mandatory KPPs and system performance/functional KPPs and KSAs (including supply chain)
  - Key Characteristics and key processes management
    - Include critical characteristics and critical processes (including Critical Technologies List of CTEs with CSIs and CAIs included) analyses (See E.5 and G.6)
  - DT&E requirements
  - System safety requirements
  - Environmental Safety, Occupational Health (ESOH) requirements and preliminary hazards list
  - Manufacturing security and access (physical and cyber)
  - Quality assurance requirements (including tolerances/design margin analyses for a robust design)
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)

- Provide the manufacturing and quality inputs to the assessment establishing the system functional baseline, including inputs for:
  - Preliminary designs of hardware, software, and procedures including interfaces is complete, satisfies all requirements in the system functional baseline and is under Configuration Management without any major To Be Determined (TBD) or open items
  - System, segment, subsystem, and component-level interfaces
  - Manufacturing and quality aspects of C4I equipment, interfaces, processes, and procedures across segments, subsystems, and components
  - Implication of the threat scenario to manufacturing and quality processes and environments (traceable to all segments, subsystems, and components)

- Manufacturing and quality data collected to date, including test data, on the subsystems, items, and components for the preliminary design
  - Data should be traceable to requirements via specifications and verification cross-reference matrix (from SFR)
  - Data should support bidirectional traceability between functional and allocated baselines

- Provide the manufacturing and quality inputs and documentation to the technical planning process to include:
  - Manufacturing and quality analyses of the Supplier(s) SEMP to determine adequacy and alignment with the manufacturing and quality provisions in the SEP
  - Manufacturing and quality analyses of lower-level PDRs to identify risks and issues and determination of actions required
  - A review of the Manufacturing Management and Quality Management plans in the SEMP and the SEP for adequacy to meet proposed EMD requirements
    - Include requirements for sub-tier SE reviews and audits such as PDR, CDR, PRR, etc.
  - The assessment of design maturity for the manufacturing and quality components of TPMs for the technical planning process
  - Manufacturing Management Plan and Quality Management Plan approaches to support program Validation and Verification (V&V) processes as part of design, development, test, data acquisition, etc.
  - Manufacturing and quality inputs to the hazardous materials management and pollution prevention processes and procedures
  - Inputs on adequacy of facilities chosen to perform design verification (includes facilities, equipment, GFE, etc.)
  - Status of ongoing system producibility and trade studies
  - Identification of long-lead materials and supply chain elements (including multi-sourcing of items, parts, and components)
  - Inputs to the requirements for software development plans
    - Coordination, scheduling, and availability of assets (e.g., facilities, labs, equipment, etc.) for test and integration
    - Hardware/software interfaces and integration
    - Data storage, handling, and security (physical and cyber)
    - Built-in test and performance

- Review manufacturing and quality plans for completeness and adequacy to include
  - Analyses, demonstrations, and prototypes to confirm the design/development approach in a relevant environment
  - Trade studies that address COTS, re-use, and other related issues
  - A draft Bill of Materials for the system

- An updated IMP and IMS that includes all major phases with acceptable risks and executable budget
- Use of computer modeling, design tools, and test and integration labs
- Identification, definition, and characterization of critical manufacturing processes, metrics, and the management process
- Collection of manufacturing and quality data for Reliability and Maintainability processes
- A failure reporting and corrective action system (FRACAS) process
- Inputs to the TEMP components and items, facilities, equipment, fixtures, and interfaces
- Capability to meet rate and schedule

- Provide manufacturing and quality support to the Life Cycle Support Plan.
- Provide inputs to the program risk, issue, and opportunity assessment process for identification and mitigation of manufacturing and quality cost, schedule, and technical risks.
- Provide inputs to the program life cycle cost estimates for manufacturing and quality.

Metrics

- Evidence that manufacturing and quality inputs to the entry criteria for the preliminary PDR process per industry best practices (i.e., IEEE 15288) have been provided to include:
  - Acceptability criteria for technical review outputs
  - Preparatory actions for the specific program
  - Inputs to allocated baseline and budget
  - Review of lower level subsystem PDRs
- Evidence that manufacturing and quality inputs to the exit criteria for the PDR process per industry best practices (i.e., IEEE 15288) have been documented and address:
  - Adequacy, accuracy, and completeness of required manufacturing and quality PDR criteria
  - Closure of manufacturing and quality action items with appropriate corrective action plans
  - Risk and issue mitigation and opportunity planning
  - Adequacy of the allocated and functional baselines
- Manufacturing and quality has conducted MRL assessment(s) and provided documented results to support the PDR that the manufacturing system meets expectations for effectiveness and suitability (quality) within the allocated budget and schedule including inputs on:
  - Manufacturing equipment, tooling, and software (including ManTech)
  - Processes, process control, and process capabilities (C_{pk}s)
    - Included initial data analyses
  - Interfaces and interface requirements
  - Materials management (including hazardous)

- Workforce (personnel, skill sets, training, etc.)
- Supply chain (includes industrial base alternatives)
- Facilities (including GFE)

- Manufacturing and quality has participated in and provided documented design inputs for reviews, analyses, assessments, and contractor deliverables to support the determination that the allocated baseline is mature and meets contractual entry requirements for a PDR including:
  - Completed analyses of system-level performance, producibility, growth allocations, and traceability
  - Completed Design trade studies to the lowest level
  - Completed analyses of software and firmware development and re-use
  - Performance requirements for interoperability allocated
  - Preliminary long-lead production requirements documented
  - Documented requirements for parts, materials, and processes incorporated in the preliminary design including recommended mitigations of risks and issues (e.g., obsolescence; fragile, sole, single, foreign sources, hazardous, etc.)
    - Documented recommendations for opportunities
  - Documented manufacturing and quality control processes and procedures (e.g., EMI, hazardous, environmental, etc.)
  - Documented design verifications that the Mandatory KPPs and system performance/functional KPPs and KSAs (including supply chain) have been met for PDR entrance criteria
  - Documented Key Characteristics, key processes, and management processes
    - Including critical characteristics and critical processes (including Critical Technologies List of CTEs with CSIs and CAIs included) documentation
  - Documented inputs to DT&E requirements analyses
  - Documented inputs System safety requirements analyses
  - Documented inputs to ESOH requirements and preliminary hazards list analyses
  - Manufacturing security and access (physical and cyber) requirements analyses
  - Quality assurance requirements analyses (including tolerances/design margin for a robust design)
  - Documented inputs to Modular Open Systems Approach (includes interfaces and subsystems) requirements analyses

- Manufacturing and quality has provided documented inputs to the system functional baseline, which included inputs for:
  - Completed preliminary designs of hardware, software, and procedures (including interfaces), which satisfied all requirements in the system functional baseline and are under CM

- System, segment, subsystem, and component-level interfaces which are under configuration control
- Manufacturing and quality requirements for C4I equipment, interfaces, processes, and procedures across segments, subsystems, and components
- Implications of the threat scenario to manufacturing and quality processes and environments (traceable to all segments, subsystems, and components)
- Analyses of manufacturing and quality data collected to date, including test data, on the subsystems, items, and components for the preliminary design
  - Data traceability to requirements via specifications and verification cross-reference matrix (from SFR)
  - Data bidirectional traceability between functional and allocated baselines

- Manufacturing and quality has provided inputs and documentation to the technical planning processes to include:
  - Analyses of the Supplier(s) SEMP for adequacy and alignment with the manufacturing and quality provisions in the SEP
  - Analyses of risks and issues and mitigation actions required from lower-level PDRs (subsystems, items, and components)
  - Review of the Manufacturing Management and Quality Management plans in the SEP and the SEMP for accuracy and adequacy to meet proposed EMD requirements
    - Include requirements for sub-tier SE reviews and audits such as PDR, CDR, PRR, etc.
  - Design maturity assessment results for the manufacturing and quality components of TPMs
  - To the program, V&V processes as part of design, development, test, data acquisition, etc.
  - To the hazardous materials management and pollution prevention processes and procedures
  - Analysis results on adequacy of facilities chosen to perform design verification (includes facilities, equipment, GFE, etc.)
  - Status and adequacy of ongoing system producibility and trade studies
  - Validated list of long-lead materials and supply chain elements (including multi-sourcing of items, parts, and components)
  - Validated list of manufacturing and quality requirements for software development plans:
    - Coordination, scheduling, and availability of assets (e.g., facilities, labs, equipment, etc.) for test and integration
    - Hardware/software interfaces and integration
    - Data storage, handling, and security (physical and cyber)
    - Built-in test and performance

- Manufacturing and quality plans have been reviewed for accuracy and adequacy with results documented for PDR, to include:
  - Analyses, demonstrations, and prototypes to confirm the design/development approach in a relevant environment
  - Trade studies that address COTS, re-use, and other related issues
  - A draft Bill of Materials for the system
  - An updated IMP and IMS that includes all major phases with acceptable risks and executable budget
  - Use of computer modeling, design tools, and test and integration labs
  - Identification, definition, and characterization of critical manufacturing processes, metrics, and the management process
  - Collection of manufacturing and quality data for Reliability and Maintainability processes
  - A failure reporting and corrective action system (FRACAS) process
  - Inputs to the TEMP components and items, facilities, equipment, fixtures, and interfaces
  - Capability to meet rate and schedule
- Manufacturing and quality has provided documented inputs to the Life Cycle Support Plan.
- Manufacturing and quality have documented and provided manufacturing and quality risks, issues, and opportunities for inclusion and mitigation as part of the program RIO Process.
- Manufacturing and quality life cycle cost estimates have been provided for the PDR.

Tools

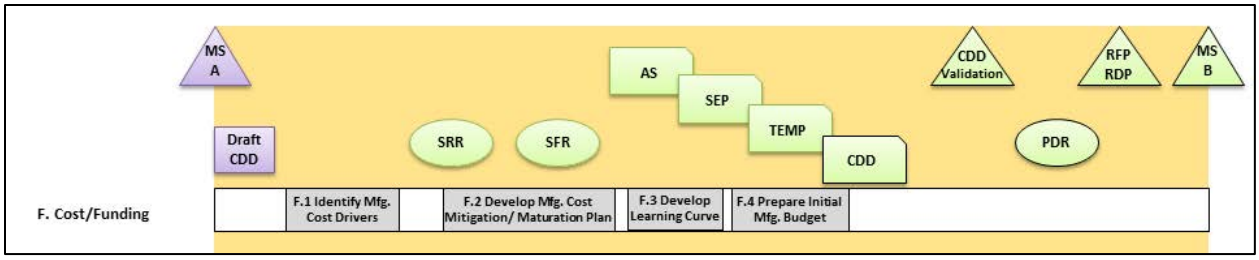
- Preliminary Design Review checklist

Resources

- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MIL-STD-882E DoD Standard Practice: System Safety, May 2012
- Preliminary Design Review, DAG Chapter 3-3.3.4

F. COST/FUNDING

Detailed manufacturing cost estimates could not be developed during the MSA phase, but cost drivers should have been identified based on proposed materials and process selections that were inherent in the proposed material solutions. In addition, producibility cost could be assessed and investments in manufacturing technologies could be estimated. In TMRR, costs need to be defined and finalized.



Cost estimates should be used to evaluate affordability and establish initial program thresholds. In most cases, the estimates in MSA were developed through the use of statistically based cost estimating relationships or by comparison of the proposed systems with similar systems whose costs are known. The cost estimates will be used as the initial basis for concept costs in the TMRR phase.

Manufacturing and quality cost estimating is a process used to predict life cycle manufacturing costs based upon the capabilities and processes to produce and support the components of a system. Manufacturing and quality specialists within the program predict system costs using the results of trade studies and probable process yields. Manufacturing and quality should-cost inputs should be provided to the Cost Analysis Requirements Document (CARD) to update it for consistency with the approved system specification.

Within any program there will be certain systems, subsystems, items, and components the cost of which will dramatically impact the overall system cost which are the cost drivers. Any analysis of manufacturing and quality risks and producibility issues will generally identify a cost driver. Manufacturing and quality focuses on producibility planning and risk and issue mitigation for identification and reduction of cost drivers. Areas that are ripe for discovering and eliminating manufacturing cost drivers include the following areas:

- Emerging technologies
- Industrial base
- Design/producibility
- Funding for maturing the manufacturing and quality processes
- Materials availability and environmental impacts
- Supply chain management
- Process capability and control
- Manufacturing and quality management/supplier quality management
- Workforce
- Facilities, capital equipment, tooling, and test equipment

After identifying manufacturing cost drivers a concerted effort should be initiated to reduce these drivers and the overall costs wherever possible. There are several cost tools that can be used within the program that can help identify and achieve overall cost reductions.

A should-cost review uses an integrated team to conduct coordinated, in-depth cost analyses of a contractor's plans and ongoing efforts. The purpose of the review is to identify inefficient and uneconomical contractor practices, to quantify the impact of these practices on system cost, and to use the findings to develop a realistic price objective. The approved cost reduction efforts or initiatives are used to incentivize contractor performance towards achievement of the new should-cost target. The should-cost analysis is intended to not only evaluate proposed contractor costs, but to then track and monitor those costs and to identify further savings opportunities that will lead to further cost reductions.

Will-cost estimates should be verified by an office that is external to and independent of the program office. Additionally, it is DOD policy that programs actively manage the budget baseline using the current will-cost estimates for all acquisition, budget and program execution decisions (e.g. source-selection, contract negotiations, major reviews, etc.). The programs budget baseline is based on a will-cost estimate and is sometimes referred to as the Independent Cost Estimate (ICE) or verified Program Office Estimate. This estimate is historical in nature and aims to provide sufficient funds to execute the program under normal conditions (average program risks). This will-cost estimate is used to support the budget and ensures sufficient funding.

Program Managers will employ Earned Value Management (EVM). The purpose of EVM is to ensure sound planning and resourcing of all tasks required for contract performance. EVM provides a disciplined, structured, objective, and quantitative method to integrate technical work scope, cost, and schedule objectives into a single cohesive contract baseline plan called a Performance Measurement Baseline for tracking contract performance.

Manufacturing and quality personnel must analyze contractor data in order to develop, update, and support plans for mitigation and/or maturation of cost drivers.

As the program matures the manufacturing budget will become more refined and accurate. During the TMRR phase, as the design matures, the contractor and the program should be able to create budgets based upon specific design characteristics and knowledge of the manufacturing and quality capabilities and processes which will be used to produce the system. The budget should include:

- Manufacturing and quality cost reduction initiatives.
- Accurate costs based on analyses and assessments of cost data against cost targets and trends.
- Manufacturing and quality funding estimates for emerging requirements including investment opportunities and investment roadmaps
- Budgeting for manufacturing and quality initiatives and manufacturing technology investment programs.

When budgeting for manufacturing and quality, interaction with the contractor will enable the program to understand the significant cost impacts experienced by the contractor. Interaction increases the program’s understanding of the contractor's manufacturing and quality operations and

manufacturing and quality costs, as well as the factors that can impact manufacturing and quality operations.

F.1 Identify Manufacturing Cost Drivers

Manufacturing and Quality Tasks

- Analyze and update manufacturing and quality should-cost inputs and provide these to the Cost Analysis Requirements Document (CARD) update for consistency with the approved system specification and budget for the SRR.
    - Include updates to the will-cost model based on industry best practices
    - Include updates to manufacturing and quality cost sensitivity analyses
- Analyze and update manufacturing and quality cost drivers from manufacturing, quality, materials, and unique or specialized requirements and associated risks and issues for the SRR.
    - Include contractor descriptions and plans for processes, materials, rates, supplier quality, workforce, special handling, environmental compliance, security (physical and cyber), etc.
    - Include identified subsystems, parts, items, and components
    - Include “should-cost” analyses
    - Quantify the cost driver uncertainties
    - Update the estimate for the cost of quality
    - Update the estimate for the cost and impact of testing
- Analyze and update the contractor producibility planning for cost drivers and associated risks for the SRR to include:
    - Emerging technologies
    - Design producibility
    - Cost reduction and avoidance
    - Manufacturing processes
    - Materials availability
    - Environmental compliance
    - Supply chain
    - Process capability and control
    - Quality and supplier quality
    - Workforce training
    - Security, required special handling, cyber protection
    - Facilities, capital equipment, tooling, and test equipment
- Analyze the contractor initial manufacturing and quality risk assessment for mitigation plan costs and drivers within budget and schedule for the SRR.

- Include risks from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources

- Analyze the contractor manufacturing and quality cost planning for realistic and appropriate allocation of cost drivers for the SRR.
- Update manufacturing and quality cost estimates for predicted life cycle costs of the evolving design for consistency with program affordability constraints for the SRR.
- Analyze and update manufacturing and quality cost estimates and budget for prototype demos and validations contributing to cost drivers for the SRR.
- Ensure manufacturing and quality cost should-cost estimates (inputs) to the CARD are consistent with the allocated baseline for the PDR.

  - Include manufacturing and quality cost sensitivity analyses validation

- Update manufacturing and quality cost drivers from manufacturing, quality, materials, and unique or specialized requirements and associated risks and issues for the MRL assessment and the PDR including:

  - Contractor processes, materials, rates, supplier quality, workforce, special handling, environmental compliance, security (physical and cyber), etc.
  - Subsystems, parts, items, and components
  - Quantified cost drivers
  - Cost of quality estimates
  - Estimates for the cost of testing

- Validate the contractor producibility cost drivers and associated risks, issues, and mitigation plans for the MRL assessment and the PDR including SRR producibility planning areas above.
- Update status of contractor manufacturing and quality risks and issues mitigation costs and drivers (budget and schedule) for the MRL assessment and the PDR.

  - Include risks and issues from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
  - Cost, schedule, and technical risks are identified, and mitigation plans are in place

- Validate the contractor manufacturing and quality costs and cost planning for realism and allocation of cost drivers for the MRL assessment and the PDR.
- Update manufacturing and quality cost estimates for predicted life cycle costs for the MRL assessment and the PDR.
- Validate manufacturing and quality cost estimates and budget for prototype actual costs and validation costs for cost drivers for the MRL assessment and the PDR.
- Update manufacturing and quality hardware estimates for quantity, effort (costs), and schedule for the MRL assessment and the PDR.
- Update manufacturing and quality inputs to the system cost model and budget including allocations to lower system element levels, tracking against targets, and the production cost model for the MRL assessment and the PDR.

Metrics

- Manufacturing and quality should-cost inputs have been analyzed for consistency with the approved system specification and budget for the SRR and the documented results provided as input to the Cost Analysis Requirements Document (CARD) including:
  - Updated will-cost model based on industry best practices
  - Updated manufacturing and quality cost sensitivity analyses
- Manufacturing and quality cost drivers from manufacturing, quality, materials, and unique or specialized requirements and associated risks and issues have been updated, documented, and provided for the SRR including:
  - Contractor descriptions and plans for processes, materials, rates, supplier quality, workforce, special handling, environmental compliance, security (physical and cyber), etc.
  - Identified subsystems, parts, items, and components
  - "Should-cost" analyses
  - Quantified the cost driver uncertainties
  - Estimated cost of quality
  - Estimated cost of testing
- Manufacturing and quality have analyzed the contractor producibility plans for cost drivers and associated risks and provided the documented results for the SRR to including the required aspects of:
  - Emerging technologies
  - Design producibility
  - Cost reduction and avoidance
  - Manufacturing processes
  - Materials availability
  - Environmental compliance
  - Supply chain
  - Process capability and control
  - Quality and supplier quality
  - Workforce training
  - Security, required special handling, cyber protection
  - Facilities, capital equipment, tooling, and test equipment
- Contractor initial manufacturing and quality risk assessments and mitigation plans have been analyzed and results documented for costs and cost drivers against budget and schedule for the SRR including:
  - Risks from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources

- Contractor manufacturing and quality planning has been analyzed and documented for realistic and appropriate allocation of cost drivers for the SRR.
- Manufacturing and quality cost estimates for predicted life cycle costs of the evolving design have been documented and provided for the SRR, and are consistent with program affordability constraints.
- Manufacturing and quality cost estimates and budget for prototype demos and validations to confirm cost drivers have been analyzed and documented for the SRR.
- Manufacturing and quality should-cost cost estimates (documented inputs) to the CARD have been validated and are consistent with the allocated baseline for the PDR.
    - Included manufacturing and quality cost sensitivity analyses validation
- Manufacturing and quality cost drivers from manufacturing, quality, materials, and unique or specialized requirements and associated risks and issues have been updated and documented to support the MRL assessment and the PDR including:
    - Contractor processes, materials, rates, supplier quality, workforce, special handling, environmental compliance, security (physical and cyber), etc.
    - Subsystems, parts, items, and components
    - Quantified cost drivers
    - Cost of quality estimates
    - Estimates for the cost of testing
- Contractor producibility cost drivers and associated risks, issues, and mitigation plans have been validated and results provided for the MRL assessment and the PDR (included the SRR producibility planning areas above).
- Contractor manufacturing and quality risks and issues mitigation costs and drivers (budget and schedule) have been analyzed, updated, and results provided for the MRL assessment and the PDR, which included:
    - Risks and issues from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
    - Identified costs, schedule, and technical risks and issues with mitigation plans in place
- Contractor manufacturing and quality costs and cost plans have been validated and documented for realism and appropriate allocation of cost drivers for the MRL assessment and the PDR.
- Manufacturing and quality cost estimates for predicted life cycle costs have been updated and documented to support the MRL assessment and the PDR.
- Manufacturing and quality cost estimates and budget updated and documented with prototype actual costs and validated cost drivers for the MRL assessment and the PDR.
- Manufacturing and quality hardware estimates for quantity, effort (costs), and schedule have been updated and documented for the MRL assessment and the PDR.

- Manufacturing and quality inputs to the system cost model and budget including allocations to lower system element levels, tracking against targets, and the production cost model have been updated and documented for the MRL assessment and the PDR.
- Documented evidence that cost models have been updated with design requirements, material specifications, tolerances, integrated master schedule, results of system/subsystem simulations and production relevant prototype demonstrations have been provided for the MRL assessment and the PDR.

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- MRL assessment for the Cost Thread
- Cost, Schedule Control Systems Criteria (CSCSC)
- See CAPE website for tools

Resources

- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- Should-cost and Affordability Memo, Aug 2011
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MRL Deskbook Version 2016
- CARD Website and process

F.2 Develop Manufacturing Cost Mitigation/Maturation Plan

Manufacturing and Quality Tasks

- Utilizing the outputs (SRR/SFR) from the should-cost and will-cost analyses, develop cost reduction (i.e., mitigation) plans.
    - Conduct a coordinated, in-depth should-cost review on the contractor(s) planning and ongoing efforts against best practices
    - Incorporate identified cost drivers
    - Conduct will-cost analyses on the results
    - Plans include tracking and monitoring costs to identify further savings opportunities and reductions
    - Plans address manufacturing and quality cost risks and issues mitigation plans

- Plans include completion of major cost and performance trades, and risk and issue reduction efforts to support the CDD Validation Decision prior to PDR

- If an Independent Cost Estimate (ICE) or verified Program Office Estimate is requested, provide manufacturing and quality inputs and support.
  - Provide validated manufacturing and quality capability requirements
  - Provide manufacturing and quality inputs on required funding for the FYDP
  - Verify manufacturing and quality compliance with affordability goals for production and sustainment
- Analyze the contractor manufacturing and quality Earned Value Management (EVM) plan to include the critical path documentation.
- Update the cost model to include cost targets and include:
  - Design/Producibility analyses considerations and results
  - Manufacturing and quality costs
    - New manufacturing and quality processes implementation
    - Materials availability and maturity
    - Environmental management and disposal impacts
    - Process capability and throughput (setup, yield, scrap, rework, Work In Progress)
    - Quality (including supplier quality) issues
    - Workforce issues
    - Facilities costs
    - Security, required special handling, cyber protection
    - Special Tooling and Test Equipment
    - Equipment availability, capacity, and constraints
    - New Technologies analyses and impacts
  - Support of Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs.)
- Update the manufacturing and quality cost models to support mitigation/maturation planning to include the capability for the models to support:
  - Design trades to assess the cost impacts of specific design changes
  - Alternative production processes or process improvements
- Incorporation of the current estimates and actual (if available) manufacturing costs into the cost estimates
- Planning for EMD, production, developmental and operational test, and life cycle sustainment of proposed products.
  - The CDD Validation Decision process
- Develop cost maturation and mitigation plans to support independent evaluations (MRL assessments)

- Manufacturing Maturation Plan incorporates and document the costs associated for maturing manufacturing capability that does not meet required maturity levels

Metrics

- Manufacturing and quality cost risks and cost issues mitigation plans utilizing should-cost and will-cost analyses have been completed, documented, and are being executed with progress tracked and reported on a recurring basis (PMRs, etc.).
  - A coordinated, in-depth should-cost review on the contractor(s) planning and ongoing efforts against best practices has been conducted
  - Identified cost drivers have been incorporated
  - Tracking and plans to monitor costs to identify further savings opportunities and reductions have been included
  - Manufacturing and quality cost risks and issues mitigation plans have been addressed
  - Completion of major cost and performance trades, and risk and issue reduction efforts have been included to support the CDD Validation Decision prior to PDR
- Manufacturing and quality inputs and support have been provided to an Independent Cost Estimate (ICE) or verified Program Office Estimate (if requested) and includes:
  - Validated manufacturing and quality capability requirements
  - Manufacturing and quality inputs on required funding for the FYDP
  - Manufacturing and quality verified compliance with affordability goals for production and sustainment
- Contractor manufacturing and quality EVM plan is in place, has been reviewed for adequacy and completeness, documents the critical path, and is up-to-date.
- Evidence that an updated, robust cost model is documented and maintained, to include cost targets and includes:
  - Design/Producibility analyses considerations and results
  - Manufacturing costs
    - New manufacturing processes implementation
    - Materials availability and maturity
    - Environmental management and disposal impacts
    - Process capability and throughput (setup, yield, scrap, rework, Work In Progress)
    - Quality (including supplier quality) issues
    - Workforce issues
    - Facilities costs
    - Security, required special handling, cyber protection
    - Special Tooling and Test Equipment
    - Equipment availability, capacity, and constraints
    - New Technologies analyses and impacts

    - Support of Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs)

- The updates to manufacturing and quality cost models have been documented to support mitigation/maturation planning which included the capability for the models to support:
- Design trades to assess the cost impacts of specific design changes
    - Alternative production processes or process improvements
    - Incorporation of the current estimates and actual (if available) manufacturing costs into the cost estimates
    - Planning for EMD, production, developmental and operational test, and life cycle sustainment of proposed products
    - The CDD Validation Decision process
- Cost maturation and mitigation plans have been developed and are in place to support independent evaluations (MRL assessments)
    - Manufacturing Maturation Plan incorporates and documents the costs associated for maturing manufacturing capability that does not meet required maturity levels.

Tools

- Parametric, Engineering and Actual estimating
- CARD - Cost Analysis Requirements Description (see CAPE website for tools)
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding Thread
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan (no template available)

Resources

- 10 USC Sec. 2334 Independent Cost Estimation and Cost Analysis
- CARD - Cost Analysis Requirements Description Template (See CAPE website for guidance)
- DODI 5000.73 Cost Analysis Guidance and Procedures
- NDAA DY 2017 (Public Law 114-328), §807, Cost, Schedule and performance of major defense acquisition programs
- JCIDS Manual
- MRL Deskbook Version 2016
- Cost/Schedule Control Systems Criteria Reference Guide, Sep 1992
- DoDI 5000.73, Cost Analysis Guidance and Procedures, Jun 2015
- DoDI 5000.02, Feb 2017, Change 1, Jan 2017

F.3 Develop Learning Curve

Manufacturing and Quality Tasks

- Manufacturing and quality defines appropriate learning curves for the system and subsystems to include initiation and reporting requirements.
    - Include the basis for the slope (quantity and schedule) for the learning curves
- Define requirements for the baseline data and data collection to include:
    - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
    - Labor efficiency
    - Improvements in methods, equipment, tools, automation
    - Standardization and common processes
    - Design changes (producibility/manufacturability)
- Plan for collection of data to support learning curves development that includes the following factors and improvements, at a minimum:
    - Workforce learning, worker and supervisor
    - Process, line, and workstation
    - Machinery, equipment, and tooling
    - Design producibility changes
    - Work methods and processes
    - Planning and scheduling processes
    - Lot and batch sizing and optimization (just-in-time)
    - Engineering and test activities and changes
    - Quality inspections/tests sampling requirements
    - Inventory, storage, re-work, and scrap levels
    - Operation sequencing and synchronization
    - Pre-Planned Product Improvement program and processes

Metrics

- Manufacturing and quality has defined the learning curves for the system and subsystems and documented them in the program management system for technical and program reviews
    - Initiation (system and subsystems) and reporting requirements with frequency of review and goals have been included
    - Basis for the slope has been defined as appropriate and realistic
- Baseline data and data collection requirements have been defined, documented, and distributed to the appropriate IPT including:
    - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.

- Labor efficiency
- Improvements in methods, equipment, tools, automation
- Standardization and common processes
- Design changes (producibility/manufacturability)

- Collection of data to support learning curve development has been planned, documented, and distributed and includes the following factors and improvements, at a minimum:
  - Workforce learning, worker and supervisor (%/time)
    - Skill improvements (#)
    - Tooling improvements (#/% throughput)
    - Workstations efficiency improvements (#)
  - Process, line, and workstation (% throughput)
  - Machinery, equipment, and tooling (% throughput)
  - Design producibility changes (#/%)
  - Work methods and processes (% throughput)
  - Planning and scheduling processes (% throughput)
  - Lot and batch sizing and optimization (just-in-time) ($)
  - Engineering and test activities and changes (#/$/time)
  - Quality inspections/tests sampling requirements (#/time)
  - Inventory, storage, re-work, and scrap levels (#/$/%)
  - Operation sequencing and synchronization (% throughput)
  - Pre-Planned Product Improvement program and processes (#/$)

Tools

- Learning Curve Worksheet in Excel

Resources

- Application of Learning Curve Theory to Systems Acquisition, Defense Acquisition University (DAU) Teaching Note, Feb 2011
- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8 Learning Curve

F.4 Prepare Initial Manufacturing Budget

Manufacturing and Quality Tasks

- Update the manufacturing and quality cost estimates from MSA to validate and update the TMRR budget to include fact-of-life changes.
  - Verify that cost estimates include all manufacturing and quality cost drivers and risk estimates from the updated cost model

- Verify manufacturing and quality quantification of cost driver uncertainties and associated budget impact estimates as inputs to the budget process
- Verify the producibility costs (cost drivers and risks) are included in budget process
- Update investment estimates in manufacturing and quality technologies, processes, equipment, etc. (including ManTech) as inputs to the budget process to include:
  - Capital equipment (tooling, machines, structures, etc.)
  - Test equipment (specialized, environmental, etc.)
  - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
  - GFE
  - Environmental compliance (processes, facilities, equipment, etc.)
  - Manufacturing systems security (physical, cyber, etc.)
- Update cost estimating (should-cost and will-cost) with contractor data on manufacturing and quality aspects of the proposed system (include similar systems whose costs are known)
- Validate established manufacturing and quality targets (from initial thresholds) affordability cost estimates (should-cost and will-cost) for TMRR based on contractor data
- Update identified ManTech investments to mitigate manufacturing and quality technology gaps in TMRR for implementation
  - Contact and coordinate with potential funding sources for ManTech projects (program office, Service, and/or DoD-wide funding)
- Provide analyses of the adequacy, reasonableness, and necessity of contractor-proposed manufacturing labor hours and material costs and determine the adequacy of the manufacturing budget for TMRR

- All outstanding manufacturing and quality risks and issues understood for the SRR and the SFR with approved TMRR budget for mitigation plans to achieve PDR entrance criteria including:
  - Technology
  - Industrial Base
  - Design
  - Cost and Funding
  - Materials
  - Process and Capability Control
  - Quality Management
  - Manufacturing Workforce
  - Facilities
  - Manufacturing Management

- Analyze the manufacturing and quality TMRR budget sufficiency for the capability to produce a prototype system or subsystem in a production relevant environment prior to Milestone B.
    - Assess each TMRR prototype requirements (system or subsystem) for manufacturing and quality process needs, risks and issues, and affordability analyses with budget impacts.
- Evaluate the ongoing manufacturing technology investments (ManTech programs) for sufficiency to meet program objectives (e.g., EMD, P&D, and O&S).
    - Include sponsored initiatives in the program budget and from other sources
- Monitor the execution of the TMRR program, and evaluate for impacts to recommend appropriate changes to the manufacturing and quality budget.
    - Assess the affordability and executability of the manufacturing processes
    - Recommend quality and manufacturing cost reduction initiatives
    - Analyze the quality, manufacturing, and production cost data (if available) down to the component level against cost targets, and identify trends
    - Identify quality and manufacturing emerging issues
    - Identify manufacturing investment opportunities and develop investment roadmaps to further the manufacturing development efforts
- Identify budget resources to support an MRL assessment and a TRA prior to PDR.
- Develop manufacturing and quality budget inputs for EMD.
    - Ensure program management includes required support by manufacturing and quality to program processes and technical and programmatic reviews for:
        - Producibility
        - Key Characteristics
        - Manufacturing Risks
        - Material and supply chain management
        - Manufacturing Technology
        - Manufacturing Surveillance and Audits
        - Manufacturing Security (physical and cyber)
        - GFE
        - Continuous improvement
        - Process control and capability
        - First article inspection and test
    - Provide an assessment of requirements for manufacturing processes, risks and issues, and affordability analyses with budget impacts
    - Perform analyses of proposed manufacturing labor hours and material costs for adequacy, reasonableness, and necessity for a budget estimate
        - Utilize data from contractor reported manufacturing labor hours and material costs, if available

- Perform analyses of proposed manufacturing and quality cost reduction initiatives and incentives for a budget estimate
- Analyze manufacturing and quality EMD cost estimates and supporting TMRR performance data to develop appropriate budget requests that include:
  - Monitoring and managing Key Characteristics (includes critical characteristics, and all KPPs)
  - Assessment of identified trends
  - Emerging quality and manufacturing initiatives
  - Cost/funding estimates and recommendations on emerging requirements
  - Investment opportunities with associated roadmaps
- Provide manufacturing and quality EMD phase budget inputs that include comprehensive manufacturing and quality planning for EMD, production, developmental and operational test, life cycle sustainment, and disposal of proposed products including:
  - Investments for quality and test (e.g., training, equipment, personnel, process improvement, etc.)
  - Quantities and rates through Low-Rate Initial Production (LRIP), Production, and Sustainment
  - Materials (e.g., obsolescence, long-lead purchase, storage and handling, transportation, etc.)
  - Capital equipment requirements (e.g., production equipment, facilities, etc.)
  - Facilities (e.g., production, storage, handling, waste disposal, etc.)
  - Risk and issue identification and mitigation
  - Technology investment programs including emerging quality and manufacturing initiatives
  - Manufacturing workforce (e.g., availability, training, etc.)
  - Manufacturing processes (e.g., existing and new, scale-up, modifications, process capability and control, corrective actions, etc.)
  - Manufacturing management and control
  - Manufacturing Security (physical and cyber)
  - Resources to support contractor, sub-tier, and supplier MRL assessments prior to CDR and PRR.
  - Resources to support an MRL assessment and a TRA prior to Milestone C
  - Demonstration of pilot line capability and readiness to begin LRIP

- All outstanding manufacturing and quality risks and issues understood for the Milestone B Decision with approved EMD budget for mitigation plans to achieve CDR and LRIP entrance criteria including:
  - Technology
  - Industrial Base
  - Design
  - Cost and Funding

- Materials
- Process and Capability Control
- Quality Management
- Manufacturing Workforce
- Facilities
- Manufacturing Management

Metrics

- MSA Manufacturing and quality cost estimates have been updated to validate and documented in the TMRR budget to include fact-of-life changes.
  - Cost estimates have been verified and included all manufacturing and quality cost drivers and risk estimates from the updated cost model
  - Manufacturing and quality cost driver uncertainty quantification and associated budget impact estimates have been verified and provided as inputs to the budget process
  - Producibility costs (cost drivers and risks) have been verified and included in budget process
  - Manufacturing and quality technologies, processes, equipment, etc. (including ManTech) investment estimates have been updated and provided as inputs to the budget process to include:
    - Capital equipment (tooling, machines, structures, etc.)
    - Test equipment (specialized, environmental, etc.)
    - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
    - GFE
    - Environmental compliance (processes, facilities, equipment, etc.)
    - Manufacturing systems security (physical, cyber, etc.)
  - Cost estimates (should-cost and will-cost) utilizing contractor data on manufacturing and quality aspects of the proposed system (include similar systems whose costs are known) have been updated and validated and utilized to update the budget
  - Manufacturing and quality targets established from initial thresholds have been validated utilizing affordability cost estimates (should-cost and will-cost) based on contractor data for the budget process
  - ManTech investments identified to mitigate manufacturing and quality technology gaps during TMRR have been identified for implementation
    - Potential funding sources for ManTech projects (program office, Service, and/or DoD-wide funding) have been identified and contacted
  - Analyses of the adequacy, reasonableness, and necessity of contractor-proposed manufacturing labor hours and material costs have been completed and adequacy validated for the TMRR manufacturing budget

- All outstanding manufacturing and quality risks and issues have been evaluated and documented for the SRR and the SFR with allocated TMRR budget for mitigation plans to achieve PDR entrance criteria including:
  - Technology
  - Industrial Base
  - Design
  - Cost and Funding
  - Materials
  - Process and Capability Control
  - Quality Management
  - Manufacturing Workforce
  - Facilities
  - Manufacturing Management
- Manufacturing and quality TMRR budget has been validated and documented as sufficient to produce a prototype system or subsystem in a production relevant environment prior to Milestone B.
  - Each TMRR prototype (system or subsystem) has been assessed for manufacturing and quality process needs, risks and issues, and affordability with required budget documented
- Manufacturing and quality technology investments (ManTech programs) have been evaluated as sufficient to meet program objectives including sponsored initiatives in the program budget and from other sources.
- The execution of the TMRR program budget is being monitored and evaluated for impacts to the manufacturing and quality budget and budget changes and updates have been provided that include:
  - Affordability and executability of the manufacturing processes
  - Quality and manufacturing cost reduction initiatives
  - Quality, manufacturing, and production cost data analyses (down to the component level) against cost targets, and identified trends
  - Quality and manufacturing emerging issues
  - Manufacturing investment opportunities and investment roadmaps to improve manufacturing
- Resources to support an MRL assessment and a TRA prior to PDR have been documented in the budget
- Manufacturing and quality budget estimates have been provided for the EMD budget.
  - Manufacturing and quality have documented and provided budget inputs on required support by manufacturing and quality to program processes and technical and programmatic reviews to include support for:
    - Producibility

- Key Characteristics
- Manufacturing Risks
- Material and supply chain management
- Manufacturing Technology
- Manufacturing Surveillance and Audits
- Manufacturing Security (physical and cyber)
- GFE
- Continuous improvement
- Process control and capability
- First article inspection and test

- An assessment of requirements for EMD manufacturing processes, risks and issues, and affordability analyses has been provided with required budget estimates
- Analyses of proposed manufacturing labor hours and material costs for adequacy, reasonableness, and necessity has been conducted and budget estimate provided
  - Contractor reported data for manufacturing labor hours and material costs has been utilized, if available
- Analyses of proposed manufacturing and quality cost reduction initiatives and incentives has been conducted and budget estimate provided
- Budget requests have been developed based on manufacturing and quality EMD cost estimates and supporting TMRR performance data and include:
  - Monitoring and managing Key Characteristics (includes critical characteristics, and all KPPs)
  - Assessment of identified trends
  - Emerging quality and manufacturing initiatives
  - Cost/funding estimates and recommendations on emerging requirements
  - Investment opportunities with associated roadmaps
- Manufacturing and quality EMD phase budget inputs have been provided that include comprehensive manufacturing and quality planning for EMD, production, developmental and operational test, life cycle sustainment, and disposal of proposed products including:
  - Investments for quality and test (e.g., training, equipment, personnel, process improvement, etc.)
  - Quantities and rates through LRIP, Production, and Sustainment
  - Materials (e.g., obsolescence, long-lead purchase, storage and handling, transportation, etc.)
  - Capital equipment requirements (e.g., production equipment, facilities, etc.)
  - Facilities (e.g., production, storage, handling, waste disposal, etc.)
  - Risk and issue identification and mitigation
  - Technology investment programs including emerging quality and manufacturing initiatives
  - Manufacturing workforce (e.g., availability, training, etc.)

- Manufacturing processes (e.g., existing and new, scale-up, modifications, process capability and control, corrective actions, etc.)
- Manufacturing management and control
- Manufacturing Security (physical and cyber)
- Resources to support contractor, sub-tier, and supplier MRL assessments prior to CDR and PRR.
- Resources to support an MRL assessment and a TRA prior to Milestone C
- Demonstration of pilot line capability and readiness to begin LRIP

- All outstanding manufacturing and quality risks and issues have been evaluated and documented for the Milestone B Decision with approved EMD budget for mitigation plans to achieve CDR and LRIP entrance criteria including:
  - Technology
  - Industrial Base
  - Design
  - Cost and Funding
  - Materials
  - Process and Capability Control
  - Quality Management
  - Manufacturing Workforce
  - Facilities
  - Manufacturing Management

Tools

- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding Thread
- Technology Readiness Level Assessment Checklist

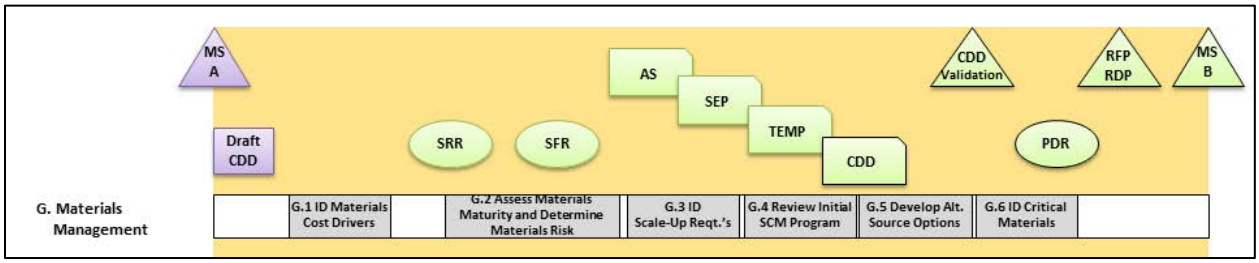
Resources

- AS6500, Manufacturing Management Program, Nov 2014
- DoDI5000.02
- IEEE 15288.2
- MRL Deskbook Version 2016
- Public Law 114-328, §807

G. MATERIALS MANAGEMENT

Material cost like manufacturing cost is estimated early in the program and turns to actual cost when production begins. As the program matures and the design becomes stable the estimates become more actual costs. Material cost drivers can vary from the cost of the material itself to the cost of the material and processing it into an end item. Selecting the most producible materials for their

capability, maturity, availability, and handling characteristics during the TMRR phase will reduce costs and benefit program on cost and schedule.



Based on contractor data, manufacturing and quality personnel must assess all materials for all manufacturing and quality risks, issues, and opportunities. This begins with an update of the evaluation of material maturity and availability from the previous phase including an assessment of the validity and maturity of emerging materials. Material availability should consider lead times with associated impacts to schedule, budget, and critical path, etc. The assessment should also include analyses for fluctuations, rarity, availability, capacity, regulatory issues, ITAR, anti-tamper, and military vulnerability. The contractor may have proposed alternate materials which will require the same rigorous assessment for properties, characteristics, and quality requirements applicable to this system. There may be other opportunities for alternate materials that address known risks and issues that should be included. Finally, manufacturing and quality risks, issues, and opportunities based on potential materials obsolescence and lack of availability based on the business climate (e.g., business failures, market changes, political, etc.) should be incorporated for the SRR and the SFR, and updates for the PDR.

During the TMRR phase, while it is not expected that contractors would have a complete factory and supply chain established, key knowledge must be obtained to determine requirements for EMD scale-up efforts, and the resulting supply chain issues. Scale up for EMD considerations should include:

- Manufacturing processes and techniques not currently available
- Probability of meeting delivery dates
- Potential impacts from critical and long-lead time materials
- Facility, equipment, tooling availability (acquisition and/or scheduling)
- Trade-offs among manufacturing and quality materials alternatives
- Anticipated in-process testing and demonstration
- Methods for conserving critical and strategic materials and mitigating supply disruption risks and associated impacts
- Transportation and security including ITAR considerations

TMRR presents the first opportunity to assess the contractor's Supply Chain Management (SCM) program. Ideally, the contractor chosen adheres to industry manufacturing and quality best practices for manufacturing management, quality management, systems engineering, sourcing, and configuration management (CM) with strong contracts and supplier interactions including processes,

plans, scheduling, variability reduction, and lead times with associated impact on the critical path. If not, it can be extremely difficult to effectively manage a program's supply chain.

Alternate source options are a technique for risk mitigation due to material availability risks. If availability of materials or components, subsystems or systems is at risk, qualifying an alternative source may be a viable solution. Having an alternate source will mitigate issues with diminishing manufacturing sources and material shortages (DMSMS).

Manufacturing and quality should analyze the contractor Critical Supplier's List (hardware and software) for completeness and identification of single points of failure for potential mitigation in EMD phase.

G.1 Identify Materials Cost Drivers

Manufacturing and Quality Tasks

- Based on manufacturing, quality, and unique or specialized requirements, specifications, and tolerances, and associated risks and issues; analyze and update manufacturing and quality materials cost drivers for the SRR.
    - Include contractor descriptions and plans for materials, materials processes, rates and quantities (including lot buys), supplier quality, special handling and training, environmental compliance and training, materials security (physical and cyber), etc.
    - Include as materials identified subsystems, parts, items, and components (supply chain commodities)
    - Include materials "should-cost" analyses
    - Quantify the materials cost driver uncertainties
    - Include cost drivers from methods used to conserve critical and strategic materials
    - Include cost drivers for mitigation of supply disruptions
    - Update the estimate for the cost of quality
    - Update the estimate for the cost and impact of materials testing
- Analyze and update the contractor planning (producibility) with respect to materials cost drivers and associated risks (see G.2) for the SRR to include:
    - Emerging materials
    - Materials design requirements
    - Price stability, cost reduction and avoidance
    - Materials processes
    - Materials availability
    - Environmental factors and compliance
    - Supply chain
    - Processes and quality
    - Security, required special handling, cyber protection
    - Facilities, capital equipment, tooling, and test equipment

- Update materials cost drivers based on manufacturing, quality, and unique or specialized requirements, specifications, and tolerances, and associated risks and issues for the MRL assessment and the PDR including:
  - Contractor materials and materials processes used
  - Materials rates and quantities obtained
  - Supplier quality levels, special handling, environmental compliance reported
  - Materials security (physical and cyber) required, etc.
  - Utilized supply chain commodities (subsystems, parts, items, and components)
  - Quantified cost drivers with continuing uncertainties
  - Cost of quality reported
  - cost of completed and projected materials testing
- Validate the contractor materials cost drivers and associated materials risks, issues, and mitigation plans for the MRL assessment and the PDR including SRR materials planning areas above.

Metrics

- Manufacturing and quality materials cost drivers have been analyzed and documented as inputs to cost driver identification and analyses (F.1) based on manufacturing, quality, and unique or specialized requirements, specifications, and tolerances, and associated risks and issues for the SRR.
  - Contractor descriptions and plans for materials, materials processes, rates and quantities (including lot buys), supplier quality, special handling and training, environmental compliance and training, materials security (physical and cyber), etc. have been included
  - Subsystems, parts, items, and components identified as supply chain commodities have been included
  - Materials “should-cost” analyses have been included
  - Materials cost driver uncertainties have been quantified for the SRR
  - Cost drivers for methods to be used to conserve critical and strategic materials have been included
  - Cost drivers for mitigation plans for supply disruptions included
  - Cost of quality estimates updated
  - Estimated costs and impacts of materials testing included
- Contractor planning (producibility) with respect to materials cost drivers and associated risks (see G.2) have been analyzed and documented for the SRR to include:
  - Emerging materials
  - Materials design requirements
  - Price stability, cost reduction and avoidance
  - Materials processes
  - Materials availability
  - Environmental factors and compliance

- Supply chain
- Processes and quality
- Security, required special handling, cyber protection
- Facilities, capital equipment, tooling, and test equipment

- Materials cost drivers based on manufacturing, quality, and unique or specialized requirements, specifications, and tolerances, and associated risks and issues have been updated and documented for the MRL assessment and the PDR including:
  - Contractor materials and materials processes used
  - Materials rates and quantities obtained
  - Supplier quality levels, special handling, environmental compliance reported
  - Materials security (physical and cyber) required, etc.
  - Utilized supply chain commodities (subsystems, parts, items, and components)
  - Quantified cost drivers with continuing uncertainties
  - Cost of quality reported
  - Cost of completed and projected materials testing

- Contractor identified materials cost drivers and associated contractor materials risks, issues, and mitigation plans have been validated and documented for the MRL assessment and the PDR including SRR materials planning areas above.

Tools

- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Cost, Schedule Control Systems Criteria (CSCSC)
- MRL assessment for the Material Management Thread
- Producibility Assessment

Resources

- Cost/Schedule Control System Criteria
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MRL Deskbook Version 2016
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999

G.2 Assess Materials Maturity and Determine Materials Risk

Manufacturing and Quality Tasks

- Analyze and update the contractor planning (producibility) with respect to manufacturing and quality maturity of materials (risks, issues, and the associated cost drivers in G.1) for the SRR and the SFR to include:

- Emerging materials
- Materials design requirements
- Cost reduction and avoidance
- Materials processes
- Materials availability and lead times
- Environmental factors and compliance
- Supply chain
- Processes and quality
- Security, required special handling, physical and cyber protection
- Facilities, capital equipment, tooling, and test equipment

- Based on contractor data, assess all materials for manufacturing and quality risks and issues:
  - Update evaluation of material maturity and availability from the AoA process:
    - Assess validity and maturity of emerging (from Research and development and experiments in MSA) for manufacturability
  - Update the manufacturing and quality evaluation of lead times including:
    - Impacts to schedule, budget, and critical path, etc.
    - Analyses for fluctuations, rarity, availability, capacity, regulatory issues, ITAR, Anti-Tamper, etc.
  - Evaluate maturity of other materials (contractor proposed) for properties, characteristics, and quality requirements for application in this system
  - Evaluate military vulnerability or gaps that could result from the lack of reasonable materials alternatives
  - Identify opportunities for alternative materials (to mitigate known risks and issues)
- Assess and identify manufacturing and quality risks, issues, and opportunities based on potential materials obsolescence and lack of availability based on the business climate (e.g., business failures, market changes, political, etc.) for the SRR and the SFR, and update for the PDR.
  - Include availability from single or sole sources (domestic or foreign), within the NTIB, only from sources that are outside the NTIB, vulnerable to foreign acquisition
  - Assess business climate for disruptive conditions (e.g., natural disasters, strikes, etc.)
  - Develop mitigation for known risks to critical and strategic materials
  - Assess availability issues to be addressed for prototype builds
  - Initiate government mitigation plans as appropriate as specified in the program SEP
  - Monitor contractor mitigation processes and plans as specified in the contractor SEMP in alignment with the program SEP
- Analyze and Assess the contractor's make/buy process for adequacy and completeness to include:

- Contractor's make/buy processes for key and/or critical subsystems, items, parts, and components to include volatility
- Contractor's supply chain (including other divisions) make/buy processes for vendors to meet quality requirements, schedule and cost targets
- Identification of and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
- Identify hazardous and special handling/storage/environmental compliance procedures, risks, and issues to include:
  - Potential regulatory requirements
  - Hazardous materials and handling procedures
  - Security requirements (physical, cyber, etc.)
  - Transportation, storage and shelf life
  - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
  - Disposal
- Assess the characterization of materials (maturity) and degree of manufacturing and quality risks applicable to the system under development.
- Determine if materials have been manufactured or produced in a relevant environment (e.g., a factory, a similar application/program, as part of a prototype, etc.)
- Assess and characterize all GFE, GFF, GFM, GFP
  - Methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials
- Analyze government and contractor maturation efforts to mitigate material (existing and new) production risks

- Complete manufacturing and quality materials planning for EMD including preliminary specifications and material properties characterization. This should address:
  - Verification of materials maturity through technology demonstration subsystems, items, and components (articles)
  - Availability risks, issues, and opportunities
  - Long-lead items
  - Future DMSMS risks, issues, and opportunities

Metrics

- Contractor planning with respect to manufacturing and quality maturity of materials (risks, issues, and the associated cost drivers as in G.1) has been analyzed for adequacy and sufficiency and documented as an manufacturing and quality input for the SRR and the SFR including:
  - Emerging materials
  - Materials design requirements
  - Cost reduction and avoidance

- Materials processes
- Materials availability and lead times
- Environmental factors and compliance
- Supply chain
- Processes and quality
- Security, required special handling, physical and cyber protection
- Facilities, capital equipment, tooling, and test equipment

- All Materials maturity and availability has been assessed and results documented for manufacturing and quality risks and issues to include:
  - Material maturity, manufacturability, and availability for the chosen concept(s) has been updated and documents the validity and maturity of emerging materials (from R&D and experiments in MSA)
  - Material lead times have been updated and documented in the TMRR IMS and the budget including results for fluctuations, rarity, availability, capacity, regulatory issues, ITAR, Anti-Tamper, etc.
  - Other contractor-proposed materials for properties, characteristics, and quality requirements for application in this system
  - Military vulnerability or gaps that could result from the lack of materials alternatives
  - Opportunities for alternative materials, contractor or GFE for mitigation of known risks and issues

- Based on potential materials obsolescence and lack of availability due to the business climate (e.g., business failures, market changes, political, etc.), manufacturing and quality risks, issues, and opportunities have been analyzed, assessed, and documented for the SRR and the SFR, and updated for the PDR, to include:
  - Availability from single or sole sources (domestic or foreign), within the NTIB, only from sources that are outside the NTIB, vulnerable to foreign acquisition
  - Disruptive conditions to the business climate (e.g., natural disasters, strikes, etc.)
  - Mitigation known risks and issues to critical and strategic materials
  - Prototype build availability issues
  - Government mitigation plans specified in the program SEP
  - Contractor mitigation processes and plans as specified in the contractor SEMP
    - Aligned with the program SEP

- Contractor's Make/Buy process has been assessed, analyzed, and results documented for adequacy and completeness including:
  - Contractor's make/buy processes for key and/or critical subsystems, items, parts, and components to include volatility
  - Contractor's supply chain make/buy processes for meeting quality requirements, schedule and cost targets for:
    - Other contractor divisions

        - Vendors
    - Identification of and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
    - Identification of hazardous and special handling, storage, and environmental compliance procedures and mitigation of risks and issues in areas, such as
        - Regulatory requirements
        - Procedures for hazardous materials and handling
        - Security (physical, cyber, etc.)
        - Transportation, storage and shelf life
        - GFP and GFE (tooling, test equipment, ranges, chambers, etc.)
        - Disposal
    - Characterization of materials' maturity and manufacturing and quality risks applicable to the system under development
    - Documentation that materials have been manufactured or produced in a relevant environment (e.g., a factory, a similar application/program, as part of a prototype, etc.)
    - All GFE, GFF, GFM, and GFP (includes methods for conserving critical and strategic materials and mitigating supply)
    - Government and contractor maturation efforts (should be a joint effort) to mitigate material (existing and new) production risks
- Manufacturing and quality planning and documentation for EMD with preliminary specifications complete and material properties characterized addresses:
    - Verification of materials maturity through technology demonstration subsystems, items, and components (articles)
    - Availability risks and issues mitigation, and opportunities
    - Long-lead items
    - Future DMSMS risks, issues, and opportunities

Tools

- DMSMS Product Life Cycle Assessment (Consult DLA)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- MRL Assessment Questionnaire for the Materials Thread
- Supply Chain Management Risk Assessment Checklist
- Producibility Assessment Worksheet
- TRL Assessment Questionnaire

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition; and
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel.

- DMSMS Guidebook, SD-22, Sep 2009
- DOD 4140.1-R, Supply Chain Management Regulation
- DOD 5000.60, Defense Industrial Capabilities Assessments
- DOD 5000.60H, Assessing Defense Industrial Capabilities
- DoDM 4140.1, DoD Supply Chain Management Procedures, Feb 2014
- IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs, May 2015
- MRL Deskbook Version 2016
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999
- Technology Readiness Assessment Guidance, Apr 2011

G.3 Identify Scale-Up Requirements

Manufacturing and Quality Tasks

- Conduct assessments of materials producibility (manufacturing processes and techniques), and availability to meet future program requirements (scale-up for prototypes, pilot line, LRIP, and FRP) and determine materials risks, issues, and opportunities.
    - Consider new materials (to the industry, to the program, to the suppliers)
    - Consider source criticality and fragility (e.g., sole or single sources, foreign sources, domestic foreign-owned, etc.)
    - Consider lead times from suppliers where availability is not proven
    - Consider volume rates that are higher or lower than typical
    - Consider obsolescence due to product improvements and market/technology changes
    - Consider regulatory requirements and impacts (e.g., US law, ITAR, environmental, REACH concerns, etc.)
- Develop manufacturing and quality plans to address scale-up risks, issues, and opportunities. Plans may include:
    - Manufacturing processes and techniques not currently available
    - Probability of meeting delivery dates
    - Addressing potential impacts from critical and long-lead time materials
    - Addressing production equipment availability (acquisition and/or scheduling)
    - Impact analyses to support trade-offs among manufacturing and quality materials alternatives
    - Recommendations for anticipated in-process testing and demonstration
    - Methods for conserving critical and strategic materials and mitigating supply disruption risks and associated impacts
    - Issues associated with materials transportation and security including ITAR considerations

Metrics

- Assessments of materials producibility and availability for future program requirements (e.g., prototypes, pilot line, LRIP, and FRP) have been conducted and document materials risks, issues, and opportunities and include considerations for:
    - Mew materials (to the industry, to the program, to the suppliers)
    - Critical and fragile source (e.g., sole or single sources, foreign sources, domestic foreign-owned, etc.)
    - Lead times from suppliers and the supply chain
    - Rates that are potentially higher or lower than typical
    - Obsolescence (product improvements and/or market/technology changes)
    - Meeting regulatory requirements (e.g., US law, ITAR, environmental, REACH concerns, etc.)
- Manufacturing and quality plans have been developed and documented in the appropriate program plans (e.g., EMD RFP, AS, SEP, etc.) to address scale-up risks, issues, and opportunities. Plans included:
    - Development of new manufacturing processes and techniques
    - Actions necessary to meet required delivery dates
    - Mitigation of impacts from critical and long-lead time materials
    - Production equipment availability (acquisition and/or scheduling)
    - Trade-off analyses impacts, results, and recommendation for manufacturing and quality materials alternatives
    - In-process testing and demonstration recommendations and schedule
    - Recommended methods for conserving critical and strategic materials and mitigating supply disruption risks and associated impacts
    - Actions necessary for materials transportation and security including ITAR considerations
- Evidence that a manufacturing processes, techniques, producibility, and realism scale-up

Tools

- Cost and Lead Time Worksheet
- Producibility Assessment Worksheet
- MRL Assessment Materials Thread
- ManTech Strategic Plan

Resources

- MRL Deskbook Version 2016
- MRL Users Guide
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9

- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
- DoDD 4200.15, ManTech
- Air Force Technology Development and Transition Strategy Guidebook, Nov 2010

G.4 Review Initial Supply Chain Management (SCM) Program

Manufacturing and Quality Tasks

- Assess the contractor's Supply Chain Management (SCM) program for veracity and adherence to industry manufacturing and quality best practices to include:
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)
  - Manufacturing management standards (e.g., AS6500, MIL-STD-896A, IEEE 15288, etc.)
  - Configuration management,
  - Sourcing processes
  - Development of strategic partnerships with vendors and suppliers
  - Sub-contract management
    - Monitoring sub-tier compliance to contract manufacturing and quality requirements
    - Sub-tier supplier processes (e.g., configuration management, parts management, counterfeit parts management, electro-static discharge program, etc.)
    - Collaboration of information (especially quality and forecasting data)
  - Procurement processes (schedule, quantity, packaging, kitting, identification, quality)
  - Variability reduction
  - Logistics and inventory management
    - Order Fulfillment (schedule, kitting, identification)
    - Warehouse Management (storage, schedule, kitting, packaging, environmental, security)
    - Transportation Management (methods, special handling, packaging, environment, identification)
    - Vendor Managed Inventory (schedule, quantity, packaging, kitting, identification, quality)
  - A robust risk, issue, and opportunity management process for integration of risks, criticality, obsolescence, sourcing
- Assess the contractor manufacturing and quality processes for compliance with or adherence to Company policy, process, and contracts, utilizing DCMA support (if available).
  - Contract Management with evidence of strong contracts and supplier interaction process with plans and schedule to reduce variability and lead times and associated impact on the critical path
  - Assess supply chain interdependencies with regards to other programs
  - Strategic Sourcing to minimize risks, criticality, and obsolescence
  - Supplier qualification, approval, and monitoring processes to include

        - Suppliers with known risks
        - Supplier parts usage and sources (i.e., GIDEP prohibited)
    - Requirements and data flow processes (two-way)
        - Program milestones and metrics (consistent with the IMS)
        - Demand Planning consistent with the IMS
        - Quality, safety, technical, and inspection requirements
        - Key and critical characteristics
    - Make or buy decision analysis processes
    - DMSMS management processes
    - Material waiver process (should only be utilized in limited circumstances)
    - Requirements for use of industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
    - Requirements for first article/qualification unit(s) (i.e., AS 9103)
    - Vendor survey requirements
    - Identification of Sub-tier supplier processes for embedded software and firmware risks, issues, and opportunities management including requirements:
        - For conducting Software Acceptance Test (SAT)/ Software Formal Qualification Testing (SFQT)
        - For performing surveillance of this activity
- Initiate SCM planning for EMD, production, developmental and operational test, and life cycle sustainment.

Metrics

- Contractor's SCM program has been assessed and documented (for engineering and management review, as required) for adherence to industry manufacturing and quality best practices for manufacturing management and quality management including:
    - Configuration management
    - Sourcing processes
    - Strategic partnerships with vendors and suppliers
    - Sub-contract management
        - Sub-tier compliance to contract manufacturing and quality requirements
        - Sub-tier supplier processes (e.g., configuration management, parts management, counterfeit parts management, electro-static discharge program, etc.)
        - Collaboration of information (quality and forecasting data)
    - Procurement processes (schedule, quantity, packaging, kitting, identification, quality)
    - Variability reduction
    - Logistics and inventory management
        - Order Fulfillment (schedule, kitting, identification)

        - Warehouse Management (storage, schedule, kitting, packaging, environmental, security)
        - Transportation Management (methods, special handling, packaging, environment, identification)
        - Vendor Managed Inventory (schedule, quantity, packaging, kitting, identification, quality)
    - A robust risk, issue, and opportunity management process for integration of risks, criticality, obsolescence, sourcing

- Contractor manufacturing and quality processes have been assessed for adherence to Company policy, process, and contractual requirements and documented for engineering and management reporting and reviews (e.g., root cause analyses, PMRs, award fee determination, PDR, etc.).
    - Contract Management process metrics demonstrate a strong contracts and supplier interaction process for planning and scheduling that have reduced variability and lead times
    - Supply chain interdependencies with regards to other programs have been analyzed with impacts documented
    - Strategic Sourcing has been utilized and documents reduction of risks, criticality, and obsolescence
    - Supplier management processes have been documented to show adherence to qualification, approval, and monitoring processes that include
        - Suppliers with known risks
        - Supplier parts usage and sources (i.e., GIDEP prohibited)
    - Requirements and data flow processes have been established and document two-way flow for contract requirements to include:
        - Program milestones and metrics (consistent with the IMS)
        - Demand Planning consistent with the IMS
        - Quality, safety, technical, and inspection requirements
        - Key and critical characteristics
    - Make or buy decision analysis processes have been determined and documented as compliant
    - DMSMS management processes have been documented as compliant
    - Material waiver process has been implemented and results and decisions documented (should only be utilized in limited circumstances)
    - Requirements for selected industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.) have been established, applied, and compliance documented
    - Requirements for first article qualification and first article tests (i.e., AS 9103) have been established and compliance documented
    - Contractor vendor survey requirements have been met and documented

- Sub-tier supplier processes for embedded software and firmware risks, issues, and opportunities management have been established and compliance documented including requirements for:
  - Conducting Software Acceptance Test (SAT)/ Software Formal Qualification Testing (SFQT)
  - Performing surveillance
- Manufacturing and quality SCM planning (EMD, production, developmental and operational test, and life cycle sustainment) has been initiated and documented in the Acquisition Strategy and the SEP and provided for the PDR process.

Tools

- Supply Chain Assessment
- MRL Assessment using the Material thread

Resources

- AS 9133, Qualification Procedure for Aerospace Standard Parts
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016

G.5 Develop Alternate Source Options

Manufacturing and Quality Tasks

- Provide analyses of the program materials (system, subsystem, items, and components) for manufacturing and quality sourcing strategies to address:
  - Qualification planning
  - Contingencies for capacity, economic/political impacts, disaster impacts, etc.)
  - Dual source competition (include GFE)
  - Readily available materials that have environmental or health concerns
  - Single, sole, foreign, foreign-owned domestic, etc. vulnerability mitigation
  - Materials only available outside the NTIB
  - Quality, schedule, transportation, fulfillment, etc. requirements
  - Hazardous, difficult to obtain, or process materials

- Based on manufacturing and quality analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, develop recommendations for alternate sources and options.
- Initiate planning to address DMSMS including:
  - Development of recommended options or mitigation plans
  - Analyses of materials, sources, and issues from the GIDEP database relevant to the program

Metrics

- Analyses of the program materials (system, subsystem, items, and components) has been conducted to support manufacturing and quality sourcing strategies and document the following:
  - Qualification planning
  - Contingencies for capacity, economic/political impacts, disaster impacts, etc.)
  - Competition (including dual source, GFE, etc.)
  - Problematic materials that have environmental or health concerns
  - Vulnerability mitigation (e.g., single, sole, foreign, foreign-owned domestic, etc.)
  - Materials sources external to the NTIB
  - Meeting the requirements for quality, schedule, transportation, fulfillment, etc.
  - Requirements and plans for hazardous, difficult to obtain, or process materials
- Recommendations for alternate sources and options have been developed based on manufacturing and quality analyses and assessments of materials maturity, availability, risks, issues, and opportunities; and recommendation have been documented for systems engineering, program management, and support of the program technical review process (e.g., SEP, AS, PDR, etc.)
- Plans for DMSMS have been developed and documented to include:
  - Recommended options, metrics, and mitigation plans
  - Continuous processes for analyses of materials, sources, and issues in the GIDEP database relevant to the program

Tools

- Supply Chain Assessment
- MRL Assessment using the Material thread

Resources

- AS 9133, Qualification Procedure for Aerospace Standard Parts
- FAR Part 46, Quality Assurance
- MIL-STD-896A, Manufacturing Quality Program
- MRL Deskbook Version 2016

G.6 Identify Critical Materials

Manufacturing and Quality Tasks

- Perform analyses (e.g., FMECA, DFMEA, PFMEA, etc.) to identify KCs, critical characteristics, and key manufacturing and quality processes (See E.5 and E.7)
    - Include Critical Technologies list of CTEs with CSIs and CAIs
    - Include sub-tier supplier subsystems, items, and components
    - Include software and firmware configuration items
    - Develop a preliminary list, which includes where produced or accomplished and associated rationale for inclusion, of:
        - Key Characteristics
        - Critical characteristics
        - Critical Application Items (CAIs) (e.g., systems, subsystems, software, materials, components, etc.)
        - Key manufacturing and quality processes
        - Critical Safety Items (CSIs)
- Analyze and validate that the contractor Critical Supplier's List (hardware and software) is up-to-date.
    - Include contractor materials planning and management process (See L.3)
    - Include risks and issues management process (See G.2)
- Analyze and validate material maturity through demonstration of subsystems, items, and components in a relevant environment
    - Validate material properties have been characterized
    - Verify material specifications in place

Metrics

- Analyses of FMECA, DFMEA, PFMEA, etc. have been conducted and have identified KCs, critical characteristics, and key manufacturing and quality processes and have been documented to support program management, reviews, and the PDR processes to include:
    - Critical Technologies list of CTEs with CSIs and CAIs
    - Sub-tier supplier subsystems, items, and components
    - Software and firmware configuration items
- A preliminary list, which includes where produced or accomplished and associated rationale has been developed and documents:
        - Key Characteristics
        - Critical characteristics
        - Critical Application Items (CAIs) (e.g., systems, subsystems, software, materials, components, etc.)

        - Key manufacturing and quality processes
        - Critical Safety Items (CSIs)
- The contractor Critical Supplier's List of hardware and software items has been analyzed and validated, is up-to-date, and being tracked to include:
    - Contractor materials planning and management processes
    - Risks and issues management processes
- Material maturity has been validated by successful demonstrations of subsystems, items, and components in relevant environments
    - Material properties have been characterized
    - Material specifications are in place

Tools

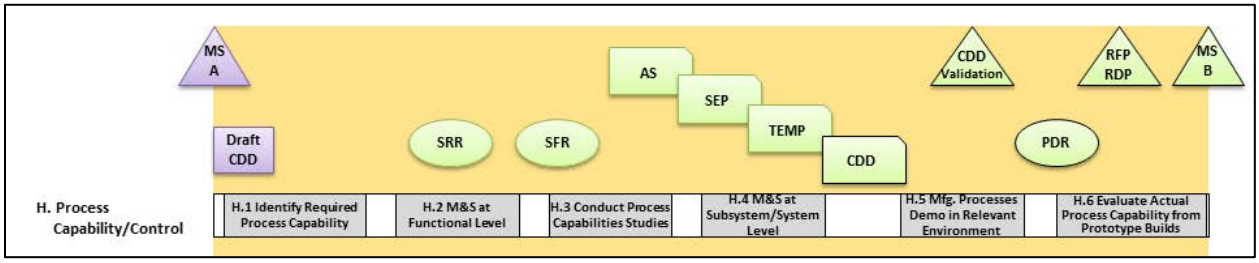
- MRL Assessment Checklist for Materials thread
- Producibility Assessment Worksheet (PAWs)
- Technology Readiness Assessment
- TRL Calculator
- FMECA, DFMEA, PFMEA templates

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- Defense Acquisition Guide, Chapter 4
- Defense Acquisition Program Support Methodology, Ver. 3.0
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.4.5.5 Failure Mode and Effects Analysis (FMEA)
- DoDI4140.69
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Integrated Product Support (IPS) Element Guide, Chapter 2.1.1.3 FMECA, Apr 2017
- MRL Deskbook Version 2016
- NAVSO P-3687 Producibility Systems Guidelines, Dec 1999
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA), Jan 2009
- Technology Readiness Assessment Guidance, Apr 2011

H. PROCESS CAPABILITY/CONTROL

Manufacturing and quality process capability and control should be a part of any development program. Manufacturing and quality engineering efforts should lead to a producible and testable system with objective of achieving effective and efficient manufacturing processes with the necessary process controls to satisfy requirements with consistent, repeatable products and minimize manufacturing costs. During MSA phase required process capabilities were identified for critical manufacturing and quality processes with the associated risks. In TMRR, process capability data collection begins and continues into EMD.



In preparation for SRR and SFR, prior identified manufacturing and quality process capabilities should be refined and updated based on data collected and the contractor's plans, processes, and procedures to identify the process capabilities required for the system. During the development process, additional studies at the system, subsystem, item, and component levels will be conducted to define the appropriate level of process capability and control. A thorough knowledge of a contractor's and supply chain's process capabilities is critical to developing a successful system. Process capabilities and data must be understood, measured, controlled, and documented, and process capability information must be up-to-date.

Program manufacturing and quality personnel should have an understanding of the state-of-the-art and industry best practices in manufacturing and production Modeling and Simulation (M&S) tools and or products. In TMRR, the contractor will have proposed use of certain M&S manufacturing and quality tools which must be verified for adequacy, applicability, and consistency with other system models. Additionally, manufacturing and quality must understand the contractor's plans and processes for maturing and validating their M&Ss as high-fidelity representations of the manufacturing and quality systems and systems performance and capability based on actual program data.

During the TMRR phase the contractor will produce prototypes that will be used during tests to ensure they will meet the customers' requirements. These prototypes will be built in a relevant manufacturing environment, meaning that there are some elements of production realism present on the manufacturing line. To the extent practicable, the processes used for prototype build should be evaluated to better understand the difficulties and risks that will need to be overcome during the EMD phase. In preparation for PDR and EMD transition, manufacturing processes, products, and prototypes demonstrated and assessed in a relevant environment results are incorporated in to the

appropriate M&Ss. These assessments and demonstrations should provide an understanding of the contractor's M&S tools and provide the basis for program manufacturing planning, resource loading, and facilities management, etc. for future phases.

H.1 Identify Required Process Capability

Manufacturing and Quality Tasks

- Update the analyses of the current state and gaps in process capability within industry for manufacturing and quality processes appropriate to the system, subsystems, items, and components.
- Update or identify manufacturing and quality process capability risks, issues, and opportunities for the SRR and the SFR from the manufacturing feasibility and other prior assessments including risks to:
    - Key Characteristics
    - Manufacturing and quality processes (new equipment and technology)
    - Potential cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - Testing and qualification
    - Environmental, transportation, storage, etc.
    - Data management (collection, storage, cybersecurity, etc.)
- Assess and estimate process maturity and capability for processes with insufficient data utilizing information from similar subsystems, items, and components that are currently or have been previously manufactured.
- Analyze if planned manufacturing and production processes are capable of producing units (subsystems, items, and components) in quantities to the contract specifications and schedule.
    - Determine if the contract requires the contractor provide estimated and actual yield rates by source and/or facility for materials, components, items, and subsystems.

Metrics

- Analyses of the current state and gaps in process capability within industry for manufacturing and quality processes appropriate to the system, subsystems, items, and components has been updated and documented for the SFR and SRR.
- Manufacturing and quality process capability risks, issues, and opportunities have been identified and/or updated and documented for the SRR and the SFR. Analyses included data from the manufacturing feasibility and other prior assessments including:
    - Key Characteristics
    - Manufacturing and quality processes (new equipment and technology)
    - Potential cost and schedule impacts
    - Producibility

- Tooling and facilities
- Testing and qualification
- Environmental, transportation, storage, etc.
- Data management (collection, storage, cybersecurity, etc.)

- Process maturity and capability for processes with insufficient data has been estimated and documented utilizing information from similar subsystems, items, and components that are currently or have been previously manufactured for the SRR and SFR.
- Planned manufacturing and production processes have been analyzed and documented to determine capability to producing units (subsystems, items, and components) in quantities to the contract specifications and schedule.
  - If required by the contract, contractor provided estimates and actual yield rates by source and/or facility for materials, components, items, and subsystems, have been included.

Tools

- MRL Assessment Checklist for the Process Capability and Control Thread

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- Capability-Based Assessment (CBA) Handbook, Mar 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016

H.2 Modeling and Simulation at Functional Level

Manufacturing and Quality Tasks

- Update analyses of the state of the art and industry best practices in manufacturing and production modeling and simulation tools and or products (i.e., software) that support the functional analyses of the system.
- Assess and analyze the contractor-proposed modeling and simulation tools and plan for adequacy and sufficiency for system manufacturing and quality, process capability, control, and maturation.
  - Include analyses of capability to provide inputs to manufacturing planning, resource loading, and facilities management
  - Include analyses of contractor usage of tools against industry standards for potential improvements and to determine functional constraints

Metrics

- Analyses of the state of the art and industry best practices in manufacturing and production modeling and simulation tools and or products (i.e., software) have been conducted and documented to support the functional analyses of the system.

- Contractor-proposed modeling and simulation tools and plans have been analyzed and documented for adequacy and sufficiency as inputs to the SRR and the SFR to include:
    - System manufacturing and quality, process capability, control, and maturation
    - Capability to provide inputs to manufacturing planning, resource loading, and facilities management
    - Contractor usage of tools against industry standards for potential improvements and to determine functional constraints

Tools

- MRL Assessment Checklist for the Process Capability and Control Thread
- System Capabilities Analytic Process (SCAP)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- Process Modeling Tools (/Siemens PLM, Delmia, etc.)
- Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)

Resources

- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- Modeling and Simulation Guidance for the Acquisition Workforce, Oct 2008
- MRL Deskbook Version 2016

H.3 Conduct Process Capabilities Studies

Manufacturing and Quality Tasks

- Utilizing results of the SRR/SFR, update manufacturing and quality process capability risks, issues, and opportunities for the AS, the SEP, the TEMP, and the CDD including:
    - Key Characteristics
    - Manufacturing and quality processes (new equipment and technology)
    - Potential cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - Testing and qualification
    - Environmental, transportation, storage, etc.
    - Data management (collection, storage, cybersecurity, etc.)
- Conduct process capability and variability studies and analyses on:
    - Similar subsystems, items, and components that are currently or have been previously manufactured utilizing previous estimates

- Current subsystems, items, and components manufacturing and production processes and equipment
- Incorporate data collected from contractor yield rates for subsystem, item, component, and prototype builds

- Identify required process capability and variability studies and analyses for planned subsystems, items, and components manufacturing and production processes and equipment for the AS, the SEP, and the PDR.
- Determine process capability requirements for pilot line and production.
  - Identify C_{pk} goals for each key manufacturing process

Metrics

- Manufacturing and quality process capability risks, issues, and opportunities have been updated and documented as inputs for the AS, the SEP, the TEMP, and the CDD to include inputs on:
  - Key Characteristics
  - Manufacturing and quality processes (new equipment and technology)
  - Potential cost and schedule impacts
  - Producibility
  - Tooling and facilities
  - Testing and qualification
  - Environmental, transportation, storage, etc.
  - Data management (collection, storage, cybersecurity, etc.)
- Process capability and variability studies and analyses have been completed and documented where appropriate for currently available and similar subsystems, items, components, and prototype builds including:
  - Manufacturing and production processes and equipment
  - Data collected from contractor yield rates
- Required process capability and variability studies and analyses for planned subsystems, items, and components manufacturing and production processes and equipment have been identified for the AS, the SEP, and the PDR will be conducted as data from the contractor becomes available.
- Process capability requirements and indices for pilot line and production have been identified, documented for the SEP and the PDR, and will be monitored.
  - Cpk goals for each key manufacturing process have been identified and documented
  - Recommended improvement actions for low yield processes or unacceptable variability have been documented

Tools

- Cause and Effect Diagram

- Cost of Quality Estimates
- Feasibility Study Checklist (TBD)
- First Pass Yield Estimates Worksheet
- Histograms
- MRL Assessment using Process Capability and Control Thread
- Pareto Analysis
- Process Capability Studies (C_p and C_{pk} assessment)
- Producibility Assessment Worksheet (PAWs)
- Six Sigma Worksheet
- First Pass Yield Estimates Worksheet

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program, May 2008
- DoD Continuous Process Improvement Transformation Guide, May 2006
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999

H.4 Modeling and Simulation at Subsystem/System Level

Manufacturing and Quality Tasks

- Assess contractor Modeling and Simulation (M&S) tools prior to product and/or process implementation for the capability to model the proposed design concept(s) for the PDR process. Tools should include:
    - Capability to evaluate the proposed design and manufacturing concepts to meet manufacturing and quality objectives
    - Capability to estimate outputs of design performance
    - Outputs for updating cost models (see F.2)
    - Identification of potential manufacturing and quality bottlenecks or constraints
    - Confirmation of planned manufacturing and quality cycle times achievability
    - Impacts of manufacturing and quality process variability
    - Capability to model the factory floor, process flows, assembly lines, yields/ throughput, cycle times, etc.
    - Capability to estimate required quantities of tooling, personnel, and inventory
    - Sufficient complexity to represent and support the complexity of the product being manufactured

- Assess the manufacturing and quality aspects of the contractor and/or government prototype environment (i.e., system simulation/integration lab) to validate M&S emulation of subsystems, components, and items, including:
  - A mix of mature hardware, prototypes, and models and simulations
  - Integration and interdependencies
  - Identification of constraints
  - Performance
  - Status of contractor M&S of the "to be" system or subsystem
- Provide manufacturing and quality recommendations to the contractor for innovative M&S capabilities (factory simulations) that go beyond basic capabilities and will allow the manufacturing engineer to address:
  - Sustainable manufacturing goals (energy, water and other resource usage)
  - Monitor and optimize maintenance and calibration requirements
  - Supply chain collaboration for product design, quality and scheduling
  - Manufacturing execution and execution systems networked to machines, test and measurement devices, robotics and process planning

Metrics

- Contractor Modeling and Simulation (M&S) tools have been assessed and analyzed prior to product and/or process implementation for the capability to model the proposed design concept(s) and documented to support the PDR process. Tools have documented:
  - The evaluation of the proposed design and manufacturing concepts to meet manufacturing and quality objectives
  - Estimated outputs of design performance
  - Cost model updates (see F.2)
  - Potential manufacturing and quality bottlenecks and constraints
  - Confirmation of planned manufacturing and quality cycle times achievability
  - Impacts of manufacturing and quality process variability
  - Modeling and demonstrations of the factory floor, process flows, assembly lines, yields/ throughput, cycle times, etc.
  - Estimates of required quantities of tooling, personnel, and inventory
  - Sufficient complexity to represent and support the complexity of the product being manufactured
- Manufacturing and quality aspects of the contractor and/or government prototype environment (i.e., system simulation/integration lab) to validate M&S emulation of subsystems, components, and items have been assessed and documents the following attributes:
  - Capability to mix mature hardware, prototypes, and models and simulations in the environment
  - Inclusion of integration and interdependencies

- Constraints
- Performance
- Status of contractor M&S of the "to be" system or subsystem

- Recommendations have been provided for EMD and future phases to the contractor for innovative M&S capabilities (factory simulations) that go beyond basic capabilities and allows the manufacturing engineer to address:
  - Sustainable manufacturing goals (energy, water and other resource usage)
  - Monitor and optimize maintenance and calibration requirements
  - Supply chain collaboration for product design, quality and scheduling
  - Manufacturing execution and execution systems networked to machines, test and measurement devices, robotics and process planning

Tools

- MRL Assessment using Process Capability and Control Thread
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Modeling and Simulation Guidance for the Acquisition Workforce, Oct 2008
- MRL Deskbook Version 2016

H.5 Manufacturing Processes Demonstration in Relevant Environment

Manufacturing and Quality Tasks

- Based on government/contractor IPT interactions, define and document the appropriate manufacturing and quality production relevant environment(s) to be used for process demonstrations and prototypes.
- Assess demonstrations of manufacturing processes in an environment with some shop floor production realism present (e.g., actual production facilities, manufacturing personnel, using production tooling, processes, materials) incorporating factors such as:
  - Minimum reliance on laboratory resources
  - Environmental conditions (i.e. temperature, humidity, air quality)
  - Equipment (i.e., accuracy, calibration, age and condition, suitability, capacity, reliability)
  - Workforce (i.e., training, skills, and certifications)
  - Human factors (i.e., noise, vibrations, ergonomics)

- Ability to meet the cost, schedule, and performance requirements of the EMD phase

- Evaluate demonstrations to determine environmental factors impacting the manufacturing of subsystems, items, and components.
  - Include ambient temperature, humidity, noise, vibrations, personnel skills levels, materials specifications, etc.
- Evaluate process demonstrations and production of prototypes for mitigation of manufacturing and quality risks.
- Evaluate and analyze yields and rates from process demonstrations and production of components and items for prototype builds.
  - Utilize results as inputs to improvement plans
- Collect data from process demonstrations and production of components and items for prototype builds to support verification, validation, and authentication of M&S processes.
- Develop a comprehensive plan for EMD to demonstrate manufacturing and quality processes in a production representative environment by CDR and on a pilot line to support the Milestone C decision process.
  - Include all manufacturing and quality risks
- Assess manufacturing readiness by conducting an MRL assessment to support PDR and the Milestone B decision process. (See A.3)
  - Support a the Technology Readiness Assessment, if conducted
  - Support identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment

Metrics

- An initial contractor-delivered and government-approved plan for TMRR with schedule and budget detailing how the contractor(s) intends to achieve and demonstrate manufacturing and quality processes and prototypes in appropriate production relevant environment(s).
- Successful demonstration of documented manufacturing processes in an environment with some shop floor production realism present (i.e., actual production facilities, manufacturing personnel, using actual tooling, processes, materials) completed with evaluation performed incorporating factors such as:
  - Minimum reliance on laboratory resources
  - Environmental conditions (i.e. temperature, humidity, air quality)
  - Equipment (i.e., accuracy, calibration, age and condition, suitability, capacity, reliability)
  - Workforce (i.e., training, skills, and certifications)
  - Human factors (i.e., noise, vibrations, ergonomics)
  - Ability to meet the cost, schedule, and performance requirements of the EMD phase
- Demonstration results have been analyzed and document the environmental factors that impacted the manufacturing and quality of subsystems, items, and components.

- Factors included and document ambient temperature, humidity, noise, vibrations, personnel skills levels, materials specifications, etc.

- Results of process demonstrations and production of prototypes effect on mitigation of manufacturing and quality risks have been analyzed, quantified, and documented for the risk, issue, and opportunity process.
- Yields and rates from process demonstrations and production of components and items for prototype builds have been analyzed against target and results utilized as inputs to manufacturing and quality improvement plans.
- Verification and validation data have been specified, collected, and documented for use in verification, validation, and authentication of the M&S processes.
- A comprehensive plan for EMD to demonstrate manufacturing and quality processes in a production representative environment by CDR and on a pilot line to support the Milestone C decision process including all manufacturing and quality risks has been developed and documented for the AS, the SEP, etc.
  - Includes impacts to overall program planning (e.g., IMP/IMS, etc.)
- A MRL assessment has been conducted and documented in support PDR and the Milestone B decision process. (See A.3)
  - Manufacturing and quality inputs to the TRA has been documented
  - Identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment has been documented for the report to Congress

Tools

- MRL Assessment using Process Capability and Control Thread

Resources

- MRL Deskbook Version 2016
- Public Law 114-328
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017

H.6 Evaluate Actual Process Capability from Prototype Builds

Manufacturing and Quality Tasks

- Based on analyses and evaluations of M&S models, process demonstrations, production of components and items, and prototype builds, summarize, define, and finalize manufacturing and quality processes, process capabilities, and limitations for EMD Acquisition Strategy and SEP planning.
  - Refine process capability requirements for the EMD phase.

- Develop plans to transition from production relevant environment with some shop floor realism present to the production representative environment with as much production realism as possible prior to CDR
- Update models and simulations for use in EMD with actual data to increase fidelity and confidence that the model and prototypes realistically represent the final product

Metrics

- Analyses and evaluations of M&S models, process demonstrations, production of components and items, and prototype builds have been summarized, defined, and have finalized documentation for manufacturing and quality processes, process capabilities, and limitations for EMD Acquisition Strategy and SEP planning.
  - Process capability requirements have been refined and documented for the EMD phase
  - Plans to transition from production relevant environment with some shop floor realism present to the production representative environment with as much production realism as possible prior to CDR have been documented
  - Models and simulations have been updated for use in EMD with actual data to increase fidelity and confidence that the model and prototypes realistically represent the final product

Tools

- MRL Assessment using Process Capability and Control Thread
- Process Capability Studies (C_p and C_{pk} assessments)
- Producibility Assessment Worksheet (PAWs)

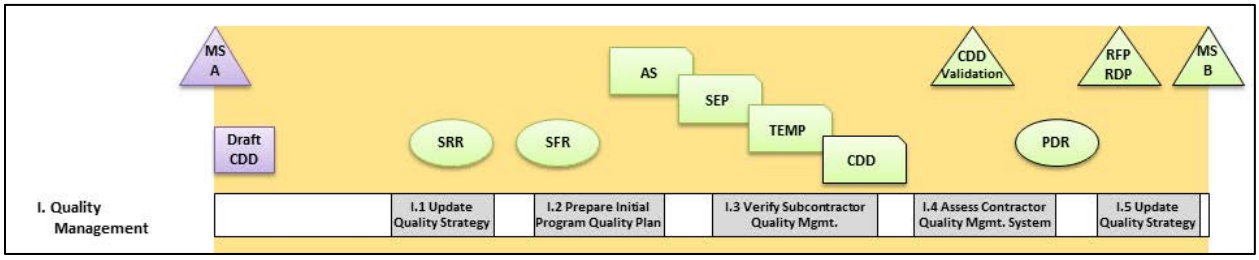
Resources

- AS6500, Manufacturing Management Program, Nov 2014
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MRL Deskbook Version 2016
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999
- Process Capability Control and Improvement Requirements – Process Control Plan Reference Guide, Picatinny Arsenal, Oct 2011
- Public Law 114-328

I. QUALITY MANAGEMENT

An effective quality management strategy and contractor Quality Management System are required if the program is to deliver operationally safe, suitable and effective weapon systems. The initial quality strategy should have been developed during the MSA phase. The QMS assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The quality strategy serves as the basis for the management and control function within the program systems

engineering process and should be continuously updated in each phase. The strategy requires basic controls over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. It also requires monitoring and measuring of processes and products (including embedded software and firmware) to ensure they conform to requirements. Quality strategy development must begin during the earliest stages of system development and must continue throughout the program life cycle.



A QMS compliant with industry best practices, ISO 9000 or AS9100, is the foundation for the contractor to deliver a system that meets requirements. The program must evaluate the contractor's QMS to ensure implementation of industry best practices. The program and the contractor should develop a joint government/contractor manufacturing and quality plan that specifies:

- Roles, responsibilities, and quality processes
- Tasks, schedules, and outcomes
- Standards, requirements, and metrics
- Joint risk, issue, and opportunity processes and procedures
- Quality tools such as Continuous Process Improvement (CPI)

Everything a contractor does will be related to the quality of its products or services, a contractor's QMS should be the basis for integrating all other management systems within an enterprise. The Program must assess the contractor QMS to ensure that the contractor has an effective QMS and an effective subcontractor quality management system and plan. Manufacturing and quality personnel must ensure that all manufacturing and quality systems are working toward the same goals and are not creating conflicting or dysfunctional results. It is important for the program to convey to the contractor the requirement and importance of quality throughout supply chain and effective supply chain management, as quality deficiencies often occur in the lower tiers. The contractor, in addition to having list of qualified vendors, should have visibility into their subcontractors' planned suppliers with the same requirements.

Effective quality management activities are important for identifying and reducing process-related risks. If not managed and mitigated, these risks may start a chain of events leading to undesirable outcomes such as defects discovered later in production or testing, not meeting requirements, degraded mission effectiveness, overruns, shortages, etc. The later these risks are identified, the greater the cost of corrective action and the greater the delays in schedule.

Quality will permeate all levels of a company only if certain important factors are present in the contractor's QMS:

- Corporate strategic vision, objectives, policies and procedures with a commitment to quality in-house and in the supply chain
- Communication of organizational direction and values regarding quality
- Structures and resources for full implementation of the QMS
- Commitment to continuous processes improvement
- Goals, objectives, and metrics throughout the organization for customer satisfaction
- Management accountability

At the conclusion of TMRR phase, post PDR evaluation, the program quality strategy should be updated for entry into EMD based on TMRR results, assessment of the contractor and subcontractor QMSs, and the revised program quality plans for EMD.

I.1 Update Quality Strategy

Manufacturing and Quality Tasks

- Update and revise the draft Program Quality Management Strategy in the Acquisition Strategy and the SEP based on the contractor's Quality Management System and strategies to include:
    - The contractor's quality management strategy should address compliance to established standards (e.g., AS9100, ISO 9000, etc.)
    - Alternatively the contractor's quality management requirements should address:
        - Management responsibility requirements
        - Quality management system requirements
        - Resource management requirements
        - Product Realization requirements (e.g., risk management, design and development, purchasing, etc.)
        - Risks, issues, and opportunities
        - Measurement, analysis, and improvement requirements
- Verify that the Program Quality Management Strategy
    - Incorporates new quality technologies and processes (state of the art), unique product quality requirements, metrics, and the review frequency.
    - Includes compliance with FAR 52.246-11, Higher-Level Contract Quality Requirements.
    - Encompasses the quality aspects of contractor compliance to industry best manufacturing practices (i.e., AS6500).
        - Management, measurement, and control of key and critical characteristics and processes

- Addresses use of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
- Encompasses supply chain quality management requirements that include:
  - Need for focused supplier quality management requirements
  - Contractor supplier quality management plan
  - Supply chain best practices and standards (e.g., AS9100, ISO 9000, etc.)
  - Metrics and review frequency
  - Solutions, tools, techniques, and procedures
  - Use of government furnished quality and testing equipment and assets
- Establishes appropriate agreements, delegations and contracts with other agencies, e.g. the Defense Contract Management Agency (DCMA) throughout the supply chain
- Addresses software and firmware development quality assurance and configuration management.

Metrics

- Program Quality Management Strategy has been revised and updated in the Acquisition Strategy and the SEP based on the contractor's Quality Management System which includes:
  - The contractor's quality management strategy and compliance to established standards (e.g., AS9100, ISO 9000, etc.)
  - Alternatively the contractor's quality management strategies and processes that address:
    - Management responsibility requirements
    - Quality management system requirements
    - Resource management requirements
    - Product Realization requirements (e.g., risk management, design and development, purchasing, etc.)
    - Risks, issues, and opportunities
    - Measurement, analysis, and improvement requirements
- Program Quality Management Strategy has been reviewed and documents:
  - Incorporation of new quality technologies and processes (state of the art), unique product quality requirements, metrics, and the review frequency.
  - Compliance with FAR 52.246-11, Higher-Level Contract Quality Requirements.
  - The quality aspects of Contractor compliance to industry best manufacturing practices (i.e., AS6500).
    - Management, measurement, and control of key and critical characteristics and processes
  - The use of COTS items, GOTS items, and NDIs) and their incorporation into the contractor's QMS.
  - Supply chain quality management requirements that include:

- Need for focused supplier quality management requirements
- Contractor supplier quality management plan
- Supply chain best practices and standards (e.g., AS9100, ISO 9000, etc.)
- Metrics and review frequency
- Solutions, tools, techniques, and procedures
- Use of government-furnished quality and testing equipment and assets

- Agreements, delegations and contracts with other agencies, e.g. the DCMA throughout the supply chain
- Software and firmware development quality assurance and configuration management

Tools

- Acquisition Strategy Template
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread

Resources

- AFMC Instruction 63-145 Manufacturing and Quality
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- DAG Chapter 14.3.1.3.6 Quality Plans
- DSMC Acquisition Strategy Guide, Dec 1999
- FAR 52.246-11
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016

I.2 Prepare Initial Program Quality Plan

Manufacturing and Quality Tasks

- Evaluate the contractor's QMS for processes and procedures that are in alignment with industry best practices (e.g., AS9100, ISO 9000, etc.) to include elements such as:

- Effective policies and procedures that encourage adherence to the quality system
- Organizations with defined authorities and responsibilities
- Objectives to drive people, processes, and the system
- Methods to analyze and resolve quality problems
- Metrics that reflect desired outcomes
- Interacting processes to transform inputs into outputs
- Records as evidence of what happened

- Based on MSA documentation, evaluate Contractor's proposed quality plan for previously determined product quality requirements, metrics, frequency of metrics reviews, and manufacturing and quality risks, issues, and opportunities, and update accordingly.
    - Include software development quality requirements
    - Include impacts of safety processes and procedures
    - Include Contactor's planned supply chain
    - Include DCMA inputs on Contractor and supply chain quality performance against quality requirements for similar products or processes
- Evaluate Contractor-proposed or planned solutions, capabilities, equipment, and processes that address product quality requirements in the form of:
- Quality technologies (i.e., metrology technologies) that could improve product quality (e.g., new quality technologies, state of the art, etc.)
    - Proposed or planned solutions or processes to improve low-yield processes and components product quality
- Develop a joint government/contractor manufacturing and quality plan based upon the evaluations of contractor's and supplier's QMSs and proposed plans that specifies:
    - Roles, responsibilities, and quality processes for government and contractor quality management including:
        - Role and participation of DCMA (contractor and supply chain)
        - Key Characteristics management
        - Acceptance test procedures including software
        - In-process and final inspections
        - Statistical process controls and management
        - Quality improvement plans
        - Certification requirements (e.g., flight safety, man-ratings, etc.)
        - Issues and dispositions (i.e., material review boards and processes)
        - Continuous process improvement
        - Software quality assurance
        - Data storage, management, and security (physical and cyber)
        - Use of COTS items, GOTS items, and NDIs
        - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
        - Audits and verifications
    - Tasks, schedules, and outcomes
    - Standards and requirements to be followed (e.g., industry product standards, MIL-STDs, etc.)
    - Joint risk, issue, and opportunity processes including supply chain quality capabilities and risk, issue, and opportunity identification processes
    - Quality processes, roles, and responsibilities identified for:

5939 ▪ Key Characteristics management
5940 ▪ Acceptance test procedures including software
5941 ▪ In-process and final inspections
5942 ▪ Statistical process controls and management
5943 ▪ Quality improvement plans

5944 o Quality workforce qualifications and training requirements
5945 o Quality tooling and equipment requirements
5946 o Quality targets, metrics, incentives, and process capabilities (C_{pk}s)
5947 o Quality failures identification and analyses processes
5948 o Software requirements
5949 o Requirements for tracking quality costs
5950 o New quality technology identification and introduction processes to include
5951 transformative processes

5952 • Update the joint government/contractor risk, issue, and opportunity process to ensure
5953 inclusion of updated manufacturing and quality process capability risks, issues, and
5954 opportunities from the SRR and the SFR (see H.1) including:

5955 o Key Characteristics
5956 o Manufacturing and quality processes (new equipment and technology)
5957 o Potential cost and schedule impacts
5958 o Producibility
5959 o Tooling and facilities
5960 o Testing and qualification
5961 o Environmental, transportation, storage, etc.
5962 o Data management (collection, storage, cybersecurity, etc.)
5963 o Process maturity and capabilities
5964 o Yields, rates, and quantities

5965 **Metrics**

5966 • Contractor's QMS has been evaluated and documented for use in developing the joint quality
5967 plan for processes and procedures that implement industry best practices (e.g., AS9100, ISO
5968 9000, etc.) including elements such as:

5969 o Effective policies and procedures that adhere to the quality system
5970 o Defined organizational authorities and responsibilities
5971 o Quality objectives for people, processes, and the system
5972 o Processes and procedures to analyze and resolve quality risks, issues, and opportunities
5973 o Quality metrics that reflect desired outcomes
5974 o Integrated transformative processes (inputs into outputs)
5975 o Documented results (storage and retrieval)

- Contractor's proposed quality plan has been evaluated for specified product quality requirements, metrics, frequency of metrics reviews, and manufacturing and quality risks, issues, and opportunities, and updated to include:
  - Software development quality requirements
  - Impacts of safety processes and procedures
  - Contactor's planned supply chain
  - DCMA inputs on contractor and supply chain quality performance against quality requirements for similar products or processes
- Contractor-proposed and planned solutions, capabilities, equipment, and processes have been evaluated for the capability to measure, monitor, and track product quality to meet program requirements in the form of:
- New quality technologies (i.e., metrology technologies)
- Proposed or planned solutions or processes to improve low-yield processes and components product quality
- Based upon the evaluations of contractor's and supplier's QMSs, proposed plans, solutions, capabilities, and equipment, a joint government/contractor quality plan has been developed and documented that specifies:
- Roles and responsibilities of government and contractor for quality management including:
  - DCMA role and participation both at the contractor facilities and in the supply chain
  - Key Characteristics management
  - Acceptance test procedures including software
  - In-process and final inspections
  - Statistical process controls and management
  - Quality improvement plans
  - Certification requirements (e.g., flight safety, man-ratings, etc.)
  - Processes for issues and dispositions (i.e., material review boards and processes)
  - Continuous process improvement
  - Software quality assurance
  - Data storage, management, and security (physical and cyber)
  - Use of COTS items, GOTS items, and NDIs
  - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Participation in and support to audits and verifications
- Tasks, schedules, and outcomes
- Standards and requirements to be met (e.g., industry product standards, MIL-STDs, etc.)
- Joint risk, issue, and opportunity processes including supply chain quality capabilities and risk, issue, and opportunity identification processes
- Quality requirements for:
  - Workforce qualifications and training requirements
  - Tooling and equipment requirements

- Targets, metrics, incentives, and process capabilities (C_{pk}s)
- Failures identification and analyses processes
- Software
- Cost of quality tracking

- Identification and introduction processes for new quality technologies to include transformative processes
- The joint government/contractor risk, issue, and opportunity process has been updated and documented for inclusion of manufacturing and quality process capability risks, issues, and opportunities (see H.1) from:

- Key Characteristics
- Manufacturing and quality processes (new equipment and technology)
- Potential cost and schedule impacts
- Producibility
- Tooling and facilities
- Testing and qualification
- Environmental, transportation, storage, etc.
- Data management (collection, storage, cybersecurity, etc.)
- Process maturity and capabilities
- Yields, rates, and quantities

Tools

- Quality Management Plan Template
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- Specified Industry and Military Standards
- MRL Deskbook Version 2016
- Systems Engineering Plan (SEP) Outline, Jun 2015

I.3 Verify Subcontractor Quality Management

Manufacturing and Quality Tasks

- Verify that the contractor supplier management system requires subcontractor QMS processes and procedures that are in alignment with industry best practices (e.g., AS9100, ISO 9000, etc.) to include elements such as:

- Management responsibility requirements

- Quality management system requirements
- Resource management requirements
- Product Realization requirements (e.g., risk management, design and development, purchasing, etc.)
- Risks, issues, and opportunities
- Measurement, analysis, and improvement requirements

- Analyze the contractor's supplier management system capability to perform the anticipated design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including:
  - Effectiveness of prime and subcontractor communication and interaction processes to include:
    - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
    - Quality data exchange processes
    - Integration of risk, issue, and opportunity management
    - Responses, status, and reports for cost, schedule, and performance actuals
    - Corrective and preventative actions, communication, and end user feedback
    - Specification and production of prototypes
  - Key Characteristics management
  - Supplier risk, issue, and opportunity management processes for quality, technical, schedule, material, facility, scale-up, financial impacts, etc.
  - Make/buy processes for supplier quality performance and impacts
  - Approval/removal and qualification processes for suppliers which includes period re-assessment
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials (See AS5553 and AS6174)
  - Identification of major and critical suppliers, and suppliers performing Critical Manufacturing Processes
  - Supplier development program that focuses on and measures continuous improvement
  - Effective metrics to monitor, evaluate, verify, improve processes, and prevent defects

- Analyze the contractor's supplier management system and quality management plan for:
  - Management of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
    - Request DMCA assistance in analyses and verifications
  - Roles, responsibilities, and quality processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Software and firmware quality and integration into the program Software Quality Assurance Plan (SQAP), Software Development Plan (SDP), and Software Configuration Management Plan (SCMP)

- Acceptance tests (prototypes, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP

- Verify the contract and the subcontractor management plan includes right of access for both the contractor and the government to supplier facilities and documentation, where applicable.

Metrics

- Contractor supplier management system has been verified and documents for program management and the PDR process the requirements for subcontractor QMS processes and procedures in alignment with industry best practices (e.g., AS9100, ISO 9000, etc.) including elements such as:
  - Management responsibility
  - Quality management system
  - Resource management
  - Product Realization (e.g., risk management, design and development, purchasing, etc.)
  - Risks, issues, and opportunities
  - Measurement, analysis, and improvement
- Contractor's supplier management system has been analyzed and documents for program management and the PDR process the capability to perform the anticipated design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including:
  - Effectiveness of prime and subcontractor communication and interaction processes to include:
    - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
    - Quality data exchange processes
    - Integration of risk, issue, and opportunity management
    - Responses, status, and reports for cost, schedule, and performance actuals
    - Corrective and preventative actions, communication, and end user feedback
    - Specification and production of prototypes
  - Key Characteristics management
  - Supplier risk, issue, and opportunity management processes include documenting, monitoring and tracking (includes quality, technical, schedule, material, facility, scale-up, financial impacts, etc.)
    - Risk management processes include mitigation
    - Issue management processes and procedures (e.g., Contractor Performance Assessment Reports (CPARs), Engineering Change Proposals (ECPs), Material Review Boards (MRBs), CM, etc.)
    - Opportunity management includes ECPs and incentives
  - Make/buy processes for supplier quality performance and impacts

- Approval/removal and qualification processes for suppliers which includes period re-assessment
- Processes and procedures for prevention and/or detection of counterfeit parts and materials (See AS5553 and AS6174)
- Identification of major and critical suppliers, and suppliers performing Critical Manufacturing Processes
- Supplier development program that focuses on and measures continuous improvement
- Effective metrics to monitor, evaluate, verify, improve processes, and prevent defects

- Contractor's supplier management system and quality management plans have been analyzed and documented to include:
  - Management of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
    - Request DMCA assistance in analyses and verifications
  - Roles, responsibilities, and quality processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Software and firmware quality and integration into the program SQAP, SDP, and SCMP
  - Acceptance tests (prototypes, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP
- Contract and the subcontractor management plans have been verified to include the right of access for both the contractor and the government to supplier facilities and documentation.

Tools

- Supplier QA Questionnaire
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment Questionnaire for the Quality thread

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016
- Risk, Issue, and Opportunity Management Guide, Jan 2017

I.4 Assess Contractor Quality Management System

Manufacturing and Quality Tasks

- Assess the contractor's corporate strategic vision, objectives, policies, and procedures for alignment to the contracted program needs and industry best practices (e.g., AS9100, ISO 9000, etc.) for quality both in-house and in suppliers' facilities to include:
  - Established quality policy, at the highest level in the company, based on industry best practices, which commits to continuously improving processes and exceeding customer expectations
  - Organizational direction and values regarding quality are communicated throughout the supply chain
  - Management provides structures and resources supporting full implementation of the quality management system
  - Management solicits quantitative and qualitative feedback on the effectiveness and efficiency of quality management system and takes actions based on that feedback
  - Procedures for internal reviewing of the quality management system periodically with goals and objectives throughout the organization, customer satisfaction, and continuous improvement
  - Procedures independent reporting channels for quality functions and audits
  - Management accountability with emphasis on quality results and customer satisfaction
- Conduct a functional audit of the contractor's QMS including assessment of:
  - Quality processes and supply chain quality including:
    - Role and participation of DCMA (contractor and supply chain)
    - Key Characteristics management
    - Acceptance testing including software
    - In-process and final inspection functionality
    - Statistical process controls, rates, and yields (and management of same)
    - Quality improvement plan execution
    - Certification process (e.g., flight safety, man-ratings, etc.)
    - Continuous process improvement results
    - Software quality assurance results
    - Data storage, management, and security (physical and cyber)
    - Management of safety, environmental, transportation, storage, etc.
    - Use of COTS items, GOTS items, and NDIs
    - GFE/GFP management (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
    - Audits and verifications results
  - Results and reports from contractor's developmental testing for CTEs, KPPs, KSAs, and Key Characteristics and integration into the QMS.

- Results and reports from the contractor's QMS Failure Reporting, Analysis and Corrective Action System for sufficiency and adequacy including results of dispositions (i.e., material review boards and processes)
- QMS impacts on tasks, costs, schedules, and outcomes
- QMS compliance to standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
- Integration with the Risk, Issue, and Opportunity Management processes

- Request DCMA support to assess veracity of contractor QMS for inclusion and integration of subsystems, items, and components and inclusion in the initial TEMP including:
  - Assessment of the contractor's progress in generating or updating the TEMP
  - Verification of the TEMP addressing requirements to conduct a Physical Configuration Audits (PCAs) and Functional Configuration Audits (FCAs) on designated subsystems, items, components, and software/firmware
  - Verification of Software testing, to include Software Acceptance Test (SAT)/Software Formal Qualification Testing (SFQT) is addressed in the TEMP

Metrics

- The contractor's corporate strategic vision, objectives, policies, and procedures have been assessed, results documented, and corrective actions implemented for alignment to the contract and industry best practices (e.g., AS9100, ISO 9000, etc.) for quality including:
  - An established quality policy and procedures, at all levels in the company that implements continuously improving processes and exceeding customer expectations
  - Communication throughout the supply chain of organizational direction and values
  - Management structure and resources supporting full implementation of the quality management system
  - Management processes based on quantitative and qualitative feedback that improve the effectiveness and efficiency of quality management system
  - Periodic internal reviews and updates of the quality management system throughout the organization including customer satisfaction and continuous improvement
  - Independent reporting channels for quality functions and audits in place
  - Management accountability established with emphasis on quality results and customer satisfaction

- A functional audit of the contractor's QMS has been conducted and the results and corrective actions documented for:
  - Quality processes and supply chain quality including:
    - Role and participation of DCMA (contractor and supply chain)
    - Key Characteristics management
    - Acceptance testing including software
    - In-process and final inspection functionality
    - Statistical process controls, rates, and yields (and management of same)

        - Quality improvement plan execution
        - Certification process (e.g., flight safety, man-ratings, etc.)
        - Continuous process improvement results
        - Software quality assurance results
        - Data storage, management, and security (physical and cyber)
        - Management of safety, environmental, transportation, storage, etc.
        - Use of COTS items, GOTS items, and NDIs
        - GFE/GFP management (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
        - Audits and verifications results
    - Contractor's developmental testing for CTEs, KPPs, KSAs, and Key Characteristics and integration into the QMS.
    - Contractor's QMS Failure Reporting, Analysis and Corrective Action System (FRACAS) for sufficiency and adequacy including results of dispositions (i.e., material review boards and processes)
    - QMS impacts on tasks, costs, schedules, and outcomes
    - QMS compliance to standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
    - Integration with the Risk, Issue, and Opportunity Management processes
- DCMA assistance has been requested and their support used to document the veracity of contractor QMS for inclusion and integration of subsystems, items, and components and inclusion in the initial TEMP including:
    - Assessment of the contractor's progress in generating or updating the TEMP
    - Requirements to conduct a PCAs and FCAs) on designated subsystems, items, components, and software/firmware
    - Software testing, to include SAT/SFQT is addressed in the TEMP

Tools

- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment Questionnaire for the Quality thread

Resources

- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016
- Risk, Issue, and Opportunity Management Guide, Jan 2017

I.5 Update Quality Strategy

Manufacturing and Quality Tasks

- Update and revise the initial Program Quality Management Strategy from the Acquisition Strategy and the SEP:
  - Incorporate changes based the results of the assessment of the contractor's QMS
  - Update all quality factors from tasks accomplished in I.1 through I.4
- Initiate quality planning for EMD, production, developmental and operational test, and life cycle sustainment.

Metrics

- Initial Program Quality Management Strategy has been updated, revised, and documented including impacts to cost and schedule in the Acquisition Strategy and the SEP:
  - Changes required by the results of the quality assessment of contractor's QMS have been incorporated
  - Changes required by the results from all quality tasks performed in I.1 through I.4 have also been included
- Initial Quality Plan for EMD, production, developmental and operational test, and life cycle sustainment has been drafted and documented in the AS, SEP, TEMP, and the IMP/IMS.

Tools

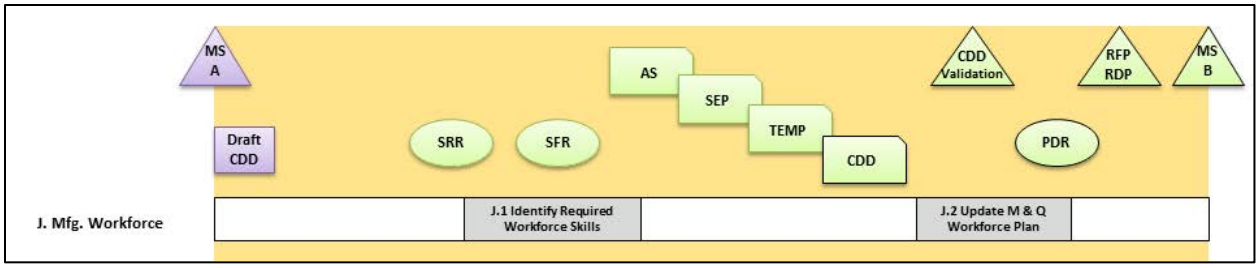
- Acquisition Strategy Template

Resources

- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016
- Risk, Issue, and Opportunity Management Guide, Jan 2017
- DSMC Acquisition Strategy Guide, Dec 1999

J. MANUFACTURING WORKFORCE

A comprehensive assessment of contractor manufacturing plans for prototype and system development is necessary to understand the requirements workforce skills, capabilities, training, and certifications. Workforce skills identification and plans provide quantitative inputs to program planning. Workforce planning should align the skills required to the scope of the technical effort required to develop, field, and sustain the system.



To determine the scope of the manufacturing and quality workforce plan to develop, field, and sustain the system, the following should be included:

- Work Breakdown Structure for the technical activities and tasks (including the Bill of Materials)
- Contractor's make/buy plans
- Contractor's manufacturing and quality plans, process, and procedures
- Identified risks, issues, and opportunities
- Integrated Master Plan for all technical activities and tasks
- Time-phased sequence of the technical efforts (Integrated Master Schedule)
- Other resources (support equipment, tools, facilities, training, etc.

Based on contractor manufacturing and quality planning, execution, and results of the system development and prototypes efforts, update the program manufacturing and quality workforce plans for required skills, capabilities, training, and certifications for EMD.

J.1 Identify Required Workforce Skills

Manufacturing and Quality Tasks

- Assess contractor initial Manufacturing Plans for prototypes and system development to identify workforce requirements for skills, capabilities, training, and certifications, including:
  - Contractor's make/buy processes for factors that determine the outsourcing of workforce skills
  - Scale-up of materials, subsystems, items, and components for TMRR
  - Contractor's labor market (availability, stability, capabilities, training, etc.)
  - Potential ManTech changes, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
  - Potential facilities changes (e.g., location, improvements and expansion, lay-out changes, etc.)
  - Materials handling (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
  - Environmental, safety, and health
  - Manufacturing machinery and equipment (e.g., programming and operation, maintenance, calibration, and repair, etc.)

- Facilities and tooling (e.g., operation and maintenance, safety, security, cleanliness, acoustics, Heating, Ventilation, Air Conditioning (HVAC), and environmental controls, etc.)
- Quality (e.g., inspections, equipment operation, maintenance, calibration, etc.)

- Review contractor's processes for impacts on the workforce:
  - Identify impacts on personnel, training, etc.
  - Identify risk, issues, and opportunities concerning the workforce
  - Include manufacturing and quality requirements on workforce environmental, safety, and health

Metrics

- Contractor initial Manufacturing Plans have been assessed and documented for required workforce skills, capabilities, training, and certifications have been identified for system development and prototypes, including:
  - Contractor's make/buy processes have been assessed for factors impact outsourcing of workforce skills and the results documented
  - TMRR scale-up of materials, subsystems, items, and components has been included
  - Contractor's labor market assessed for availability, stability, capabilities, and training to meet program workforce requirements and the results documented
  - Potential ManTech changes, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.) have been included
  - Potential facilities changes (e.g., location, improvements and expansion, lay-out changes, etc.) have been included
  - Materials handling (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
  - Environmental, safety, and health
  - Manufacturing machinery and equipment (e.g., programming and operation, maintenance, calibration, and repair, etc.)
  - Facilities and tooling (e.g., operation and maintenance, safety, security, cleanliness, acoustics, HVAC and environmental controls, etc.)
  - Quality (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- Contractor's processes have been assessed for risks, issues, and opportunities and identify impacts workforce personnel, training, environmental, safety, and health, etc.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis

- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management System, Sep 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016
- Manufacturing Resource Planning (MRP II) software

J.2 Update Manufacturing and Quality Workforce Plan

Manufacturing and Quality Tasks

- Based on contractor Manufacturing and Quality planning, execution, and results of the system development and prototypes efforts, update manufacturing and quality plans for required workforce skills, capabilities, training, and certifications for EMD planning, update the Acquisition Strategy and as input for PDR and other decision reviews. Updates include:
    - Workforce skills requirements based on contractor's make/buy decisions for internal and/or outsourcing of workforce skills
    - Contractor's labor market impacts on availability, stability, capabilities, and training to meet manufacturing and quality workforce requirements
    - Scale-up of materials, subsystems, items, and components
    - Materials handling requirements changes (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
    - Environmental, safety, and health requirements changes
    - Manufacturing machinery and equipment improvements and changes (e.g., programming and operation, maintenance, calibration, and repair, etc.)
    - ManTech demonstrations, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
    - Facilities re-locations, and changes (e.g., location, improvements and expansion, lay-out changes, etc.)
    - Tooling improvements and changes (e.g., operation and maintenance, safety, security, cleanliness, acoustics, HVAC and environmental controls, etc.)
    - Quality requirements changes and additions (e.g., inspections, equipment operation, maintenance, calibration, etc.)

- Assess contractor Manufacturing and Quality workforce management and plans for EMD to include:
  - Synchronization with the SEP, the IMP/IMS, and the Subcontractor Management Plan
  - Consistency with the contractor's Manufacturing Plan
  - Staffing rate requirements for pilot line and initial production
  - Workforce skills availability (i.e., number of trained capable workers)
  - Workforce stability (e.g., labor force age, turn-over rate, labor force sustainability, etc.)
  - Special skills certification and training requirements
- Analyze TMRR planned versus actual staffing rates, training, turn-over, etc.
- Assess manufacturing and quality workforce and environmental, safety, and health requirements in current guidance, regulations, and laws for impact.

Metrics

- Manufacturing and quality plans for required workforce skills, capabilities, training, and certifications have been updated for EMD planning, documented in the Acquisition Strategy and provided as input for PDR and other decision reviews including updates on:
  - Workforce skills required based on contractor's make/buy decisions for internal and/or outsourcing of workforce skills
  - Contractor's labor market impacts based on availability, stability, capabilities, and training to meet manufacturing and quality workforce requirements
  - Scale-up of materials, subsystems, items, and components
  - Materials handling requirements changes (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
  - Environmental, safety, and health requirements changes
  - Manufacturing machinery and equipment improvements and changes (e.g., programming and operation, maintenance, calibration, and repair, etc.)
  - ManTech demonstrations, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
  - Facilities re-locations, and changes (e.g., location, improvements and expansion, lay-out changes, etc.)
  - Tooling improvements and changes (e.g., operation and maintenance, safety, security, cleanliness, acoustics, HVAC and environmental controls, etc.)
  - Quality requirements changes and additions (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- Contractor Manufacturing and Quality workforce management and plans for EMD have been assessed sufficiency and robustness including:
  - Agreement and consistency with the SEP, the IMP/IMS, and the Subcontractor Management Plan
  - Consistency with the contractor's Manufacturing Plan
  - Staffing rates for pilot line and initial production

  - Workforce skills availability and sustainability (i.e., number of trained capable workers)
  - Workforce stability (e.g., labor force age, turn-over rate, labor force sustainability, etc.)
  - Special skills certification and training

- Analyses of TMRR planned versus actual staffing rates, training, turn-over, etc. have been conducted and validates contractor plan and performance.
- Manufacturing and quality workforce and environmental, safety, and health requirements in current guidance, regulations, and laws have been assessed and impacts on workforce documented for management planning.

Tools

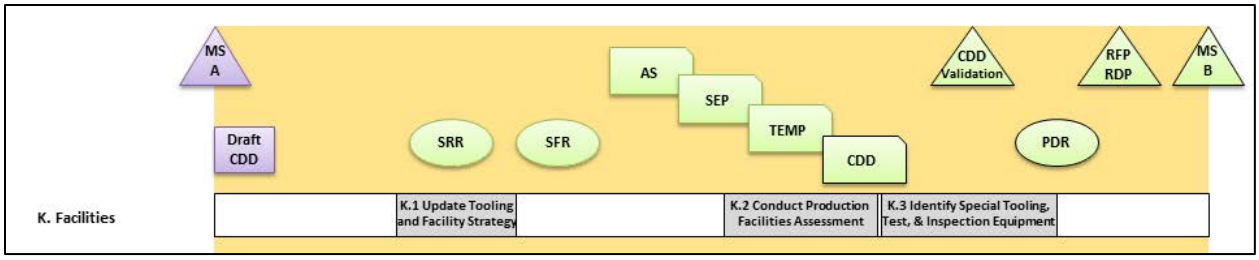
- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Management System, Sep 2016
- ISO 9001:2015, Quality Management System
- Manufacturing Resource Planning (MRP II)

K. FACILITIES

During the TMRR phase, manufacturing and quality personnel should update the facility and tooling strategies and plans developed for the concept during MSA, and conduct assessments of proposed production facilities, and update and finalize the tooling plan for EMD and future phases.



Based on the concept, new facilities and tools may be required for new materials, new technologies, and new processes. Programs and the contractor(s) need to address and plan for the capability and capacity to develop, produce, maintain, and support the program. Included in this are considerations of the availability of essential tooling, facilities, and production and test equipment for the sustained production of systems capable of meeting the performance objectives, as well as sustained operations, maintenance, and repair. Capacity is normally constrained by physical facilities, available equipment, tooling and/or test equipment. The portion of this capacity actually utilized is determined by the demand on the plant for current and known future workload. Final validation of manufacturing and quality plans must be accomplished prior to PDR and prior to entry into EMD.

Manufacturing and quality personnel should conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases. These assessments should include subcontractors and key suppliers identified in the contractor's manufacturing management plan. Assessments of the contractor's manufacturing management plans should include tooling and facilities plans with utilization, and any relocation/consolidation considerations, schedules, and requirements for manufacturing maturity. These assessments should be conducted on-site and can be included as part of the MRL assessment. The results of these assessments should identify and document risks, issues, and opportunities arising from facility and tooling shortfalls and document the required planning for mitigation.

Prior to PDR and entry into EMD, the program tooling plan which includes specialized tooling and test equipment is finalized. This requires that all facilities, tooling, and test equipment has been appropriately identified from assessments conducted as required by the FAR Section 2.101.

The lack of attention to facilities, tooling, and test equipment will increase risk and can be a major factor in cost overruns and schedule delays. Facilities, tooling, and test equipment is a common production risk that can greatly affect cost, schedule and performance if the program is not proactive in managing it.

K.1 Update Tooling and Facility Strategy

Manufacturing and Quality Tasks

- Update the Manufacturing Strategy (tooling and facilities plans from the MSA Acquisition Strategy and SEP) for tooling and facilities to include:

- Design, fabrication, and control of tooling and test equipment
- Mix of "soft" and "hard" tooling
- Availability
- Surge capability to meet rates and/or fluctuating demand
- Procurement of commercial or existing tooling,
- Identification of any unique tooling required to support production
- Planning for Manufacturing and Quality ManTech initiatives for new tools
- Specific material specifications that require peculiar production facilities or special handling
- Manufacturing and quality environmental and safety factors
- Security requirements for manufacturing and quality facilities (physical and cyber)

- Initiate planning for construction, fabrication, test, and demonstration of required new or modified facilities or tools.
- Update the planning for Special Test Equipment (STE) and Special Inspection Equipment (SIE) based on prototyping results (e.g., acquisition of specialized fixtures, construction of test chambers, upgrading laboratories and clean rooms, upgrading waste storage and disposal equipment, etc.).
- Update planning for new manufacturing tooling and facilities required for new technologies.
- Update manufacturing and quality tooling and facilities plans based on the availability, storage, and handling requirements of essential raw materials, special alloys, composite materials, components, tooling, and production test.
- Update plans for mitigation of identified tooling and facility shortfalls and risk areas associated with the proposed facility.
- Initiate manufacturing and quality planning for EMD tooling and facilities.

Metrics

- Manufacturing Strategy has been updated for the Acquisition Strategy and the SEP for tooling and facilities strategies and plans (TMRR and subsequent phases) to include:

  - Design, fabrication, and control of tooling and test equipment
  - Mix of "soft" and "hard" tooling
  - Availability
  - Surge capability to meet rates and/or fluctuating demand
  - Procurement of commercial or existing tooling,
  - Identification of any unique tooling required to support production
  - Planning for manufacturing and quality ManTech initiatives for new tools
  - Specific material specifications that require peculiar production facilities or special handling
  - Manufacturing and quality environmental and safety factors
  - Security requirements for manufacturing and quality facilities (physical and cyber)

- Plans for construction, fabrication, test, and demonstration of required new or modified facilities or tools have been documented in the Acquisition Strategy as part of the Manufacturing Strategy.
- Plans for required STE and SIE (based on prototyping and future requirements for specialized fixtures, construction of test chambers, upgrading laboratories and clean rooms, upgrading waste storage and disposal equipment, etc., have been documented in the Acquisition Strategy and in the SEP.
- Plans for new manufacturing tooling and facilities required for new technologies have been documented as part of the Manufacturing Strategy in the AS.
- Manufacturing and quality tooling and facilities plans for essential raw materials, special alloys, composite materials, components, tooling, and production test based on the availability, storage, and handling requirements have been documented in the Acquisition Strategy and in the SEP.
- Mitigation plans for identified tooling and facility shortfalls and risk areas associated with the proposed facility have been initiated and documented in the Risk, Issues, and Opportunity management system.
- Manufacturing and quality planning for EMD and subsequent phases tooling and facilities has been documented as part of the Manufacturing Strategy in the AS.

Tools

- Acquisition Strategy Template
- Manufacturing Strategy (no template available)
- Manufacturing Readiness Level Assessment Questionnaire, Facilities thread

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016
- Risk, Issue, and Opportunity Management Guide, Jan 2017

K.2 Conduct Production Facilities Assessments

Manufacturing and Quality Tasks

- Conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases, including prime/subcontractors and key suppliers identified in the contractor's manufacturing management plan for the program.
- Assess the contractor's manufacturing management plans for tooling and facilities including plans, utilization, and any relocation/consolidation, program schedules, and manufacturing maturity requirements for adequacy, compliance, and impact to the contract to include:

- Identification new to the contractor materials, technologies, manufacturing methods that require new manufacturing and quality processes requiring additional facilities, equipment, and tools
- Review of the technical data package to identify specific material specifications that require unique production facilities
- Assessment of current utilization for proposed manufacturing facilities
  - Assess adequacy of contractor identified facility, manufacturing equipment, test and quality assurance equipment
  - Review contractor capabilities required for special handling, material storage, ultra-clean work environments, material and part handling, storage and transportation, etc.
- Planned relocation and/or consolidation of production facilities, tooling, and production lines impacts to schedule and costs
- Impacts to schedule and costs from planned changes to increase manufacturing maturity (i.e., manufacturing technology)
- Manufacturing and quality environmental and safety factors
- Security requirements for manufacturing and quality facilities (physical and cyber)
- Request DCMA data and assistance for these efforts

- Conduct on-site capability assessments of contractor's current and proposed manufacturing facilities (including critical and prototype suppliers) for:
  - Adequacy of contractor-identified facility and layout, tooling, manufacturing equipment, test and quality assurance equipment
  - Contractor capabilities required for special handling, material storage, ultra-clean work environments, material and part handling, storage and transportation, etc.
  - Adequacy for prototype builds
  - Program unique production facility and tooling requirements
  - Manufacturing and quality environmental and safety factors
  - Security requirements for manufacturing and quality facilities (physical and cyber)
  - Request DCMA data and assistance for these efforts
- Identify production facility and tooling shortfalls and risks, issues, and opportunities associated with the proposed facility (include current and subsequent phases).
  - Include data from the prototype builds into overall facility risks, issues and opportunities process
  - Identify capacity constraints
  - Request DCMA data and assistance for these efforts

Metrics

- Contractor's proposed facilities and tooling have been assessed for TMRR and subsequent phases, including prime/subcontractors and key suppliers identified in the contractor's manufacturing management plan and updated in the program Manufacturing Plan and the AS.

- Contractor's manufacturing management plans for tooling and facilities have been assessed for adequacy and compliance with the contract (includes plans, utilization, and any relocation/consolidation, program schedules, and manufacturing maturity).
  - Shortfalls, gaps, and opportunities have been identified with mitigation and opportunity plans implemented (e.g., ECPs, contract changes, etc.)
  - New to the contractor materials, technologies, manufacturing methods that require new manufacturing and quality processes requiring additional facilities, equipment, and tools have been identified, analyzed, and results utilized for programmatic action
  - Technical data packages have been analyzed to identify specific material specifications that require unique production facilities and plans developed
  - Contractor current utilization for proposed manufacturing facilities has been assessed and results documented in the SEP and in the RIO management system for:
    - Adequacy of contractor identified facility, manufacturing equipment, test and quality assurance equipment
    - Contractor capabilities to meet special handling, material storage, ultra-clean work environments, material and part handling, storage and transportation, etc. requirements
  - Impacts to schedule and costs have been assessed and documented for program budget, schedule impacts, and funding with appropriate updates to the Acquisition Strategy and the SEP including:
    - Contractor planned relocation and/or consolidation of production facilities, tooling, and production lines
    - Changes planned to increase manufacturing maturity (i.e., manufacturing technology)
    - Manufacturing and quality environmental and safety factors
    - Security requirements for manufacturing and quality facilities (physical and cyber)
  - DCMA data and assistance have been requested and utilized for the above analyses.
- On-site capability assessments of contractor's current and proposed manufacturing facilities with the assistance of DCMA (including critical and prototype suppliers) have been conducted and results documented (in the AS, SEP, Manufacturing Plan, PDR process, etc.) for the adequacy of:
  - Contractor identified facility and layout, tooling, manufacturing equipment, test and quality assurance equipment
  - Contractor capabilities for special handling, material storage, ultra-clean work environments, material and part handling, storage and transportation, etc.
  - Prototype build tooling and facilities
  - Program unique production facilities and tooling
  - Manufacturing and quality environmental and safety
  - Security for manufacturing and quality facilities (physical and cyber)

- Production facility and tooling shortfalls and risks, issues, and opportunities associated with the proposed facility have been identified with DCMA assistance and plans are in place for current and subsequent phases in the SEP and the RIO management system including:
  - Data from the prototype builds into overall facility risks, issues and opportunities process
  - Capacity constraints

Tools

- Manufacturing Readiness Level Assessment Questionnaire, Facilities thread
- DCMA Production Planning and Control Risk Assessment Checklist
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- DCMA-INST-204 Manufacturing and Production
- DoDI 5000.02DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016
- Risk, Issue, and Opportunity Management Guide, Jan 2017

K.3 Identify Special Tooling, Test, and Inspection Equipment

Manufacturing and Quality Tasks

- For EMD and subsequent phases, finalize the Tooling Plan (developed in MSA) for specialized tooling whose use is limited to the development or production of particular supplies or parts or to the performance of particular functions for the program including jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items including foundations and similar improvements necessary.
- For EMD and subsequent phases, finalize the Tooling Plan for single or multipurpose integrated specialized test equipment (STE/SIE) that is engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items or assemblies of equipment including inter-connected or interdependent, and foundations and similar improvements necessary.
- Assess contractor demonstrations of Prototype tooling and STE/SIE in production relevant environment for functionality and sufficiency.

Metrics

- The Tooling Plan for EMD and subsequent phases for specialized tooling has been finalized and included in the Manufacturing Plan and the SEP with supporting rationale and schedule.

- The Tooling Plan for EMD and subsequent phases for single or multipurpose integrated specialized test equipment (STE/SIE) has been finalized and included in the Manufacturing Plan and the SEP with supporting rationale and schedule.
- Specialized tooling and STE/SIE plans, fabrication requirements, and lead-times established and tracked.
    - Long-lead item plan in place
- Contractor demonstrations of prototype tooling and STE/SIE have been assessed in production relevant environment for functionality and meet program requirements.
    - Planning initiated for production environment demonstrations with required metrics (e.g., pilot line, LRIP, etc.
    - Documentation has been provided for the PDR process
- Production facilities assessment (see K.2) verifies proposed special tooling and STE/SIE meet current and planned production requirements (e.g. capacity, facilities and equipment, etc.).

Tools

- DCMA Production Planning and Control Risk Assessment Checklist
- DCMA Manufacturing Systems Risk Assessment Checklist
- Rough Cut Capacity Planning Spreadsheet
- Material Requirements Planning
- Capacity Requirements Planning Assessment Worksheet
- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Manufacturing Resource Planning (MRPII)
- Manufacturing Readiness Level Assessment Questionnaire, Facilities thread
- Plant Design and Facility Layout Software Evaluation Tools

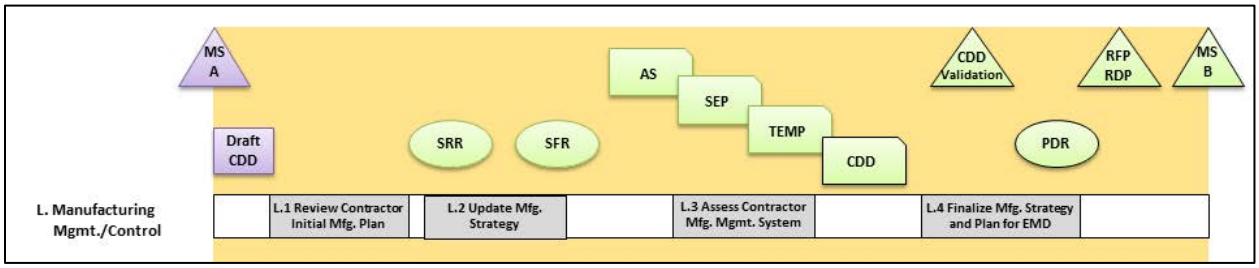
Resources

- AS6500, Manufacturing Management System, Sep 2016
- DCMA-INST-204 Manufacturing and Production
- FAR Part 2, §2.101 Definitions
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016

L. MANUFACTURING MANAGEMENT/CONTROL

The initial program manufacturing and quality strategy should have been developed as part of the program's Acquisition Strategy in MSA phase. The manufacturing and quality strategy is a major

aspect of the master schedule for development, test, production, fielding, modification, postproduction management, and other activities essential for program success. Now that there is a contractor responsible for technology maturation and risk reduction, the manufacturing and quality strategy will require updating. This requires an assessment of the contractor's manufacturing plans for adequacy and alignment with the AS.



Manufacturing resources consist of facilities, materials, machines, manpower, methods, measurement systems, and capital that are used to convert or transform raw materials and component parts into end products. Contractors must have an effective combination of people and systems in order to plan for, monitor, and control these manufacturing resources. Effective implementation of a manufacturing management system is required to manage these resources. A well-structured manufacturing management system generally employs the use of industry best practices. Assessment of the contractor's manufacturing management and quality systems should be performed against the recognized industry best practices such as AS6500, ISO 9000, AS9100, etc.

Additionally, the government requires contractors to implement cyber threat protection measures and manufacturing control systems which include safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security. This would be in compliance with:

- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST, Cybersecurity Framework

In preparation for PDR, the Request for Proposal Release Decision Point (RFP RDP), and Milestone B, the program's Manufacturing and Quality Management Strategies and Plans should be updated. The knowledge gained from the results of TMRR assessments, prototypes, demonstrations, and accomplishments, risk, issue, and opportunity plans and on-going mitigations, etc., should be utilized for the updates. These comprehensive strategies and plans will provide the basis for program manufacturing and quality management in the EMD phase.

L.1 Review Contractor Initial Manufacturing Plan

Manufacturing and Quality Tasks

- Compare, contrast, and assess the contractor's Manufacturing Plan for agreement with the program's overall Acquisition Strategy and the program's Manufacturing Strategy for TMRR and future phases to include:
  - Consistency with program IB risk and issue mitigation plans
  - Development and incorporation of enabling/critical technologies (and constraints)
  - Requirements and schedules for incorporating manufacturing development projects (ManTech)
  - Design feasibility, methodology, and producibility
  - Planned rates and schedules (includes processes, tooling, make/buy, etc.)
  - Management of key and critical characteristics
  - Costs, schedule, budgets, and affordability requirements
  - Management of materials, including lead-times, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
  - Management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
  - Processes for managing the schedule, including contingencies, variances, and risks
  - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Processes and process capability control requirements
  - Workforce capabilities, training, certifications, availability, etc.
  - Facilities, tooling, and test equipment (including GFE and assets) requirements
  - Environmental, security, and safety requirements
- Assess the contractor's Manufacturing Plan for appropriate cyber threat protection measures including safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper , and security-related activities such as physical security and industrial security.
  - Verify that the contractor and subcontractors can comply with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Verify periodic assessments are conducted to understand the risk to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems
  - Verify contractor's Industrial Control Systems (ICS) are included in plans for cyber threat protection measures to be applied to manufacturing and quality systems

- Assess the contractor's Manufacturing Plan for proposed processes, methods, actions and metrics that address manufacturing and quality capability improvement, feasibility, producibility, and risks, issues, and opportunities.
    - Review plan for a scheduled review cycle of the above commensurate with the risks and issues
- Assess the contractor's Risk, Issue, and Opportunity Management System and planning for this contractual TMRR phase (may be part of the SEMP or Reliability plan).
    - Verify the contractor has included in their plan a requirement for a joint government/contractor program risk and issue registers
- Assess the contractor's Configuration Management Plan for control and management of manufacturing and quality data for the program's TMRR phase contract.
- Assess the contractor's manufacturing and quality safety analyses processes and procedures for compliance to required program standards (i.e., MIL-STD-882) and integration into the Manufacturing Management System.
- Evaluate the contractor's proposed processes and methods for submission, review, revision, and process for obtaining approval of CDRLs, DIDs, etc. to support manufacturing and quality processes for consistency with program plans and procedures.
- Evaluate the contractor's proposed processes and methods for providing manufacturing and quality data and support to:
    - Milestone and technical reviews
    - Manufacturing and quality reviews (with frequency of reviews)
    - Cost models and data (including Cost of Quality)
    - Key characteristic management process
    - Risk, issue, and opportunity identification, management, and mitigation system
    - Variability reduction processes
    - Materials management processes
    - Supply chain management system
    - Facilities, tooling, and test equipment planning
    - Workforce planning
- Assess the contractor's Manufacturing Plan for manufacturing and quality TMRR phase goals/exit criteria.
- Assess the contractor's strategy and plans for acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life cycle costs including methods to encourage investment in U.S. domestic sources.
- Assess contractor's capability to comply with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting.

Metrics

- Contractor's Manufacturing Management Plan has been assessed and consistency with the program's overall Acquisition Strategy and the program's Manufacturing Strategy and plans and gaps and risks and issues documented for program management to include:
    - Consistency with program IB risk and issue mitigation plans
    - Development and incorporation of enabling/critical technologies (and constraints)
    - Requirements and schedules for incorporating manufacturing development projects (ManTech)
    - Design feasibility, methodology, and producibility
    - Planned rates and schedules (includes processes, tooling, make/buy, etc.)
    - Management of key and critical characteristics
    - Costs, schedule, budgets, and affordability requirements
    - Management of materials, including lead-times, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
    - Management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
    - Processes for managing the schedule, including contingencies, variances, and risks
    - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
    - Processes and process capability control requirements
    - Workforce capabilities, training, certifications, availability, etc.
    - Facilities, tooling, and test equipment (including GFE and assets) requirements
    - Environmental, security, and safety requirements
- Contractor's Manufacturing Plan for cyber threat protection measures have been assessed with recommendations documented for program management and incorporation into the SEMP and the SEP including safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper , and security-related activities.
    - Contractor and Subcontractors have been verified in compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
    - Periodic assessments have been planned and scheduled for understanding the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of CUI by manufacturing information systems
    - Contractor's ICSs have been included in plans for cyber threat protection measures to be applied to manufacturing and quality systems
- Contractor's Manufacturing Plan has been assessed for proposed processes, methods, actions and metrics that address manufacturing and quality capability improvement, feasibility, producibility, and risks, issues, and opportunities with recommendations documented for program management.

- Plan documents a scheduled review cycle of the above commensurate with the risks and issues

- Contractor's Risk, Issue, and Opportunity Management System and planning for this contractual TMRR phase has been assessed and incorporated into the SEMP and the SEP.
  - Contractor has included in their plan a requirement for joint government/contractor program risk and issue registers, and appropriate management reviews
- Contractor's Configuration Management Plan (CMP) for control and management of manufacturing and quality data has been assessed and meets program requirements or recommendations documented for program management.
- Contractor's manufacturing and quality safety analyses processes and procedures have been assessed and meet required program standards (i.e., MIL-STD-882) and are integrated into the Manufacturing Management System for program management.
- Contractor's proposed processes and methods for submission, review, revision, and process for obtaining approval of CDRLs, DIDs, etc. in support of manufacturing and quality processes have been evaluated for consistency with program plans and procedures with and recommendations documented for program management.
- Contractor's proposed processes and methods have been assessed and meet contract requirements for providing manufacturing and quality data and support to:
  - Milestone and technical reviews
  - Manufacturing and quality reviews (with frequency of reviews)
  - Cost models and data (including Cost of Quality)
  - Key characteristic management process
  - Risk, issue, and opportunity identification, management, and mitigation system
  - Variability reduction processes
  - Materials management processes
  - Supply chain management system
  - Facilities, tooling, and test equipment planning
  - Workforce planning
- Contractor's Manufacturing Plan has been assessed for manufacturing and quality TMRR phase goals/exit criteria consistent with industry best practices (i.e., IEEE 15288).
- Contractor's strategy and plans have been assessed and include acquisition of modern technology, production equipment, and production systems to increase the productivity and reduce life cycle costs (including methods to encourage investment in U.S. domestic sources) consistent with contractual requirements and program goals.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management

- Learning Curve Estimator
- Line of Balance Template
- Material Requirements Planning (MRP)
- Manufacturing Resource Planning (MRPII)
- Material Management and Accounting System (MMAS) audit
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)
- Manufacturing Readiness Level (MRL) assessment questionnaire using Manufacturing Management/Control thread
- Risk, Issues and Opportunities assessment

Resources

- MIL-STD-882E DoD Standard Practice: System Safety, May 2012
- AS6500, Manufacturing Management Program, Nov 2014
- Systems Engineering Preparation Guide, Apr 2008
- DAG, Chapter 3-4 3.18, Producibility, Quality and Manufacturing Readiness, 2017
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017, Enclosure 14
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- Systems Engineering Preparation Guide, Apr 2008
- DAG, Chapter 3-4 3.18, Producibility, Quality and Manufacturing Readiness, 2017
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017
- DFARS 252.72 Contractor Material Management and Accounting System
- Risk, Issue, and Opportunity Management Guide, Jan 2017

L.2 Update Manufacturing Strategy

Manufacturing and Quality Tasks

- From the assessment of the contractor's Manufacturing Strategy and plans, update the program Manufacturing Strategy (and the AS) and plans (and the SEP) for TMRR and future phases to include:

- Incorporation of industry and government manufacturing and quality best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
- Compliance with policy directives and regulations
- Requirements for the EMD Acquisition Strategy and RFP
- Program plans for IB risk and issue mitigation (government plans) complementary to contractor plans
- The joint Risk, Issue, and Opportunity Management plans
- Development and incorporation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
- Development and incorporation of system required technologies (and constraints)
- Requirements and schedules for manufacturing development projects (ManTech)
- Management of Intellectual Property
- Design feasibility, methodology, and producibility initiatives
- Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
- Management of key and critical characteristics
- Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
- Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
- Management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
- Processes for managing the schedule, including contingencies, variances, and risks
- Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
- Processes and process capability control requirements
- Workforce needs, capabilities, training, certifications, availability, etc.
- Facilities, tooling, and test equipment (including GFE and assets) requirements
- Acceptance testing (including incorporation in the IMP/IMS)
- Environmental, security, and safety requirements

- Based on assessments of the contractor's Manufacturing System and plans for cyber threat protection measures, update the SEP technical approaches for cybersecurity and related program security
  - Include technical risk, processes, industrial control systems, resources, organization, metrics, and design considerations
  - Provide manufacturing and quality input to the Program Protection Plan (PPP) for considerations of contractor level of compliance, risks, and issues

- Validate that the updated program Manufacturing Strategy (and AS) includes appropriate agreements, delegations, and contracts with other agencies (e.g. DCMA), Defense Logistics Agency (DLA), etc.)
- For the SEP, update the Program Manufacturing Management Plan to address each key area of the Manufacturing Strategy (in accordance with AS6500) to include:

- Manufacturing Management System
- Design Analysis for Manufacturing
- Manufacturing Risk Identification (including mitigation)
- Manufacturing Planning
- Manufacturing Operations Management

- Identify requirements for Integrated Product Support for the program and update the Program Manufacturing Strategy accordingly (if required).

Metrics

- Program Manufacturing Strategy and plans have been assessed for adequacy, updated, and documented in the AS, SEP, and other appropriate documentation to include:
  - Incorporation of industry and government manufacturing and quality best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
  - Compliance with policy directives and regulations
  - Requirements for the EMD Acquisition Strategy and RFP
  - Program plans for IB risk and issue mitigation (government plans) complementary to contractor plans
  - Joint Risk, Issue, and Opportunity Management plans
  - Development and incorporation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
  - Development and incorporation of system required technologies (and constraints)
  - Requirements and schedules for manufacturing development projects (ManTech)
  - Management of Intellectual Property
  - Design feasibility, methodology, and producibility initiatives
  - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
  - Management of key and critical characteristics
  - Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
  - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
  - Management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
  - Processes for managing the schedule, including contingencies, variances, and risks
  - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Processes and process capability control requirements
  - Workforce needs, capabilities, training, certifications, availability, etc.
  - Facilities, tooling, and test equipment (including GFE and assets) requirements
  - Acceptance testing (including incorporation in the IMP/IMS)
  - Environmental, security, and safety requirements

- Manufacturing plans for cyber threat protection measures have been updated in Manufacturing Strategy and the SEP for cybersecurity and related program security and include risks, processes, industrial control systems, resources, organization(s), metrics, and design considerations; and provided as manufacturing and quality input to the PPP.
- Program Manufacturing Strategy and Acquisition Strategy have been updated and document appropriate agreements, delegations, and contracts with other agencies (e.g. DCMA, DLA, etc.)
- Program Manufacturing Management Plan has been updated in the SEP and addresses each key area of the Manufacturing Strategy (in accordance with AS6500) including:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management
- Requirements for IPS for the program have been identified and documented in the Program Manufacturing Strategy accordingly.

Tools

- Acquisition Strategy Template
- Manufacturing Readiness Level assessment questionnaire using Manufacturing Management/Control thread

Resources

- Acquisition Plan Preparation Guide, Jan 2009
- DSMC Acquisition Strategy Guide, Dec 1999
- MRL Deskbook Version 2016
- AS6500, Manufacturing Management System, Sep 2016
- DoDI 5000.02, Operation of the Defense Acquisition System, Feb 2017
- Service specific policies and regulations (i.e., AFI 63-145)
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

L.3 Assess Contractor Manufacturing Management System

Manufacturing and Quality Tasks

- Assess the contractor's Manufacturing Management system capability to perform the design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including (See I.3) for:
  - Effectiveness of program and contractor communication and interaction processes to include:
    - Cost, schedule, and performance requirements and timely notification of changes
    - Manufacturing data management processes (to include responses, status, and reports for cost, schedule, and performance actuals)
    - Integration of risk, issue, and opportunity management processes
    - Failures, corrective, and preventative actions, communication processes
    - Specification and production of prototypes
  - Design analyses incorporating producibility and manufacturing feasibility
  - Failure mode analyses processes
  - Key Characteristics management processes
  - Risk, issue, and opportunity management processes (to include quality, technical, schedule, material, facility, scale-up, financial impacts, etc.)
  - Make/buy processes (to include performance and impacts)
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials
  - Development program that focuses on and measures continuous improvement
  - Effective metrics management processes to identify, monitor, evaluate, and verify to improve processes, and prevent defects
  - Supplier management system that tracks and reports supplier performance which includes a supplier quality assessment process
  - Manufacturing verification system that verifies the proposed production processes, tooling, and test equipment meet program requirements (including Special Tooling and Special Test Equipment)
  - Manufacturing assessment and self-assessment processes to measure progress in manufacturing maturation and risk reduction including suppliers
  - Management processes for COTS items, GOTS items, and NDIs
  - Management processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.) including roles and responsibilities
  - Production Process Verifications (PPVs) that verify manufacturing processes, tooling, and equipment are statistically capable of producing required parts and assemblies
  - Process control planning incorporating process capability studies
  - Variability Reduction (VR) processes and techniques
  - Manufacturing software and firmware management processes and integration (including the SDP, and SCMP

7110 - Development processes for in-process and acceptance tests (including prototypes, first
7111 articles, hardware, software, and firmware), test procedures including test equipment, and
7112 incorporation into the TEMP

7113 • Assess the contractor's materials and inventory control systems for sufficiency and capability
7114 to effectively meet program requirements consistent with industry best practices including:

7115 - An appropriate materials, manufacturing, or enterprise resources planning system
7116 (MRP/MRP II/Enterprise Resource Plan (ERP)) including cost control, capacity and
7117 facility planning, economic order quantities, inventory control, shop floor control, bills of
7118 material, scheduling, purchasing, etc.
7119 - Appropriate organization/expertise to effectively operate, analyze, and maintain the
7120 system

7121 • Assess the contractor's Manufacturing Management System processes for incorporation of
7122 manufacturing and quality in the development, management, execution, and maintenance of
7123 the IMP/IMS including processes to:

7124 - Identify and assess actual progress versus planned progress
7125 - Monitor and manage the Critical Path
7126 - Monitor the status of risk, issue, and opportunity management
7127 - Manage Key Performance Parameters , Key System Attributes , Technical Performance
7128 Measures , and Key Characteristics

7129 • Assess the contractor's Manufacturing Management System for capability to develop an
7130 Integrated Product Support Plan (if required) including planning for EMD, production,
7131 developmental and operational test, and life cycle sustainment
7132 • Assess the contractor's Manufacturing Management System make or buy decision process
7133 for compliance with program manufacturing and quality objectives including:

7134 - Rationale for specific make/buy decisions
7135 - Identification of items that could become obsolete or are from a diminishing or fragile
7136 manufacturing source and contingency plans
7137 - Identification sole source, single source, or foreign sourced items and contingency plans
7138 - Availability and lead-times (including long lead)
7139 - ITAR and anti-tamper considerations
7140 - Security implications
7141 - COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges,
7142 specialized equipment, test facilities, etc.)

7143 • Analyze the contractor's Supplier Management System capability to perform the anticipated
7144 design and manufacturing work scope in accordance with industry best practices (i.e.,
7145 AS6500) including:

7146 - Effectiveness of prime and subcontractor communication and interaction processes to
7147 include:

        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Quality data exchange processes
        - Integration of risk, issue, and opportunity management
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions, communication, and end user feedback
        - Specification and production of prototypes
    - Key Characteristics management
    - Supplier risk, issue, and opportunity management processes for quality, technical, schedule, material, facility, scale-up, financial impacts, etc.
    - Make/buy processes for supplier quality performance and impacts
    - Approval/removal and qualification processes for suppliers which includes period re-assessment
    - Processes and procedures for prevention and/or detection of counterfeit parts and materials (See AS5553 and AS6174)
    - Identification of major and critical suppliers, and suppliers performing Critical Manufacturing Processes
    - Supplier development program that focuses on and measures continuous improvement
    - Effective metrics to monitor, evaluate, verify, improve processes, and prevent defects
- Analyze the contractor's Supplier Management System and Quality Management Plan for:
    - Management of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
    - Roles, responsibilities, and quality processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
    - Software and firmware quality and integration into the program Software Quality Assurance Plan , Software Development Plan , and Software Configuration Management Plan
    - Acceptance tests (prototypes, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP
- Verify the contract and the subcontractor management plan includes right of access for both the contractor and the government to supplier facilities and documentation, where applicable.
- Request DMCA assistance in data collection, assessment, analyses, and verification of the contractor Manufacturing Management System including the supply chain.

Metrics

- Contractor's Manufacturing Management system has been assessed and results documented in program documentation (Acquisition Strategy and SEP) and utilized for RFP development, to support MRL assessments, and the PDR decision process. The results document the contractor capability to perform based on design and manufacturing work scope in accordance with industry best practices including: (See I.3)

- Effectiveness of communications and interaction processes to include:
  - Cost, schedule, and performance requirements and timely notification of changes
  - Manufacturing data management processes (to include responses, status, and reports for cost, schedule, and performance actuals)
  - Integration of risk, issue, and opportunity management processes
  - Failures, corrective, and preventative actions, communication processes
  - Specification and production of prototypes
- Design analyses of producibility and manufacturing feasibility
- Failure mode analyses
- Key Characteristics management
- Risk, issue, and opportunity management (to include quality, technical, schedule, material, facility, scale-up, financial impacts, etc.)
- Make/buy (to include performance and impacts)
- Prevention and/or detection of counterfeit parts and materials
- Continuous process improvement
- Metrics management including identification, monitoring, evaluation, and verification to improve processes, and prevent defects
- Supplier management system that supplier quality assessment
- Manufacturing verification system that meets program requirements (including Special Tooling and Special Test Equipment)
- Manufacturing assessment and self-assessment processes including suppliers
- Management of COTS items, GOTS items, and NDIs
- Management of GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
- Production Process Verifications (PPVs)
- Process control and capability studies
- Variability Reduction
- Manufacturing software and firmware management and integration (including the program Software Development Plan , and Software Configuration Management Plan
- Documentation of in-process and acceptance tests (including prototypes, first articles, hardware, software, and firmware), and test procedures in the TEMP

- Contractor's materials and inventory control systems has been assessed and documented in program documentation and utilized for RFP development, to support MRL assessments, and the PDR decision process for compliance with program requirements consistent with industry best practices including:
  - An appropriate materials, manufacturing, or enterprise resources planning system (MRP/MRP II/ERP) including cost control, capacity and facility planning, economic order quantities, inventory control, shop floor control, bills of material, scheduling, purchasing, etc.
  - Appropriate organization/expertise to effectively operate, analyze, and maintain the system

- Contractor's Manufacturing Management System has been assessed for development, management, execution, and maintenance of, and documents the incorporation of manufacturing and quality into the Integrated Master Plan and Integrated Master Schedule (IMP/IMS) to include:
    - Actual progress versus planned progress
    - Status of the critical path
    - Status of risks, issues, and opportunities
    - Status of KPPs, TPMs, and Key Characteristics
- Contractor's Manufacturing Management System has been assessed and documents an Integrated Product Support Plan (if required) which includes plans for EMD, production, developmental and operational test, and life cycle sustainment
- Contractor's Manufacturing Management System make or buy decision process has been assessed and documented in appropriate program for compliance with program manufacturing and quality objectives including:
    - Rationale for specific make/buy decisions
    - Identification of items that could become obsolete or are from a diminishing or fragile manufacturing source and contingency plans
    - Identification sole source, single source, or foreign sourced items and contingency plans
    - Availability and lead-times (including long lead)
    - ITAR and anti-tamper considerations
    - Security implications
    - COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
- Contractor's Supplier Management System has been assessed to be in compliance with industry best practices (i.e., AS6500) and documented to include:
    - Effectiveness of prime and subcontractor communication and interaction processes to include:
        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Quality data exchange processes
        - Integration of risk, issue, and opportunity management
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions, communication, and end user feedback
        - Specification and production of prototypes
    - Management of Key Characteristics
    - Management of supplier risks, issues, and opportunities for quality, technical, schedule, material, facility, scale-up, financial impacts, etc.
    - Make/buy decision considering supplier quality performance and impacts

- Approval/removal and qualification processes for suppliers including period re-assessment
- Prevention and/or detection of counterfeit parts and materials
- Identification of major and critical suppliers, and suppliers performing Critical Manufacturing Processes
- Supplier development program that focuses on and measures continuous improvement
- Effective metrics to monitor, evaluate, verify, improve processes, and prevent defects

- Contractor's Supplier Management System and Quality Management Plan has been assessed and documents Supplier:
  - Management of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
  - Roles, responsibilities, and quality processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Software and firmware quality and integration into the program Software Quality Assurance Plan , Software Development Plan , and Software Configuration Management Plan
  - Acceptance tests (prototypes, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP
- Access for both the contractor and the government to supplier facilities and documentation has been documented in the contract and the subcontractor management plan.
- DMCA Letters of Delegation are in place to assist in data collection, assessment, analyses, and verification of the contractor Manufacturing Management System including the supply chain.

Tools

- Manufacturing Readiness Level (MRL) Assessment Questionnaire for the Manufacturing Management and Control thread
- AS6500 Assessment
- Material Management and Accounting System Audit

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- MRL Deskbook Version 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- DFAR 242.72 Contractor Material Management and Accounting System
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs

- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs

L.4 Finalize Manufacturing Strategy and Plan for EMD

Manufacturing and Quality Tasks

- Update the Program Manufacturing Strategy for EMD to include:
  - Incorporation of direction and results from a completed PDR (e.g., date, open items, issues, etc.)
  - Incorporation of requirements for EMD that were included in the EMD RFP
  - Incorporation of all Risks, Issues, and Opportunities
  - Maturity and plans for manufacturing development and enabling manufacturing technologies
  - Manufacturing maturity and plans for system required technologies
  - Results of design feasibility, methodology, and producibility initiatives
  - Management of Intellectual Property and data rights
  - Revised rates and schedules (includes processes, surges, tooling, make/buy, etc.)
  - Key and critical characteristics
  - Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
  - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
  - Revisions and updates to development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Revisions and updates for use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
  - Revised process capability requirements
  - Revised requirements for in-process and acceptance tests (including prototypes, first articles, hardware, software, and firmware), test procedures including test equipment
  - Revised workforce needs, capabilities, training, certifications, availability, etc.
  - Revised facilities, tooling, and test equipment (including GFE and assets) requirements
  - Revised processes and procedures for prevention and/or detection of counterfeit parts and materials
  - Revised acceptance testing (including incorporation in the IMP/IMS)
  - Revised environmental, security, and safety requirements
  - ITAR and anti-tamper
  - Revised plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations
- Update the Program Manufacturing Management Plan, based on assessments, analyses, and incremental updates (including issues, open items, etc.) conducted to address each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
  - Manufacturing Management System

- Design Analysis for Manufacturing
  - Design analysis
  - Producibility analysis
  - Key Characteristics
  - Failure Mode Effects Analyses
- Manufacturing Risk Identification (including mitigation)
  - Manufacturing feasibility assessments
  - MRL assessments
  - Production readiness reviews
- Manufacturing Planning
  - Supply chain and material management
  - Manufacturing technology development
  - Manufacturing cost
  - Modeling and simulations
  - Manufacturing system verification
  - Manufacturing workforce
  - Tooling, test equipment and facilities
- Manufacturing Operations Management
  - Production Scheduling and Control
  - Manufacturing Surveillance
  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - Production Process Verification
  - First Article Inspection and test
  - Supplier Management
  - Supplier Quality

- Update the Program Manufacturing Management Plan for manufacturing software and firmware management processes and integration (including the program Software Development Plan , and Software Configuration Management Plan .
- Provide revised manufacturing and quality inputs to the Program Protection Plan (PPP) for considerations of contractor compliance, risks, and issues for EMD.
- Update the Program Manufacturing Strategy (and AS) for EMD to include development of appropriate agreements, delegations, and contracts with other agencies (e.g. DCMA), DLA, National Test Facilities, etc.).
- Update manufacturing and quality planning for EMD, production, developmental and operational test, and life cycle sustainment of proposed products.
  - Initial manufacturing approach developed

- All system related manufacturing events included in Integrated Master Plan and Schedule
- Manufacturing risk mitigation approach for pilot line or technology insertion programs defined
- Most material decisions complete (make/buy)
- Material risks identified and mitigation plans developed

Metrics

- Program Manufacturing Strategy has been updated and documented in the Acquisition Strategy for EMD to include:
  - Direction and results from a completed PDR (e.g., date, open items, issues, etc.)
  - Requirements for EMD that were included in the EMD RFP
  - All Risks, Issues, and Opportunities
  - Plans for continued maturation of manufacturing development and enabling manufacturing technologies
  - Plans for continued manufacturing maturation for system required technologies
  - Results of design feasibility, methodology, and producibility initiatives
  - Management of Intellectual Property and data rights
  - Revised rates and schedules (includes processes, surges, tooling, make/buy, etc.)
  - Key and critical characteristics
  - Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
  - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
  - Revisions and updates to development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Revisions and updates for use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
  - Revised process capability requirements
  - Revised requirements for in-process and acceptance tests (including prototypes, first articles, hardware, software, and firmware), test procedures including test equipment
  - Revised workforce needs, capabilities, training, certifications, availability, etc.
  - Revised facilities, tooling, and test equipment (including GFE and assets) requirements
  - Revised processes and procedures for prevention and/or detection of counterfeit parts and materials
  - Revised acceptance testing (including incorporation in the IMP/IMS)
  - Revised environmental, security, and safety requirements
  - ITAR and anti-tamper requirements
  - Revised plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations

- Based on assessments, analyses, and incremental updates to each key area of the Manufacturing Strategy, the Program Manufacturing Management Plan has been updated and documented in the AS, the SEP and other appropriate program documents to include:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management
- The Program Manufacturing Management Plan for manufacturing software and firmware management processes and integration has been updated and documented and includes the program SDP, and SCMP.
- Revised manufacturing and quality inputs to the PPP have been documented and provided for EMD including considerations of contractor compliance, risks, and issues.
- The Program Manufacturing Strategy (and AS) for EMD has been updated to include plans for appropriate agreements, delegations, and contracts with other agencies (e.g. DCMA, DLA, National Test Facilities, etc.).
- Manufacturing and quality planning for EMD, production, developmental and operational test, and life cycle sustainment of proposed products has been documented in appropriate program documents (e.g., TEMP, SEP, IMP/IMS, etc.) to include:
  - Initial manufacturing approach
  - All system related manufacturing events
  - Manufacturing risk mitigation approach for pilot line and technology insertion
  - Completed material decisions
  - Identification and mitigation of material risks, and issues

Tools

- Acquisition Strategy Template
- Manufacturing Plan (DID-MGMG-81889)
- Manufacturing Readiness Level (MRL) Assessment Questionnaire for the Manufacturing Management and Control thread

Resources

- Acquisition Strategy Plan Preparation Guide, Jan 2009
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- MRL Deskbook Version 2016
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

4. Engineering and Manufacturing Development (EMD) Phase (Milestone B)

Introduction

As stated in Department of Defense Instruction (DoDI) 5000.02, Operation of the Defense Acquisition System, "The purpose of the EMD phase is to develop, build, and test a product to verify that all operational and derived requirements have been met, and to support production or deployment decisions." To accomplish this, the EMD phase involves completing all hardware and software detailed designs, mitigation and closure of open risks and issues, and building and testing of prototypes and/or first articles and verifying compliance with requirements. EMD also includes the Critical Design Review (CDR), which establishes of the initial product baseline and transfers configuration control to the program. In preparation for transition to Low-Rate Initial Production (LRIP), the final stage of EMD is producing products that look and operate like final production units. These units are built on a pilot line.

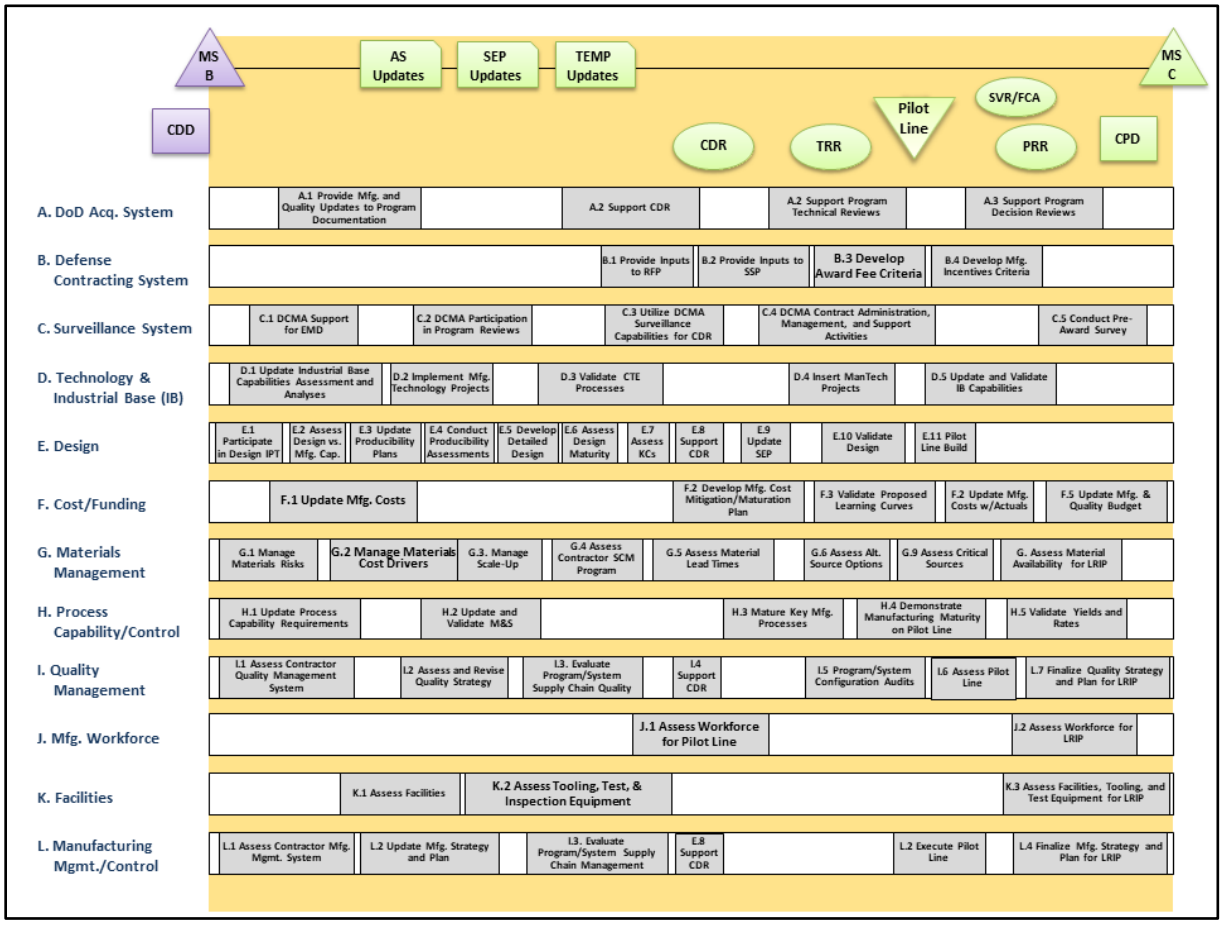


Figure 4-1. EMD Phase Manufacturing and Quality Activities

During EMD, the program will assess the maturity of critical manufacturing processes to ensure they are affordable and executable. Early in the EMD phase, the program's initial manufacturing and quality requirements are identified and allocated. They are refined during EMD based on the results of assessments and analyses to include: the design, the contractor, the supply chain, the Industrial Base, materials, processes, procedures, etc., and are finalized at CDR. Later in EMD, programs will demonstrate manufacturing and quality process maturity by production of initial systems on a pilot line. This enables the program to ensure manufacturing and quality producibility risks are acceptable, qualifications are complete throughout the supply chain, and manufacturing processes for Key Characteristics (KC) and critical characteristics will be under statistical process control for LRIP, prior to the production decision at Milestone C.

Manufacturing and quality should be a key contributor and participant in all technical reviews and program documentation, providing inputs and recommendations based on results from assessments, analyses, and demonstrations. Key program documentation and reviews during EMD include:

- Acquisition Strategy (AS)
  - Manufacturing Strategy
  - Quality Strategy
- Systems Engineering Plan (SEP)
  - Manufacturing Plan
  - Quality Plan
- Test and Engineering Master Plan (TEMP)
- Capabilities Development Document (CDD)
  - Transitioning to Capabilities Production Document (CPD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)
- Critical Design Review(s) (CDR)
- Test Readiness Review (TRR)
- Pilot Line Demonstration(s)
- System Verification Review (SVR)/Functional Configuration Audit (FCA)
- Production Readiness Review(s) (PRR)
- Milestone C Decision (MS C)

Manufacturing and Quality Objectives

Manufacturing and quality risks, issues, and opportunities are important factors in making the decision to proceed within all phases of development and production. The producibility of the design and risks were reviewed prior to entry into the EMD phase, however, there may be a new contractor(s), a changed Industrial Base and/or technology base, etc. requiring new or additional assessments.

To meet the EMD phase objective, the program must demonstrate on a pilot line a product capable of meeting system performance requirements within cost and schedule constraints. This requires complete and thorough planning and documentation of hardware and software designs, mitigation and closure of open risks and issues, and compliance with requirements. Manufacturing and quality's contributions to the EMD phase objective are documented in updates to the Manufacturing Strategy and Plan and the Quality Strategy and Plan which are incorporated into the AS, the SEP, and the TEMP.

To meet the P&D phase objective of producing "products in Low-Rate Initial Production (LRIP) and deliver to receiving military organizations," manufacturing and quality should have a key role during the EMD phase in development of the Request for Proposal (RFP) and the Source Selection Plan (SSP), including providing manufacturing and quality Award Fee and Incentives Criteria for the P&D phase. A cohesive effort between the Contracts and manufacturing and quality personnel is essential to assuring that manufacturing and quality processes are sufficiently mature for entry into the P&D phase and Low-Rate Initial Production (LRIP).

Day-to-day surveillance of contractor and supply chain activities is key to monitoring progress and maturity of the program as it moves through finalizing the design and demonstration on a pilot line. Reviews and assessments are important oversight tools that the program can use to review and evaluate the state of the system and the program, re-directing activity if necessary. DCMA is key to providing monitoring, tracking, and reporting of contractor and supply chain performance, actions, and compliance with all contractual requirements. DCMA and program audits and reviews should be multi-disciplined to ensure that all of functional aspects of the program are addressed. This systematic process assesses risk and issues and verifies the application of manufacturing and quality best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.) at the contractor and in the supply chain.

DoD policy requires an analysis of the capabilities of the National Technology and Industrial Base (NTIB) to support the design, development, production, operation, uninterrupted maintenance support, and eventual disposal of the system. Without a supporting Industrial Base, the program may find that accomplishing objectives within the defined cost and schedule will be difficult because of incompatibilities between the requirements and the NTIB available to support it. A key manufacturing and quality focus should be on risk mitigation measures needed to sustain a reliable, technologically superior, affordable and resilient defense industrial base.

The necessity to reduce program risk and the desire to improve program performance while reducing costs can benefit from development, maturation, and implementation of advanced manufacturing technologies. As manufacturing technology project are matured, these ManTech projects should be completed, integrated, and demonstrated on a pilot line at the appropriate contractor and/or supply chain facilities. Additionally, DoDI 5000.02 requires a systematic process that assesses the maturity of Critical Technology Elements (CTE) for all acquisition programs. In completing the development

of a system or incremental capability, one of the key tasks is to mature Critical Manufacturing Processes (CMP) associated with KCs, and therefore with CTEs.

At CDR, all of the design information necessary to plan the detailed manufacturing operations for the system should be available. Manufacturing and quality participation early in the design process through active participation in the Design IPT is the key to creating a producible design. Manufacturing and quality planning in EMD should address all areas of manufacturing and quality impacting cost, schedule, and performance requirements such as KCs, selection of specific materials, specific manufacturing and quality processes, changes in requirements, changes in workforce, facilities, tooling, equipment, etc.

Producibility assessments of the design should be conducted throughout the supply chain using industry best practice tools, techniques, and procedures. Prior to a system-level CDR, the detailed design must be developed from the component level up to the system level with CDRs conducted to assure meeting design requirements at all levels of the supply chain. Prior to release of drawings to manufacturing, the detailed design drawings, bills-of-material, and product and process specifications must be completed.

Risks associated with manufacturing and quality will have a major impact on the maturity of the design. Many system-level risks occur from immature designs and the failure to consider design risks. Manufacturing and quality must assess maturity based on manufacturing feasibility, capability, producibility, and KCs, in accordance with industry best practices. Manufacturing maturity can be verified and validated by demonstrations of manufacturing and quality processes and procedures in a representative environment at the system, subsystem, item, and component level.

Prior to CDR the list of KCs may be reduced through producibility activities as the product design is refined to make key characteristics less sensitive to variation. As the KCs are finalized by CDR, the corresponding list of critical manufacturing and quality processes should also be completed. An assessment of manufacturing readiness to a system-level target of Manufacturing Readiness Level (MRL) 7 can be conducted to confirm manufacturing maturity for CDR.

The role of manufacturing and quality to influence the design culminates at CDR. Design decisions made at CDR related to manufacturing and quality have major impacts on future production and life-cycle costs. These decisions should be documented in the SEP and the AS via updated Manufacturing and Quality Strategies and Plans. Post-CDR activities, including pilot line, will provide the basis for validation of the design and adequacy of the contractor’s processes and capabilities including control of KCs.

A successful pilot line build provides validation of the system design, demonstrating the system design is complete. Outputs of the pilot line will produce articles subject to First Article Inspections (FAI) and/or First Article Tests (FAT) and will provide validation that manufacturing and quality processes are stable, under control, and ready for LRIP.

Manufacturing and quality cost estimates should be based on detailed manufacturing and quality processes and procedures according to industry best practices. Updates should be performed, as necessary, based on current program status and/or learning curves in order to develop a time-phased manufacturing cost. These updates will require analyses of contractor Manufacturing and Quality Plans regarding costs, cost controls, and cost drivers. As the design progresses to final design at CDR, cost estimates, cost models, and associated cost drivers should be updated with actual cost data from lower level (item and component) pilot lines and production.

Within any program there will be certain systems, subsystems, items, and components the cost of which will dramatically impact the overall system cost. These manufacturing and quality cost drivers originate with and evolve from:

- Emerging technologies
- Industrial base limitations and constraints
- Design producibility factors and impacts
- Maturing of manufacturing and quality processes (i.e., capability and control)
- Materials (e.g., sourcing, availability, handling, etc.)
- Environmental and Environmental, Safety, and Occupational Health (ESOH) impacts
- Security impacts
- Manufacturing and Quality management
- Supply chain management
- Workforce constraints
- Facilities, equipment, tooling, and test equipment constraints
- Program budget and funding resource limitations and constraints

Manufacturing and quality should focus on producibility, planning, and risk and issue mitigation for reduction and mitigation of cost drivers.

Manufacturing and quality should refine the learning curves for the system established in TMRR and collect data to maintain up-to-date cost estimates and budgeting through CDR. Learning curves are then validated by data collected on the pilot lines. Manufacturing cost estimates for LRIP should be based on the completed design, known manufacturing processes, execution of planned manufacturing and quality operations, and actual costs realized at the system level on a pilot line. Based on actual data, up-to-date manufacturing and quality cost estimates should be inputs to the program budget and spending plan.

One of the key elements in a successful program is aggressive materials management and planning. Materials management ranges from basic considerations of maturity and availability to understanding management of the supply chain and to details of government-furnished property (GFP), shelf life, security, safety, hazardous materials, storage environment, etc. All program manufacturing and quality materials risks, issues, and opportunities should be assessed based on contractor data and plans to meet program manufacturing and quality requirements

Manufacturing and quality should obtain key knowledge on scale-up efforts, and potential supply chain risks and issues to meet CDR exit criteria. Manufacturing capability should be assessed to baseline needed industrial capability. Materials cost drivers must be updated and appropriate management plans implemented by CDR. This includes assessments of the contractor's materials supply chain for application, implementation, and adherence to industry manufacturing and quality best practices, as well as compliance to contractor company policies, processes, procedures, and contracts. Materials and components lead times are critical to both meeting program schedules and defining program requirements for long lead and advanced buys. Lead times for defense materials and components can be long and volatile due to various reasons, such as imbalances between capacity and demand, competition from commercial customers, etc. Pilot line and LRIP procurement requirements (e.g., schedule and quantities), and associated mitigation plans should be developed and implemented for all procurement risks and issues by CDR.

In the EMD phase, manufacturing and quality should focus on improving process capability and maturity, reducing costs, maintaining (or improving) schedule, supporting the Industrial Base, and promoting competition by qualification of alternative sources. Based on pilot line results, manufacturing and quality should validate the identification of critical sources throughout the supply chain, including sources of key and/or critical subsystems, items, parts, and components.

In support of updates to Industrial Capabilities Assessment required for MS C, manufacturing and quality should assess and verify material availability for LRIP. This assessment should address risks, issues, and changes in long-lead procurement, supply chain, counterfeit parts, physical/cyber/industrial security, handling, transportation, storage, and environmental compliance, business climate, diminishing sources, and program plans for P^3I.

Successful completion of the EMD phase with a thorough understanding of materials capabilities, capacities, and limitations and the aggressive management of and planning for materials will ensure effective transition to LRIP and the Production and Deployment phase.

Manufacturing and quality process capability and control should be an integral part of any development program. Manufacturing and quality efforts should lead to a producible system with the objective of achieving effective and efficient manufacturing processes with process controls to satisfy program requirements with consistent and repeatable products at minimum manufacturing costs. Manufacturing process capabilities and the quality data collected must be measured, controlled, documented, and understood with up-to-date process capability information and indices.

Contractor Modeling and Simulation (M&S) tools and or products should be familiar to manufacturing and quality program personnel, if not, an understanding of the contractor tools, as well as the industry state-of-the-art and best practices for M&S is necessary. The contractor tools should be up-to-date and validated for applicability, adequacy, and consistency with industry best practices.

During the EMD phase the contractor will conduct demonstrations that include testing and analysis to ensure products meet the program requirements. These products will be built on pilot lines. The processes used on the pilot lines should be evaluated to understand the difficulties and quantify the risks to be mitigated for LRIP. Results of the pilot lines and the associated assessments should be incorporated to provide an up-to-date, accurate M&S of the system. Actual data collected on the pilot lines provide up-to-date data for yields and rates, and validation of all manufacturing and quality learning curves for the system and subsystems.

These assessments and demonstrations should provide an understanding of the contractor's process capabilities, M&S tools, and yields and rates, and support program manufacturing and quality planning, resource loading, facilities management, etc. for future phases.

An effective quality management system is required for operationally safe, suitable and effective systems. A quality management system compliant with industry standards ISO 9001 or AS9100 is the foundation to producing products that meet requirements. The quality system ensures the as-delivered configuration is the same as the as-designed and as-tested configuration. In early EMD, during design development, programs should assess that the contractor’s QMS supports and aligns with program manufacturing and quality strategy, objectives, and goals. This requires the use of process audits of the contractor’s and supply chain activities, resources, and behaviors. Participation of DCMA will provide expert assistance in conducting these audits.

The Manufacturing and Quality Strategies should require quality assessments of the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a pilot line, prior to Milestone C. Revision to the quality strategy, plans, and objectives may be required based on the results of process audits and quality assessments. For CDR, an assessment of the allocated baseline against the initial product baseline should ensure that quality parameters (e.g., tolerance, process capability indices, etc.) for considerations such as weight, power, cooling, etc. have been appropriately specified in the detailed design. This includes completion of all drawings and specifications with tolerances and test points under configuration control for all KCs, CSIs, and CAIs.

A system-level Functional Configuration Audit (FCA) should be conducted to assess performance of the system against the functional baseline, and may be conducted in conjunction with the system-level System Verification Review (SVR). Quality and quality personnel should be an integral element in both the FCA and the SVR. The system-level FCA should assess the collected data, test results, analysis results, and M&S output and accuracy of the system after completion of development testing and pilot line. The SVR should address all changes or additions generated since CDR to ensure the as-tested product on the pilot line includes all Engineering Change Proposals, specification change notices and revisions, interface control changes, and all manufacturing and quality process changes.

Quality assessments and analyses of pilot lines demonstrate that the manufacturing and quality processes and capabilities required for production have matured with high confidence of success. These results should be used to finalize the Quality Strategy and Plan to build production configuration products in the P&D phase.

Workforce skills identification and plans provide inputs to program planning. Workforce planning should align the skills required to the scope of the effort required to develop, field, and sustain the system. In EMD, a comprehensive assessment of contractor manufacturing plans for system development is necessary to understand the requirements for workforce skills, capabilities, training, and certifications in support of pilot line and LRIP workforce requirements. Based on contractor execution of the pilot line and the manufacturing and quality workforce results, the program workforce plans contained in the Manufacturing and Quality Strategies should be updated.

Based upon the results of PDR and program progress during early EMD, manufacturing and quality personnel should assess the contractor and supply chain facility, tooling, test and inspection equipment plans. This should include pre-CDR assessments and an update to the Manufacturing and Quality Strategies and Plans for EMD. The results of these assessments should identify and document risks, issues, and opportunities arising from facility and tooling shortfalls and document the required planning for mitigation prior to CDR. By CDR, plans should be finalized along with the associated risk and issue mitigation actions. Manufacturing and quality plans must be finalized prior to execution of a pilot line.

Based on results of pilot line demonstrations re-assess facilities, tooling, equipment, and test equipment requirements, resource requirements, and schedules for LRIP and FRP using the actual data collected. Focused attention on facilities, tooling, equipment, and test equipment in EMD will decrease risk and can be a major factor in avoiding or preventing cost overruns and schedule delays for LRIP and FRP.

The Manufacturing Strategy and Plan are major aspects of development, test, initial production, and other activities essential for program success. With the potential for a new contractor or contractors in the EMD phase, responsible for engineering and manufacturing development through completion of pilot line production, the contractor Manufacturing Management System should be assessed and the Manufacturing and Quality strategies and Plans may require updating. This includes an assessment of the contractor, and their supply chain for adequacy and alignment of manufacturing with the program Acquisition Strategy (AS). A well-structured manufacturing management system requires effective implementation of industry best practices to include management and mitigation of risks, issues, and opportunities. Assessment of the contractor’s manufacturing management system should be performed against the recognized industry best practice (i.e., AS6500).

Contractor implementation of best practices should include processes and procedures for supply chain Management. This includes supply chain communications, risks and issues identification and mitigation, KCs control and management, management, control, and monitoring of Technical

Performance Measures (and consequently Key Performance Parameters (KPP), Key System Attributes (KSA)), process control plans, cyber threat protection measures and manufacturing control systems, security, etc. Results of all of these assessments are the basis for maintaining the currency of the program Manufacturing Strategy and Plans.

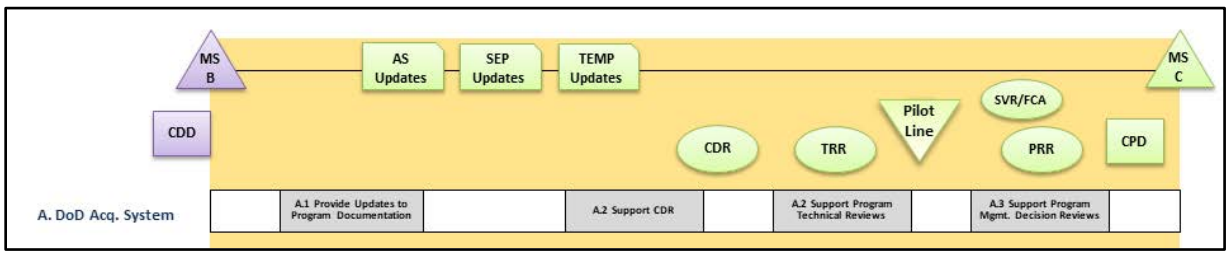
At CDR, the initial product baseline and documentation is transferred to the program for configuration control. This should include all drawings and specifications with tolerances and test points, all KCs, CSIs, and CAIs specifications, and may include process control plans, work instructions, etc. (i.e., the Technical Data Package) to be incorporated in the Manufacturing Strategy and Plans. These should be sufficient, complete, and adequate to enable manufacture of all components and hardware with embedded software throughout the supply chain on a pilot line.

The contractor designated pilot lines should be assessed for production realism and affordability in production of the system, subsystem, items, and components. Verification and validation of contractor and supply chain manufacturing plans, processes, and procedures should be analyzed during the demonstrations. Based upon these demonstrations and assessments, the Manufacturing Strategy and Plan should be updated, and the Technical Data Package should be finalized for LRIP.

The EMD phase ends when the design is stable, the system meets validated capability requirements demonstrated by developmental and initial operational testing as required in the TEMP, manufacturing processes have been effectively demonstrated and are under control, software sustainment processes are in place and functioning, industrial production capabilities are reasonably available, and the system has met or exceeds all directed EMD phase exit criteria and Milestone C entrance criteria.

A. DOD ACQUISITION SYSTEM

The EMD phase objective is to design, develop, and demonstrate on a pilot line a product capable of meeting system performance requirements within cost and schedule constraints. To complete all hardware and software detailed designs, mitigation and closure of open risks and issues, and building and testing of products and first articles, and verifying compliance with requirements, necessitates complete and thorough planning and documentation updates to the Acquisition Strategy, containing the Manufacturing and Quality Strategies, the Systems Engineering Plan (SEP), the Test Engineering Master Plan (TEMP), and plans for program reviews and pilot line demonstrations.



The EMD Acquisition Strategy should document the strategy for completing and verifying the system design, and assessing the manufacturing and industrial base readiness. During EMD, industrial and manufacturing readiness should be assessed to include the effective demonstration of manufacturing processes in an appropriate environment, such as a pilot line environment, prior to Milestone C. The pilot line should incorporate key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in low-rate production, utilizing the documented rate production processes planned to be used in LRIP. The Acquisition Strategy should describe the EMD phase plans to assess and demonstrate that manufacturing processes and/or capabilities have matured to a level of high confidence required for production products in the P&D phase.

EMD execution also requires appropriate planning updates in the SEP for all key program events. These reviews include the CDR, the Test Readiness Review (TRR), and after pilot line, the System Verification Review (SVR)/Functional Configuration Audit (FCA), and the end-of-phase Production Readiness Review (PRR) in preparation for transition to Low-Rate Initial Production (LRIP) and the Milestone C Decision.

Manufacturing and quality considerations should be important criteria at each decision point of the system life cycle, and manufacturing criteria used to ensure that a manufacturing and quality capabilities exist or will exist when required to produce the system. This capability includes the industrial base, factory, workers, processes, material, sub-Contractors, etc. that will be required to produce the system at rate and quality standards necessary to deliver the required capability. During early EMD phase, the producibility of the design and manufacturing and quality risks and issues are assessed and mitigated to support finalizing the design culminating in a CDR, which establishes the initial product baseline and transfers configuration control to the program.

Manufacturing and quality should be a key contributor and participant in all technical reviews, providing documented inputs and recommendations based on results from assessments, analyses, and demonstrations. Post-CDR, the major technical reviews commonly conducted during EMD include the following:

- Test Readiness Review (TRR)
- Human Rating Certification, Flight Readiness Review (FRR), etc.
- System Verification Review (SVR)
- Functional Configuration Audit (FCA)
- Production Readiness Review (PRR)

During the post-CDR phase leading up to the Milestone C Decision (MS C), the contractor should demonstrate manufacturing of the system on a pilot line. While TRR, certification reviews, SVR/FCA occur sequentially, pilot line can occur simultaneously with any of these reviews, but all should be complete prior to PRR. In addition to these reviews, manufacturing and quality should

support and participate in both a Manufacturing Readiness Level (MRL) assessment of the system using MRL 8 criteria (the target for MS C) and a PRR to support MS C.

Based on post-CDR, pilot line, and PRR assessment results, manufacturing and quality should also provide inputs on the myriad of statutory and regulatory program required updates per DoDI 5000.02 by MS C. These include the Acquisition Strategy (e.g., Contracting Strategy, Industrial Base Considerations, Intellectual Property Considerations, Risk, Issue, and Opportunity Management Approach, etc.), the Acquisition Program Baseline, the Cost Analysis Requirements Description (CARD), the Program Protection Plan (PPP), the SEP, etc.

Based on the effective demonstrations of manufacturing processes conducted on the pilot line, manufacturing and quality should support and participate in the program's decision processes on acceptability of manufacturing and producibility risks, supplier qualifications, and verification of manufacturing processes under statistical process control required for a MS C decision.

A.1 Provide Updates to Program Documentation

Manufacturing and Quality Tasks

- Based on the results, action items, and resolutions pertaining to manufacturing and quality requirements, risks, issues, and opportunities from the PDR, CDR, pilot line, and PRR, (i.e., throughout EMD) maintain and provide manufacturing and quality updates to the Acquisition Strategy (AS) to address technical progress and management strategy for:
    - Competition and contracting strategies
    - Program manufacturing priorities, allocations, and allotments, and justifications (DPAS code)
    - Management of manufacturing, quality, supply chain, etc.
    - Design feasibility, producibility, KCs, critical characteristics, etc.
    - Implementation of new manufacturing technologies
    - Demonstrations of manufacturing processes in the appropriate environment prior to Milestone C
    - Application of Modular Open Systems Approach (MOSA)
    - Management of Intellectual Property rights (including deliverables and associated license rights over the entire product life cycle)
    - Management of Materials (characteristics, sourcing, risks, etc.)
    - Manufacturing cyber threat protection measures (See L.2)
    - Manufacturing and quality inputs Life-Cycle Support Plan
    - Manufacturing and quality process, rates, and quantities (capabilities, control, risks, etc.) (See H.1)
    - Facilities, Tooling, and Workforce (including government-furnished equipment (GFE)/government-furnished information (GFI), special test equipment (STE)/special inspection equipment (SIE), special requirements, etc.)

- Provide in the Manufacturing Strategy and Plan and the Quality Strategy and Plan (for potential inclusion in appropriate program documentation and management reviews) detailed manufacturing and quality requirements and metrics for:
  - Manufacturing maturity and progress against manufacturing and quality goals required for each technical review (PDRs, CDRs, and at other appropriate reviews)
  - Production quantities per year and the total planned production quantity
  - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
  - Environmental Safety and Heath (ESOH) (Human safety and health)
  - Hazardous materials management and pollution prevention
  - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security (physical and cyber) for both hardware and software
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data)
  - Manufacturing supportability and sustainment
  - Management of commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and government-furnished equipment (GFE) (including diminishing manufacturing sources)
  - Management of parts, materials, and processes (PM&P)
- Update the Manufacturing Strategy and Plan and the Quality Strategy and Plan to address the sustainment of industrial base capabilities (including manufacturing technologies and capabilities) and the maturation required during the EMD and subsequent phases.
  - Include manufacturing and quality inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystems, item, and component levels.
  - Include manufacturing and quality inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
    - Domestic alternatives through regeneration of prior capability
    - Creation of new capability for manufacturing products and processes
    - Lifetime buy of items at the subsystems, and component levels
  - Include manufacturing and quality inputs on Diminishing Manufacturing Sources and Material Shortages (DMSMS)
  - Maintain a watch-list of critical items, parts, and components and their sources through a Critical Capabilities List (CCL)
- Provide manufacturing and quality Industrial Base (IB) capability analyses update for the AS (per DoDI 5000.02) and the RFP to include inputs on:

  - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical processes, parts, components, etc.)
  - Capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Impacts and interdependencies of the program on the National Technology Industrial Base (NTIB) and the analyses used to make this determination including management and future assessments
  - Government strategy and actions necessary to preserve the IB capabilities (e.g., incentivizing the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)

- Maintain manufacturing and quality inputs to Manufacturing Strategy and Plan and the Quality Strategy and Plan up-to date on ManTech and/or contractor manufacturing technology project implementation and status for high-risk manufacturing capabilities and processes (See D.2)
  - Include manufacturing and quality risks, issues, and opportunities
  - Include plans for insertion of the new manufacturing capability
- Provide and maintain up-to-date manufacturing and quality inputs and plans to the IMP/IMS including:
  - Schedule for any planned use of government-furnished special test equipment, government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.).
  - Schedule impacts from the requirements for special materials and allotments with justification
  - Manufacturing and quality internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
  - Inputs on reviews including the sub-tier level (including CDR, PRR, etc.), documentation inputs (e.g., CDD, TEMP, AS, SEP, CDR, PRR etc.), production events, and deliveries
- Update the government Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan for EMD to include: (See I.1 and L.1 for assessment of contractor and I.2 and L.2 for update considerations)
  - Updates to manufacturing and quality requirements
  - Definition and agreement on requirements for manufacturing environments pilot line, LRIP, and FRP
  - Up-to-date Technical Data Package
  - Manufacturing and quality resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to manufacturing and quality organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower

  - Changes to manufacturing and quality support organization required to meet program projected needs for P&D and subsequent phases including:
    - Earned Value Management requirements
    - Cost control requirements
    - Data collection, reporting, and management
- Update the manufacturing and quality requirements for the P&D contractor's Manufacturing Management System (MMS) and Quality Management System (QMS) to be included in the AS and the RFP.
  - Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - If manufacturing and quality standards are not specified, develop alternative requirements for program specific manufacturing management plan and quality management plan.
  - Identify manufacturing and quality opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- Ensure a joint manufacturing and quality comprehensive Risk, Issue and Opportunity Management System that is capable of identifying and tracking risks and associated mitigation plans is in place.
  - Ensure requirements are up-to-date and maintained for identification, analysis, mitigation, tracking, and control of manufacturing and quality risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program
  - Analyze mitigation plans for adequacy and completeness, and potential impacts on EMD and subsequent phases to include:
    - Industry being unable to provide program design and/or manufacturing capabilities at planned cost and schedule
    - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
    - Required maturation of critical technologies and manufacturing processes to the appropriate level
    - Manufacturing and quality cost and schedule impacts
- Ensure other agencies are providing inputs on strategies (e.g., DCMA, DLA, etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing and quality.
- Provide and maintain up-to-date manufacturing and quality inputs to the SEP and Test Engineering Master Plan (TEMP) to address technical progress and strategy including the following:

- Manufacturing and quality updates on KCs, critical characteristics, and Technical Performance Measures, and the associated impacts on KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
- Updates on significant activities to the EMD program schedule including:
  - Risk and issue mitigations
  - Manufacturing assessments
  - Critical Design Reviews (including supply chain)
  - Long-lead or advanced procurements
  - Prototype builds and demonstrations
  - Projected lots or phases
  - Production Readiness Reviews
  - Independent reviews and audits
  - Changes or impacts to the workforce (i.e., strikes), supply chain (i.e., disruptions)
  - Environmental impacts (e.g., floods, fires, earthquakes, etc.)
- Updated outputs and status from the joint Risk, Issue and Opportunity Management System and mitigations.
- Updated manufacturing and quality inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
  - Compliance with DFARS, PPP, ITAR, etc.
  - Management of Controlled Unclassified Information
  - Technical approaches to cybersecurity and related manufacturing and quality security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
- Application of up-to-date industry best practices for manufacturing to include:
  - Manufacturing Management System
  - Design for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management
- Up-to-date inputs on the manufacturing and quality organization, billets and key assignments including:
  - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
- Up-to-date manufacturing and quality planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
- Up-to-date manufacturing and quality inputs to the configuration managed IMP/IMS including critical path
- Requirements for manufacturing environments (e.g., pilot line, LRIP, FRP)

- Requirements the Technical Data Package (including Intellectual Property)

- Provide manufacturing and quality requirements for sustainment (e.g., maintainability, serviceability, etc.) and sustainment processes and activities for the LCSP.

Metrics

- The AS has been maintained and is up-to-date based on the results, action items, and resolutions pertaining to manufacturing and quality requirements, risks, issues, and opportunities and provides current status for program technical progress and management strategy for:
  - Competition and contracting strategies
  - Program manufacturing priorities, allocations, and allotments, and justifications (DPAS code)
  - Management of manufacturing, quality, supply chain, etc.
  - Design feasibility, producibility, KCs, critical characteristics, etc.
  - Implementation of new manufacturing technologies
  - Demonstrations of manufacturing processes in the appropriate environment prior to Milestone C
  - Application of Modular Open Systems Approach (MOSA)
  - Management of Intellectual Property rights
  - Management of Materials
  - Manufacturing cyber threat protection measures
  - Manufacturing and quality inputs Life-Cycle Support Plan
  - Manufacturing and quality process, rates, and quantities
  - Facilities, Tooling, and Workforce

- Manufacturing Strategy and Plan and the Quality Strategy and Plan document detailed manufacturing and quality requirements and metrics for:
  - Manufacturing maturity and progress against manufacturing and quality goals required for each technical review
  - Production quantities per year and the total planned production quantity
  - Certifications (e.g., Flight Operations/Safety, Human Rating, etc.)
  - ESOH
  - Hazardous materials management and pollution prevention
  - Environmental parameters
  - Security (physical and cyber) for both hardware and software
  - Data management and software
  - Manufacturing supportability and sustainment
  - Management of COTS, GOTS, and GFE
  - Management of PM&P

- Manufacturing Strategy and Plan and the Quality Strategy and Plan have been updated and document the sustainment of industrial base capabilities and the required maturation to occur during the EMD and subsequent phases, including inputs on:
  - Product or component obsolescence, use and replacement of limited-life items, options for unique manufacturing processes and products, and the capability to convert off-the-shelf items to required specifications at the subsystems, item, and component levels
  - Products or components from sole, single, fragile, or foreign sources including options for:
    - Domestic alternatives through regeneration of prior capability
    - Creation of new capability for manufacturing products and processes
    - Lifetime buy of items at the subsystems, and component levels
  - DMSMS
  - Watch-list of critical items, parts, and components and their sources through a CCL
- Up-to-date manufacturing and quality Industrial Base (IB) capability analyses have been provided as input for the AS (per DoDI 5000.02) and the RFP to include:
  - IB capabilities, fragility, gaps, and risks
  - Capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Impacts and interdependencies of the program on the NTIB and the analyses used to make this determination including management and future assessments
  - Government strategy and actions necessary to preserve the IB capabilities
- Manufacturing and quality inputs to Manufacturing Strategy and Plan and the Quality Strategy and Plan have been maintained and are up-to date for ManTech and/or contractor manufacturing technology project implementations and status including:
  - Manufacturing and quality risks, issues, and opportunities
  - Plans for insertion of the new manufacturing capability
- Up-to-date manufacturing and quality inputs and plans have been provided to the IMP/IMS including:
  - Schedule for any planned use of government-furnished special test equipment, government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.).
  - Schedule impacts from the requirements for special materials and allotments with justification
  - Manufacturing and quality internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
  - Inputs on reviews including the sub-tier level (including CDR, PRR, etc.), documentation inputs (e.g., CDD, TEMP, AS, SEP, CDR, PRR etc.), production events, and deliveries

- Government Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan for EMD has been updated and includes:
  - Updates to manufacturing and quality requirements
  - Definition and agreement on requirements for manufacturing environments pilot line, LRIP, and FRP
  - Up-to-date Technical Data Package
  - Manufacturing and quality resource management
  - Potential changes to manufacturing and quality organization and staffing with KLP and necessary skilled manpower
  - Changes to manufacturing and quality support organization required to meet program projected needs for P&D and subsequent phases including:
    - Earned Value Management requirements
    - Cost control requirements
    - Data collection, reporting, and management
- Manufacturing and quality requirements for the P&D contractor's MMS and QMS have been updated in the AS and the RFP, including:
  - Standards to be used for industry best practices
  - Alternative requirements for program specific manufacturing management plan and quality management plan, if manufacturing and quality standards are not specified
  - Manufacturing and quality opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- A joint manufacturing and quality comprehensive Risk, Issue and Opportunity Management System has been implemented, is in place, including:
  - Up-to-date and maintained identification, analysis, mitigation, tracking, and control of manufacturing and quality risks, issues, and opportunities
  - Mitigation plans that adequately and completely address impacts on EMD and subsequent phases to include:
    - Industry being unable to provide program design and/or manufacturing capabilities at planned cost and schedule
    - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
    - Required maturation of critical technologies and manufacturing processes to the appropriate level
    - Manufacturing and quality cost and schedule impacts
- Other agencies are providing documented inputs on strategies (e.g., DCMA, DLA, etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing and quality.

- Manufacturing and quality inputs to the SEP and TEMP are maintained and provide up-to-date status for technical progress and strategy including:
  - Manufacturing and quality updates on KCs, critical characteristics, and Technical Performance Measures, and the associated impacts on KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Updates on significant manufacturing and quality scheduled activities during EMD including:
    - Risk and issue mitigations
    - Manufacturing assessments
    - Critical Design Reviews (including supply chain)
    - Long-lead or advanced procurements
    - Prototype builds and demonstrations
    - Projected lots or phases
    - Production Readiness Reviews
    - Independent reviews and audits
    - Changes or impacts to the workforce (i.e., strikes), supply chain (i.e., disruptions)
    - Environmental impacts (e.g., floods, fires, earthquakes, etc.)
  - Updated outputs and status from the joint Risk, Issue and Opportunity Management System and mitigations.
  - Updated manufacturing and quality inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
    - Compliance with DFARS, PPP, ITAR, etc.
    - Management of Controlled Unclassified Information
    - Technical approaches to cybersecurity and related manufacturing and quality security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
  - Application of up-to-date industry best practices for manufacturing to include:
    - Manufacturing Management System
    - Design for Manufacturing
    - Manufacturing Risk Identification (including mitigation)
    - Manufacturing Planning
    - Manufacturing Operations Management
  - Up-to-date inputs on the manufacturing and quality organization, billets and key assignments including:
    - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)

  - Up-to-date manufacturing and quality planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
  - Up-to-date manufacturing and quality inputs to the configuration managed IMP/IMS including critical path
  - Requirements for manufacturing environments (e.g., pilot line, LRIP, FRP)
  - Requirements the Technical Data Package (including Intellectual Property)
- Manufacturing and quality requirements for sustainment (e.g., maintainability, serviceability, etc.) and sustainment processes and activities have been documented and provided for the LCSP.

Tools

- Acquisition Strategy Outline
- AS6500 Manufacturing Management System Checklist
- AS9100 Quality Management System Checklist
- ISO 9001 Quality Management System Checklist
- Capability Production Document Template
- Manufacturing Readiness Level (MRL) Assessment Checklist
- Technology Readiness Level (TRL) Assessment Checklist
- ManTech Proposal Rating Worksheet
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Integrated Master Plan/Integrated Master Schedule use MS Project
- Risk Management Plan Template
- Systems Engineering Plan Outline
- TEMP Outline
- Life Cycle Sustainment Plan Outline

Resources

- Acquisition Strategy Guide, DSMC, Dec 1999
- AS6500, Manufacturing Management Program, SEP 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- ISO 9001:2015, Quality Management System
- CDD-CPD Writing Guide, Feb 2015
- IEEE 15288, System and Software Engineering, 2015
- Systems Engineering Plan Preparation Guide, Apr 2008
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- MRL Deskbook Version 2016

- Risk, Issue and Opportunity Management Guide, Jun 2015
- Test and Evaluation Management Guide, Dec 2012
- TRA Deskbook, Apr 2012
- DoDI 5000.02, Enclosure 2, 6.d., Jan 2017
- DoDI 4200.15, Manufacturing Technology (ManTech) Program, Dec 2003
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities, Apr 1996
- Life Cycle Sustainment Plan Content Guide

A.2 Support CDR

Manufacturing and Quality Tasks

- Ensure the program's Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan are updated for CDR.
    - Include program manufacturing and quality staffing, training, and certifications
    - Include an update to program manufacturing and quality processes and metrics
    - Ensure draft certification plans have been developed and cover all required system certifications (e.g., Flight Operations/Safety, Human Rating, etc.)
- Support an MRL assessment of the system using MRL 7 criteria as the target for CDR.
    - Assess and validate manufacturing and quality materials, facilities, tooling, etc. availability
- Ensure system baseline documentation for manufacturing and quality is under configuration control, and is sufficient, complete, and adequate to enable component manufacturing, hardware fabrication and software implementation to proceed.
    - Ensure all subsystem, item, and components are included in the system baseline
    - Ensure all KCs, CSIs, and CAIs have complete drawings and specifications under configuration control
    - Ensure all product data essential (e.g., drawings, specifications, interfaces, etc.) for component manufacturing has been released
- Ensure all manufacturing and quality inputs to the AS and the SEP are up-to-date for CDR (See A.1).
- Ensure all subsystem, item, and component CDRs are complete, under configuration control, and the results available for the system CDR.
    - Ensure all design maturity assessments are closed and approved for system CDR
    - Include all appropriate subsystem, item, and component reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.)
    - Include all system, subsystem, item, and component interfaces (internal and external)
- Ensure all manufacturing and quality trade studies and producibility assessments are complete and are incorporated into the system for CDR.

754 - Include ongoing producibility enhancement efforts
755 • Ensure manufacturing and quality input to the schedule (IMP/IMS) and the associated critical
756 path is up-to-date and is executable with acceptable risks.
757 - Includes supply chain
758 - Includes integration and test
759 • Ensure all key and critical manufacturing processes, including process control plans and
760 metrics, have been defined, characterized, updated for the detailed design, and the capability
761 to meet design tolerances and are tracked.
762 • Ensure manufacturing and quality data management system addresses:
763 - Communications and availability
764 - Data collection, capacity, processing, storage, and control
765 - Security (physical and cyber), information security and access
766 • Analyze plans for make/buy and long-lead procurement requirements and incorporate results
767 into procurement plans.
768 • Analyze the assessments of adequacy and completeness of manufacturing and quality
769 requirements validation activities (See E.6):
770 - Include prototypes and demonstrations in a representative environment at the system
771 level for design maturity
772 - Ensure all Critical Safety Items (CSI) and/or Critical Application Items (CAI) are
773 traceable to key and critical manufacturing and quality processes
774 - Include demonstrations of manufacturing processes in appropriate environments for the
775 required level of maturity (e.g., subsystem, item, and component)
776 - Ensure all identified KCs, CSIs, and CAIs are incorporated into the Verification Cross-
777 Reference Matrix (VCRM) for required testing and verification
778 • Ensure traceability of manufacturing and quality KCs to Critical Manufacturing Processes
779 (CMP) to Technical Performance Measures (TPM) to allocated baseline requirements up to
780 KPPs and KSAs.
781 • Based on support to design reviews at all levels of the supply chain, assess adequacy and
782 completeness of manufacturing and quality requirements verification and validation activities
783 for system CDR including
784 - Producibility (subsystem, item, and component)
785 - Product maturity
786 - Technology maturity
787 - Interoperability, interdependencies, and interfaces (internal and external)
788 - Alternate sources to include availability and maturity
789 - User interfaces and Human Systems Integration (HSI)
790 - Environmental, Safety, and Occupational Health (ESOH)
791 - Hazardous materials management and pollution prevention processes
792 - MOSA

- COTS, NDIs, and GFE

- Provide manufacturing and quality inputs to the Life Cycle Support Plan for CDR.
- Ensure contractor manufacturing and quality management systems for manufacturing and quality metrics and data collection and tracking to the component level are in place and functional.
- Ensure manufacturing and quality inputs to DT&E processes and assessments are complete and up-to-date for CDR.
  - Including environments (e.g., thermal, vibrations, shock, and accelerated life testing, etc.)
  - Include required traceability
- Ensure manufacturing and quality plans support of OT&E requirements for data and traceability at CDR.
- Ensure the TEMP incorporates all manufacturing and quality subsystems, items, and components into plans for tests, test facilities, and test equipment.
  - Include all identified KCs, CSIs, and CAIs are incorporated into the required testing and verification plans
    - Include manufacturing and quality impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Include planned significant activities from the up-to-date EMD program schedule (e.g., manufacturing assessments, long-lead or advanced procurements, prototype demonstrations, projected lots or phases, PRRs, etc.)
  - Include up-to-date inputs to the joint Risk, Issue and Opportunity Management System including industrial base, manufacturing, quality, engineering, software (firmware), and risk reduction and/or mitigation efforts
  - Updated planning for manufacturing and quality tests, assessments, and verification and validation activities to be conducted, facilities and test equipment to be used, metrics to be tracked, progress against goals, thresholds and objectives, etc.
- Assess and validate contractor manufacturing and quality plans for pilot line requirements.
  - Include materials, facilities, workforce, equipment, test facilities and equipment, tooling, etc.
  - Include EMI control processes and procedures
- Ensure the manufacturing and quality considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
  - Parts and Materials (Management) Plan (PMP)
  - Configuration Management Plan (CMP)
  - Software Development Plan (embedded software)
  - Quality Assurance Plan
  - Systems Security Engineering (SSE), COMSEC, cybersecurity, and PPP
  - SEMP

- TEMP

- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure manufacturing and quality design producibility improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (See E.4).
- Ensure manufacturing and quality plans, activities, and processes are executable within the existing manufacturing and quality budget to support the approved product baseline and critical path.
- Provide up-to-date manufacturing and quality inputs to the program budget and the CARD.
    - Update and allocate manufacturing and quality (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure manufacturing and quality cost data including required production costs and production schedule estimates (See F.1) are provide for all cost and budget estimates for CDR.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) for manufacturing and quality risks, issues, and opportunities and appropriate mitigation plans.
- Ensure adequacy and completeness of mitigation activities for mitigation of manufacturing and quality risks, issues, and opportunities in the joint government/ contractor Risk, Issue, and Opportunity (RIO) Management System, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment
- Analyze manufacturing and quality plans for adequacy and capability of achieving manufacturing readiness level 8 by initial production.

Metrics

- Program's Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan have been updated for CDR, including:
  - Program manufacturing and quality staffing, training, and certifications
  - Program manufacturing and quality processes and metrics
  - Draft certification plans (e.g., Flight Operations/Safety, Human Rating, etc.)
- Manufacturing and quality have supported and provided documented inputs for the system MRL assessment to MRL 7 criteria.
- Manufacturing and quality inputs to system baseline are under configuration control and document sufficiency, completeness, and adequacy to enable component manufacturing, hardware fabrication and software implementation to proceed.
  - All subsystem, item, and components are included in the system baseline
  - All KCs, CSIs, and CAIs have complete drawings and specifications under configuration control
  - All product data essential (e.g., drawings, specifications, interface control documents, etc.) for component manufacturing has been released
- Manufacturing and quality have provided documented, up-to-date inputs to the AS and the SEP (See A.1).
- All subsystem, item, and component CDRs are complete, under configuration control, and the documented manufacturing and quality results available for the system CDR.
  - All manufacturing and quality design maturity assessments are closed and approved for system CDR
  - All manufacturing and quality data from appropriate subsystem, item, and component reviews are included
  - All manufacturing and quality system, subsystem, item, and component interfaces (internal and external) are included
- All manufacturing and quality trade studies and producibility assessments are complete and results are documented for the system CDR.
- Manufacturing and quality have provided up-to-date (executable with acceptable risks) inputs to the schedule (IMP/IMS) and the associated critical path.
- All key and critical manufacturing processes, including process control plans and metrics, have been updated and documented for the detailed design, and are being tracked.
- Manufacturing and quality data management system has been assessed and the results document adequacy and sufficiency of:
  - Communications and availability
  - Data collection, capacity, processing, storage, and control
  - Security (physical and cyber), information security and access

- Plans for make/buy and long-lead procurement requirements have been assessed and recommendations documented for procurement plans.
- Manufacturing and quality requirements validation activities have been assessed and document the adequacy and completeness of (See E.6):
    - Prototypes and demonstrations in a representative environment at the system level
    - Traceability of all CSIs and/or CAIs to key and critical manufacturing and quality processes
    - Demonstrations of manufacturing processes in appropriate environments for the required level of maturity (e.g., subsystem, item, and component)
    - The VCRM for all identified KCs, CSIs, and CAIs
- Traceability of manufacturing and quality KCs to CMPs to TPMs to allocated baseline requirements up to KPPs and KSAs has been established and documented for CDR.
- Manufacturing and quality requirements verification and validation activities for system CDR have been assessed and document the adequacy and completeness (at all levels of the supply chain), including:
    - Producibility (subsystem, item, and component)
    - Product maturity
    - Technology maturity
    - Interoperability, interdependencies, and interfaces (internal and external)
    - Alternate sources to include availability and maturity
    - User interfaces and Human Systems Integration (HSI)
    - Environmental, Safety, and Occupational Health (ESOH)
    - Hazardous materials management and pollution prevention processes
    - MOSA
    - COTS, NDIs, and GFE
- Manufacturing and quality have provided documented inputs to the Life Cycle Support Plan for CDR.
- Contractor manufacturing and quality management systems have been assessed and documented as in place and functional for manufacturing and quality metrics, data collection, and tracking to the component level.
- Manufacturing and quality have provided documented, up-to-date inputs to DT&E processes and assessments for CDR, including environments and traceability.
- Manufacturing and quality have provided documented plans for support of OT&E requirements for data and traceability.
- Manufacturing and quality have reviewed the TEMP for inclusion of:
    - All manufacturing and quality subsystems, items, and components
    - All identified KCs, CSIs, and CAIs (for required testing and verification)
        - Including manufacturing and quality impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)

945 - Planned significant manufacturing and quality activities from EMD schedule (e.g.,
946 manufacturing assessments, long-lead or advanced procurements, prototype
947 demonstrations, projected lots or phases, PRRs, etc.)
948 - Up-to-date manufacturing and quality inputs from the joint Risk, Issue and Opportunity
949 Management System including mitigation efforts
950 - Updated planning for manufacturing and quality tests, assessments, and verification and
951 validation activities to be conducted, facilities and test equipment to be used, metrics to
952 be tracked, progress against goals, thresholds and objectives, etc.

953 • Contractor manufacturing and quality plans for pilot line manufacturing and quality
954 requirements have been assessed and the results with recommendations have been
955 documented for CDR, including:

956 - Materials, facilities, workforce, tooling and equipment
957 - Test facilities, equipment, tooling, etc.
958 - EMI control processes and procedures

959 • Contractor's manufacturing and quality plans and inputs for CDR have been assessed, are up-
960 to-date, and approved, and include documentation for:

961 - Parts and Materials (Management) Plan (PMP)
962 - Configuration Management Plan (CMP)
963 - Software Development Plan (embedded software)
964 - Quality Assurance Plan
965 - SSE, COMSEC, cybersecurity, and PPP
966 - SEMP
967 - TEMP

968 • Based on program system requirements, component yield and rate data, and results from
969 prototype demonstrations; manufacturing and quality quantity estimates for subsystems,
970 items, and components have been updated and documented for CDR.
971 • Manufacturing and quality design producibility improvements have been documented and
972 implemented in the system design and/or specifications according to the joint
973 government/contractor schedule (See E.4).
974 • Manufacturing and quality plans, activities, and processes have been assessed, documented,
975 and are executable within the existing manufacturing and quality budget, the approved
976 product baseline, and the critical path.
977 • Up-to-date manufacturing and quality inputs have been documented and provided for the
978 Program budget and the CARD.

979 - Manufacturing and quality (production) cost models for subsystem, item, and
980 component levels have been updated and are tracked against targets

981 • Up-to-date manufacturing and quality cost data including required production costs and
982 production schedule estimates (See F.1) have been documented and provided for the CDR
983 cost and budget estimates.

- Contractor and key supply chain have been assessed for manufacturing and quality risks, issues, and opportunities and appropriate mitigation plans (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) and the results are documented for CDR.
- Mitigation of manufacturing and quality risks, issues, and opportunities in the joint government/ contractor Risk, Issue, and Opportunity (RIO) Management System, have been assessed and the results document the adequacy and completeness of mitigation activities, including:
  - Key and critical manufacturing processes including embedding software
  - Materials and sourcing
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and hazardous materials management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment
- Manufacturing and quality plans for achieving manufacturing readiness level 8 by initial production have been documented.

Tools

- Critical Design Review (CDR) Checklist

Resources

- DoDI 5000.02
- MRL Deskbook Version 2016
- IEEE 15288.2-2014, IEEE Standard for Technical Reviews and Audits on Defense Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits
- MIL-STD-1521B, Jun 1985 (retired)

A.3 Support Program Technical Reviews

Manufacturing and Quality Tasks

- Provide manufacturing and quality support and inputs to the Test Readiness Review to include:

- SEMP review and recommendations made for CDR
- TEMP review and approval process (to include manufacturing and quality requirements to the appropriate level)
- Need for verification and validation of manufacturing and quality requirements for Critical Manufacturing Processes (CMP) (and therefore KCs)
- Results of changes in manufacturing and quality processes (flowing from design changes since CDR, other than CMPs) impacting testing requirements and events
- Requirements for manufacturing and quality configuration management of system, subsystem, item, and components (hardware and software) to be tested
- Status of system, subsystem, item, and components manufacturing process maturity including:
  - Certification processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
  - Process capability indices (C_{pk}) on demonstrated processes
- Requirements for process capabilities (target $C_{pk)}$
- Status of established bi-directional traceability (manufacturing and quality TPMs to CMPs to KCs
- Definition of manufacturing and quality development test environments utilized (e.g., thermal, vibrations, shock, and accelerated life testing, etc.)
- Requirements for manufacturing and quality security (physical, cyber, and industrial)
- Processes, procedures, and documentation of the Failure Reporting, Analysis, and Corrective Action System (FRACAS)
- Verification that system, subsystem, item, and component parts are produced to approved specifications
- Direct support of quality personnel to test execution

- Participate in and support the System Verification Review (SVR) including:
  - Provide verification that all manufacturing and quality CDR action items have been closed and any corrective actions have been successfully completed
  - Provide manufacturing and quality inputs on:
    - Verification of requirements from all system, subsystem, item, and component manufacturing and quality test data and analyses
    - Verification of performance to the function baseline based on manufacturing and quality data
    - Verification through analysis of manufacturing and quality data the adequate management and integrity of all critical program information (CPI) (e.g., performance data, yield and rate data, etc.)
    - Verification that manufacturing and quality risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
    - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available manufacturing and quality test data, analysis, and inspection

        - Required “certification” activities (e.g., human rating, flight, space, etc.)
        - Analyses of support and maintenance requirements for incorporation into the LCSP
        - Risks of operational test failures during Initial Operational Test and Evaluation (IOT&E)
    - Provide manufacturing and quality inputs to:
        - Ensure adequate manufacturing and quality processes and metrics are in place
        - Analysis of contractor’ s SEMP for appropriate incorporation of manufacturing and quality activities and data collection, analysis, and storage
        - Detailed manufacturing and quality planning and schedules (with required resources for proceeding into LRIP and IOT&E)
        - Updates of the SEP and contractor’s SEMP for the production and deployment (P&D) phase
        - The CARD for up-to-date cost of quality inputs
        - The LCSP
        - The TEMP (i.e., up-to-date)
        - The Configuration Management Plan (CMP) (i.e., up-to-date)
- Provide manufacturing and quality inputs and support of the Functional Configuration Audit (FCA) to include:
    - Support to program and the contractor agreements that development is complete and data from development tests (DT), analyses, and simulations are sufficient to achieve performance goals
    - Manufacturing and quality inputs for:
        - Verification of manufacturing and quality performance to the baseline
        - Verification traceability documentation for each manufacturing and quality requirement
        - Validity and the completeness of embedded software and integration
    - Manufacturing and quality verification of all approved engineering change proposals (ECP), requests for deviation, and requests for waiver impacting manufacturing and quality
    - Verification that all KCs, CSIs, and CAIs are identified, managed, and included in the Verification Cross-Reference Matrix (VCRM)
    - Ensure manufacturing and quality provides support to verification activities and tasks to include:
        - Each requirement listed in the VCRM is traceable and is verified with test data, analysis, and/or inspection
        - Demonstration of manufacturing and quality processes to provide the capability to satisfy TPMs, KPPs and KSAs thresholds
        - Review of acceptance test reports and deficiencies with root cause and closed corrective actions

        - Certification activities (e.g., human rating, flight/safety, etc.)

- Provide for PRR results and recommendations of manufacturing and quality assessments of contractor's manufacturing and quality efforts in accordance with industry best practices (i.e., AS6500) on a pilot line to include:
    - All manufacturing and quality processes including continuous improvement efforts
    - Manufacturing surveillance and quality data collection and analyses (including supply chain data for items and components)
    - Physical and functional interfaces
    - All work instructions, sequencing, and procedures
    - Process capabilities and process control plans
    - Production scheduling and control
    - Model and Simulations
    - Materials
    - Workforce capabilities
    - Manufacturing technology implementations
    - Tooling, work holding fixtures, jigs, etc.
    - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
    - Facilities, transportation, storage, and handling equipment
    - Interdependencies (not all will be validated on the pilot line)
    - Safety processes, procedures, and compliance
    - ESOH processes, procedures, and compliance
    - Security processes, procedures, capabilities, and compliance
    - Risk and issue mitigation results and adequacy of resolution
    - Manufacturing and quality costs, schedule, performance
    - Materials sources and selections
    - Integration of embedded software
- Provide for PRR results and recommendations of manufacturing and quality assessments of Industrial Base Capability and support, conducted for CDR and pilot line demonstrations, for changes in:
    - Sources and alternatives
    - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
    - Vulnerabilities (supply chain)
        - Sole, single, foreign, etc.
        - Military
        - Counterfeit
        - Potential exploitation
        - Fragility and uncertainty of demand
    - Production capability and capacity
    - Security requirements (physical, cyber, and industrial)

- Availability (e.g., materials, components, equipment, facilities, etc.)
- Required COTS and NDIs
- External dependencies
- Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
- Required government and/or contractor Depot and Maintenance and Repair Operations

- Provide for PRR results and recommendations of manufacturing and quality assessments of outputs from the pilot line for adequacy and completeness and validate:
  - Process control plans, including key and critical processes
  - All Production Process Verifications (PPV) performed
  - Attainability of KCs (will be capable and under process control for LRIP)
  - Variability Reduction including updates based on process improvements
  - All FAIs and FATs against specifications, drawings, models, etc.
  - Design changes and process changes identified during pilot line operations, testing, and qualification
  - Certification processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)

Metrics

- Manufacturing and quality support and inputs to the Test Readiness Review has been documented and include the following:
  - SEMP review and recommendations
  - TEMP review and recommended changes
  - Manufacturing and quality requirements verification and validation needs (CMPs and KCs)
  - Results of changes in manufacturing and quality processes impacting testing requirements and events
  - Manufacturing and quality configuration management requirements for system, subsystem, item, and components (hardware and software) to be tested
  - Status of system, subsystem, item, and component certification manufacturing and quality processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
  - Status of system, subsystem, item, and components manufacturing process maturity with process capability indices (C_{pk})
  - Requirements for process capabilities targets (C_{pk})
  - Status of established bi-directional traceability (manufacturing and quality TPMs to CMPs to KCs
  - Definition of manufacturing and quality development test environments utilized (e.g., thermal, vibrations, shock, and accelerated life testing, etc.)
  - Requirements for manufacturing and quality security (physical, cyber, and industrial)
  - Processes, procedures, and documentation of FRACAS implementation

- Verification that system, subsystem, item, and component parts have been produced to approved specifications

- Manufacturing and quality personnel have participated in and provided documented inputs to the SVR including:
  - Verification that all manufacturing and quality CDR action items have been closed and any corrective actions have been successfully completed
  - Manufacturing and quality inputs on:
    - Verification of requirements from all system, subsystem, item, and component manufacturing and quality test data and analyses
    - Verification of performance to the function baseline based on manufacturing and quality data
    - Verification through analysis of manufacturing and quality data the adequate management and integrity of all CPI (e.g., performance data, yield and rate data, etc.)
    - Verification that manufacturing and quality risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
    - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available manufacturing and quality test data, analysis, and inspection
    - Required "certification" activities (e.g., human rating, flight, space, etc.)
    - Results of support and maintenance requirements analyses for incorporation into the LCSP
    - Risks of operational test failures during IOT&E
  - Manufacturing and quality inputs have been developed and document:
    - Adequate manufacturing and quality processes and metrics are in place
    - Adequacy of the contractor' s SEMP with incorporation of manufacturing and quality activities; data collection, analysis, and storage; and any recommended changes
    - Detailed manufacturing and quality planning and schedules (with required resources for proceeding into LRIP and IOT&E)
    - Updates to the SEP for the production and deployment (P&D) phase
    - Changes to the CARD with up-to-dated cost of quality inputs
    - Updates for the LCSP, TEMP, and the Configuration Management Plan

- Manufacturing and quality have supported and participated in, and provided inputs to the FCA to include:
  - Documented support to program and the contractor agreements that development is complete and data from development tests (DT), analyses, and simulations are sufficient to achieve performance goals
  - Documented manufacturing and quality inputs to:
    - Verification of manufacturing and quality performance to the baseline
    - Verification traceability documentation for each manufacturing and quality requirement

        - Validity and the completeness of embedded software and integration
    - Manufacturing and quality verification of all approved engineering change proposals (ECP), requests for deviation, and requests for waiver impacting manufacturing and quality
    - Verification that all KCs, CSIs, and CAIs have been identified, are managed and documented, and are included in the VCRM
    - Documented manufacturing and quality input to verification activities and tasks which included:
        - Each requirement's traceability and verification with test data, analysis, and/or inspection
        - Demonstration of manufacturing and quality processes for meeting TPMs, KPPs and KSAs thresholds
        - Review of acceptance test reports and deficiencies with root cause and closed corrective actions
        - Certification activities (e.g., human rating, flight/safety, etc.)
- In accordance with industry best practices (i.e., AS6500), manufacturing and quality verification and validation of contractor pilot line has been successfully conducted and the results have been documented for PRR including:
    - All manufacturing and quality processes with rigorous continuous improvement processes
    - Disciplined, functional, and accessible manufacturing surveillance and quality data collection system including supply chain
    - Documented, tested, and approved physical and functional interfaces
    - Functional work instructions, sequencing, and procedures
    - Process capabilities and process control plans
    - Functional production scheduling and control processes
    - Refined model and simulations
    - Materials
    - Confirmed workforce requirements, skills, and capabilities
    - Manufacturing technology implementations
    - Tooling, work holding fixtures, jigs, etc.
    - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
    - Facilities, transportation, storage, and handling equipment
    - Pilot line interdependencies
    - Safety processes, procedures, and compliance
    - ESOH processes, procedures, and compliance
    - Security processes, procedures, capabilities, and compliance
    - Risk and issue closures and remaining mitigation plans
    - Confirmation of and updates to manufacturing and quality costs, schedule, performance
    - Materials sources and selections

- Integration of embedded software

- Industrial Base Capability assessments have been updated by manufacturing and quality, based on results from CDR and pilot line demonstrations, and have been documented and provided to the PRR for changes in:
  - Sources and alternatives
  - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
  - Vulnerabilities (supply chain)
    - Sole, single, foreign, etc.
    - Military
    - Counterfeit
    - Potential exploitation
    - Fragility and uncertainty of demand
  - Production capability and capacity
  - Security requirements (physical, cyber, and industrial)
  - Availability (e.g., materials, components, equipment, facilities, etc.)
  - Required COTS and NDIs
  - External dependencies
  - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
  - Required government and/or contractor Depot and Maintenance and Repair Operations

- Results and recommendations from manufacturing and quality assessments of adequacy and completeness of outputs from the pilot line have been documented and validate the following:
  - Process control plans, including key and critical processes
  - All Production Process Verifications (PPV)
  - Attainability of KCs
  - Variability Reduction plans including updates based on process improvements
  - All FAIs and FATs against specifications, drawings, models, etc.
  - All design changes and process changes identified during pilot line operations, testing, and qualification
  - Certification processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)

Tools

- Acquisition Strategy Outline
- Test Readiness Review (TRR) Checklist
- Technology Readiness Assessment (TRA) Checklist
- MRL Assessment Checklist
- System Verification Review (SVR) Checklist

- Functional Configuration Audit (FCA) Checklist
- Production Readiness Review (PRR) Checklist

Resources

- Acquisition Strategy Guide, DSMC, Dec 1999
- AS6500, Manufacturing Management Program, SEP 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- ISO 9001:2015, Quality Management System
- CDD-CPD Writing Guide, Feb 2015
- Systems Engineering Plan Preparation Guide, Apr 2008
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- MRL Deskbook Version 2016
- TRA Deskbook, Apr 2012
- Risk, Issue and Opportunity Management Guide, Jun 2015
- Test and Evaluation Management Guide, Dec 2012
- IEEE 15288.2, IEEE Standard for Technical Reviews and Audits on Defense Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.7.4 Technical Reviews, and Chapter 12.5 Technical Reviews and Audits

A.4 Support Program Management Decision Reviews

Manufacturing and Quality Tasks

- Support an MRL assessment of the system using MRL 8 criteria as the target for the Milestone C decision.
    - Capture the results of manufacturing and quality processes, demonstrated on a pilot line, as inputs
    - Verify and validate attainability of KCs (i.e., will be capable and under process control for LRIP) including yields and rates
    - Incorporate results of the required Technology Readiness Assessment
    - Incorporate industrial base viability
    - Verify and validate producibility issues, design stability, and configuration management
    - Verify and validate all LRIP manufacturing and quality requirements (e.g., materials, supply chain, workforce, facilities, tooling, manufacturing planning and management, etc.)
- Assess the contractor designated pilot lines for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:

- Manufacturing readiness for manufacture of equipment
- Materials, components, and tooling availability
- Adequacy of manufacturing and quality workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
- Capability to meet manufacturing and quality requirements for LRIP
- Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
- Capability and capacity to meet rate production (ramp-up to FRP)
- Capability and capacity to meet program objectives for cost and schedule

- Provide manufacturing and quality inputs and updates, for the Milestone C Decision following post-CDR, pilot line, and PRR assessment results, the following statutory and regulatory program required updates (per DoDI 5000.02) to:
  - The Acquisition Strategy
    - Acquisition Approach
    - Benefit Analysis and Determination (required if no MS B decision)
    - Business Strategy
    - Contracting Strategy (type and termination liability)
    - Cooperative Opportunities (if necessary)
    - General Equipment Valuation
    - Industrial Base Considerations
    - Intellectual Property Considerations
    - Modular Open Systems Approach
    - Multiyear Procurement
    - Risk, Issue, and Opportunity Management Approach
    - Small Business Innovation Research/Small Business Technology Transfer
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives (regulatory)
  - Bandwidth Requirements Review
  - Capability Production Document
  - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - Life-Cycle Sustainment Plan (LCSP)
  - Programmatic Environmental Safety and Occupational Health Evaluation (PESHE)and National Environmental Policy Act (NEPA) compliance Schedule
  - Preservation and Storage of Unique Tooling Plan
  - Program Protection Plan (PPP)
  - Request for Proposal (RFP)
  - Should Cost Target
  - Spectrum Supportability Risk Assessment

  - Systems Engineering Plan (SEP)
  - Technology Readiness Assessment (TRA)
  - Test and Evaluation Master Plan (TEMP)
  - Validated On-line Life-cycle Threat (VOLT) Report

- Provide manufacturing and quality inputs, updates, and proposed changes for the proposed Production and Deployment (i.e., LRIP) contract, based on post-CDR, pilot line, and PRR assessment results.
- Manufacturing and quality provide support for the Program Manager's decision process for acceptability of manufacturing and producibility risks, supplier qualifications, and verification of manufacturing processes under statistical process control.
- Manufacturing and quality provide support for the Program Manager's modular approach to product design and Intellectual Property (IP).
- Manufacturing and quality provide verification and validation of adequacy and completeness of Technical Data Packages (to include management of IP) for Production and Deployment
- Manufacturing and quality provide support to the corrosion prevention and control process to reduce, control, or mitigate corrosion in sustainment.
- Manufacturing and quality provide input to the Program Managers for assessment of ESOH risks and acceptance decisions.
- Provide updates to manufacturing and quality exit criteria metrics for EMD.
  - Update the manufacturing and quality support plan for an assessment of manufacturing readiness and the mandated independent assessment
- Provide manufacturing and quality updates to the joint Risk, Issue, and Opportunity Management System for the Milestone C decision.

Metrics

- An MRL assessment of the system using MRL 8 criteria as the target for the Milestone C decision has been conducted by trained SMEs and supported by program manufacturing and quality personnel and documents:
  - Results of manufacturing and quality processes, demonstrated on a pilot line
  - Attainability of KCs including yields and rates (i.e., will be capable and under process control for LRIP)
  - Results of the required Technology Readiness Assessment
  - Industrial base viability and/or recommendations for IB support activities
  - Closure and/or mitigation of producibility issues
  - Design stability
    - Detailed design of product features and interfaces is complete
    - All product data essential for system manufacturing has been released and is under configuration management

- All LRIP manufacturing and quality requirements (e.g., materials, supply chain, workforce, facilities, tooling, manufacturing planning and management, etc.)

- Pilot lines have been assessed and documented for production realism and affordability of elements required to manufacture systems, subsystems, items, and components including:
  - Manufacturing readiness for manufacture of equipment
  - Materials, components, and tooling availability
  - Adequacy of manufacturing and quality workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
  - Capability to meet manufacturing and quality requirements for LRIP
  - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
  - Capability and capacity to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule

- Manufacturing and quality inputs and updates for the Milestone C Decision have been documented and provided to support the following statutory and regulatory program required updates (per DoDI 5000.02) including:
  - Acquisition Strategy
    - Acquisition Approach
    - Benefit Analysis and Determination (required if no MS B decision)
    - Business Strategy
    - Contracting Strategy (type and termination liability)
    - Cooperative Opportunities (if necessary)
    - General Equipment Valuation
    - Industrial Base Considerations
    - Intellectual Property Considerations
    - Modular Open Systems Approach
    - Multiyear Procurement
    - Risk, Issue, and Opportunity Management Approach
    - Small Business Innovation Research/Small Business Technology Transfer
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives (regulatory)
  - Bandwidth Requirements Review
  - Capability Production Document
  - CARD, RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - LCSP
  - Programmatic Environmental Safety and Occupational Health Evaluation and National Environmental Policy Act Compliance Schedule

- Preservation and Storage of Unique Tooling Plan
- PPP
- RFP
- Should Cost Target
- Spectrum Supportability Risk Assessment
- SEP
- TRA
- TEMP
- VOLT Report

- Manufacturing and quality inputs, updates, and proposed changes have been provided to program management for the proposed LRIP contract, based on post-CDR, pilot line, and PRR assessment results.
- Manufacturing and quality has provided documented input to:
  - Program Manager's decision process, including:
    - Acceptability of manufacturing and producibility risks
    - Supplier qualifications
    - Verification of manufacturing processes under statistical process control
  - Program Manager's modular approach to product design and Intellectual Property
  - Corrosion prevention and control processes to reduce, control, or mitigate corrosion in sustainment
  - Program Manager's for assessment of ESOH risks and acceptance decisions
- Technical Data Packages (to include management of IP) have been verified and validated by manufacturing and quality for adequacy and completeness and are up-to-date for P&D.
- Manufacturing and quality has provided documented updates to exit criteria metrics for EMD.
- Provide manufacturing and quality updates to the joint Risk, Issue, and Opportunity Management System for the Milestone C decision.

Tools

- Market Research using Pugh Template
- CARD use Cost and Lead Time Worksheet
- Life Cycle Sustainment Plan
- Technology Readiness Assessment
- MRL Assessment
- Test and Evaluation Master Plan
- Integrated Master Plan/Schedule
- Transition to Production Assessment

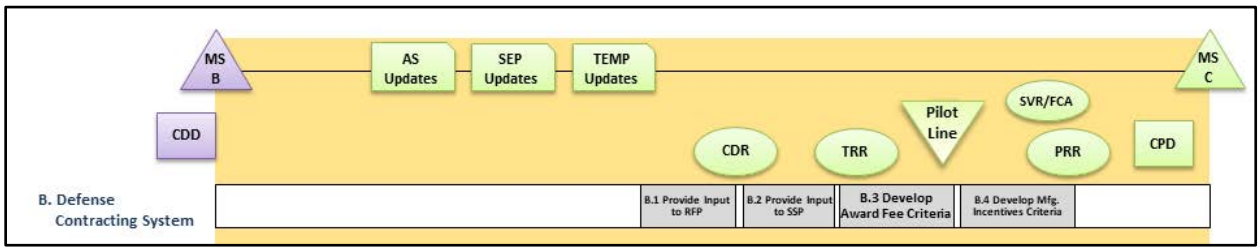
Resources

- DoDI 5000.02

- MRL Deskbook Version 2016
- IEEE 15288.2, Systems and Software Engineering, 2015
- DoDI 4245.7-M Transition from Development to Production, Sep 1985

B. DEFENSE CONTRACTING SYSTEM

During the latter part of the EMD phase an essential program activity is to prepare the Request for Proposal (RFP) for the milestone C decision and entrance to the P&D phase. This RFP will delineate what is required from the contractor to produce and deliver requirements compliant products to receiving military organizations. A cohesive effort between all program functional areas and Contracts is essential to managing and completing the steps in this phase of the contracting process.



An RFP is a formal negotiated solicitation resulting in a contract that includes the contract form, contract clauses, work statements, specifications, the delivery schedule and payment terms. The contract's primary function is technical with the administrative function secondary. The RFP must contain clear and sufficient technical guidance so the contractor has a definite picture of how the system is envisioned to perform once delivered. It is also important that a technical functional description of hardware requirements is included and that those requirements are clearly defined and scoped. Inconsistencies, insufficient detail, and inappropriate requirements in the RFP will result in an inadequate response from industry. From a manufacturing and quality perspective, the RFP should include, at a minimum:

- Manufacturing Management and Control (best practices)
- Design Development and Demonstration
- Quality Management and Systems (best practices)
- Manufacturing and Quality Costs
- Industrial Base
- Process Control and Capability (best practices)
- Materials, Workforce, Facilities, and Tooling
- Risk, Issues, and Opportunity Management

The RFP should specify the requirements for best practices for the contractor’s Manufacturing Management System (MMS) and Quality Management System (QMS) and what quality level contract requirement should be met per FAR 52.246-11 (e.g., ISO 9000, AS9100, etc.). Manufacturing and quality should ensure that the RFP includes specific requirements for the

integration of producibility into the design process. During each stage of development, an organized and systematic pattern of events must take place if a design is to fully meet all of its objectives. Implicit in these objectives is the requirement that a design achieve the highest possible degree of producibility. The requirements for the contractor to identify and describe in detail in the RFP their proposed specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and manufacturing and quality risks and issues associated with the proposed system should also be included. Manufacturing and quality inputs provided to the RFP development process should be utilized in development of the Source Selection Plan (SSP) and the Statement of Work (SOW) in order to ensure availability of the necessary disciplines from the contractor. This includes general and specific requirements for developing data packages, designing special purpose production equipment, and performing computer modeling or simulation of the manufacturing process.

Based on the SSP, proposal evaluation is an assessment of the proposal and the offeror's ability to perform the prospective contract successfully. The SSP evaluations generally include on or more of the following evaluations:

- Cost and/or Price
- Past performance
- Producibility
- Technical and Quality processes
- Manufacturing and Quality capabilities
- Manufacturing and Quality risks, issues, and opportunities
- application of best practices for the MMS and QMS

SSP should delineate and include metrics and scoring for the above including preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, and quality associated with the proposed system. Additionally, the SSP should include accommodation and support of on-site government Quality Assurance personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA).

The proposal evaluation criteria must be clearly identified and defined in the RFP and applied in the SSP. Proposal evaluations must be conducted so the government can select the proposal providing the best value to the government.

Management tools such as Award Fees and Incentive Fees can provide increased interaction of program and contractor manufacturing and quality management and provide the program with increased visibility into the contractor’s best practices for manufacturing, quality, and supply chain processes and procedures. Award fees in the contract should be based on contractor performance to industry manufacturing and quality best practices and program goals and objectives, rewarding specific accomplishments such as:

- Producibility improvements

- Materials characterization in production relevant environment
- Manufacturing cost reduction efforts
- Manufacturing maturation plan risks burned down
- Variation and variability reduction
- Manufacturing process definition and characterization
- Progress in achieving the targeted Manufacturing Readiness Level (MRL)
- Progress in maturation and demonstration of KCs (i.e., meeting KPPs/KSAs)
- Progress in achieving specific yield and rate goals
- Progress in meeting the EMD exit criteria

Incentive Fees in the contract should be consistent with the Acquisition Strategy (AS) and also tied to goals for exceeding contract requirements and program expectations. Manufacturing and quality incentives in contracts should be designed to obtain specific manufacturing and quality objectives by establishing reasonable and attainable criteria that can meet the goals or targets. These criteria must be clearly communicated to the contractor; and include appropriate incentive arrangements that will motivate contractor efforts that might not otherwise be emphasized and discourage contractor inefficiency and waste.

Important manufacturing and quality management goals and expectations to be exceeded in contract incentives include:

- Cost (e.g., Cost reductions, Should Costs, Life-Cycle Costs)
- Schedule (e.g., expedited development or delivery, early delivery, on-time delivery, etc.)
- Technical (e.g., quality, reliability, maintainability, product improvement, etc.)
- Management commitment
- Producibility processes
- Risk, Issue and Opportunity Management processes
- Commercial best practices

These assist both government and contractor in understanding of program progress and expedites resolution of manufacturing and quality issues. This interaction can serve as a forcing function for the top contractor design personnel to communicate and coordinate decisions with their own manufacturing personnel.

B.1 Provide Input to Request for Proposal (RFP)

Manufacturing and Quality Tasks

- Ensure that manufacturing and quality personnel are included in the RFPs writing and review teams.
- As a basis for RFP requirements and inputs, analyze all manufacturing and quality outputs and results to provide manufacturing and quality requirements on:

- Risk, Issue, and Opportunity Management System and processes
- Design producibility, process capability, and manufacturability assessments, analyses, and reviews (i.e., CDR)
- Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
- Prototypes, demonstrations, and development tests and analyses
- Materials characterizations, scale-ups, and analyses
- Make/buy processes, procedures, and analyses
- Costs and budget analyses
- Market research and analyses
- Modeling and simulations analyses
- Process capability and production process verification analyses
- ESOH, environmental, hazardous materials, safety, security analyses and risks
- Manufacturing and quality processes, procedures, and associated data (especially CMPs)
- Workforce availability, training, and certification analyses
- Work measurement/learning curve analyses
- Industrial Base assessments and analyses
- ManTech projects
- supply chain assessments and analyses
- DCMA surveillance reports

- Specify the requirements for best practices for the contractor's Manufacturing Management System (MMS) (per Section L.2) and Quality Management System (QMS) (per Section I.2 and per FAR 52.246-11, Higher-Level Contract Quality Requirement) to be used (e.g., AS6500, ISO 9000, AS9100, etc.).
  - Specify the requirements for the contractor to identify and describe in detail their proposed specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and manufacturing and quality risks and issues associated with the proposed system
  - Specify a requirement for on-site government Quality Assurance personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA)
  - Specify a requirement for on-site government Quality Assurance personnel to have access to and inputs on:
    - Perform source inspections and data monitoring
    - Failures and Corrective Actions and resolutions (i.e., FRACAS)
    - Material Review actions and dispositions (i.e., Material Review Boards)
    - Requests for Variance actions and approvals
    - Engineering Change process and approvals

- If AS6500 is not invoked in the contract(s), the manufacturing management requirements cited in AS6500 should be the basis for specific contractual requirements for a contractor Manufacturing Management System and Plan. The requirements, at a minimum, should specify that the contractor addresses:
  - Manufacturing Management System:
    - Documenting how, when, and by whom each requirement of their system is to be accomplished, and define the authority and responsibility for each.
  - Design Analysis for Manufacturing:
    - Conducting producibility analyses
    - Identifying and managing key and critical characteristics in the Technical Data Package (TDP)
    - Implementing Variability Reduction (VR) to reduce part to part variation of key and critical characteristics
    - Identifying and managing key and critical manufacturing processes
    - Conducting Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
  - Manufacturing Risk Identification:
    - Integrating manufacturing risk management activities into the program risk, issue and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
    - Conducting and documenting manufacturing feasibility assessments for a competing design alternative
    - Identifying MRL targets and documenting manufacturing risks through the MRL assessments
  - Manufacturing Planning:
    - Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing modeling and simulation, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities.
  - Manufacturing Operations Management including:
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - Production Process Verification
    - First Article Inspections and First Article Tests

        - Supplier Management and Quality

- If ISO 9000 or AS9100 is not invoked in the contract(s), the quality management requirements cited in the standards should be the basis for specific contractual requirements for a contractor Quality Management System and Plan. The requirements, at a minimum, should specify that the contractor addresses:
    - Quality Management Leadership
        - Leadership and Commitment
        - Policy
        - Organizational Roles, Responsibilities, and Authorities
    - Quality Planning
        - Actions to Address Risks and Opportunities
        - Quality Objectives and Planning
        - Planning of Changes
    - Quality Support
        - Resources
        - Competence
        - Awareness
        - Communication
        - Documented Information
    - Operation
        - Operational Planning and Control
        - Requirements for Products and Services
        - Design and Development of Products and Services
        - Control of Externally Provided Processes, Products, and Services
        - Production and Service Provision
        - Release of Products and Services
        - Control of Non-conforming Outputs
    - Quality Performance
        - Monitoring, Measurement, Analyses, and Evaluation
        - Internal Audit
    - Quality Improvement
        - Nonconformity and Corrective Actions (i.e., FRACAS)
        - Continual Improvement
- Specify appropriate requirements for manufacturing and quality CDRLs, Data Item Description (DID), etc. to support manufacturing and quality processes, include the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.)

  - Specify a requirement for on-site government Quality Assurance personnel will have access to perform source inspection of the plan (include on-site government Quality Assurance personnel (i.e., DCMA) in contractual distribution of the Program Quality Plan (ref. I.2))

- Provide manufacturing and quality inputs and support for specification of industry best practices for Systems Engineering to be used (e.g., IEEE 15288, -1, -2, etc.) in the RFP.
  - Include requirements for the contractors to identify and to describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering

- Provide manufacturing and quality inputs and support to contractual requirements for:
  - Content for Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (See B.4)
  - Conducting manufacturing and quality reviews of engineering and software (with frequency of reviews)
  - Intellectual Property and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Identification and description of producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
  - Facilities, tooling, test equipment, and workforce
  - Supply chain management
  - Management of parts and materials (e.g., make/buy, planning, etc.) including:
    - Long-lead
    - Sources and risks (sole, single, foreign, fragile, and critical)
    - Handling and storage
    - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
    - Conservation of critical/strategic materials
    - Counterfeit avoidance
    - Obsolescence
    - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
    - Reduction/elimination of foreign dependency
    - Standardization of components, items and parts
  - Configuration management
  - Life-cycle Support Plan (LCSP)
  - Performing analyses of failure mode effects and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
  - Traceability of CSIs and/or CAIs to all key and critical manufacturing and quality processes (CMP)
  - Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)

- Providing systematic application of statistical process controls and meeting required process capability (C_{pk}) goals
- Providing a system for collection, storage, analysis, and management of manufacturing and quality data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
- Manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life-cycle costs
- A joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
- Manufacturing and quality Variability Reduction program
- Appropriate cyber threat protection program including:
  - Safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
  - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security
- Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
- COTS, GOTS, GFE, and NDIs
- Metrics to be met as exit criteria

- Provide manufacturing and quality inputs and support to specialized system requirements and/or certifications, such as Flight Operations, Space Operations, etc.
- Specify the requirements that the contractor support and/or conduct, as required, manufacturing and quality:
  - Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to Full-Rate Production Decision Review (FRPDR)
  - MRL assessments with trained personnel utilizing the MRL criteria
  - Independent risk assessments as directed
  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions

- Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities

- Provide manufacturing and quality inputs on requirements for the contractor to:
  - Support of on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
  - Address capital investments
  - Provide specific, detailed workforce, facilities, and capacity plans for LRIP and FRP including:
    - Relocations
    - Restarts
    - Changes in materials, manufacturing processes, and/or suppliers
    - Processes, procedures, improvements, etc.
  - Address meeting program schedule and critical path
  - Manage the supply chain (e.g., products, locations, capacities, capabilities, monitoring, etc.)
  - Manage tooling, Special Test Equipment (STE), and Special Inspection Equipment (SIE)
  - Support and conduct a Continuous Process Improvement (CPI) program
  - Utilize, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
  - Support and maintain the IMP/IMS including the critical path

- Provide manufacturing and quality inputs on requirements for the contractor to define manufacturing methods and production flow to include:
  - Advanced or unique manufacturing technologies required
  - Production flow including the planned fabrication and assembly key points
  - Production test and/or inspections
  - Planned flow of major manufacturing operations
  - Expected process yields and statistical or other methods for process control

- Provide manufacturing and quality inputs on requirements for contractor support and maintenance of and up-to-date Technical Data Package.

Metrics

- As a basis for RFP requirements and inputs, all manufacturing and quality outputs and results have been analyzed and documented manufacturing and quality requirements have been provided for:
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, process capability, and manufacturability assessments, analyses, and reviews
  - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)

- Demonstrations and development tests and analyses
- Materials characterizations, scale-ups, and analyses
- Make/buy processes, procedures, and analyses
- Costs and budget analyses
- Market research and analyses
- Modeling and simulations analyses
- Process capability and production process verification analyses
- ESOH, environmental, hazardous materials, safety, security analyses and risks
- Manufacturing and quality processes, procedures, and associated data (especially CMPs)
- Workforce availability, training, and certification analyses
- Work measurement/learning curve analyses
- Industrial Base assessments and analyses
- ManTech projects
- Supply chain assessments and analyses
- DCMA surveillance reports

- Requirements for best practices for the contractor's MMS (per Section L.2) and QMS (per Section I.2) to be used have been documented and specify:
  - Requirements for the contractor to describe in detail proposed specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and manufacturing and quality risks and issues associated with the proposed system
  - Requirements for on-site government Quality Assurance personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA)
  - Requirements for on-site government Quality Assurance personnel to have access to and inputs on:
    - Source inspections and data monitoring
    - FRACAS and resolutions
    - Material Review actions and dispositions (i.e., Material Review Boards)
    - Requests for Variance actions and approvals
    - Engineering Change process and approvals

- If AS6500 is not invoked in the contract(s), the AS6500 manufacturing management requirements have been contractually specified as requirements for a contractor MMS and Plan. The requirements, at a minimum, specify that the contractor addresses:
  - Manufacturing Management System
  - Design Analysis for Manufacturing:
  - Manufacturing Risk Identification:
  - Manufacturing Planning:
  - Manufacturing Operations Management including:

- If ISO 9000 or AS9100 is not invoked in the contract(s), the quality management requirements cited have been contractually specified as requirements for a contractor QMS and Plan. The requirements, at a minimum, specify that the contractor addresses:

- Quality Management Leadership
- Quality Planning
- Quality Support
- Operation
- Quality Performance
- Quality Improvement

- Appropriate requirements for manufacturing and quality CDRLs, DIDs, etc. have been documented that specify support of manufacturing and quality processes, including the requisite approval and change process, including:
  - Requirement for on-site government Quality Assurance personnel access to perform source inspection of the plans
- Manufacturing and quality inputs and support have been documented and provided for specification of industry best practices to be used for Systems Engineering in the RFP.
  - Requirements that the contractor describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering are included
- Manufacturing and quality have documented and provided contractual inputs and/or requirements for:
  - Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (See B.4)
  - Conducting manufacturing and quality reviews of engineering and software (with frequency of reviews)
  - Intellectual Property and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Identification and description of producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
  - Facilities, tooling, test equipment, and workforce
  - Supply chain management
  - Management of parts and materials (e.g., make/buy, planning, etc.) including:
    - Long-lead
    - Sources and risks (sole, single, foreign, fragile, and critical)
    - Handling and storage
    - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
    - Conservation of critical/strategic materials
    - Counterfeit avoidance
    - Obsolescence
    - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
    - Reduction/elimination of foreign dependency
    - Standardization of components, items and parts

- Configuration management
- Life-cycle Support Plan (LCSP)
- Analyses of failure modes, effects, and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
- Traceability of CSIs and/or CAIs to all key and critical manufacturing and quality processes (CMPs)
- Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Systematic application of statistical process controls and meeting required process capability (C_{pk}) goals
- A system for collection, storage, analysis, and management of manufacturing and quality data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
- Manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life-cycle costs
- A joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
- Manufacturing and quality Variability Reduction program
- A cyber threat protection program including:
  - Safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
  - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security
- Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
- COTS, GOTS, GFE, and NDIs
- Metrics to be met as exit criteria

- Manufacturing and quality have documented and provided inputs and support to specialized system requirements and/or certifications, such as Flight Operations, Space Operations, etc.
- Manufacturing and quality requirements have been documented and specify that the contractor support and/or conduct:

- Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to Full-Rate Production Decision Review (FRPDR)
- MRL assessments with trained personnel utilizing the MRL criteria
- Independent risk assessments as directed
- Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
- Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities

- Manufacturing and quality documented inputs have been provided on contractor's requirements to:
  - Support of on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
  - Address capital investments
  - Provide specific, detailed workforce, facilities, and capacity plans for LRIP and FRP including:
    - Relocations
    - Restarts
    - Changes in materials, manufacturing processes, and/or suppliers
    - Processes, procedures, improvements, etc.
  - Address meeting program schedule and critical path
  - Manage the supply chain (e.g., products, locations, capacities, capabilities, monitoring, etc.)
  - Manage tooling, Special Test Equipment (STE), and Special Inspection Equipment (SIE)
  - Support and conduct a Continuous Process Improvement (CPI) program
  - Utilize, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
  - Support and maintain the IMP/IMS including the critical path
- Manufacturing and quality documented inputs have been provided on requirements for the contractor to define manufacturing methods and production flow including:
  - Advanced or unique manufacturing technologies
  - Planned fabrication and assembly key points
  - Production test and/or inspections
  - Major manufacturing operations
  - Expected process yields and statistical or other methods for process control
- Manufacturing and quality have documented and provided inputs for contractor requirements to maintain an up-to-date Technical Data Package.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist, Sep 2016
- ISO 9001, Quality Management System Checklist, Sep 2016
- IEEE 15288, System and Software Engineering, 2015
- IG5315.204-5(b) Section L Guide and Template
- IG5315.204-5(c) Section M Guide and Template

Resources

- AS6500, Manufacturing Management Program, SEP 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9000, Quality Management System, Sep 2016
- IEEE 15288, System and Software Engineering, 2015
- IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- MRL Deskbook Version 2016
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- NIST 800-82 Guide to Industrial Control Systems (ICS) Security
- MIL-STD-882, DoD System Safety, May 2012

B.2 Provide Input to Source Selection Plan (SSP)

Manufacturing and Quality Tasks

- Ensure that manufacturing and quality personnel are included in the Source Selection Plan (SSP) writing and review teams.
- Utilizing analyses of EMD manufacturing and quality outputs, specify metrics and scoring that at a minimum address the contractor(s) plans, processes, and procedures for:
    - Risk, Issue, and Opportunity Management System and processes
    - Design producibility, process capability, and manufacturability assessments, analyses, and technical and management reviews
    - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
    - Demonstrations and development tests

- Materials
- Materials management (i.e., make/buy processes, procedures, and analyses)
- Costs and budget estimates
- Market research and analyses
- Modeling and simulations
- Process capability and production process verifications
- ESOH, environmental, hazardous materials, safety, and security (physical, cyber, and industrial)
- Manufacturing and quality and associated data (especially CMPs)
- Workforce (e.g., availability, training, and certification)
- Work measurement (i.e., learning curve analyses)
- ManTech project implementation
- Supply chain assessments and analyses

- Specify in the SSP metrics and scoring for application of best practices for the contractor(s) Manufacturing Management System (MMS) and Plan and Quality Management System (QMS) and Plan (e.g., AS6500, ISO 9000, AS9100, etc.).
  - SSP should delineate and include metrics and scoring for preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and manufacturing and quality risks and issues associated with the proposed system
  - Plan should delineate and include metrics and scoring for accommodation and support of on-site government Quality Assurance personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA) including:
    - Source inspections and data monitoring
    - Failures and Corrective Actions and resolutions (i.e., FRACAS)
    - Material Review actions and dispositions (i.e., Material Review Boards)
    - Requests for Variance actions and approvals
    - Engineering Change process and approvals
- If manufacturing management industry best practice requirements (i.e., AS6500) are not invoked in the contract, the requirements cited in AS6500 should be the basis for specific SSP metrics and scoring of the contractor(s) Manufacturing Management System and Plan. The SSP should delineate and specify metrics and scoring for:
  - Documenting how, when, and by whom each requirement of their system is to be accomplished, and define the authority and responsibility for each
  - Conducting producibility analyses
  - Identification and management key and critical characteristics in the Technical Data Package (TDP)
  - Implementation of VR to reduce part to part variation of key and critical characteristics
  - Identification and management of key and critical manufacturing processes
  - Conducting Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes

- Integration of manufacturing risk management activities into the program risk, issue and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
- Conducting and documenting manufacturing feasibility assessments for a competing design alternative
- Identification of MRL targets and documenting manufacturing risks through the MRL assessments
- Establishing and maintaining a manufacturing plan that includes:
  - Supply chain and material management
  - Manufacturing technology development
  - Manufacturing modeling and simulation
  - Manufacturing costs
  - Manufacturing system verification
  - Manufacturing workforce
  - Tooling, test equipment, and facilities
- Management of operations including:
  - Production Scheduling and Control
  - Manufacturing Surveillance
  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - Production Process Verification
  - First Article Inspections and First Article Tests
  - Supplier Management and Quality

- If ISO 9000 or AS9100 quality management industry best practices are not invoked in the contract, the requirements cited in the standards should be the basis for specific SSP metrics and scoring of the contractor(s) Quality Management System and Plan. The SSP should delineate and specify metrics and scoring for:
  - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
  - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management
  - Quality support with resources, competence, awareness, communication, and documented information
  - Operation including operational planning and control, products and services requirements, and design and development
  - Control of externally provided processes, products, and services
  - Production and service provision
  - Release of products and services
  - Control of non-conforming outputs

- Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
- Quality improvement including nonconformities and corrective actions, and continual improvement

- Specify metrics and scoring to rank contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment with program goals (and corrective actions and/or mitigation plans, if required) for managing manufacturing and quality CDRLs, DIDs, etc., including the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.).
- Specify in the SSP metrics and scoring for contractor(s) application of industry best practices for manufacturing and quality aspects of Systems Engineering management (e.g., IEEE 15288, -1, -2, etc.).
  - Include metrics and scoring for the contractors proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specify manufacturing and quality metrics and scoring for contractor(s) plans for timeliness, completeness, accuracy, and alignment to program goals (with corrective actions and/or mitigation, if required) to include:
  - Meeting each requirement in the Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (See B.4)
  - Manufacturing and quality reviews of engineering and software (with frequency of reviews)
  - Intellectual Property management and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
  - Utilization of facilities, tooling, test equipment, and workforce
  - Supply chain management (e.g., products, locations, capacities, capabilities, monitoring, etc.)
  - Parts and materials management (e.g., make/buy, planning, etc.) including:
    - Long-lead
    - Sources and risks (sole, single, foreign, fragile, and critical)
    - Handling and storage
    - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
    - Conservation of critical/strategic materials
    - Counterfeit avoidance
    - Obsolescence
    - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
    - Reduction/elimination of foreign dependency
    - Standardization of components, items and parts
  - Configuration management

- Analyses of failure mode effects and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
- Management (including traceability) of CSI and/or CAIs to all key and critical manufacturing and quality processes (CMP)
- Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Application of statistical process controls and meeting required process capability (C_{pk}) goals
- Collection, storage, analysis, and management of manufacturing and quality data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
- Manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life-cycle costs
- Investments in workforce development including processes, work systems, and skill development
- Joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
- Manufacturing and quality Variability Reduction program
- Cyber threat protection including:
  - Safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
  - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security
- Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
- Utilization of COTS, GOTS, GFE, and NDIs
- Manufacturing and quality in the Life-cycle Support Plan (LCSP)
- Metrics to be met as exit criteria for LRIP

- Specify metrics and scoring to rank the contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specify manufacturing and quality metrics and scoring on timeliness, completeness, accuracy, and alignment with program objectives for contractor planning and processes to support and/or conduct as required manufacturing and quality:
    - Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to Full-Rate Production Decision Review (FRPDR)
    - MRL assessments with trained personnel utilizing the MRL criteria
    - Independent risk assessments as directed
    - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
    - Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities
- Specify manufacturing and quality metrics and scoring for the contractor(s) plans to:
    - Support on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
    - Address capital investments
    - Support LRIP and FRP with specific, detailed workforce, facilities, and capacity plans including:
        - Relocations
        - Restarts
        - Changes in materials, manufacturing processes, and/or suppliers
        - Processes, procedures, improvements, etc.
    - Address meeting program schedule and critical path
    - Manage Special Test Equipment (STE), and Special Inspection Equipment (SIE)
    - Support and conduct a Continuous Process Improvement (CPI) program
    - Utilize, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
    - Support and maintain the IMP/IMS including the critical path
    - Support and maintenance of an up-to-date Technical Data Package
- Specify manufacturing and quality metrics and scoring for the contractor(s) plans for manufacturing methods and production flow to include:
    - Advanced or unique manufacturing technologies
    - Planned fabrication and assembly key points
    - Production test and/or inspections

- Flow of major manufacturing operations
- Process yields and statistical or other methods for process control

Metrics

- SSP manufacturing and quality metrics and scoring have been developed and documented that rank the contractor(s) plans, processes, and procedures for:
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, process capability, and manufacturability assessments, analyses, and technical and management reviews
  - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
  - Demonstrations and development tests
  - Materials
  - Materials management (i.e., make/buy processes, procedures, and analyses)
  - Costs and budget estimates
  - Market research and analyses
  - Modeling and simulations
  - Process capability and production process verifications
  - ESOH, environmental, hazardous materials, safety, and security (physical, cyber, and industrial)
  - Manufacturing and quality and associated data management (especially CMPs)
  - Workforce management (e.g., availability, training, and certification)
  - Work measurement (i.e., learning curve analyses)
  - ManTech project implementation
  - Supply chain assessments and analyses
- Manufacturing and quality metrics and scoring have been developed and documented in the SSP for application of best practices in the contractor(s) MMS and Plan and QMS and Plan including:
  - Preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and manufacturing and quality risks and issues
  - Accommodation and support of on-site government Quality Assurance personnel to have access to perform management and quality audits including:
    - Source inspections and data monitoring
    - Failures and Corrective Actions and resolutions (i.e., FRACAS)
    - Material Review actions and dispositions (i.e., Material Review Boards)
    - Variance actions and approvals
    - Engineering changes and approvals
- If manufacturing management industry best practice requirements (i.e., AS6500) are not invoked in the contract, then specific metrics and scoring have been documented and included in the SSP that rank the contractor(s) plans, processes, and procedures for:

- Documenting how, when, and by whom each requirement of their system is to be accomplished, and define the authority and responsibility for each
- Conducting producibility analyses
- Identification and management key and critical characteristics in the Technical Data Package (TDP)
- Implementation of VR to reduce part to part variation of key and critical characteristics
- Identification and management of key and critical manufacturing processes
- Conducting Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
- Integration of manufacturing risk management activities into the program risk, issue and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
- Conducting and documenting manufacturing feasibility assessments for a competing design alternative
- Identification of MRL targets and documenting manufacturing risks through the MRL assessments
- Establishing and maintaining a manufacturing plan that includes:
  - Supply chain and material management
  - Manufacturing technology development
  - Manufacturing modeling and simulation
  - Manufacturing costs
  - Manufacturing system verification
  - Manufacturing workforce
  - Tooling, test equipment, and facilities
- Management of operations including:
  - Production Scheduling and Control
  - Manufacturing Surveillance
  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - Production Process Verification
  - First Article Inspections and First Article Tests
  - Supplier Management and Quality

- If quality management industry best practice requirements (e.g., ISO 9000, AS9100, etc.) are not invoked in the contract, then specific metrics and scoring have been documented and included in the SSP that rank the contractor(s) plans, processes, and procedures for:
  - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
  - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management

  - Quality support with resources, competence, awareness, communication, and documented information
  - Operation including operational planning and control, products and services requirements, and design and development
  - Control of externally provided processes, products, and services
  - Production and service provision
  - Release of products and services
  - Control of non-conforming outputs
  - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
  - Quality improvement including nonconformities and corrective actions, and continual improvement

- Specific metrics and scoring have been documented in the SSP that rank the contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing manufacturing and quality CDRLs, DIDs, etc., including the requisite approval processes.
- Specific metrics and scoring have been documented in the SSP for contractor(s) application of industry best practices for manufacturing and quality aspects of Systems Engineering management (e.g., IEEE 15288, -1, -2, etc.).
  - Metrics and scoring include the contractor(s) proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specific manufacturing and quality metrics and scoring have been documented in the SSP for contractor(s) plans (including timeliness, completeness, accuracy, and alignment to program goals) to include:
  - Meeting each requirement in the Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (See B.4)
  - Manufacturing and quality reviews of engineering and software (with frequency of reviews)
  - Intellectual Property management and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
  - Utilization of facilities, tooling, test equipment, and workforce
  - Supply chain management (e.g., products, locations, capacities, capabilities, monitoring, etc.)
  - Parts and materials management (e.g., make/buy, planning, etc.) including:
    - Long-lead
    - Sources and risks (sole, single, foreign, fragile, and critical)
    - Handling and storage
    - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)

- Conservation of critical/strategic materials
- Counterfeit avoidance
- Obsolescence
- Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
- Reduction/elimination of foreign dependency
- Standardization of components, items and parts

- Configuration management
- Analyses of failure mode effects and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
- Management (including traceability) of CSIs and/or CAIs to all key and critical manufacturing and quality processes (CMP)
- Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Application of statistical process controls and meeting required process capability (C_{pk}) goals
- Collection, storage, analysis, and management of manufacturing and quality data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
- Manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life-cycle costs
- Investments in workforce development including processes, work systems, and skill development
- Joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
- Manufacturing and quality Variability Reduction program
- Cyber threat protection including:

  - Safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
  - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security

  - Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
  - Utilization of COTS, GOTS, GFE, and NDIs
  - Manufacturing and quality aspects of the Life Cycle Sustainment Plan (LCSP)
  - Metrics to be met as exit criteria for LRIP

- Specific manufacturing and quality metrics and scoring have been documented in the SSP to rank contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment for managing specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specific manufacturing and quality metrics and scoring (alignment with program objectives) have been documented in the SSP for contractor(s) plans and processes to support and/or conduct as required manufacturing and quality:

  - Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to Full-Rate Production Decision Review (FRPDR)
  - MRL assessments with trained personnel utilizing the MRL criteria
  - Independent risk assessments as directed
  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
  - Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities

- Specific manufacturing and quality metrics and scoring have been documented in the SSP for the contractor(s) plans to:

  - Support on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
  - Address capital investments
  - Support LRIP and FRP with specific, detailed workforce, facilities, and capacity plans including:

    - Relocations
    - Restarts
    - Changes in materials, manufacturing processes, and/or suppliers
    - Processes, procedures, improvements, etc.

  - Address meeting program schedule and critical path
  - Manage Special Test Equipment (STE), and Special Inspection Equipment (SIE)
  - Support and conduct a Continuous Process Improvement (CPI) program
  - Utilize, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
  - Support and maintain the IMP/IMS including the critical path

    - Support and maintenance of an up-to-date Technical Data Package
- Specific manufacturing and quality metrics and scoring have been documented in the SSP for the contractor(s) plans for manufacturing methods and production flow to include:
    - Advanced or unique manufacturing technologies
    - Planned fabrication and assembly key points
    - Production test and/or inspections
    - Flow of major manufacturing operations
    - Process yields and statistical or other methods for process control

Tools

- Source Selection Plan Template, USMC
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- IEEE 15288, System and Software Engineering

Resources

- DoD Source Selection Procedures Memo, Mar 2011
- AS6500, Manufacturing Management Program, SEP 2016
- MIL-HDBK 2450, DoD Handbook for Preparation of Statement of Work, 1996
- Source Selection Plan Guide, IG5315.303 SSP Guide, Dec 2008
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- ISO 9001:2015, Quality Management System
- IEEE 15288, System and Software Engineering, 2015
- MIL-STD-882, DoD System Safety, May 2012
- MRL Deskbook Version 2016
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- NIST 800-82 Guide to Industrial Control Systems (ICS) Security

B.3 Develop Award Fee Criteria

Manufacturing and Quality Tasks

- Provide manufacturing and quality input to Award Fee Criteria, appropriate to the contract type and consistent with the Acquisition Strategy, that specify program goals and address the necessary manufacturing and quality (including supply chain) cost, schedule, and performance improvements (to include progress against goals, partial progress, recovery, and penalty) in the areas of:
    - Manufacturing and quality CDRLs, DIDs, etc. (e.g., timely submission and approval)
    - Compliance with cyber-threat protection and industrial security requirements (e.g., PPP, DFARS 252.204-7012, NIST 800-82, etc.)
    - Manufacturing and quality Industrial Base risk mitigations to schedule goals (#,%, milestones)
    - Manufacturing readiness progress (MRL assessments) against targets
    - Manufacturing and quality risk and issues mitigations complete (schedule/#)
    - Manufacturing and producibility projects planned and implemented (#/%)
    - Progress of manufacturing and quality learning curves (% to goals) including rates, yields, variability, process times, re-work and repair, etc.
    - Manufacturing and quality systems operations (production line, tooling, equipment, ManTech insertion, etc.) performance to goals (schedule/ %)
    - KCs maturation and management to goals (% to goal and schedule progress)
    - Technical Performance Measures (TPMs) (% progress to schedule)
    - Manufacturing processes and advanced manufacturing capability improvement, and implementation (#/% to goals)
    - Management of CSIs and CAIs to requirements
    - Process Capability improvement (Cpk value to goals)
    - Quality improvement projects planned and completed (#/% to goals)
    - Variation and Variability reduction efforts (yields/rates/trends)
    - Manufacturing improvement projects implemented (#/% to goals)
    - Parts and materials management against appropriate manufacturing and quality goals (e.g., availability, capacity, sourcing, standardization, etc.)(#/%)
    - Facilities and equipment utilization (% to plan)
    - Workforce development and management to plan (e.g., hiring, training, and reductions) (#/% to plan)
    - Testing completion to schedule (% successfully completed)
    - Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
    - Manufacturing Plan progress against completion (cost and schedule)
    - Manufacturing costs and cost reduction (schedule/#/%)
        - Cost sharing when goals are not met must also be specified.

- Quality Management System compliance to best practices and/or contract requirements (# to standard)
- Quality Plan progress against completion (cost and schedule)
- Quality costs and cost reduction (including cost of quality) (schedule/#/%)
- Manufacturing and quality safety system requirements (% compliance)
- System Engineering management compliance to best practices for manufacturing and quality technical processes, technical management processes, and essential specialty engineering (# to standard)
- Performance to IMP/IMS (schedule)
- Progress toward meeting LRIP exit criteria

Metrics

- Manufacturing and quality inputs to Award Fee Criteria consistent with the Acquisition Strategy have been documented and specify periodic phase goals that require manufacturing and quality (including the supply chain) cost, schedule, and performance improvements, measured as progress against goals (or partial progress, recovery, and penalty), for:
  - Timely submission and approval of manufacturing and quality CDRLs, DIDs, etc.
  - Compliance with cyber-threat protection and industrial security requirements (e.g., PPP, DFARS 252.204-7012, NIST 800-82, etc.)
  - Mitigation of manufacturing and quality Industrial Base risks to schedule goals (#,%, milestones)
  - Manufacturing readiness progress (MRL assessments) against targets
  - Manufacturing and quality risk and issues mitigations completion (schedule/#)
  - Manufacturing and producibility projects planned and implemented (#/%)
  - Manufacturing and quality achievement of learning curves (% to goals) including rates, yields, variability, process times, re-work and repair, etc.
  - Manufacturing and quality systems operations (production line, tooling, equipment, ManTech insertion, etc.) performance to goals (schedule/ %)
  - Maturation and management of KCs to goals (% to goal and schedule progress)
  - Management of Technical Performance Measures (TPMs) (% progress to schedule)
  - Implementation of manufacturing processes and advanced manufacturing capability improvements (#/% to goals)
  - Management of CSIs and CAIs to requirements
  - Process Capability improvement (C_{pk} value to goals)
  - Quality improvement projects completion (#/% to goals)
  - Variation and Variability reduction (yields/rates/trends)
  - Implementation of manufacturing improvement projects (#/% to goals)
  - Management of parts and materials against appropriate manufacturing and quality goals (e.g., availability, capacity, sourcing, standardization, etc.)(#/%)
  - Facilities and equipment utilization (% to plan)
  - Workforce development and management to plan (e.g., hiring, training, and reductions) (#/% to plan)

- Testing completion to schedule (% successfully completed)
- Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
- Manufacturing Plan progress (cost and schedule)
- Manufacturing costs and cost reduction (schedule/#/%)
  - Cost sharing when goals are not met must also be specified.
- Quality Management System compliance to best practices and/or contract requirements (# to standard)
- Quality Plan progress (cost and schedule)
- Quality costs and cost reduction (including cost of quality) (schedule/#/%)
- Manufacturing and quality safety system compliance (%)
- System Engineering compliance to best practices for manufacturing and quality technical processes, technical management processes, and essential specialty engineering (# to standard)
- Meeting schedule (IMP/IMS and critical path)
- Meeting required LRIP exit criteria

Tools

- Award Fee Template, USAF

Resources

- Air Force Award Fee Guide, Oct 2008 (Army and Navy guides available)
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)
- AS6500, Manufacturing Management Program, SEP 2016
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- NIST 800-82 Guide to Industrial Control Systems (ICS) Security
- MIL-STD-882, DoD System Safety, May 2012

B.4 Develop Manufacturing Incentives Criteria

Manufacturing and Quality Tasks

- Develop and provide manufacturing and quality inputs to Incentives Criteria appropriate to the contract type and consistent with the Acquisition Strategy that address reduction of manufacturing and quality cost and improving schedule and performance (including supply chain) in the areas of:
  - Management commitment to industry best practices, effective communications, team empowerment, and management visibility in manufacturing and quality planning, teamwork, and execution (i.e., world class behavior)
  - Innovative workforce management and training
  - Manufacturing readiness and maturity of the lower-tier supply chain in advance of the System maturity targets (#/%)
  - Reductions in manufacturing cost (Δ$), and cost avoidance
  - Early completion of manufacturing and quality risk and issue mitigations (schedule/#/$)
  - Improvements in schedule (e.g., increased slack time, expedited development, early delivery, or just-in-time implementation, etc.)
  - Exceeding contract requirements for technical enhancements in quality, reliability, maintainability, product improvement, yields, rates, etc.
  - Innovative parts and materials management initiatives
  - Early achievement of manufacturing and quality learning curves (% to goals) including rates, yields, variability, process times, re-work and repair, etc.
  - Early completion of manufacturing and producibility projects (schedule/#)
  - Improvements in testing and reliability (i.e., positive trends) (%)
  - Exceeding contract test requirements through innovative test reductions and/or combinations
  - Improvements in quality (e.g., positive trends, exceeding goals, acceleration of improvements, etc.)(%)
  - Key and critical manufacturing process capability improvement (i.e., C_{pk} improvements on key and critical processes beyond contract)
  - Variation and Variability reduction efforts exceeding contract requirements (yields, rates, and trends)
  - Predictive and pro-active maintenance and modernization of facilities, tooling, and equipment (including GFE)
  - Investments in modern manufacturing methods, software, and equipment (cost share %)
  - Qualification and investments in additional sources within the U.S. IB ($)

Metrics

- Manufacturing and quality have developed, documented, and provided inputs to Incentives Criteria to address reduction of manufacturing and quality cost and improving schedule and performance (including supply chain) in the areas of:

- Management commitment to industry best practices (e.g., AS6500, AS9100, ISO 9000, etc.), effective communications, team empowerment, and management visibility in manufacturing and quality planning, teamwork, and execution (i.e., world class behavior)
- Innovative workforce management and training
- Manufacturing readiness and maturity of the lower-tier supply chain in advance of the System maturity targets (#/%)
- Reductions in manufacturing cost (Δ$), and cost avoidance (Δ$)
- Early completion of manufacturing and quality risk and issue mitigations (schedule/#/$)
- Improvements in schedule (e.g., increased slack time, expedited development, early delivery, or just-in-time implementation, etc.) (schedule/$)
- Exceeding contract requirements for technical enhancements in quality, reliability, maintainability, product improvement, yield, rates, etc. ($)
- Innovative parts and materials management initiatives ($)
- Early achievement of manufacturing and quality learning curves (% to goals) including rates, yields, variability, process times, re-work and repair, etc.
- Early completion of manufacturing and producibility projects (schedule/#)
- Improvements in testing and reliability (i.e., positive trends) (%)
- Exceeding contract test requirements through innovative test reductions and/or combinations (schedule/$)
- Improvements in quality (e.g., positive trends, exceeding goals, acceleration of improvements, etc.)(%)
- Key and critical manufacturing process capability improvement (i.e., C_{pk} improvements on key and critical processes beyond contract) ($)
- Variation and Variability reduction efforts exceeding contract requirements (yields, rates, and trends)($)
- Predictive and pro-active maintenance and modernization of facilities, tooling, and equipment (including GFE)($)
- Investments in modern manufacturing methods, software, and equipment (cost share %/$)
- Qualification and investments in additional sources within the U.S. IB ($)

Tools

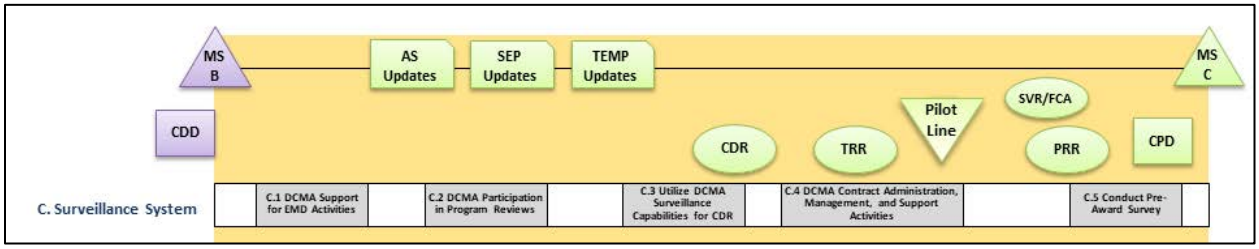
- Award/Incentive Fee Plan

Resources

- FAR Subpart 16.4 Incentive Contracts
- DoD/NASA Incentive Contracting Guide
- AS6500, Manufacturing Management Program, SEP 2016
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016

C. SURVEILLANCE SYSTEM

DCMA is a unique program asset that can provide access to reliable and accurate QMS data and process information on costs, schedule, and technical performance and can assist with objective assessment of Contractor and supply chain plans to include verification of and compliance with requirements.



DCMA audits, support for program reviews, and day-to-day surveillance of Contractor and supply chain activities are tools that provides a way to assess progress and maturity of the program as it moves through finalizing the design and demonstration on a pilot line. DCMA and program audits and reviews should be multi-disciplined to ensure that all of functional aspects of the program are addressed. This systematic process that assesses risk and issues should facilitate transition from final design development to initial production and beyond by assessing the maturity of the design effort, verifying and validating design requirements, verifying the system configuration, and providing a database of surveillance results and technical decisions with rationale.

Reviews and assessments are important oversight tools that the program can use to review and evaluate the state of the system and the program for CDR, re-directing activity if necessary. DCMA can provide status of the application of manufacturing and quality best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.), which includes Contractor and supply chain use of Failure Mode, Effects and Criticality Analysis (FMECA), FRACAS, etc., and monitoring and review of Technical Performance Measures (TPMs) status. Additionally, DCMA monitoring, tracking, and reporting of Contractor and supply chain performance, actions, and compliance with all contractual requirements is major input to the CDR.

The Defense Contract Management Agency (DCMA) conducts nearly all pre-award surveys required by government buying activities. The process begins with a buying activity's request for a survey and concludes with a Procuring Contracting Officer's (PCO) decision based on a recommendation by a DCMA Contract Management Office (CMO) survey team. A Production and Deployment pre-award survey can focus on virtually every facet of the Contractors business operations from technical capability to financial stability, from quality assurance to plant safety. Manufacturing and quality should provide recommendations and inputs to program management for the pre-award survey requirements to be addressed by DCMA. In a sense, the survey process is the Contractor’s opportunity to provide evidence (i.e., Plan of Performance) that they can successfully fulfill the terms of the contract.

C.1 DCMA Support for EMD Activities

Manufacturing and Quality Tasks

- Ensure manufacturing and quality provides inputs to the program development of a Letter of Delegation for DCMA support.
- Ensure manufacturing and quality provides inputs on contractual requirements for Contractor and supply chain activities and functions to be monitored, tracked, and reported by DCMA and/or program personnel in support of EMD, including:
    - DCMA surveillance of Contractor and supply chain use and application of best practices (e.g., AS6500, AS9100, ISO 9000, etc.)
    - Participate in Post Award Orientation Conference
    - Verify closure of PDR actions supply chain (required in the PDR if the PDR was conducted in the TMRR phase)
    - Updates on supply chain CDRs, developmental testing, Physical Configuration Audits (PCAs), Functional Configuration Audits (FCAs), other "critical Path" events, and notifications to the program office of potential or actual program milestone issues
    - Government surveillance of Contractor and supply chain First Article Inspections (FAI)/First Article Tests (FATs) and Qualifications (QUAL)
    - Surveillance support of Contractor’s Earned Value Management System (EVMS)
        - Conduct cost, schedule, and technical performance variance evaluations
    - Surveillance of Human Rating Certification processes (e.g., Flight Operations, etc.) with unrestricted government access to inspect and/or test processes (i.e., Safety of Flight (SOF) characteristics)
    - Government Contract Quality Assurance (GCQA) of engineering development models, engineering models, production prototypes, production representative models/articles, production readiness models/articles, as requested by the program office in the contract
    - Authority to accept or reject minor Requests for Variation (RFVs), Material Review Board (MRB) proposals for Use-As-Is (UAI), and post-CDR repair non-conformances (i.e., after the final product (configuration) baseline (PBL) is established)
    - Surveillance of the supplier’s compliance to DFARS 252.242-7004, Material Management and Accounting System (MMAS)
    - Verification of Contractor and supply chain compliance with contractual Special Packaging Instructions (SPIs) for end item systems and spares
    - Verification of Contractor and supply chain compliance with Surveillance Critical Designator (SCD) (FAR 42.11) requirements applied to the contract
    - Surveillance of manufacturing and quality processes, procedures, and Contractor program systems (e.g., Risk, Issue, and Opportunity Management System, Configuration Management System, FRACAS, FMECA processes, test and evaluation processes, etc.)
- Ensure manufacturing and quality participates in the development of a Memorandum of Agreement (MOA) for DCMA support.

Metrics

- Manufacturing and quality has provided inputs to the program development of a Letter of Delegation for DCMA support.
- Manufacturing and quality has provided documented contractual requirements for monitoring, tracking, and reporting of Contractor and supply chain activities and functions by DCMA and/or program personnel in support of EMD, including:
    - Surveillance of Contractor and supply chain use and application of best practices (e.g., AS6500, AS9100, ISO 9000, etc.)
    - Participation in Post Award Orientation Conference
    - Verification of PDR actions closure for the entire supply chain
    - Supply chain CDRs, developmental testing, PCAs, FCAs, and other "critical Path" events
    - Government surveillance of Contractor and supply chain FAIs/FATs and QUAL
    - Surveillance of Contractor's EVMS
        - Monitor cost, schedule, and technical performance variances
    - Surveillance of Human Rating Certification processes
    - GCQA of engineering development models, engineering models, production prototypes, production representative models and articles, production readiness models and articles, etc.
    - Authority to accept or reject minor RFVs, MRB proposals for UAI, and repair non-conformances (after the final PBL is established post-CDR)
    - Surveillance of the supplier's compliance to DFARS 252.242-7004, MMAS
    - Verification of Contractor and supply chain compliance with contractual SPIs for end item systems and spares
    - Verification of Contractor and supply chain compliance with SCD (FAR 42.11) requirements applied to the contract
    - Surveillance of manufacturing and quality processes, procedures, and Contractor program systems (e.g., Risk, Issue, and Opportunity Management System, Configuration Management System, FRACAS, FMECA processes, test and evaluation processes, etc.)
- Memorandum of Agreement (MOA) has been executed with manufacturing and quality inputs and implemented between with program and DCMA.

Tools

- DCMA Program Assessment Report

Resources

- DCMA-INST-204 Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning

- DCMA-INST-401, Industrial Analysis

C.2 DCMA Participation in Program Reviews

Manufacturing and Quality Tasks

- Manufacturing and quality requests DCMA support and participation in program reviews (e.g., IPRs, IPT meetings, etc.), including government only, to provide data on:
    - Contractor operations (performance and financial)
    - Supply chain operations (performance and financial)
    - Program goals and metrics
- Request DCMA input on ongoing manufacturing and quality Contractor and supply chain activities concerning:
    - Technical Performance Measures (TPMs)
        - Including CIs, CSIs, KCs, and critical characteristics
    - Design status
    - Manufacturing capabilities and capacities
    - Quality assurance processes and procedures (i.e., compliance to best practices)
    - EVMS processes, procedures, and data
    - Government Property Control (e.g., GFE, GFP, etc.)
    - Transportation, storage, and packaging processes and controls
    - Security (physical, cyber, and industrial)
    - System Safety
    - Plant safety, materials handling, hazardous waste disposal, etc.
    - Environmental and Energy compliance with applicable policies and statutes
    - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Configuration management processes and procedures
    - Software surveillance
    - Test planning, test equipment, and test results

Metrics

- Manufacturing and quality has requested DCMA participation in program reviews and DCMA is supporting and participating, providing data on:
    - Contractor operations (performance and financial)
    - Supply chain operations (performance and financial)
    - Program progress to goals
- DCMA is providing data on Contractor and supply chain manufacturing and quality activities for the following:

- TPMs
  - Including CIs, CSIs, KCs, and critical characteristics
- Design status
- Manufacturing capabilities and capacities
- Quality assurance processes and procedures (i.e., compliance to best practices)
- EVMS processes, procedures, and data
- Government Property Control (e.g., GFE, GFP, etc.)
- Transportation, storage, and packaging processes and controls
- Security (physical, cyber, and industrial)
- System Safety
- Plant safety, materials handling, hazardous waste disposal, etc.
- Environmental and Energy compliance with applicable policies and statutes
- Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
- Configuration management processes and procedures
- Software surveillance
- Test planning, test equipment, and test results

Tools

- DCMA Program Assessment Report

Resources

- DCMA-INST-204 Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-401, Industrial Analysis

C.3 Utilize DCMA Surveillance Capabilities for CDR

Manufacturing and Quality Tasks

- Utilize DCMA surveillance capabilities in monitoring, tracking, and reporting for Contractor and supply chain use and application of manufacturing and quality best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.).
- Utilize DCMA surveillance capabilities to monitor manufacturing and quality Failure Mode, Effects and Criticality Analysis (FMECA) contract requirements for Contractor and supply chain for:

- Identification of subsystems, items, components, characteristics and/or features, and processes, which if nonconforming, could result in a catastrophic or critical failure of the system:
  - Items and components will be designated as either a critical item (CI) or CSI
  - Product characteristics and/or features will be designated as either key characteristics (KCs) or critical characteristics
  - Processes will be designated as critical manufacturing processes (CMPs)
- Review of the FMECA and/or Critical Items List (CIL) for CIs, CSIs, KCs, and critical characteristics to specify the need for government surveillance of these items
- Verification of updates of FMEA/FMECA based on FRACAS and developmental testing results

- Utilize DCMA surveillance capabilities to monitor manufacturing and quality aspects of System Safety contract requirements including:
  - Review Safety Assessment Reports (SARs) and/or CIL for CIs, CSIs, KCs, and critical characteristics
- Utilize DCMA surveillance capabilities to monitor manufacturing and quality aspects of Test and Evaluation contract requirements for surveillance of Contractor's and supply chain's:
  - Physical Configuration Audits (PCAs) of the required sub-systems/components identified in the contract. Perform government surveillance, as required
  - Functional Configuration Audits (FCAs) of the required sub-systems/components identified in the contract. Perform government surveillance, as required
  - Developmental Testing for achievement of Critical Technology Elements (CTEs), KPPs, and KSAs
  - Software Testing, to include Software Acceptance Test (SAT)/Software Formal Qualification Test (SFQT), if conducted in the EMD phase
  - Environmental testing (e.g., Environmental Stress Screening (ESS), Highly Accelerated Life Testing (HALT), Highly Accelerated Stress Screen (HASS), Thermo-Cycling, Thermo-Shock, Pyrotechnic Shock, Vibration, etc.), if conducted
  - Live Fire Test and Evaluation), if applicable
  - Acceptance Testing
- Utilize DCMA surveillance capabilities to enhance manufacturing and quality monitoring of KPPs and KSAs progress and periodic review of TPMs.
- Utilize DCMA surveillance capabilities to monitor Contractor's and supply chain's manufacturing and quality FRACAS contract requirements including:
  - Government personnel attending FRACAS meetings, or review minutes, and adjusting Government surveillance based on FRACAS results, as required
  - Verifying Contractor and supply chain updates of FMEA/FMECA based on FRACAS result, when required

- Utilize DCMA surveillance capabilities to monitor manufacturing and quality contract requirements for Contractor and supply chain compliance to manufacturing and quality aspects of Systems Engineering best practices as specified in IEEE 15288.2.
- Utilize DCMA surveillance capabilities to monitor manufacturing and quality Risk, Issue and Opportunity (RIO) Management contract requirements.
- Utilize DCMA surveillance capabilities to monitor manufacturing and quality contract Parts Management requirements including:
    - Contractor's compliance to Parts Management contract requirements (i.e., MIL-STD-11991A)
    - Verification that Contractor and supply chain use parts and/or components in the design that are qualified under a government or Industry specifications or standards
    - Validation of Non-Standard Parts Approval Requests (NSPARs) made to the program office for approval in accordance with specified CDRLs, or DDF1423, that specifies what the supplier must provide as part of the NSPAR
- Utilize DCMA surveillance capabilities to monitor manufacturing and quality contract Configuration Management requirements including Contractor's and supply chain compliance to requirements (e.g., SAE/EIA649B, Service specific policies, etc.).
- Utilize DCMA surveillance capabilities to monitor manufacturing and quality contract Software Development, Quality Assurance, Configuration Management and Testing requirements including:
    - Contractor's and supply chain compliance to software development, quality assurance, configuration management and testing requirements
    - Contractor's progress in performance of Software Acceptance Testing (SAT)/Software Formal Qualification Testing (SFQT)

Metrics

- DCMA is monitoring, tracking, and reporting on Contractor and supply chain use and application of manufacturing and quality best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.) for CDR.
- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality FMECA contract requirements for CDR including:
    - Identification of subsystems, items, components, characteristics and/or features, and processes, which if nonconforming, could result in a catastrophic or critical failure of the system:
        - Items and components will be designated as either a CI or CSI
        - Product characteristics and/or features will be designated as either KCs or critical characteristics
        - Processes will be designated as CMPs

  - Review of the FMECA and/or CIL for CIs, CSIs, KCs, and critical characteristics to specify the need for government surveillance of these items
  - Verification of updates of FMEA/FMECA based on FRACAS and developmental testing results

- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality aspects of System Safety contract requirements for CDR including:
  - Review SARs and/or CIL for CIs, CSIs, KCs, and critical characteristics
- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality aspects of Test and Evaluation contract requirements for CDR including:
  - PCAs of the required sub-systems/components identified in the contract. Perform government surveillance, as required
  - FCAs of the required sub-systems/components identified in the contract. Perform government surveillance, as required
  - Developmental Testing for achievement of CTEs, KPPs, and KSAs
  - Software Testing, to include SAT/SFQT, if conducted in the EMD phase
  - Environmental testing (e.g., ESS, HALT, HASS, Thermo-Cycling, Thermo-Shock, Pyrotechnic Shock, Vibration, etc.), if conducted
  - LFT&E, if applicable
  - Acceptance Testing
- DCMA is monitoring, tracking, and reporting on manufacturing and quality aspects of KPPs and KSAs including progress and periodic reviews of TPMs for CDR.
- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality FRACAS contract requirements for CDR including:
  - Attending FRACAS meetings, or review minutes, and adjusting government surveillance based on FRACAS results, as required
  - Verifying Contractor and supply chain updates of FMEA/FMECA based on FRACAS result, when required
- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality aspects of Systems Engineering best practices as specified in IEEE 15288.2 for CDR.
- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality RIO Management contract requirements for CDR.
- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality Parts Management contract requirements (MIL-STD-11991A) for CDR including:
  - Verification that Contractor and supply chain use parts and/or components in the design that are qualified under a government or Industry specifications or standards

  - Validation of NSPARs made to the program office for approval in accordance with specified CDRLs, or DDF1423, that specifies what the supplier must provide as part of the NSPAR

- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality Configuration Management contract requirements (e.g., SAE/EIA649B, Service specific policies, etc.) for CDR.
- DCMA is monitoring, tracking, and reporting on Contractor and supply chain compliance to manufacturing and quality Software Development, Quality Assurance, Configuration Management and Testing contract requirements for CDR including:
  - Contractor's and supply chain compliance to software development, quality assurance, configuration management and testing requirements
  - Contractor's progress in performance of SAT/SFQT

Tools

- Critical Design Review Checklist

Resources

- Defense Acquisition Guide (DAG) Chapter 3-3.3.5 Critical Design Review
- AS6500, Manufacturing Management Program, Sep 2016
- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- IEEE 15288.2, System and Software Engineering, 2015
- DD 1423, Contract Data Requirements List
- ISO 9001, Quality Management System, Sep 2016
- MIL-STD-11991A General Standard for Parts, Materials, and Processes, Reinstated Aug 2015
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management
- SAE EIA 649B Configuration Management Standard

C.4 DCMA Contract Administration, Management, and Support Activities

Manufacturing and Quality Tasks

- Request the following manufacturing and quality support from the appropriate (local) Contract Administration Office (CAO)/Contract Management Office (CMO) in attending, monitoring, and reporting on Contractor reviews, performance, and meetings including:
  - Inputs from DMCA monitoring, tracking, and reporting on Contractor and supply chain manufacturing and quality activities and functions to meet contractual requirements as delineated in C.3
  - Interim Program Reviews (IPRs) including supply chain

  - Performance of Physical Progress Reviews (PPRs) in support of Program Progress Payments
  - Corrective Action Board (CAB) or similar meetings (e.g., quality, manufacturing, supply chain, engineering, and software issues, corrective actions, and dispositions)

- Request manufacturing and quality support from the appropriate (local) CAO/CMO in monitoring, tracking, reporting on Contractor performance and actions related to and including the following:
  - Estimates to Completion (EACs) as requested
  - Delivery delay notices to the customer
  - Performance Base Payment requests (validation and/or verification)
  - Support to customer priority delivery requests (DX rating)
  - Contractor and supply chain pilot lines
- Ensure manufacturing and quality provides inputs for updates to the Memorandum of Agreement (MOA) between the program and the government contract administration for necessary activities.

Metrics

- Manufacturing and quality has requested the appropriate DCMA CAO/CMO support in attendance, monitoring, and reporting on Contractor reviews, performance, and meetings including:
  - Contractor and supply chain manufacturing and quality performance to meet contractual requirements as delineated in C.3
  - Contractor and supply chain IPRs and results
  - PPRs in support of Contractor progress payments
  - CABs or similar meetings (e.g., quality, manufacturing, supply chain, engineering, and software issues, corrective actions, and dispositions)
- Manufacturing and quality has requested the appropriate DCMA CAO/CMO support in monitoring, tracking, reporting on Contractor performance and actions related to and including the following:
  - EACs
  - Delivery delay notices
  - Performance Base Payment requests (validation and/or verification)
  - Priority delivery requests (DX rating)
  - Results of Contractor and supply chain pilot lines
- Manufacturing and quality has provided inputs for updates to the MOA between the program and the government contract administration for changes based on fact-of-life program status.

Tools

- DCMA Pre-Award Survey System (PASS) review

Resources

- AS6500, Manufacturing Management Program, Sep 2016
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001, Quality Management System, 2015
- IEEE 15288.2, Systems and Software Engineering, 2015
- DD 1423, Contract Data Requirements List
- MIL-STD-11991A General Standard for Parts, Materials, and Processes, Reinstated Aug 2015
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management
- SAE EIA 649B Configuration Management Standard

C.5 Conduct Pre-Award Survey

Manufacturing and Quality Tasks

- Ensure manufacturing and quality provides inputs for the request to DCMA to conduct Pre-award Surveys of potential LRIP Contractor(s) (including their designated supply chain) for manufacturing and quality capabilities in the areas of:
    - Compliance to appropriate industry best practices (e.g., AS6500, AS9100, etc.)
    - Technical Performance including TPMs, CIs, CSIs, KCs, and critical characteristics
    - Design
    - Manufacturing capabilities and capacities
    - Quality assurance including processes and procedures compliance to best practices
    - EVMS processes, procedures, and data
    - Government Property management and control (e.g., GFE, GFP, etc.)
    - Transportation, storage, and packaging processes and controls
    - Security (physical, cyber, and industrial)
    - System Safety
    - Plant safety, materials handling, hazardous waste disposal, etc.
    - Environmental and Energy compliance with applicable policies and statutes
    - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Configuration management processes and procedures
    - Software surveillance
    - Test planning, test equipment, and test results

Metrics

- Manufacturing and quality has documented and provided inputs for the request Pre-award Surveys of potential LRIP Contractor(s) including the supply chain for:

- Compliance to appropriate industry best practices (e.g., AS6500, AS9100, etc.)
- Technical Performance including TPMs, CIs, CSIs, KCs, and critical characteristics
- Design
- Manufacturing capabilities and capacities
- Quality assurance including processes and procedures compliance to best practices
- EVMS data and performance
- Government Property management and control (e.g., GFE, GFP, etc.)
- Transportation, storage, and packaging processes and controls
- Security (physical, cyber, and industrial)
- System Safety
- Plant safety, materials handling, hazardous waste disposal, etc.
- Environmental and Energy compliance with applicable policies and statutes
- Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
- Configuration management processes and procedures
- Software surveillance
- Test planning, test equipment, and test results

Tools

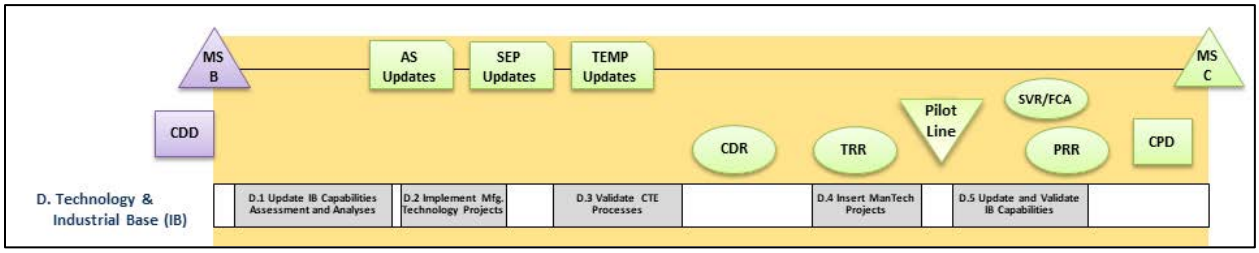
- SF 1404 Pre-award Survey – Technical
- SF 1405 Pre-award Survey – Production
- SF 1406 Pre-award Survey – Quality Assurance
- SF 1407 Pre-award Survey – Financial Capability
- DCMA Pre-Award Survey System (PASS) review

Resources

- Pre-Award Survey System (PASS) 2.0 (On-line)
- Pre-Award Survey System Users Guide (On-Line)
- AS6500, Manufacturing Management Program, Sep 2016
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001, Quality Management System, 2015
- IEEE 15288.2, Systems and Software Engineering, 2015
- DD 1423, Contract Data Requirements List
- MIL-STD-11991A General Standard for Parts, Materials, and Processes, Reinstated Aug 2015
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management
- SAE EIA 649B Configuration Management Standard

D. TECHNOLOGY AND INDUSTRIAL BASE

During the Engineering and Manufacturing Development (EMD) phase, Industrial Base (IB) readiness to support program objectives should be assessed to identify risks, issues, and opportunities. The Manufacturing and Quality Strategies, and subsequent inputs to the program Acquisition Strategy (AS), should highlight the strategy for assessing and mitigating any industrial and manufacturing risks. According to DODI 5000.02 Acquisition Strategies must consider Industrial Base capabilities at Milestones B and C, and provide an update to the Analysis of Alternatives (AoA) conducted in the MSA phase which included an assessment of manufacturing feasibility and required an assessment of the industrial base capabilities.



Policy requires an analysis of the capabilities of the National Technology and Industrial Base (NTIB) to support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal. Without this assessment, the program may find that the program cannot be accomplished within the defined cost and schedule thresholds as a result of incompatibilities between the system requirements and the NTIB available to support it.

Manufacturing risk resolution involves assessing risks through the formal technical reviews and in demonstrating the manufacturing capability and maturity. Manufacturing technology development needs to be accomplished in a phased approach to define and demonstrate capabilities. The TMRR developer should have demonstrated that the required advanced processes or material capabilities were achievable in a production relevant environment. The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing and transitioning advanced manufacturing technologies. These ManTech projects or other projects must be implemented in time to support production. The focus is on providing a reasonable expectation that the advanced manufacturing materials and processes, required in EMD and production, can be achieved.

A systematic process that assesses the maturity of Critical Technology Elements (CTEs) is a DODI 5000.02 requirement for all acquisition programs. In completing the development of a system or incremental capability, one of the key tasks is to mature Critical Manufacturing Processes (CMPs) associated with KCs (KCs), and therefore with CTEs. Manufacturing process demonstrations include affordable and executable manufacturing processes, system fabrication, production of prototypes and first articles that demonstrate system integration, interoperability, supportability, safety and utility. The focus of demonstrations is on risk reduction in a pilot line environment.

Based on funding, schedule, and implementation progress, ManTech projects should be updated and managed to achieve program objectives. Projects should address and reduce risks, improve manufacturing and quality processes, and improve cost and schedule performance. ManTech projects should be completed, integrated, and demonstrated on a pilot line at the appropriate Contractor and/or supply chain facilities.

A key manufacturing and quality focus should be on continually analyzing risks and identifying risk mitigation measures needed to sustain a reliable, technologically superior, affordable and resilient defense industrial base. DODI 5000.60 provides policy and identifies responsibilities for assessing defense industrial capabilities. These assessments ensure that the industrial capabilities needed to meet current and future national security requirements are available and affordable. The industrial base capability assessment will be used to use to determine if a specific industrial capability is required to meet DOD needs, and if any action should be taken to ensure the continued availability of the capability.

The effectiveness of actions or investments made in areas of manufacturing capability, obsolescence, fragility, capacity, and resilience to address manufacturing and quality Industrial Base risks to cost, schedule, performance should be assessed and validated. These results should be incorporated into the joint Risk, Issues, and Opportunity Management System in support of LRIP and Production and Deployment phase. Additionally, the updated manufacturing and quality inputs should be included in the Industrial Base Capabilities Considerations Summary Report for MS C.

D.1 Update Industrial Base Capabilities Assessment and Analyses

Manufacturing and Quality Tasks

- Maintain the relevance and applicability of the Industrial Base Capabilities Considerations analyses (from TMRR) of the national technology and industrial base to develop, produce, maintain, and support the program, including foreign dependency. The analyses should include the following components:
    - Relevant sources including identification of:
        - Unique manufacturing capabilities
        - Capabilities not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
        - Major systems and items available only from sources outside the national technology and industrial base
        - Alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base
        - Government and Contractor Depot and Maintenance and Repair Operations (as part of the Industrial Base)

- Vulnerabilities of and effect on the supply chain including sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
- Capability to produce using existing manufacturing capabilities and capacities while meeting quality, production rate and cost requirements
- Capability to protect program and system information and data (software and firmware) including system definition, design and test, contracting, and competitive prototyping
- Capability to protect industrial resources, materials, equipment, and control systems
- Capability and capacity to cost-effectively design, develop, produce, maintain, and support the system with tooling, production and test equipment, and operation, maintenance, and sustainment of systems
- Capability and capacity to meet rate and quantity changes that support a response to contingency and support objectives (surges and contractions)
- Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
- Potential obsolescence of components, parts, and materials
- Impacts of external dependencies and integration
- New and unique capabilities and processes
- Sources for key technologies, components, and processes, including known gaps and risks
- Technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact the program
- DCMA industrial analysis data and reports to include:
  - Industrial Capability Assessments
  - Appropriate Analytical Products
  - Defense Business and Economic Analysis
  - Acquisition Planning Support

- Update and maintain the relevance and applicability of manufacturing and quality inputs to the Industrial Base Capabilities Considerations Summary Report (from TMRR) and the AS and SEP:
  - Include recommended actions or investments that address risks to cost, schedule, performance, and qualitative considerations that define and recommend how and when the actions would be incorporated into the budget and schedule and, if possible, identify budget offsets
  - Ensure the report is finalized for MS C
    - Note: If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components and approved by the Under Secretary Of Defense For Acquisition, Technology, And Logistics per DOD 5000.60.

- Manufacturing and quality personnel will analyze, update, and maintain inputs to the joint Risk, Issues, and Opportunity Management System for Industrial Base capabilities and capacities throughout EMD and in support of LRIP and Production and Deployment.
    - Include manufacturing, re-manufacturing, and overhaul opportunities

Metrics

- Manufacturing and quality resources and personnel are designated to maintain the relevance and applicability of the Industrial Base Capabilities Considerations analyses of the national technology and industrial base.
- Components of the analyses to be maintained and documented for the AS and the SEP include:
    - Relevant sources that identify:
        - Unique manufacturing capabilities
        - Difficult to access or obtain capabilities (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
        - Major systems and items available only from “foreign” sources
        - Alternative “domestic” sources
        - Government and Contractor Depot and Maintenance and Repair Operations (as part of the Industrial Base)
    - Vulnerabilities and effects from sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
    - Capability of existing manufacturing capabilities and capacities
    - Capability to protect program and system information and data (software and firmware) including system definition, design and test, contracting, and competitive prototyping
    - Capability to protect industrial resources, materials, equipment, and control systems
    - Capability and capacity to cost-effectively design, develop, produce, maintain, and support the system with tooling, production and test equipment, and operation, maintenance, and sustainment of systems
    - Capability and capacity to meet rate and quantity changes (surges and contractions)
    - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment
    - Potential obsolescence of components, parts, and materials
    - External dependencies and integration
    - New and unique capabilities and processes
    - Sources for key technologies, components, and processes, including known gaps and risks
    - Technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact the program
    - Industrial analysis data and reports from DCMA

- Manufacturing and quality inputs to the Industrial Base Capabilities Considerations Summary Report have been updated for the AS and SEP and are being maintained for submission to the MS C decision.
    - Recommended actions or investments have been included to address risks to cost, schedule, performance, along with qualitative considerations that define and recommend how and when the actions should be incorporated into the budget and schedule with budget offsets
        - Note: If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components and approved by the Under Secretary Of Defense For Acquisition, Technology, And Logistics per DOD 5000.60.
- Manufacturing and quality have documented and are maintaining up-to-date inputs to the joint Risk, Issues, and Opportunity Management System for Industrial Base capabilities and capacities including support of LRIP and Production and Deployment.
    - These inputs include manufacturing, re-manufacturing, and overhaul opportunities

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- MRL Assessment Checklist for Technology and Industrial Base thread

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base
- DoDI 5000.02
- DODI 5000.60H Defense Industrial Capabilities Assessments
- MRL Deskbook Version 2016

D.2 Implement Manufacturing Technology Projects

Manufacturing and Quality Tasks

- Update program manufacturing technology plans, including approved and funded ManTech proposals, which should address:
    - Identified high-risk manufacturing process areas
    - Identified risks and issues with associated event-based mitigation plans
    - Identified manufacturing technology efforts to be funded other sources
    - Any new or emerging manufacturing technology gaps
    - Scheduled completion of manufacturing technology efforts to support program

  - Contractor/subcontractor participation in the project
  - Relevant data to support the plan (e.g., DCMA, Title III, etc.)
  - Review other program portfolios for potential alternatives/solutions (e.g., ManTech, Title III, IBAS, Technical Assistance Centers, NIST, etc.)

- Execute approved and funded manufacturing technology projects.
- Monitor and track progress of projects against the goals (e.g., process improvement, quality improvement, etc.)
- Monitor ongoing DoD/Service ManTech projects for potential applicability to program needs.

Metrics

- Approved manufacturing technology plans have been documented in the Manufacturing Plan and in the Risk, Issue, and Opportunity process, and funded ManTech proposals have been included in the budget that address:
  - High-risk manufacturing process areas
  - Event-based risk and issue mitigation planning and reduction
  - Manufacturing technology efforts funded by other sources
  - Any new or emerging manufacturing technology gaps
  - Completion of manufacturing technology efforts to support program schedule
  - Contractor/subcontractor participation in the project
  - Updated data to support the plan (e.g., DCMA, Title III, etc.)
  - Other program portfolios for potential alternatives/solutions (e.g., ManTech, Title III, IBAS, Technical Assistance Centers, NIST, etc.)
- Approved and funded manufacturing technology projects are executed and monitored to schedule and the risk burn-down plan.
- Progress of projects against the goals is reported at program reviews.
- Ongoing DoD/Service ManTech projects are being monitored on a recurring basis for potential applicability to program needs.

Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- MRL Assessment Checklist for Technology and Industrial Base thread
- TRL Assessment Checklist

Resources

- Defense Production Act, Title III
- DoDD 4200.15, ManTech
- DoDI 5000.02
- MRL Deskbook Version 2016

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- Technology Readiness Assessment Guidance, Apr 2011
- Service ManTech guidance, e.g. Air Force Technology and Transition Strategy Guidebook, Nov 2010

D.3 Validate Critical Technology Element (CTE) Processes

Manufacturing and Quality Tasks

- Update manufacturing and quality assessments to ensure all CTEs have been identified and all CTE risks and issues have been mitigated to acceptable levels.
    - Including integration, interdependencies, and associated risks and issues
    - Exceptions have mature alternative components or subsystems identified, approved, and budgeted
- Ensure all CTEs have been decomposed to specific manufacturing and quality processes.
    - Assess each manufacturing and quality processes for maturity (e.g., process capability, work instruction status, appropriate yield, etc.)
    - Validate CTEs for feasibility, affordability, and supportability

Metrics

- Manufacturing and quality assessments have been conducted to ensure all CTEs have been identified and the results documented for program management and systems engineering.
- All CTE manufacturing and quality risks and issues have been mitigated to acceptable levels, including integration and interdependencies and documented for the joint Risk, Issue, and Opportunity Management System.
    - Mature, approved, budgeted alternative components or subsystems have been included as required
- All CTEs have been decomposed and documented to specific manufacturing and quality processes.
    - Each manufacturing and quality process has been assessed and documented for its level of maturity (e.g., process capability, work instruction status, appropriate yield, etc.)
    - CTEs have been validated and documented for manufacturing and quality feasibility, affordability, and supportability in the Program Manufacturing Plan, and the Quality Plan

Tools

- MRL Assessment Checklist for Technology and Industrial Base thread
- Producibility Assessment Worksheet (PAWs)
- Technology Readiness Assessment
- TRL Calculator

Resources

- DoDI 5000.02, 5d(4)(b)3. And 5d(4)(c)
- Defense Acquisition Program Support Methodology, Ver. 3.0
- MRL Deskbook Version 2016
- NAVSO P-3687 Producibility Systems Guidelines, Dec 1999
- Technology Readiness Assessment Deskbook, Jul 2009

D.4 Insert Manufacturing Technology Projects

Manufacturing and Quality Tasks

- Update program manufacturing technology plans based on status (funding and schedule) and results of project, which should address:
    - Risk reduction manufacturing process areas
    - Improvements in manufacturing processes (cost and schedule)
    - Resulting quality improvements (e.g., C_{pk}s, yields, rates, etc.)
    - Other source manufacturing technology efforts (e.g., Title III, IBAS, Technical Assistance Centers, NIST, etc.)
    - Demonstrations of completed manufacturing technology projects to industry in the appropriate facility
    - Contractor/subcontractor level of participation in the project
    - Scheduled manufacturing technology project insertion at the Contractor/subcontractor facility
    - Relevant data collected to support insertion (e.g., DCMA, Title III, etc.)
- Manage manufacturing technology projects to plan.
- Conduct demonstrations of completed ManTech projects to industry in the appropriate facility.
- Implement, monitor, and track manufacturing technology projects at Contractor/ subcontractor facility for effectiveness and performance.
    - Demonstrate manufacturing technology development solutions in a production representative environment
    - Continue manufacturing technology efforts for validation on the Pilot Lines

Metrics

- Program manufacturing technology plans are implemented and being updated based on status and interim results from the project, which address:
    - Manufacturing process area risk reductions and issue resolutions
    - Manufacturing process improvements (with documented cost and schedule improvements)
    - Quality improvements (with documented improvements in C_{pk}s, yields, rates, etc.)

  - Results, impacts, and initiatives documented and adapted from other source manufacturing technology efforts (e.g., Title III, IBAS, Technical Assistance Centers, NIST, etc.)
  - Demonstrations to industry in the appropriate facility
  - Changes in Contractor/subcontractor level of participation in the project
  - Changes in manufacturing technology project insertion scheduling by the Contractor/subcontractor
  - Data collected to support insertion (e.g., DCMA, Title III, etc.)
- Report progress of manufacturing technology projects to plan at management reviews as required.
- Documentation of completed ManTech project industry demonstrations has been included in the Manufacturing Plan for implementation.
- Manufacturing technology projects have been implemented, are being monitored, and tracked at Contractor/ subcontractor facility with data being collected (e.g., cost, schedule, yield, rate, etc.) to document effectiveness and performance in a production representative environment.
- Data collection and documentation to support continuing manufacturing technology validation on the Pilot Lines is ongoing (e.g., cost, schedule, yield, rate, etc.).

Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- MRL Assessment Checklist for Technology and Industrial Base thread
- TRL Assessment Checklist

Resources

- Defense Production Act, Title III
- DoDD 4200.15, ManTech
- DoDI 5000.02,
- MRL Deskbook Version 2016
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- Technology Readiness Assessment Guidance, Apr 2011
- Service ManTech guidance, e.g. Air Force Technology and Transition Strategy Guidebook, Nov 2010

D.5 Update and Validate Industrial Base Capabilities

Manufacturing and Quality Tasks

- Update and validate prior Industrial Base Capability assessments based on CDR and Pilot Line demonstrations for program management and technical reviews (e.g., PRR, SVR, FCA, etc.) prior to LRIP for (See D.1) changes in:
    - Sources and alternatives
    - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
    - Vulnerabilities
        - Sole, single, foreign, etc.
        - Military
        - Counterfeit
        - Potential exploitation
        - Fragility and uncertainty of demand
    - Production capability and capacity
    - Security (threat physical and cyber)
    - Availability (e.g., materials, components, equipment, facilities, etc.)
    - LRIP required COTS and NDIs
    - External dependencies
    - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
    - Government and Contractor Depot and Maintenance and Repair Operations
- Incorporate into the update changes in manufacturing and quality maturity of new and unique capabilities and processes that are included in the system.
    - Include technological developments, market trends, processes, environmental factors, and policies, etc.
- As part of the update, include reporting and analyses from DCMA and DLA on relevant Industrial Base capabilities, status, and trends.
- Assess effectiveness of actions or investments made to address manufacturing and quality Industrial Base risks to cost, schedule, performance; areas that should have been included are:
    - Capabilities required throughout the life of the system
    - Product or technology obsolescence
    - Business fragility for unique services, products, or manufacturing and quality capabilities
    - Industrial Base resilience to rates, vulnerabilities, capacity,
    - Availability of system required materiel (e.g., materials, special alloys and composites, components, tooling, equipment, alternatives, etc.)
    - Maturation of new and unique capabilities

- Update the manufacturing and quality inputs to the joint Risk, Issues, and Opportunity Management System (to include mitigation status) for Industrial Base capabilities and capacities in support of LRIP and Production and Deployment phase.
- Update the manufacturing and quality inputs to the Industrial Base Capabilities Considerations Summary Report for Milestone (MS) C.

Metrics

- Industrial Base Capability assessments have been updated and validated by manufacturing and quality based on results from CDR and Pilot Line demonstrations and have been documented and provided to program management for technical reviews (e.g., PRR, SVR, FCA, etc.) for changes in:
  - Sources and alternatives
  - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
  - Vulnerabilities
    - Sole, single, foreign, etc.
    - Military
    - Counterfeit
    - Potential exploitation
    - Fragility and uncertainty of demand
  - Production capability and capacity
  - Security (threat physical and cyber)
  - Availability (e.g., materials, components, equipment, facilities, etc.)
  - LRIP required COTS and NDIs
  - External dependencies
  - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
  - Government and Contractor Depot and Maintenance and Repair Operations
- Changes in manufacturing and quality maturity of new and unique capabilities and processes that are included in the system have been incorporated and documented.
  - Including technological developments, market trends, processes, environmental factors, and policies, etc.
- Reporting and analyses from DCMA and DLA on relevant Industrial Base capabilities, status, and trends have been included in the manufacturing and quality updates to program planning.
- Actions and/or investments made to address manufacturing and quality Industrial Base risks to cost, schedule, performance have been assessed the results documented and include the following:
  - Capabilities required throughout the life of the system
  - Product or technology obsolescence

  - Business fragility for unique services, products, or manufacturing and quality capabilities
  - Industrial Base resilience to rates, vulnerabilities, capacity,
  - Availability of system required materiel (e.g., materials, special alloys and composites, components, tooling, equipment, alternatives, etc.)
  - Maturation of new and unique capabilities

- The joint Risk, Issues, and Opportunity Management System has been updated with manufacturing and quality inputs on Industrial Base capabilities and capacities in support of LRIP and Production and Deployment phase.
- Manufacturing and quality inputs to the Industrial Base Capabilities Considerations Summary Report for MS C have been documented and provided.

Tools

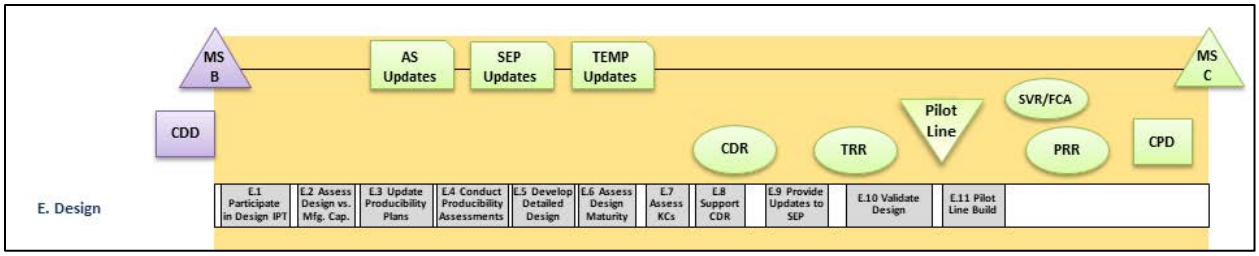
- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- MRL Assessment Checklist for Technology and Industrial Base thread

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base
- DoDI 5000.02
- DODI 5000.60H Defense Industrial Capabilities Assessments
- MRL Deskbook Version 2016

E. DESIGN

During the EMD phase, by CDR, all of the design information necessary to plan the detailed manufacturing operations for the system should be available. Manufacturing and quality participation early in the design process through active participation in the Design IPT is the key to creating a producible design. Participants should support and provide inputs on design trade studies (producibility, materials, IB capabilities, etc.), analyses, testing, configuration control, design reviews, etc. This information should be the basis for the Manufacturing Strategy and Plan and the Quality Strategy and Plan, which cover the issues of manufacturing and quality organization, make or buy planning, subcontract management, resources and capabilities, and the required detailed fabrication and assembly planning to include pilot line and ramp-up for LRIP. The Contractors' and supply chain manufacturing and quality capabilities should be assessed throughout the EMD phase as these capabilities will be required in this phase and must be in place for LRIP.



Producibility planning started during the concept exploration phase and has influenced the entire design effort from that point on. The objectives of producibility include both engineering design criteria and the producibility planning requirements. The program is required to "reduce manufacturing risk and demonstrate producibility" prior to full-rate production (per DoDD 5000.01). This requires producibility plans to be assessed and updated on a periodic basis and producibility activities to be monitored and assessed on a continuing basis. Additionally, producibility planning in EMD should address all areas of manufacturing and quality impacting cost, schedule, and performance requirements such as KCs (KCs), selection of specific materials, specific manufacturing and quality processes, changes in requirements, changes in workforce, facilities, tooling, equipment, etc.

Producibility assessments of the design should be conducted at the Contractor and in the supply chain using of a wide range of producibility tools, techniques, and procedures including Modeling and Simulation, Failure Mode and Effects Analyses (and Criticality), Design for Manufacture and Assembly, product and process capabilities with measurements utilizing Statistical Process Control, etc. Results of manufacturing and quality design producibility assessments should generate recommendations for design improvements to be integrated into the detailed system design and/or system specifications according to a joint government/ Contractor producibility schedule.

For EMD, in order to identify and obtain the required manufacturing and quality processes and resources, the design should be specified in detail. The final design (i.e., approved at CDR) results from performance requirements, outcomes of the testing accomplished, producibility studies, and other design influences related to cost, schedule, and performance. Prior to a system-level CDR, detailed design must be developed from the component level up to the system level with design reviews conducted to assure meeting design requirements and goals at all levels of the supply chain. Prior to release of drawings to manufacturing, the detailed design drawings, bills-of-material, and product and process specifications must be completed. Further, it is essential that assessments be conducted to ensure that the Contractor is complying with requirements and meeting cost/design goals.

Many system-level risks evolve from immature designs and failure to consider design risks. Risks associated with manufacturing and quality processes will have a major impact on the maturity of design. Manufacturing and quality must assess design maturity based on manufacturing feasibility, capability, producibility, and KCs, in accordance with industry best practices. Through support of all design reviews at all levels of the supply chain, the adequacy and completeness of manufacturing and

quality requirements verification and validation activities can be determined. Additional design maturity can be achieved through demonstrations of manufacturing and quality processes and procedures in a representative environment at the system, subsystem, item, and component level.

Manufacturing and quality program personnel should monitor and assess the maturity of KCs and critical characteristics, as well as the associated manufacturing and quality processes, and risk and issues mitigation activities. The correctness, adequacy, and completeness of key and critical processes for KCs and critical characteristics should be verified as part of this monitoring and assessment of maturity to include the closure of post-PDR manufacturing and quality mitigation measures.

As the design progresses from preliminary design to detailed design, the Design IPT must ensure that all design considerations are maturing on schedule for CDR and address all design risk contributors including trade studies, design policies, processes, and analyses, parts and materials selections, software design, testing, configuration control, and design reviews. The PDR and CDR are the systems engineering technical reviews that are used to measure design maturity. By CDR, the design should be mature, stable and with few engineering changes. Producibility is a best practice for ensuring that the design is producible and affordable.

Identification of KCs was initiated in the early phases of development, and the list of KCs should be continually updated and refined. In EMD phase, the list should matured to a final list of all KCs, corresponding to the finalized design at CDR. Prior to completing design, the list of KCs could be reduced through producibility activities as the product design is refined to make key characteristics less sensitive to variation. As the KCs are finalized, the corresponding list of critical manufacturing and quality processes should also be completed. Post-CDR activities, including pilot line, will provide the basis for validation and adequacy of the Contractor’s processes, capabilities, and control of KCs.

The role of manufacturing to influence the design culminates at CDR. Manufacturing and quality design decisions have major impact on future production and life-cycle costs. By the time the CDR is held the production and life-cycle costs commitment is approximately 90 percent. Therefore, manufacturing, quality, and other considerations must be finalized by CDR to enhance affordability. All key and critical manufacturing processes, including process control plans, should be defined, characterized, and up-to-date for the final detailed design. Government and contractor producibility analyses should identify manufacturing and quality risk and issues. The associated mitigation activities should be ongoing, up-to-date, and monitored in the joint government/contractor Risk, Issue, and Opportunity Management System for resolution prior to the Milestone C decision.

Programs prepare a SEP for each milestone review, beginning with Milestone A. It is intended to be a living document, tailored to the program, and a roadmap that defines comprehensive SE activities, addressing both government and Contractor technical activities and responsibilities. Additionally, the SEP describes the timing, conduct, entrance criteria, and success/exit criteria of technical reviews. A

well-managed, periodically maintained SEP should be updated post-CDR by manufacturing and quality to facilitate program success.

The Manufacturing and Quality Strategies should include assessments of the manufacturing and quality processes effective demonstrations in an appropriate environment, such as a pilot line environment, prior to Milestone C. These demonstrations on a pilot line should incorporate all key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce components, items, subsystems, or systems and validate meeting design requirements for low-rate production (LRIP). Manufacturing and quality processes and procedures required for production must be matured to a level of high confidence for LRIP in the P&D phase.

A successful pilot line build provides the means to validate that system design is complete and sufficiently stable to enter low-rate production. All materials, manpower, tooling, test equipment and facilities, STE/SIE, processes and procedures are proven on the pilot line, meeting the planned low-rate production schedule, and known manufacturing and quality risks are under control, posing no significant challenges. Outputs of the pilot line will produce articles subject to First Article Inspections (FAIs) and/or First Article Tests (FATs) and will provide validation of the design and that manufacturing and quality processes are under control and ready for LRIP.

E.1 Participate in Design IPT

Manufacturing and Quality Tasks

- Manufacturing and quality Design IPT participants assess and monitor continuing adherence to manufacturing and quality design best practices (e.g., AS6500, AS9100, ISO 9001, etc.).
- Update manufacturing and quality requirements based on analyses of system requirements and design concepts from TMRR developments and the PDR including:
    - System capabilities and constraints
    - The required manufacturing and quality capabilities baseline
    - Manufacturing and quality cost drivers and impact on schedule and performance
- Provide manufacturing and quality input to design trade studies (i.e., functional and performance requirements) that include criteria concerning:
    - KCs and the associated KPPs, KSAs, and APAs
    - Manufacturing and quality process capabilities, limitations, and concerns
    - Materials, components, and items sourcing (e.g., domestic vs. foreign risks)
    - Embedded software and firmware development and re-use
    - Use of intellectual property and proprietary data
    - Safety, handling, storage, and disposal considerations and restrictions
    - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
    - Manufacturing costs, materials, special tooling, and test equipment

- Manufacturing facility and equipment capacity, workforce availability and capability, and schedule impacts

- Manufacturing and quality participation in the design producibility process provides:
  - Analyses of products and processes that would benefit from producibility analyses (i.e., DFM/DFA)
  - Monitoring and reporting on producibility processes and testing with respect to risks, issues, and opportunities
  - Integration of producibility with other design activities including software and firmware development and re-use
  - Analyses and results of producibility design trade studies to include process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
  - Assessment of additional innovative manufacturing technology opportunities (beyond current ManTech projects)

- Provide a focal point for producibility assessments and integration with other design activities.
- Provide assessments of key and critical manufacturing and quality assembly and test processes to be evaluated and matured.
- Provide ongoing manufacturing and quality assessments of risks, issues, and opportunities (e.g., technologies, manufacturing, software development, and sustainment).
- Provide monitoring, reviews, analyses, and reports on multiple FMEAs (e.g., DFMEA, PFMEA, etc.) as part of the manufacturing and quality inputs to the FMECA process.
- For the Engineering and Manufacturing Development and demonstration process, manufacturing and quality participants should provide:
  - Inputs that establish, implement, and maintain appropriate processes to manage key and critical subsystems, components, and items including process controls for KCs
  - Criteria and metrics for design and production process verification, test, inspection, product verification and acceptance (including statistical techniques)
  - Monitoring and managing the data from the development process with acceptable frequency, quantity, and metrics
  - Criteria for and monitoring of manufacturing and quality development testing for validating design outputs (products)
  - Manufacturing and quality inputs for design configuration management (including verification, validation, and change control)

- Update the analyses of manufacturing and quality design activity impacts and interdependencies to other functional areas or activities (e.g., engineering, producibility, costs, safety, manpower, schedule, etc.).

- Perform re-assessments of manufacturing and quality risks, issues, and opportunities and the associated mitigation activities, based on the changes to and progress of the design, in meeting critical design entrance criteria (e.g., technology, manufacturing, cybersecurity, software development, and sustainment).
- Provide manufacturing and quality support to Design IPT participation in program reviews (e.g., PMRs, CDR, etc.).
- Assess and monitor the development of the system design for use of COTS, GOTS, GFP/GFE, and NDIs for impacts to manufacturing and quality, potential obsolescence requiring re-design and design changes, and sustainment (e.g., availability, storage, etc.)
- Provide updated manufacturing and quality inputs to program documentation (e.g., SEP, TEMP, AS, CDD, etc.) based on design changes and progress:
    - Include inputs and support for CPD efforts
    - Include inputs for Manufacturing Plan updates (including changes, investments, etc.)
- Manufacturing and quality participants should provide support to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.).
- Provide manufacturing and quality inputs to Program Management in support of assessments and reports mandated by Congress.
    - Inputs on **manufacturing and quality risks** associated with the program
    - Inputs on manufacturing and quality processes that **need to be matured**

Metrics

- Manufacturing and quality Design IPT participants have assessed and are monitoring continuing adherence to manufacturing and quality design best practices (e.g., AS6500, AS9100, ISO 9001, etc.) and providing documented recommendations to Program Management and the Contractor as appropriate.
- Manufacturing and quality requirements, based on analyses of system requirements and design concepts from TMRR developments and the PDR, have been updated for the SEP and included inputs on:
    - System capabilities and constraints
    - The required manufacturing and quality capabilities baseline
    - Cost drivers and impacts to schedule and performance
- Manufacturing and quality has participated in and provided documented inputs to design trade studies including criteria concerning:
    - KCs and the associated KPPs, KSAs, and APAs
    - Manufacturing and quality process capabilities, limitations, and concerns
    - Materials, components, and items sourcing (e.g., domestic vs. foreign risks)
    - Embedded software and firmware development and re-use
    - Use of intellectual property and proprietary data
    - Safety, handling, storage, and disposal considerations and restrictions

  - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
  - Manufacturing costs, materials, special tooling, and test equipment
  - Manufacturing facility and equipment capacity, workforce availability and capability, and schedule impacts

- Manufacturing and quality participants in the design producibility process have provided:
  - Reports to Program Management and the Contractor with recommendations of products and processes that require producibility analyses performed
  - Monitoring, reporting, and status of mitigation of risks and issues, and progress on opportunities from producibility processes and testing
  - Analyses and documentation of the integration of producibility with other design activities (including software and firmware development and re-use)
  - Documentation of producibility design trade studies results and impacts, including process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
  - Analyses and recommendations for addition of new innovative manufacturing technology opportunities (beyond current ManTech projects)
- Documentation has been provided for producibility assessments and integration with other design activities to Program Management and Systems Engineering.
- Key and critical manufacturing and quality assembly and test processes have been assessed for maturity with documented recommendations to finalize and implement in the Manufacturing Plan and potentially the SEP.
- Manufacturing and quality participants have provided monitoring and reports on manufacturing and quality risks and issues mitigation status (burn-down), and opportunity activities progress.
- As part of the manufacturing and quality inputs to the FMECA process, reports on reviews, analyses, and status of multiple FMEAs (e.g., DFMEA, PFMEA, etc.) have been provided to Program Management and System Engineering.
- Manufacturing and quality participants have provided and documented in the Manufacturing Plan for EMD and the demonstration process:
  - Inputs that establish, implement, and maintain appropriate processes to manage key and critical subsystems, components, and items including process controls for KCs
  - Criteria and metrics for design and production process verification, test, inspection, product verification and acceptance (including statistical techniques)
  - Future processes to monitor and manage data with acceptable frequency, quantity, and metrics based on ongoing monitoring and management activities
  - Criteria for manufacturing and quality development testing to validate the design
  - Manufacturing and quality inputs for design configuration management

- Analyses of manufacturing and quality design activity impacts and interdependencies to other functional areas or activities (e.g., engineering, producibility, costs, safety, manpower, schedule, etc.) have been updated and documented in the SEP and in the IMP/IMS.
- Based on design changes and progress in meeting critical design entrance criteria, re-assessments of manufacturing and quality risks, issues, and opportunities and the associated mitigation activities have been performed and documented for the joint RIO Management System.
- Manufacturing and quality Design IPT participants have provided support and documentation to program reviews (e.g., PMRs, CDR, etc.).
- The use of COTS, GOTS, GFP/GFE, and NDIs in the system design has been assessed and documented for impacts to manufacturing and quality as well as potential obsolescence requiring re-design and design changes and impacts on sustainment (e.g., availability, storage, etc.).
- Updated manufacturing and quality inputs have been provided to program documentation (e.g., SEP, TEMP, AS, CDD, etc.) based on design changes and progress including:
    - Inputs and support for CPD efforts
    - Inputs for Manufacturing Plan updates (including changes, investments, etc.)
- Manufacturing and quality participants have provided support and documentation (inputs) to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.).
- Manufacturing and quality has provided inputs to Program Management in support of Congressionally mandated assessments and reports including inputs on:
    - Manufacturing and quality risks associated with the program
    - Manufacturing and quality processes that **need to be matured**

Tools

- Design for Manufacturing and Assembly (DFMA)
- CDR checklist
- TRR Checklist
- TRA checklist
- MRL assessment checklist, Design thread
- PRR Checklist
- SVR Checklist
- FCA Checklist
- SEP template
- TEMP template
- Life Cycle Sustainment Plan template
- IMP/IMS template
- CPD template

Resources

- 10 USC 144B, Sec 2366 and 2448
- Acquisition Strategy Guide, DSMC, Dec 1999
- Systems Engineering Plan Preparation Guide, Apr 2011
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- TEMP Guide, Dec 2012 and DAG Chapter 8-4.1
- LCSP memo, Sep, 2011 and DAG Chapter 4-3.1
- CDD-CPD writing Guide, Feb 2015
- Critical Design Review, DAG Chapter 3-3.3.5
- Test and Evaluation Management Guide
- System Verification Review, DAG Chapter 3-3.3.6
- Functional Configuration Audit, DAG Chapter 3-3.3.6
- Production Readiness Review, DAG Chapter 3-3.3.7
- TRA Guidance 2011
- MRL Deskbook version 2016

E.2 Assess Design vs. Manufacturing Capability

Manufacturing and Quality Tasks

- Perform manufacturing and quality design trade studies and analyses on system, subsystems, items, and components for:
    - Interdependencies and interfaces
    - Design for Assembly
    - Manufacturing and quality “ilities”: maintainability, serviceability, testability, etc.
- Perform manufacturing and quality assessments of the Contractor(s) and supply chain capability to mature and manufacture the design(s) within the program overall cost, schedule, and performance goals, including:
    - Design status and progress for CDR including exit criteria
    - Quantification of risks, issues, opportunities and status of mitigation plans
        - Including shortfalls to the required baseline manufacturing and quality capability
        - Including materials, producibility, equipment, and schedule (e.g., availability, hazardous, long-lead, etc.)
    - All competing technologies, prototypes, systems, etc.
        - Including manufacturing and quality inputs to production unit cost and schedule estimates realism
    - Manufacturing and quality processes and techniques, not yet part of the Contractor’s baseline, development requirements driven by the design, including:

        - Facilities, equipment, manpower, quality technologies,
        - Planned and/or anticipated manufacturing and quality developmental testing and demonstration efforts
        - Capabilities with respect to safety, security, environmental, hazardous materials, etc.

- Update the preliminary list from TMRR of KCs, critical characteristics, CAIs, Key manufacturing and quality processes, and CSIs, based on design trade studies and assessments, and PDR results.
- Assess required manufacturing and quality budget and investments for necessary capabilities (e.g., facilities, capital equipment, tooling, test equipment, ManTech, GFE processes, M&S, etc.)

Metrics

- Manufacturing and quality design trade studies and analyses have been conducted and documented for system, subsystems, items, and components including:
    - Interdependencies and interfaces
    - Design for Assembly
    - Manufacturing and quality "ilities", maintainability, serviceability, testability, etc.
- Assessments of the Contractor(s) and supply chain capability to mature the manufacturing and quality aspects and manufacture the design(s) within the program overall cost, schedule, and performance goals have been conducted and recommendations for changes have been documented and provided to the Design IPT, including:
    - Recommendations for achieving CDR exit criteria (See E.7)
    - Updated and quantified risks and issues mitigation plans, and potential opportunities which address:
        - Shortfalls to the required baseline manufacturing and quality capability
        - Materials, producibility, equipment, and schedule (e.g., availability, hazardous, long-lead, etc.)
    - Recommendations for each competing technology, prototype, system, etc. which include inputs to production unit cost and schedule estimates realism
    - Recommendations on manufacturing and quality processes and techniques that are not yet part of the Contractor's baseline but are driven by the design, including:
        - Facilities, equipment, manpower, quality technologies,
        - Planned and/or anticipated manufacturing and quality developmental testing and demonstration efforts
        - Capabilities with respect to safety, security, environmental, hazardous materials, etc.
- Based on the design trade studies and assessments, and the PDR results, the preliminary list from TMRR of KCs, critical characteristics, CAIs, Key manufacturing and quality processes, and CSIs has been updated and provided to the Design IPT and System Engineering IPT, and recommendations provided for the Contractor(s) SEMP.

- Manufacturing and quality budget and investments have been documented and provided to Program Management for necessary capabilities (e.g., facilities, capital equipment, tooling, test equipment, ManTech, GFE processes, M&S, etc.).

Tools

- Design for Manufacturing and Assembly (DFMA)
- CDR checklist
- TRR Checklist
- TRA checklist
- MRL assessment checklist, Design thread
- PRR Checklist
- SVR Checklist
- FCA Checklist
- SEP template
- TEMP template
- Life Cycle Sustainment Plan template
- IMP/IMS template
- CPD template

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- DoDI 5000.02
- 10 USC 144B, Sec 2366 and 2448
- Acquisition Strategy Guide, DSMC, Dec 1999
- Systems Engineering Plan Preparation Guide, Apr 2011
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- TEMP Guide, Dec 2012 and DAG Chapter 8-4.1
- LCSP memo, Sep, 2011 and DAG Chapter 4-3.1
- CDD-CPD writing Guide, Feb 2015
- Critical Design Review, DAG Chapter 3-3.3.5
- Test and Evaluation Management Guide
- System Verification Review, DAG Chapter 3-3.3.6
- Functional Configuration Audit, DAG Chapter 3-3.3.6
- Production Readiness Review, DAG Chapter 3-3.3.7
- TRA Guidance 2011
- MRL Deskbook version 2016

E.3 Update Producibility Plans

Manufacturing and Quality Tasks

- Review and analyze the Contractor(s) design plans for scope, realism, completeness, and clarity of specific processes, methods, and actions to address manufacturing feasibility, producibility, and quality to include:
  - A schedule for regular reviews to monitor and support design progress
  - Delineation of responsibilities and management controls
  - Application of producibility design criteria
  - Interdependencies and integration factors
  - Manufacturing and quality technology project insertion
  - Technology insertion opportunities, schedule, and budget
- Ensure updates to Contractor producibility plans for identified and potential manufacturing and quality risks, issues, and opportunities to include:
  - KCs and critical design characteristics
  - Modeling and Simulation results from design, manufacturing, and production modeling
  - Manufacturing and quality processes, capacity, capability, yield, rates, and variability
  - Materials and components (including embedded software)
  - Cost, schedule, and performance
  - Facilities, tooling, testing, and qualification
  - Workforce
- Ensure updated Contractor producibility plans for design, manufacturing, and quality include:
  - Security (physical and cyber)
  - System safety and hazardous materials management criteria
  - Interdependencies and integration
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
  - Benchmarking
  - Costing
  - Management of manufacturing and quality data
  - Results of Failure Mode and Effects Analysis (FMEA)
    - Design Failure Mode and Effects Criticality Analysis (DFMECA)
    - System Failure Mode and Effects Criticality Analysis (SFMECA)
    - Process Failure Mode and Effects Analysis (PFMEA)
  - Results from prototype builds and demos
- Evaluate updated Contractor producibility plans for the specific applications of producibility design tools such as:
  - Failure Mode and Effects Analyses (including Design, Process, and Criticality)
  - Design of Experiments (DOE)

- Quality Functions Deployment (QFD)
- Root Cause Analyses
- Statistical Process Control (SPC)
- Tolerance Analyses
- Design for Manufacture/Assembly (DFMA)
- Design for Six Sigma
- Lean manufacturing
- Triz
- Etc.

- Manufacturing and quality personnel should evaluate Contractor's design producibility process for factors such as:
  - Robust tolerances (dimensions, mechanical, electrical)
  - Materials that provide optimum machinability, formability and weldability
  - Economic use of shapes and forms designs for castings, stampings, extrusions, etc.
  - Optimum inspection and test requirements
  - Use of available and standard inspection equipment
  - Economical methods and procedures
  - Optimized requirements for manufacturing tooling and/or special skills

Metrics

- Assessment and review of Contractor's ongoing producibility enhancement efforts documents cost and/or schedule improvements.
- Contractor(s) design plans have been evaluated for scope, realism, completeness, and clarity with respect to specific processes, methods, and actions that address manufacturing feasibility, producibility, and quality. Recommendations for and required actions or additions to the plans have been provided to Program Management and the Contractor. Documented Contractor plans should have included:
  - A schedule of regular reviews to monitoring and supporting design progress
  - Roles, responsibilities, and management controls
  - Producibility design criteria
  - Management of interdependencies and integration factors
  - Insertion points for manufacturing and quality technology projects
  - Schedule and budget for technology insertions

- Updates to the Contractor producibility plans have been identified and documented recommendations provided to Program Management and the Contractor for the following:
    - Updates to KCs and critical design characteristics
    - Results from design, manufacturing, and production modeling (i.e., M&S)
  - Changes in manufacturing and quality processes, capacity, capability, yield, rates, and variability
    - Changes in materials and components (including embedded software)

    - Updates to cost, schedule, and performance
    - Facilities, tooling, testing, and qualification updates
    - Workforce changes (e.g., skill sets, availability, training, turnover, etc.)

- Documented Contractor producibility plans have been reviewed and approved, and should include the following design, manufacturing, and quality considerations:
    - Security (physical and cyber)
    - System safety and hazardous materials management criteria
    - Interdependencies and integration
    - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
    - Benchmarking
    - Costing
    - Management of manufacturing and quality data
    - Results of Failure Mode and Effects Analysis (FMEA)
        - Design Failure Mode and Effects Criticality Analysis (DFMECA)
        - System Failure Mode and Effects Criticality Analysis (SFMECA)
        - Process Failure Mode and Effects Analysis (PFMEA)
    - Results from prototype builds and demos
- Updated Contractor producibility plans for use of specific design tools have been evaluated and analyses performed and documented to indicate expected results.
- Contractor's design producibility process has been evaluated and reported to Program Management, and should include producibility best practices of:
    - Robust tolerances (dimensions, mechanical, electrical)
    - Materials that provide optimum machinability, formability and weldability
    - Economic use of shapes and forms designs for castings, stampings, extrusions, etc.
    - Optimum inspection and test requirements
    - Use of available and standard inspection equipment
    - Economical methods and procedures
    - Optimized requirements for manufacturing tooling and/or special skills

Tools

- Producibility Engineering and Planning (PEP) Data Item Description

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- IEEE 15288.2, System and Software Engineering, 2015
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999
- MIL-HDBK-727, Design Guidance for Producibility, Apr 1984
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center, Sep 1993

- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning (PEP)

E.4 Conduct Producibility Assessments

Manufacturing and Quality Tasks

- Manufacturing and quality Design IPT participants support and/or perform producibility assessments utilizing updated and approved Contractor producibility plans and other Contractor and/or programmatic information and data including the following factors in the assessments:
  - Planned producibility goals and metrics
  - Management roles, responsibilities, and controls
  - Updates to KCs and critical design characteristics
  - Contractor core capabilities and processes (e.g., manufacturing and quality technologies, design and process disciplines, etc.)
  - Design analyses and testing (i.e., prototypes)
  - Results from design, manufacturing, and production modeling (i.e., M&S)
  - Changes in manufacturing and quality processes, capacity, capability, yield, rates, and variability
  - Changes in materials and components (including embedded software)
  - Build and test data (from subsystem, items, components, and/or the supply chain)
  - Updates to cost, schedule, and performance
  - Updates to interdependencies and integration
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
  - Risks, issues, and opportunities
  - Insertion points for manufacturing and quality technology projects
  - Technology insertion schedule and budget
  - Review of goals, realism, completeness, and clarity
  - Implementation of industry best practices, tools, and techniques
  - System safety design and hazardous materials management criteria
  - Security (physical and cyber) including all digital communications and connectivity for design, facilities, equipment, etc.
  - Facilities, tooling, testing, and qualification updates
  - Workforce changes (e.g., skill sets, availability, training, turnover, etc.)
  - GFE, etc.
- Incorporate and investigate producibility possibilities that exist in the industrial base outside the Contractor's supply chain from the assessments of the IB. (See D.1)
- Manufacturing and quality Design IPT participants monitor, recommend, and support use of a wide range of producibility tools, techniques, procedures that include:

- State of the art Modeling and Simulation software including element analyses software packages
- Failure Mode and Effects Analyses (FMEA)
  - Design Failure Mode and Effects Criticality Analysis (DFMECA)
  - System Failure Mode and Effects Criticality Analysis (SFMECA)
  - Process Failure Mode and Effects Analysis (PFMEA)
- Design for Manufacture and Assembly (DFMA)
- Design of Experiments (DOE)
- Design for Six Sigma (DSS)
- Quality Function Deployment (QFD)
- Value Stream Mapping (VSM)
- Benchmarking
- Materials and process design guides (e.g., standards organizations, materials supplier, industry association, etc.)
- Interdependencies and integration analyses
- Tolerance analyses (e.g., stacking, robustness, geometric, etc.)
- Requirements validation analyses
- Trade studies on alternative product and process designs
- Product complexity analyses
- Manufacturing process analyses (i.e., Lean Manufacturing)
- Quality and quality process analyses
- Costs, cost drivers, and controls analyses
- Materials characterization and availability
- Prototyping of component, item, subsystem, competitive, etc.
- Learning curve goals and projections
- Product, process capabilities, and measurements utilizing Statistical Process Control (SPC)
- Data and database management
- Developmental testing

- Provide program manufacturing and quality support to design producibility analyses, in order to validate and recommend appropriate producibility improvements (by rank and/or priority) to be implemented in the system design and/or specifications.
- Prepare a joint government/Contractor schedule for implementation of the producibility improvements based determined rank and priority.

Metrics

- Manufacturing and quality Design Integrated Product Team (IPT) participants have provided support and/or performed producibility assessments utilizing updated and approved Contractor producibility plans and other Contractor and/or programmatic information and data. Documented assessment results have been analyzed for potential design improvements (and possible ECPs) and include the following:

- Status and progress toward producibility goals and metrics
- Changes in management roles, responsibilities, and controls
- Improved control of KCs and critical design characteristics
- Incorporation of Contractor core capabilities and processes (e.g., manufacturing and quality technologies, design and process disciplines, etc.)
- Design analyses and testing results (i.e., prototypes)
- Improvements from design, manufacturing, and production modeling (i.e., M&S)
- Improvements in manufacturing and quality processes, capacity, capability, yield, rates, and variability
- Improvements in materials and components (including embedded software)
- Analyses of build and test data (from subsystem, items, components, and/or the supply chain)
- Improvements to cost, schedule, and performance
- Reduction of interdependencies and integration considerations
- Inclusion of MOSA interfaces and subsystems
- Risks and issues mitigation, and opportunity planning
- Scheduled insertion points for manufacturing and quality technology projects
- Scheduled technology insertion
- Review of goals, realism, completeness, and clarity or the design improvements
- Industry best practices, tools, and techniques
- Criteria for System safety design and hazardous materials management
- Improvements in security (physical and cyber) including all digital communications and connectivity for design, facilities, equipment, etc.
- Updates to facilities, tooling, testing, and qualifications
- Workforce improvements (e.g., skill sets, availability, training, turnover, etc.)
- Updates for use of GFE, etc.

- Producibility possibilities in the industrial base outside the Contractor's supply chain have been analyzed and recommended for implementation. (See D.1)
- Manufacturing and quality Design IPT participants track and document results and effectiveness of the wide range of producibility tools, techniques, procedures applied during system design. Documented reports should include:

  - Lessons learned for further application within the program and future programs
  - Updates to learning curves (goals and projections)
  - Analyses of effectiveness and realism Modeling and Simulations utilized for both the system models and the manufacturing models
  - Recommended mitigations for both system and manufacturing risks identified from FMEAs
  - Design changes and improvements to product complexity, manufacturing and quality processes, and process capabilities recommended by results from application of DOE, DFMA, DSS, VSM, and Lean Manufacturing

  - QFD analyses ranking and validating the requirements and the subsequent impacts on the design
  - Comparisons of system, subsystems, items and components designs to existing or under-development products (benchmarking) with appropriate data collection and recommendations for program actions
  - Analyses of system, subsystem, items, and components against design guides (e.g., standards organizations, materials supplier, industry association, etc.) and recommendations for design improvements
  - Analyses and impacts of interdependencies and integration down to the component level
  - Results and recommendations from tolerance analyses (e.g., stacking, robustness, geometric, etc.)
  - Results from trade studies on alternative product and process designs with recommendations
  - Results from analyses of materials characterization and availability with recommended actions or improvements
  - Results from developmental testing and prototyping of component, item, subsystem, competitive, etc.
  - Summary of impacts and improvements to costs, cost drivers, schedule and performance
- Manufacturing and quality support to design producibility assessments and analyses has produced a report that validates and recommends appropriate producibility improvements by rank and/or priority to be implemented in the system design and/or specifications.
- A joint government/contractor implementation schedule for producibility improvements has been developed based determined rank and priority.

Tools

- Producibility Assessment Worksheet

Resources

- AS6500, Manufacturing Management Program, Sep 2016
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- IEEE 15288.2, System and Software Engineering, 2015
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999
- MIL-HDBK-727, Design Guidance for Producibility, Apr 1984
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center, Sep 1993

E.5 Develop Detailed Design

Manufacturing and Quality Tasks

- Support and participate in design reviews at all possible levels of the supply chain to assure that the Contractor is complying with the manufacturing and quality design requirements within the cost/design goals to include:
    - Adherence to manufacturing and quality best practices (e.g., AS6500, AS9100, ISO 9001, etc.)
    - Ensure all PDR action items are closed and corrective actions completed.
    - Results of appropriate producibility studies including manufacturing technology improvements, recommended design changes, and recommended facilities and equipment changes
    - Results of ManTech projects
    - Detailed design drawings, bills-of-material, and product and process specifications are on track for completion by CDR
    - Performance requirements, the outcomes of the testing accomplished, producibility studies, and other design influences are part of the final design
    - Design is specified to the lowest level of detail to meet capability and capacity requirements
- As part of detailed design activities, manufacturing and quality should identify and quantify risks with associated mitigation (e.g., re-direct, re-design, etc.) to minimize manufacturing and quality risks in the completed design for CDR.
- As part of detailed design, ensure KCs whose variation has a significant influence on product fit, performance, service life, or manufacturability are specified and monitored for CDR.
- Manufacturing and quality should identify requirements for in-process and acceptance testing to be included in manufacturing and quality processes.
- Ensure manufacturing and quality requirements for physical, digital, and industrial security are in compliance with DoD policies and NIST standards incorporated into the design and manufacturing system.
- Ensure that required manufacturing and quality products and processes comply with specified security (e.g., SSE, COMSEC, and PPP) requirements of the program including trusted production of products down to the component level.
- Assess requirements for required system certifications (e.g., statutory, safety, environmental, airworthiness, others as required) and the impacts on manufacturing and quality requirements and associated costs, budget, schedule, etc.
- Assess design requirements for the following (include associated costs, budget, schedule, etc.):
    - Incorporation of all ESOH, environmental, hazardous material, etc. requirements into the detailed design

- EMI requirements and constraints for the design, control processes, procedures, and planned facilities and equipment (including EMI susceptibility)
- Radiation hardening, thermal, vibration, and shock environments, all environmental parameters, and Highly Accelerated Life Testing (HALT) requirements for impacts to and requirements of manufacturing and quality (e.g., facilities, tooling, equipment, test equipment and facilities, processes, procedures, storage, waste disposal, etc.)
- Impacts to and requirements of manufacturing and quality personnel (e.g., operators, assemblers, welders, platers, coatings specialists, etc.)
- Corrosion, contamination, hazards, hazardous combinations of materials, and impacts on manufacturing processes, quality control processes, and procedures for both
- Impacts on manufacturing and quality data requirements (e.g., collection, processing, storage, security, access, availability, etc.)
- Impacts to manufacturing and quality from materials, components, and items maturity and availability; lead-times; source availability, capability and capacity to include the supply chain
- Necessary manufacturing and quality equipment, fixtures, tooling, work-holding, parts interim storage and handling equipment, ancillary equipment, etc.

- Assess the adequacy of manufacturing and quality sustainment requirements (e.g., maintainability, serviceability, etc.), processes, and activities being considered and addressed in the design specifications.
- Assess Contractor's and supplier's configuration management systems for traceability, accuracy, sufficiency, and accessibility in preparation for CDR.
- As the system, subsystem, items, and components are being specified, analyze these to ensure manufacturing and quality constraints and requirements have been incorporated into design specifications and requirements.
- Analyze results of demonstrations in a relevant environment from the previous phases of all new technologies to be incorporated into the design to ensure they can be incorporated and integrated into a system with acceptable manufacturing and quality risks.
  - If not conducted, recommend demonstrations prior to CDR.
- Assess manufacturing and quality physical architectures, development specifications, and detailed designs for key manufacturing processes (i.e., KCs), CSIs and CAIs to be under Contractor's configuration control and on track for completion by CDR.
- Ensure all long lead production requirements are identified for CDR.
- Assess the system design for parts, materials, and processes to ensure appropriate allocation of manufacturing and quality requirements in the detailed design.
- Based on the results of the detailed design development activities, manufacturing and quality should provide updated inputs to the program Work Breakdown Structure (WBS).
- Prior to finalizing the design for CDR, manufacturing and quality should assess: (See E.8)
  - Results of all design trade studies for manufacturing and quality impacts and changes to KCs and therefore associated KPPs to verify that all requirements are being met

- Bi-directional traceability among all manufacturing and quality considerations:
  - Allocated and physical requirements
  - Engineering trade study results
  - Technical, schedule and cost risks, issues, and opportunities

Metrics

- Manufacturing and quality are active participants and support all design reviews at all possible levels of the supply chain and have documented Contractor compliance to the manufacturing and quality design requirements and are within the manufacturing and quality cost and/or design goals to include:
  - Adherence to manufacturing and quality best practices (e.g., AS6500, AS9100, ISO 9001, etc.)
  - Closure of all PDR action items and corrective actions
  - Results of manufacturing technology improvements, design changes, and facilities and equipment changes
  - ManTech projects implementations
  - Updated design drawings, bills-of-material, and product and process specifications on track for completion by CDR
  - Performance requirements, the outcomes testing, producibility studies, and other design influences are part of the final design
  - Design specifications to the lowest level of detail to meet capability and capacity requirements
- Manufacturing and quality has identified, quantified, and documented risks with associated mitigation to be at an acceptable level (i.e., minimized manufacturing and quality risks) in the completed design for CDR.
- KCs have been specified and documented in the manufacturing and quality plan, and are being tracked and monitored for CDR with risks and issues mitigation plans in place.
- Manufacturing and quality have identified and documented requirements for in-process and acceptance testing and have included these in the manufacturing and quality plans.
- Manufacturing and quality requirements for physical, digital, and industrial security have been documented to be in compliance with DoD policies and NIST standards.
- Manufacturing and quality products and processes including trusted production of products down to the component level have been documented to be in compliance with specified security requirements of the program (e.g., SSE, COMSEC, and PPP).
- Requirements for system certifications (e.g., statutory, safety, environmental, airworthiness, others as required) and the impacts on manufacturing and quality have been documented in the SEP with associated costs, budget, schedule, etc. in appropriated program documentation (e.g., IMP/IMS, etc.).
- Design with associated costs, budget, schedule, etc. has been analyzed and documents the following manufacturing and quality requirements:

- ESOH, environmental, hazardous material, etc.
- EMI consideration and constraints including control processes, procedures, and planned facilities and equipment
- Radiation hardening, thermal, vibration, and shock environments, all environmental parameters, and HALT
- Corrosion, contamination, hazards, hazardous combinations of materials
- Data collection, processing, storage, security, access, availability, etc.
- Materials, components, and items maturity and availability; lead-times; source availability, capability and capacity to include the supply chain
- Manufacturing and quality facilities, tooling, test equipment and facilities, processes, procedures, storage, waste disposal, etc.
- Item and component equipment, fixtures, work-holding, parts interim storage and handling equipment, ancillary equipment, etc.
- Manufacturing and quality workforce (e.g., operators, assemblers, welders, platers, coatings specialists, etc.)
- Manufacturing processes, quality control processes, and procedures for both

- Manufacturing and quality requirements for sustainment (e.g., maintainability, serviceability, etc.) and sustainment processes and activities have been documented and provided for the LCSP.
- Contractor's and supplier's configuration management systems have been assessed and documented to be in compliance with manufacturing and quality contractual requirements for traceability, accuracy, sufficiency, and accessibility in preparation for CDR.
- Manufacturing and quality constraints and requirements have been incorporated and documented in the design specifications and requirements for the system, subsystem, items, and components.
- Recommended demonstrations in a relevant environment have been conducted for all new technologies to be incorporated and integrated into the system and document an acceptable level of manufacturing and quality risks.
- Physical architectures, development specifications, and detailed designs have been assessed for key manufacturing processes (i.e., KCs), CSIs and CAIs and are under Contractor's configuration control and are on track for completion by CDR.
- All long lead production requirements have been identified and documented in preparation for CDR.
- System design for parts, materials, and processes with the appropriate manufacturing and quality requirements allocation for the detailed design are being documented in in the configuration management system and the requirements tracking system (i.e., DOORS) and are on schedule for completion by CDR.
- Results of all design trade studies for manufacturing and quality impacts and changes to KCs have been verified and documented that all requirements are being met for CDR. (See E.8)
- Manufacturing and quality has documented and provided updated inputs based on the results of the detailed design development activities to the program WBS.

- Completed detailed design demonstrates and documents manufacturing and quality bi-directional traceability among all allocated and physical requirements, engineering trade study results, and technical, schedule and cost risks, issues, and opportunities. (See E.8)

Tools

- Design for Manufacturing and Assembly (DFMA)
- CDR checklist
- TRR Checklist
- TRA checklist
- MRL assessment checklist, Design thread
- PRR Checklist
- SVR Checklist
- FCA Checklist
- SEP template
- TEMP template
- Life Cycle Sustainment Plan template
- IMP/IMS template
- CPD template

Resources

- 10 USC 144B, Sec 2366 and 2448
- Acquisition Strategy Guide, DSMC, Dec 1999
- Systems Engineering Plan Preparation Guide, Apr 2011
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- TEMP Guide, Dec 2012 and DAG Chapter 8-4.1
- LCSP memo, Sep, 2011 and DAG Chapter 4-3.1
- CDD-CPD writing Guide, Feb 2015
- Critical Design Review, DAG Chapter 3-3.3.5
- Test and Evaluation Management Guide
- System Verification Review, DAG Chapter 3-3.3.6
- Functional Configuration Audit, DAG Chapter 3-3.3.6
- Production Readiness Review, DAG Chapter 3-3.3.7
- TRA Guidance 2011
- MRL Deskbook version 2016
- IEEE 15288.2
- MRL Deskbook Version 2016

E.6 Assess Design Maturity

Manufacturing and Quality Tasks

- Manufacturing and quality will assess design maturity based on assessments of manufacturing feasibility, capability analyses, producibility, and KC analyses, in accordance with industry best practices (e.g., AS6500, AS9100, etc.) and assess readiness for the CDR (per IEEE 15288).
- Update manufacturing and quality assessments of the Contractor(s) and supply chain capability to mature and manufacture the detailed design within the overall cost, schedule, and performance goals (e.g., producibility, feasibility, and capability)
    - Assess manufacturing processes and quality results for each individual configuration item to verify each meets the stated performance requirements
    - Assess completeness of product data required for component manufacturing
    - Assess adequacy and robustness of the parts management and configuration control processes (e.g., design, engineering, and software)
- Through support of all design reviews at all levels of the supply chain, assess adequacy and completeness of manufacturing and quality requirements verification and validation activities including demonstrations in a representative environment at the system, subsystem, item, and component levels.
    - Assess and verify product and technology requirements and features as ready for system CDR including
        - Products producibility (subsystem, item, and component)
        - Products and technology maturity
        - Alternate sources and products producibility, maturity, and availability (i.e., second sources)
        - MOSA
        - COTS, NDIs, and GFE
    - Assess manufacturing and quality results of Technical Performance Measure (TPMs) maturation activities to support design maturity
    - Assess and validate if product data essential for item and component manufacturing is under configuration control and has been released
    - Verify completion of physical and functional interface designs for the system
    - Verify long-lead production requirements have been established and are understood
    - Verify manufacturing and quality safety requirements are in the detailed design to include all safety hazards
    - Assess and validate prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software
    - Verify completion of subsystem design (with closure schedule for open items) and percentage of subsystems in current production

- Monitor and assess the maturity of KCs and critical characteristics, the associated manufacturing and quality processes, and associated mitigation activities.
    - Verify correctness, adequacy, and completeness of key and critical processes for KCs and critical characteristics (e.g., C_{pk}, tolerances, etc.)
    - Verify correctness, adequacy, and completeness of KCs and critical characteristics to the associated KPPs
    - Verify Contractor manufacturing and quality engineering and management activities for adequacy and completeness (e.g., demonstrations, documentation, drawings, testing, data collection and management, etc.)
        - Analyze data from demonstrations of key and critical manufacturing and quality processes in a production-representative environment to satisfy design tolerances and meet objectives
- Monitor post-PDR manufacturing and quality mitigation measures and maintain the status of all mitigation measures up-to-date for all gaps, risks, and issues including those from:
    - Key and critical manufacturing processes including embedding software
    - Materials
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment
- Assess adequacy and completeness of mitigation activities for mitigation of manufacturing and quality risks, issues, and opportunities in the joint Government/ Contractor (\RIO Management System.

Metrics

- Based on assessments of manufacturing feasibility, capability analyses, producibility, and KC analyses, in accordance with industry best practices, manufacturing and quality has assessed design maturity and provided input on manufacturing and quality readiness for the CDR.
- Manufacturing and quality assessments of the Contractor(s) and supply chain have been conducted and document for CDR:
    - Capability to mature and manufacture the detailed design within the overall cost, schedule, and performance goals

  - Manufacturing processes and quality results for each individual configuration item have been verified to meet the stated performance requirements
  - Product data required for component manufacturing is complete
  - Parts management and configuration control processes are adequate and robust

- Adequacy and completeness of manufacturing and quality requirements verification and validation activities, throughout the supply chain, including demonstrations in a representative environment at the system, subsystem, item, and component levels, have been assessed, are reported in the appropriate documentation for CDR, and include the following:
  - Product and technology requirements and features as ready for system CDR including:
    - Products producibility (subsystem, item, and component)
    - Products and technology maturity
    - Alternate sources and products producibility, maturity, and availability (i.e., second sources)
    - MOSA
    - COTS, NDIs, and GFE
  - Maturation activities to support design maturity of manufacturing and quality Technical Performance Measure (TPMs)
  - Product data essential for item and component manufacturing is under configuration control and has been released
  - Physical and functional interface designs for the system are complete
  - Long-lead production requirements have been established and are understood
  - All manufacturing and quality safety requirements are in the detailed design and include all manufacturing safety hazards
  - Results of prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software
  - Completed subsystem design (with closure schedule for open items) and percentage of subsystems in current production

- Maturation progress of KCs and critical characteristics, the associated manufacturing and quality processes, and associated mitigation activities have been assessed and documented for CDR to include:
  - Correctness, adequacy, and completeness of key and critical processes for KCs and critical characteristics (e.g., C_{pk}, tolerances, etc.)
  - Correctness, adequacy, and completeness of KCs and critical characteristics to the associated KPPs
  - Adequacy and completeness of Contractor manufacturing and quality engineering and management activities (e.g., demonstrations, documentation, drawings, testing, data collection and management, etc.)
    - Results from demonstrations of key and critical manufacturing and quality processes in a production-representative environment that meet design tolerances and objectives

- Post-PDR manufacturing and quality mitigation measures have been monitored and the status of all mitigation measures is up-to-date, and is documented in the appropriate system documentation for CDR to include:
  - Key and critical manufacturing processes including embedding software
  - Materials
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and hazardous materials management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment
- Adequacy and completeness of mitigation activities for the above mitigation efforts are included in the joint Government/ Contractor RIO Management System. (See A.1)

Tools

- Design for Six Sigma
- MRL assessment checklist, Design thread

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- IEEE 15288.2
- ISO 9000
- MIL-STD 882E, System Safety
- MRL Deskbook Version 2016

E.7 Assess Key Characteristics (KC)

Manufacturing and Quality Tasks

- Analyze and verify of the flowdown of requirements to manufacturing and quality from the functional baseline to the lowest-level system detailed design element for all end items in the specification tree to ensure all are traced to specific manufacturing processes and quality metrics in the detailed design.

- Analyze all internal and external interface KCs (e.g., physical, electrical, digital, etc.) for manufacturing and quality specifications and requirements (e.g., flatness, attachment, connectivity, bi-directionality, compatibility, etc.) and changes since PDR to ensure acceptable risks for proceeding into fabrication, integration and testing.
- Analyze each specific manufacturing process and quality metric in the detailed design to verify that each is a KC (these should have been previously identified, but additional KCs may be identified).
    - Ensure each component level KCs is traceable to system design and is under control by the Contractor specified in the documentation appropriately
- Analyze identified KCs for validity and adequacy utilizing Contractor tolerances and/or process capability indexes and supporting data.
- Ensure survivability and vulnerability threat (KPPs) allocations incorporated into the design down to the component level that are tied to specific manufacturing processes and quality metrics in the detailed design have been specifically identified by the Contractor as such.
    - Ensure manufacturing and quality processes have been identified, analyzed, and are under configuration control
- Ensure that the Contractor has established and is maintaining lists of Key and/or critical items, CSIs, and CAIs with the lists including:
    - Rationale for designation
    - Control and risk mitigation plan(s)
    - Where produced or accomplished (including potential changes)
- Ensure all identified KCs are incorporated into the Verification Cross-Reference Matrix (VCRM) for required testing and verification.

Metrics

- Flowdown of requirements to manufacturing and quality from the functional baseline to the lowest-level system detailed design element for all end items in the specification tree has been verified and is documented in the Requirements System (i.e., DOORS) with each end item tied to specific manufacturing processes and quality metrics.
- All internal and external interface KCs (e.g., physical, electrical, digital, etc.) have been analyzed for manufacturing and quality specifications and requirements (e.g., flatness, attachment, connectivity, bi-directionality, compatibility, etc.) and all changes to ensure acceptable risks for proceeding into fabrication, integration and testing, and have been documented in all appropriate CDR documents for finalization at CDR.
- Each specific manufacturing process and associated quality metrics in the detailed design have been analyzed to verify that each is a KC.
    - Each component level KCs has been traced to system design and is under control by the Contractor and documented appropriately

- Utilizing Contractor tolerances and/or process capability indexes and supporting data, KCs have been analyzed for validity and adequacy and the results and recommended changes have been documented.
- Survivability and vulnerability threat (KPPs) allocations incorporated into the design have been analyzed and tied to specific manufacturing processes and quality metrics and have been specifically identified by the Contractor as such which have been placed under configuration control.
- Contractor has established and documented lists of Key and/or critical items, CSIs, and CAIs with the lists including:
  - Rationale for designation
  - Control and risk mitigation plan(s)
  - Where produced or accomplished (including potential changes)
- All identified KCs have been incorporated into the VCRM for required testing and verification.

Tools

- MRL Assessment Checklist for Process Capability and Control thread
- Critical to Quality Tree
- Failure Mode and Effects Analysis
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- Technology Readiness Level Assessment Checklist

Resources

- IEEE 15288.2
- AS6500, Manufacturing Management Program, Sep 2016
- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- JCIDS Manual
- MRL Deskbook Version 2016
- NAVSO P-3687 Producibility System Guidelines, Dec 1999
- Technology Level Assessment Guidance, Apr 2011

E.8 Support Critical Design Review (CDR)

Manufacturing and Quality Tasks

- Ensure initial product baseline documentation for manufacturing and quality is sufficient, complete, and adequate to enable component manufacturing, hardware fabrication and software implementation to proceed.

  - Ensure all KCs, CSIs, and CAIs have completed drawings and specifications under configuration control
  - Ensure all product data essential (e.g., drawings, specifications, etc.) for component manufacturing has been released

- Ensure all manufacturing and quality design trade studies and producibility assessments are completed and incorporated into the design for CDR.
  - Ensure producibility enhancement efforts ongoing for optimized integrated system (e.g. Design for Manufacturability, Design for Assembly, etc.)
- Ensure all subsystem, item, and component CDRs are complete and the results available for the system CDR.
  - Analyze the results of design maturity assessments (See E.6) including all appropriate reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.) for closure or approved rationale to enter CDR without completion is documented and accepted by the program office.
- Ensure manufacturing and quality input to the schedule (IMP/IMS) is up-to-date and is executable with acceptable risks.
- Ensure manufacturing and quality plans, activities, and processes are executable within the existing manufacturing and quality budget to support the approved initial product baseline and critical path.
- Ensure all key and critical manufacturing processes, including process control plans, have been defined, characterized, updated for the detailed design, and the capability to meet design tolerances has been determined.
- Analyze Contractor manufacturing and quality plans for materials, facilities, equipment, test facilities and equipment, and tooling to support the pilot line requirements.
- Analyze manufacturing and quality plans for adequacy and capability of achieving manufacturing readiness level 8 by initial production.
- Analyze plans for long-lead procurement requirements and incorporate results into procurement plans.
- Analyze results of Contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) for manufacturing and quality risks, issues, and opportunities and appropriate mitigation plans.
- Analyze the assessments of adequacy and completeness of manufacturing and quality requirements validation activities (See E.6) which included prototypes and demonstrations in a representative environment at the system, subsystem, item, and component levels for design maturity.
  - Include demonstrations of manufacturing processes in a representative environment
  - Include demonstrations of manufacturing and quality processes for KCs, CSIs, and CAIs
- Provide manufacturing and quality inputs to the Life Cycle Support Plan for CDR.

- Ensure Contractor manufacturing and quality management systems for manufacturing and quality metrics and data collection and tracking to the component level are in place and functional.
- Ensure the TEMP incorporates all manufacturing and quality subsystems, items, and components into plans for tests, test facilities, and test equipment.
- Ensure the manufacturing and quality considerations and aspects of Contractor's plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - PPP
    - SEMP
    - TEMP
- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure manufacturing and quality design producibility improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (See E.4).
- Provide up-to-date manufacturing and quality inputs to the program budget and the CARD.
    - Update and allocate manufacturing and quality (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure adequacy and completeness of mitigation activities for mitigation of manufacturing and quality risks, issues, and opportunities in the joint Government/ Contractor RIO Management System, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment

Metrics

- Initial product baseline documentation for manufacturing and quality analyzed, validated, and approved for component manufacturing, hardware fabrication and software implementation to proceed.
    - All KCs, CSIs, and CAIs have completed drawings and documented specifications in the configuration management system
    - All essential product data for all components throughout the supply chain is in the configuration management system and released for manufacturing
- All manufacturing and quality design trade studies and producibility assessments have been completed and results incorporated into the system design for CDR.
    - Producibility enhancement efforts for optimizing the integrated system (e.g. Design for Manufacturability, Design for Assembly, etc.) are ongoing, documented, and progress monitored
- All subsystem, item, and component CDRs have been completed including closure of actions with the documented results, risks, and/or issues available for the system CDR.
    - Results of design maturity assessments (See E.6) and all appropriate reviews have been analyzed and documented
    - Inputs on the risks and issues have been provided to and accepted by the program office
- Manufacturing and quality inputs to the schedule have been provided and included in the IMP/IMS.
- Manufacturing and quality plans, activities, and processes have been analyzed as executable within the existing manufacturing and quality budget and documented to support the approved product baseline and critical path.
- All key and critical manufacturing processes have been analyzed and documented in the manufacturing and quality plans with associated risks and issues mitigation plans for the detailed design including:
    - Process control plans
    - Process definition characterization
    - Process capability to meet design tolerances
- Contractor manufacturing and quality plans have been analyzed and document adequacy, shortfalls, and recommendations to meet pilot line requirements for materials, facilities, equipment, test facilities and equipment, and tooling.
- Manufacturing and quality have analyzed the system design and the Contractor's manufacturing and quality plans for achieving MRL 8 criteria by initial production and have documented shortfalls and recommendations for CDR.
- Long-lead procurement requirements and plans have been analyzed and shortfalls and recommendations documented for CDR.

- Results of Contractor and key supply chain assessments for manufacturing and quality risks, issues, and opportunities with appropriate mitigation plans have been analyzed and documented for consistency with Government assessments and include:
  - Costs, schedule, performance
  - Materials (e.g., lead-times, availability, etc.)
  - Subsystems, items, and components
  - Manufacturing and quality management
  - Facilities, tooling, and test equipment
  - Developmental tests
  - Workforce
  - Transportation, storage, and handling
  - Security
  - Embedded software
  - ESOH
  - Industrial Base risks and issues
- Assessments of the adequacy and completeness of manufacturing and quality requirements validation activities (See E.6) have been analyzed for design maturity and document the conduct of demonstrations, prototypes, and processes in a representative environment at all product levels for CDR, including KCs, CSIs, and CAIs.
- Manufacturing and quality have provided documented inputs to the Life Cycle Support Plan for CDR.
- Contractor's manufacturing and quality management systems for manufacturing and quality metrics and data collection and tracking to the component level have been documented as in place, functional, and consistent with industry best practices for CDR.
- TEMP has been analyzed and results document inclusion of all manufacturing and quality subsystems, items, and components into plans for tests, test facilities, and the necessary test equipment.
- Contractor's plans and inputs have been assessed to include appropriate program manufacturing and quality requirements, are up-to-date, and approved for CDR, including:
  - Parts and Materials (Management) Plan (PMP)
  - Configuration Management Plan (CMP)
  - Software Development Plan (embedded software)
  - Quality Assurance Plan
  - PPP
  - SEMP
  - TEMP
- Subsystem, item, and component quantity estimates have been updated based on program system requirements, component yield and rate data, and results from prototype demonstrations and documented in the AS for CDR.

- Manufacturing and quality design producibility improvements have been integrated into the system design and specifications, are being tracked, and are meeting the joint Government/ Contractor producibility implementation schedule (See E.4).
- Updated and documented manufacturing and quality inputs have been provided to the program budget and the CARD.
    - Manufacturing and quality (production) cost models have been updated, allocated to lowest level, and tracked against targets
- Adequacy and completeness of mitigation activities has been included in the joint Government/ Contractor RIO Management System, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment

Tools

- CDR checklist

Resources

- AS65000
- Defense Acquisition Guide (DAG) Chapter 3-3.3.5 Critical Design Review
- IEEE 15288.2
- MRL Deskbook Version 2016

E.9 Provide Updates to SEP

Manufacturing and Quality Tasks

- At a minimum manufacturing and quality should ensure updates are provided for the following:
    - System architectures and interfaces
    - Required DoD certifications (e.g., Space-worthiness, Airworthiness, Insensitive Munitions, etc.)

- Manufacturing and quality risk, issue, and opportunity assessments, including schedule, costs, performance, PRRs, pilot lines, prototypes, demonstrations, milestones, etc.
- Program manufacturing and quality structure and organization including WBS, positions, staffing, etc.
- Manufacturing and quality Technical Performance Measures and metrics including yields, rates, process capability indices, etc.
- Planned manufacturing and quality activities for the next phase including Value Engineering, ManTech and other improvements, learning curves, initiating production, etc.
- Manufacturing and quality requirements tracking and change processes including changes from prototypes, demonstrations, development testing, etc.
- Manufacturing and quality configuration and Engineering Change Proposal (ECP) management
- KCs considerations and impacts critical to the achievement of the program's technical requirements

Metrics

- Manufacturing and quality has documented and provided updates to the SEP for the following:
  - System architectures and interfaces changes
  - DoD certifications (e.g., Space-worthiness, Airworthiness, Insensitive Munitions, etc.)
  - Manufacturing and quality risk, issue, and opportunity assessments, including schedule, costs, performance, PRRs, pilot lines, prototypes, demonstrations, milestones, etc.
  - Changes in program manufacturing and quality structure and organization including WBS, positions, staffing, etc.
  - Changes to manufacturing and quality Technical Performance Measures and metrics with status including yields, rates, process capability indices, etc.
  - Planned manufacturing and quality activities and schedule for the next phase including Value Engineering, ManTech and other improvements, learning curves, initiating production, etc.
  - Changes to manufacturing and quality requirements tracking and change processes including changes from prototypes, demonstrations, development testing, etc.
  - Changes to manufacturing and quality configurations and proposed ECPs
  - Changes to KCs and resulting impacts critical to the achievement of the program's technical requirements

Tools

- SEP Outline
- Manufacturing Plan (included I n the SEP)
- Quality Assurance Plan (included in the SEP)
- Critical to Customer/Critical to Quality Tree

- Producibility Assessment Worksheet

Resources

- TAB B - SEP Outline Version 3.0 - Final V4 (provided by OSD)
- Systems Engineering Plan Preparation Guide, Apr 2008
- MRL Deskbook Version 2016
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999
- AS6500, Manufacturing Management Program, Sep 2016
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System

E.10 Validate Design

Manufacturing and Quality Tasks

- Ensure all product level manufacturing and quality design requirements are defined and validated to be consistent with the specifications.
- Ensure all manufacturing and quality inputs to the product design support meeting the program requirements.
    - Verify manufacturing and quality requirements meet program cost, schedule, and performance requirements
    - Verify manufacturing and quality requirements are met at the subsystem, item, and component levels
- Assess prototypes and demonstrations, including system, subsystem, item, and component prototypes, for adequacy and completeness to include:
    - Verification that prototypes and demonstrations occur in the appropriate environment for the system, subsystem, or component (e.g., production representative, pilot line, or production line)
    - Verification and validation of manufacturing and quality specifications, processes, procedures, metrics, etc.
    - Verification and validation of KCs and critical characteristics and the associated key and critical manufacturing processes
    - Manufacturing and quality validation activities to support proof of building the right product
    - Subsystem, item, and component development specifications
    - Verification of product and technology requirements and features necessary for system pilot line and/or LRIP including:
        - Producibility (subsystem, item, and component)
        - Products and technology maturity
        - Sources maturity and availability (including second sources)

        - MOSA
        - COTS, NDIs, and GFE
    - Verification of manufacturing and quality status and results of TPMs
    - Verify long-lead production requirements have been established and are understood
    - Verify completion of subsystem design (with closure schedule for open items)
- Analyze prototype demonstrations and manufacturing and quality demonstrations at the system, subsystem, item, and component levels for validation of:
    - Product data essential for item and component manufacturing
    - Physical and functional interface designs for the system
    - Interdependencies
    - Manufacturing and quality safety processes and procedures
    - ESOH processes and procedures
    - Security processes, procedures, and compliance
    - Risks and issues mitigation
    - Manufacturing and quality costs, schedule, performance
    - Materials sources and selections
    - Facilities, tooling, and test equipment requirements
    - Workforce requirements
    - Transportation, storage, and handling
    - Embedded software
- Ensure known producibility issues have been resolved and pose no significant risks or issues for pilot line and/or LRIP.
- Develop manufacturing and quality metrics and data requirement to support successful transition to pilot line, LRIP, and FRP
    - Metrics should provide the capability to assess, monitor, manage, and control the transition process
- Based on demonstrations, prototypes, results of CDR, assess and update the manufacturing and quality inputs to the WBS for planning, execution and control of the pilot line and LRIP.
- Manufacturing and quality ensures all product data essential for system manufacturing will be released for pilot line.
- Manufacturing and quality should ensure the adequacy and completeness of all mitigation activities in the joint Government/ Contractor Risk, Issue, and Opportunity (RIO) Management Process, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development

- Tests and demonstrations
- Security
- System safety and hazardous materials management
- Economic feasibility
- Schedule (i.e., IMP/IMS)
- Manufacturing capability obsolescence
- Manufacturing capability sustainment

Metrics

- All product level manufacturing and quality design requirements defined, validated, and documented, and are consistent with the specifications detailed in the SEP.
- All manufacturing and quality inputs to the product design support meeting the program requirements.
  - Manufacturing and quality requirements have been verified and documented to meet program cost, schedule, and performance requirements
  - Manufacturing and quality requirements have been verified and documented at the system, subsystem, item, and component levels
- Assessments of prototypes and demonstrations at the system, subsystem, item, and component levels have been conducted and documented to verify and validate:
  - That prototype and other demonstrations occurred in the appropriate environment
  - Manufacturing and quality specifications, processes, procedures, metrics, etc.
  - KCs and critical characteristics and the associated key and critical manufacturing processes
  - Manufacturing and quality activities to support proof of building the right product
  - Subsystem, item, and component manufacturing and quality development specifications
  - Product and technology manufacturing and quality requirements and features necessary for system pilot line and/or LRIP including:
    - Producibility (subsystem, item, and component)
    - Products and technology maturity
    - Sources maturity and availability (including second sources)
    - MOSA
    - COTS, NDIs, and GFE
  - Status and results of manufacturing and quality TPMs
  - That manufacturing and quality long-lead production requirements have been established and are understood
  - Completion of subsystem design and closure schedule for open items
- Prototype and manufacturing and quality demonstrations have been analyzed and the results documented at the system, subsystem, item, and component levels for the validation of:
  - Product data essential for item and component manufacturing

  - Physical and functional interface designs for the system
  - Interdependencies
  - Manufacturing and quality safety processes and procedures
  - ESOH processes and procedures
  - Security processes, procedures, and compliance
  - Risk and issue mitigations
  - Manufacturing and quality costs, schedule, performance
  - Materials sources and selections
  - Facilities, tooling, and test equipment requirements
  - Workforce requirements
  - Transportation, storage, and handling
  - Embedded software

- Known producibility issues have been resolved and documented and pose no significant risks or issues for pilot line and/or LRIP.
- Manufacturing and quality metrics and data requirement have been developed and documented to support successful transition to pilot line, LRIP, and FRP
  - Metrics provide the capability to assess, monitor, manage, and control the transition process
- Manufacturing and quality inputs to the WBS for planning, execution and control of the pilot line and LRIP have been updated and documented.
- All manufacturing and quality product data essential for system manufacturing has been documented and released for the pilot line.
- Manufacturing and quality have verified, validated, and documented the adequacy and completeness of all mitigation activities in the joint Government/ Contractor Risk, Issue, and Opportunity Management System for pilot line build, including:
  - Key and critical manufacturing processes including embedding software
  - Materials and sourcing
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and hazardous materials management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment

Tools

- System Verification Review Checklist
- Functional Configuration Audit Checklist
- Manufacturing Readiness Assessment, Design thread
- Test and Evaluation Template
- IMP/IMS Template

Resources

- DoD 5000.02
- IEEE 15288.2, System and Software Engineering, 2015
- MRL Deskbook Version 2016
- System Verification Review, DAG Chapter 3-3.3.6
- Functional Configuration Audit, DAG Chapter 3-3.3.6
- Test and Evaluation Management Guide
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005

E.11 Pilot Line Build

Manufacturing and Quality Tasks

- Assess the Contractor designated pilot lines for production realism of elements required to manufacture systems, subsystems, items, and components.
    - Evaluate the manufacturing and quality readiness to manufacture of equipment, workforce skill levels, facilities, materials, components, initial work instructions, processes, tooling, temperature, cleanliness, lighting etc.
    - Evaluate capability to meet design requirements for LRIP
    - Evaluate the use of full-rate production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
    - Evaluate production processes for capability to meet rate production (ramp-up to FRP)
    - Evaluate the production capability and capacity to meet program objectives for cost and schedule
- Validate the Contractor's manufacturing processes for affordability and execution including work instructions.
- Evaluate Contractor Production Process Verifications (PPVs) to verify process outputs for compliance to process capabilities and requirements.
- Capture necessary manufacturing and quality design and process changes identified during pilot line operations.
- Capture the results of manufacturing and quality processes, demonstrated on a pilot line, as inputs to the system MRL assessment, PRR, and to the Industrial Base Capabilities Considerations that are required for Milestone C.

- Assess Contractor's LRIP verification and validation manufacturing and quality efforts in accordance with industry best practices (i.e., AS6500) on a pilot line including:
    - All manufacturing and quality processes including continuous improvement efforts
    - Manufacturing surveillance and quality data collection and analyses (including supply chain data for items and components)
    - Physical and functional interfaces
    - All work instructions, sequencing, and procedures
    - Process capabilities and process control plans
    - Production scheduling and control
    - Model and Simulations
    - Materials
    - Workforce capabilities
    - Manufacturing technology implementations
    - Tooling, work holding fixtures, jigs, etc.
    - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
    - Facilities, transportation, storage, and handling equipment
    - Interdependencies (not all will be validated on the pilot line)
    - Safety processes, procedures, and compliance
    - ESOH processes, procedures, and compliance
    - Security processes, procedures, capabilities, and compliance
    - Risk and issue mitigation results and adequacy of resolution
    - Manufacturing and quality costs, schedule, performance
    - Materials sources and selections
    - Integration of embedded software
- Assess Contractor's conduct of First Article Inspections (FAI) and/or First Article Tests (FAT) and the outputs for manufacturing and quality impacts.
- Based on pilot line operations and demonstrations, assess all manufacturing and quality risks and issues for impacts to LRIP (e.g., producibility, quality, manufacturability, etc.)
    - Include newly identified risks, issues, and opportunities
- Based on the results of the Pilot Line build, finalize the Technical Data Package including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Metrics

- Pilot line has been assessed in manufacture of systems, subsystems, items, and components to confirm adequacy of production realism and documents the following:

  - Manufacturing and quality readiness to manufacture of equipment, workforce skill levels, facilities, materials, components, initial work instructions, processes, tooling, temperature, cleanliness, lighting etc.
  - Capability to meet design requirements for LRIP
  - Employment of full-rate production processes with little or no reliance on laboratory environment or personnel
  - Capability to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule
  - Pilot line risks, issues, and potential opportunities to be included in Risk, Issue, and Opportunity Management System

- Contractor's manufacturing processes for affordability and execution, including work instructions, have been assessed as adequate and validated, documented in Manufacturing and Quality Plans for PRR.
- Contractor PPVs have been verified for compliance with process capability requirements and documented for the PRR.
- Necessary manufacturing and quality design and process changes have been captured during pilot line operations and documented for potential ECPs and for the PRR.
- Results of demonstrations of manufacturing and quality processes on a pilot line have been documented as inputs to the system MRL assessment, the PRR, and to the Industrial Base Capabilities Considerations (required for Milestone C).
- In accordance with industry best practices, manufacturing and quality verification and validation of Contractor pilot line has been successfully conducted and the results have been documented for PRR, SVR/FCA, and Milestone C the including:

  - All manufacturing and quality processes with rigorous continuous improvement processes
  - Disciplined, functional, and accessible manufacturing surveillance and quality data collection system including supply chain
  - Documented, tested, and approved physical and functional interfaces
  - Functional work instructions, sequencing, and procedures
  - Process capabilities and process control plans
  - Functional production scheduling and control processes
  - Refined model and simulations
  - Materials
  - Confirmed workforce requirements, skills, and capabilities
  - Manufacturing technology implementations
  - Tooling, work holding fixtures, jigs, etc.
  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
  - Facilities, transportation, storage, and handling equipment
  - Pilot line interdependencies
  - Safety processes, procedures, and compliance

  - ESOH processes, procedures, and compliance
  - Security processes, procedures, capabilities, and compliance
  - Risk and issue closures and remaining mitigation plans
  - Confirmation of and updates to manufacturing and quality costs, schedule, performance
  - Materials sources and selections
  - Integration of embedded software

- Contractor's FAIs and/or FATs and the outputs for manufacturing and quality have been assessed and analyzed for impacts and the results documented for PRR.
- At the conclusion of pilot line operations and demonstrations, all manufacturing and quality risks and issues have been assessed and analyzed for impacts to LRIP and known producibility issues and risks understood (i.e., pose no significant challenges or have been accepted)
- Technical Data Package has been finalized based on the results of the Pilot Line build and includes the applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Tools

- First Article Test Checklist
- First Article Inspection Checklist
- Production Verification Test
- Production Part Approval Process (PPAP) Checklist
- Manufacturing Readiness Level Assessment, Design thread

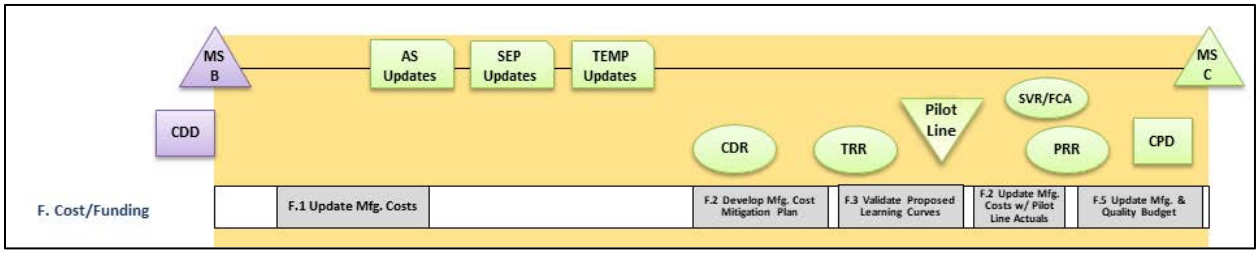
Resources

- DCMA Instruction 302, First Article and Production Lot Testing, Jan 2015
- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- AS6500, Manufacturing Management System
- DoD 5000.02
- IEEE 15288.2, System and Software Engineering, 2015
- MRL Deskbook Version 2016

F. COST/FUNDING

Manufacturing and quality cost estimates require updating regularly, based on the increasing degree of detail available from the completed PDR, the Manufacturing and Quality Strategies and Plans, and progress toward final design. These estimates should be based on detailed manufacturing and quality processes and procedures to industry best practices with updates to be performed and adjusted, as necessary, for current program status and/or learning curves in order to develop a time-phased manufacturing cost. This will require analyses of Contractor Manufacturing and Quality Plans

regarding costs, cost controls, and cost drivers. As the design progresses, cost estimates, cost models, and associated cost drivers should be updated with actual cost data from lower level (item and component) pilot lines and production.



Utilizing the DOD funding and management approach, both the should-cost and will-cost analyses, and the cost reduction and/or control plans should be updated based on the results of CDR and maintained current. Tracking and monitoring of the Contractor's planning and ongoing efforts is intended to not only evaluate proposed Contractor costs, but to track and monitor costs and to identify further savings opportunities that will lead to further cost reductions. Utilizing this process manufacturing and quality cost mitigation and/or maturation plans are maintained current to include the schedule (i.e., IMP/IMS).

Based on data collected post-PDR through CDR, established learning curves (cost improvement curve, or experience curve) should be up-to-date and validated by data collected on the pilot line. Manufacturing and quality should continue to refine the learning curves for the system and the plans for data collection to support up-to-date cost estimates and budgeting. Manufacturing cost estimates for LRIP are based on the completed design, known manufacturing processes, and execution of planned manufacturing and quality operations. Actual costs at the system level are realized for the first time on a pilot line. Once the system is being produced or constructed, the actual cost method can be accumulated for budgeting.

A Program's approved cost estimate is often used to create the budget and spending plan. Since resources are not infinite, budgeting requires the rate of spending matches the resources and funding available. This requires manufacturing and quality costs to be as accurate as possible, based on actual data. This process facilitates the development of realistic cost estimates for the Program.

F.1 Update Manufacturing Costs

Manufacturing and Quality Tasks

- Based on the results of the PDR, analyze and update manufacturing and quality design changes for technical content and should-cost inputs for consistency with the current Cost Analysis Requirements Document (CARD); and provide updates, if necessary, in order to maintain consistency with the approved system specification and budget for CDR.
    - Include updates to the will-cost model based on industry best practices
    - Include updates to manufacturing and quality cost sensitivity analyses

- Based on the results of PDR design, design changes, and program progress, analyze and update manufacturing and quality cost drivers derived from manufacturing, quality, materials, and/or unique requirements, and associated risks, issues, and opportunities for the CDR to include:
  - Identified subsystems, parts, items, and components
  - Sourcing risks from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
  - Should-cost and will-cost analyses
  - Required trade studies and engineering change requests
  - Updates to predicted life-cycle estimates and their associated models
  - Interdependencies
  - Uncertainties from quantification of cost drivers
- Analyze the Contractor Manufacturing and Quality Plans for costs and cost drivers based on:
  - Processes and procedures (i.e., best practices)
  - Producibility program and plans
  - Supplier Chain management
  - Materials (e.g., processing, handling, storage, etc.)
  - Workforce (e.g., availability, training, etc.)
  - Facilities (e.g., location, condition, maintenance, etc.)
  - Capital equipment, tooling, and test equipment, etc.
  - Special handling and environmental compliance (including disposal)
  - Security (physical and cyber), etc.
  - Updates for the cost of quality
  - Updates for costs and impacts of testing
  - Impacts from other work performed throughout the supply chain
- Ensure cost estimates, cost models, and associated cost drivers are updated with actual cost data from lower level (item and component) pilot lines and production, and from subsystem and system-level prototypes and demonstrations including:
  - Systems and sub-systems produced in a production representative environment
  - Production plant layout and design
  - Obsolescence solutions
  - Rolled up manufacturing system and sub-system actual costs vs. targets
- Update Learning Curves based on results of PDR and actual manufacturing and quality data collected from pilot lines, prototypes, and demonstrations.
- Ensure the updated cost estimates and associated drivers include the costs associated with the manufacturing and quality risks, issues, and associated mitigation plans and activities, and opportunities.
- Update the contract to include cost monitoring by DCMA throughout the Contractor's facilities and supply chain.

- Update the letter of delegation to DCMA to include cost monitoring and tracking.
- Ensure updated manufacturing and quality costs including costs for outstanding manufacturing and quality risks, issues, and mitigations for CDR and estimates for meeting manufacturing readiness requirements for Milestone C are included in all budget estimates.
- If an Independent Cost Estimate (ICE) or verified Program Office Economic Analysis is requested, provide manufacturing and quality inputs and support.
    - Provide validated manufacturing and quality capability requirements
    - Provide manufacturing and quality inputs on required funding for the FYDP
    - Verify manufacturing and quality compliance with affordability goals for production and sustainment
-

Metrics

- Manufacturing and quality design changes have been analyzed for technical content and should-cost inputs and required updates have been provided as inputs to the CARD including:
    - Updates, if necessary, in order to maintain consistency with the approved system specification and budget for CDR
    - Updates to the will-cost model based on industry best practices
    - Updates to manufacturing and quality cost sensitivity analyses
- Manufacturing and quality cost drivers derived from manufacturing, quality, materials, and/or unique requirements (e.g., processes, procedures, techniques, etc.), and associated risks, issues, and opportunities have been updated and documented for the CDR including drivers from:
    - Subsystems, parts, items, and components
    - Sourcing (e.g., sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources)
    - Should-cost and will-cost analyses
    - Trade studies and engineering change requests
    - Life-cycle estimates and their associated models
    - Interdependencies
    - Uncertainties
- Contractor Manufacturing and Quality Plans have been analyzed for costs and cost drivers and results and recommendations documented for CDR based on:
    - Processes and procedures (i.e., best practices)
    - Producibility program and plans
    - Supplier Chain management
    - Materials (e.g., processing, handling, storage, etc.)
    - Workforce (e.g., availability, training, etc.)

  - Facilities (e.g., location, condition, maintenance, etc.)
  - Capital equipment, tooling, and test equipment, etc.
  - Special handling and environmental compliance (including disposal)
  - Security (physical and cyber), etc.
  - Updates for the cost of quality
  - Updates for costs and impacts of testing
  - Impacts to schedule and resources from other work performed throughout the supply chain (i.e., other programs in the same facility)

- Comparison of rolled up manufacturing system and sub-system actual costs vs. targets has been conducted and documented for CDR, and actual cost data has been utilized to update cost estimates, cost models, and associated cost drivers for CDR including data from:
  - Systems and sub-systems produced in a production representative environment
  - Items and components produced on pilot and production lines
  - Production plant layout and design
  - Obsolescence solutions
- Learning Curves have been updated based on results of PDR and actual manufacturing and quality data collected from pilot lines, prototypes, and demonstrations, and have been documented for CDR.
- Costs associated with the manufacturing and quality risks, issues, and associated mitigation plans and activities, and opportunities have been utilized to update and document cost estimates and associated drivers for CDR.
- Contract includes cost monitoring by DCMA throughout the Contractor's facilities and supply chain.
- Letter of delegation to DCMA includes cost monitoring and tracking.
- Updated manufacturing and quality costs including those outstanding for manufacturing and quality risks, issues, and mitigations have been updated and documented for CDR and estimates for meeting manufacturing readiness requirements for Milestone C have been included in all budget estimates.
- If an Independent Cost Estimate (ICE) or verified Program Office Economic Analysis has been requested, manufacturing and quality has provided documented inputs and support including:
  - Validated manufacturing and quality capability requirements
  - Inputs on required manufacturing and quality funding for the FYDP
  - Manufacturing and quality compliance with affordability goals for production and sustainment

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)

- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- MRL assessment for the Cost Thread
- See CAPE website for tools

Resources

- DoD 5000.02
- IEEE 15288.2
- MRL Deskbook Version 2016
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766 Design to Cost
- Should-cost and Affordability Memo, Aug 2011
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- CARD Website and process

F.2 Develop Manufacturing Cost Mitigation Plan

Manufacturing and Quality Tasks

- Based on manufacturing and quality planning for CDR, ensure appropriate inputs are provided for required investments and planning for Contractor and supply chain manufacturing and quality capabilities (e.g., facilities, equipment, tooling, hardware, firmware, software, etc.)
- Utilizing the outputs from CDR update the should-cost and will-cost analyses, and cost reduction and/or control plans to include:
    - Coordinated, in-depth review of the Contractor's planning and ongoing efforts against best practices
    - Up-to-date cost drivers
    - Up-to-date tracked and monitored costs to support further savings opportunities
    - Risks and issues mitigation plans and activities
- Ensure DCMA cost monitoring and tracking data are utilized to develop and/or update manufacturing and quality cost mitigation plans.
- Update manufacturing and quality cost targets, post CDR, to include assessments of:
    - Producibility
    - Manufacturing and quality process capabilities, implementations, obsolescence, and sustainment including key and critical processes
    - Schedule (i.e., IMP/IMS)
    - Supply chain, materials and sourcing availability
    - Environmental management and disposal impacts
    - Process capability and throughput (setup, yield, scrap, rework, Work In Progress)

  - Data management (collection, storage, cyber security, etc.)
  - Manufacturing and quality risks and issues including Supplier Chain
  - Workforce risks and issues
  - Tooling, equipment availability, capacity, and constraints
  - Facilities and facility conditions (e.g., temperature control, cleanliness, lighting, factory floor, process flows, assembly lines, cycle times, etc.)
  - Yields and rates (e.g., projected and actual throughputs)
  - Inventory (e.g., WIP, backlog, customer demand, etc.)
  - System security, cyber protection, safety, and hazardous materials management
  - Testing and test equipment (including in-process tests)
  - Transportation, storage, and handling
  - New equipment and new manufacturing technologies
  - Life-cycle sustainment

- Based on results of CDR, update manufacturing and quality cost models to include:
  - Updated cost targets
  - Actuals, where available, in place of estimates
  - Cost impacts of specific design changes, production process changes, or changes in materials
- Monitor and track Contractor performance of manufacturing and quality activities in meeting the Earned Value Management System (EVMS) requirements including the critical path as an input to cost mitigation planning.
- Develop Manufacturing Maturation Plans (MMPs) for any areas assessed that do not comply with the appropriate Manufacturing Readiness Level criteria.

Metrics

- Manufacturing and quality has provided appropriate budget planning inputs to program investment plans for Contractor and supply chain manufacturing and quality capabilities (e.g., facilities, equipment, tooling, hardware, firmware, software, etc.).
- Manufacturing and quality has updated and documented in the SEP, the AS, and the CARD, the should-cost analyses, will-cost analyses, and cost reduction and/or control plans including:
  - Contractor’s planning and ongoing efforts against best practices
  - Up-to-date cost drivers
  - Up-to-date tracked and monitored costs
  - Mitigation plans and activities
- DCMA cost monitoring and tracking data has been documented in appropriate program documentation and utilized to develop and/or update cost mitigation plans in the Manufacturing and Quality Plans.

- Manufacturing and quality cost targets have been assessed, updated, and documented in the Manufacturing and Quality Strategies and Plans and appropriate program budget documents including targets derived from or impacted by:
  - Producibility
  - Manufacturing and quality process capabilities, implementations, obsolescence, and sustainment including key and critical processes
  - Schedule (i.e., IMP/IMS)
  - Supply chain, materials and sourcing availability
  - Environmental management and disposal impacts
  - Process capability and throughput (setup, yield, scrap, rework, Work In Progress)
  - Data management (collection, storage, cyber security, etc.)
  - Manufacturing and quality risks and issues including Supplier Chain
  - Workforce risks and issues
  - Tooling, equipment availability, capacity, and constraints
  - Facilities and facility conditions (e.g., temperature control, cleanliness, lighting, factory floor, process flows, assembly lines, cycle times, etc.)
  - Yields and rates (e.g., projected and actual throughputs)
  - Inventory (e.g., WIP, backlog, customer demand, etc.)
  - System security, cyber protection, safety, and hazardous materials management
  - Testing and test equipment (including in-process tests)
  - Transportation, storage, and handling
  - New equipment and new manufacturing technologies
  - Life-cycle sustainment
- Manufacturing and quality cost models have been updated, documented, and maintained current in the program cost model to include:
  - Up-to-date cost targets
  - Actuals as they become available replacing of estimates
  - Updated cost impacts from changes to design, manufacturing and quality processes and/or materials, etc.
- Contractor performance of manufacturing and quality activities is being tracked and monitored to meet the EVMS requirements including the critical path.
- MMPs have been developed for all areas assessed that do not meet the appropriate MRL cost thread criteria.

Tools

- Parametric, Engineering and Actual estimating
- CARD - Cost Analysis Requirements Description (see CAPE website for tools)
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding Thread
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control Systems Criteria (C/SCSC)

- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan (no template available)

Resources

- 10 USC Sec. 2334 Independent Cost Estimation and Cost Analysis
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- Public Law 114-328, §807, Cost, Schedule and performance of major defense acquisition programs
- CARD - Cost Analysis Requirements Description Template (See CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide, Sep 1992
- DODI 5000.73 Cost Analysis Guidance and Procedures
- DoDI 5000.02, Change 1, Jan 2017
- MRL Deskbook Version 2016

F.3 Validate Proposed Learning Curves

Manufacturing and Quality Tasks

- Update all manufacturing and quality learning curves for the system and subsystems based on CDR results, Contractor and supply chain improvements, program progress to date to include:
  - Contractor and supply chain data as required by contract
  - DCMA data to validate Contractor data for the learning curve updates
  - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
  - Design changes
  - Producibility program results
  - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
  - Planning and scheduling
  - Throughput (yield and rates)
  - Labor efficiency and ergonomics
  - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
  - Handling, transportation, and storage (including WIP)
  - Supply chain changes
  - Standardization and common processes
- Utilize data from pilot line production for validation of learning curves.
- Plan for collection of data in LRIP to support learning curve refinement that includes the following factors, improvements, and investments (at a minimum):
  - Update of cost models
  - Workforce learning, worker and supervisor

- Process, line, and workstation
- Machinery, equipment, and tooling
- Design producibility changes
- Reduced Engineering Change activities
- Mitigations of risks and issues
- Work methods and processes
- Planning and scheduling processes
- Lot and batch sizing (increases) and optimization (just-in-time)
- Engineering and test activities and changes
- Quality inspections/tests sampling requirements
- Reduction in Scrap and Rework
- Inventory levels and storage
- Operation sequencing and synchronization
- Pre-Planned Product Improvement (P^3I)program and processes

Metrics

- All manufacturing and quality learning curves for the system and subsystems have been assessed and updated based on CDR results, Contractor and supply chain improvements, program progress to date which includes:
  - Contractor and supply chain data
  - DCMA data to validate Contractor data
  - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
  - Design changes
  - Producibility program results
  - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
  - Planning and scheduling
  - Throughput (yield and rates)
  - Labor efficiency and ergonomics
  - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
  - Handling, transportation, and storage (including WIP)
  - Supply chain changes
  - Standardization and common processes
- Learning curves have been validated utilizing data from pilot line production.
- Plans for collection of data in LRIP have been developed, documented, and are in place to support learning curve refinement that includes the following:
  - Up-to-date cost models
  - Workforce learning, worker and supervisor
  - Process, line, and workstation improvements and investments
  - Machinery, equipment, and tooling improvements and investments
  - Design producibility changes

- Reduced Engineering Change activities
- Results of mitigations of risks and issues
- Work methods and processes
- Planning and scheduling processes
- Lots and batch sizes (optimization)
- Engineering and test activities and changes
- Quality inspections/tests sampling requirements
- Reduction in Scrap and Rework
- Inventory levels and storage
- Operation sequencing and synchronization
- P^3I program and processes

Tools

- Learning Curve Estimator
- Manufacturing Cost Estimating Spreadsheet

Resources

- IEEE 15288.2, System and Software Engineering, 2015
- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8 Learning Curve

F.4 Update Manufacturing Costs with Pilot Line Actuals

Manufacturing and Quality Tasks

- Based on all data collected for updated cost drivers and learning curves (See F.3) including results from pilot line, ensure cost models are updated and maintained current with up-to-date information and:
  - Drivers and estimates
  - Roll up of all tracked manufacturing and quality costs from the component level
  - Engineering change requests
  - Cost reduction and avoidance strategies
  - Mitigation of risks and issues
  - Analyses (of pilot line actual costs)
  - Analyses of proposed changes to manufacturing and quality processes and procedures
- Based on the results of CDR and the pilot line, analyze and update manufacturing and quality cost inputs for consistency with the current Cost Analysis Requirements Document (CARD); and provide updates, if necessary.
- Based on validated stable detailed design and supply chain (from pilot line), provide inputs to the program life-cycle cost estimate and schedule (IMP/IMS) for PRR.

- Provide manufacturing and quality cost estimate and realistic production unit cost goals for the P&D budget process.

Metrics

- Cost drivers (See F.2) and learning curves (See F.3) have been updated with results from pilot line, and cost models are maintained up-to-date to include:
  - Drivers and estimates
  - All manufacturing and quality cost data
  - Engineering change requests
  - Cost reduction and avoidance results
  - Risks and issues mitigation results
  - Pilot line actual costs
  - Changes to manufacturing and quality processes and procedures
- Manufacturing and quality cost inputs have been analyzed and updated for the CARD.
- Manufacturing and quality inputs to the program life-cycle cost estimate and schedule (IMP/IMS) have been provided and documented for PRR.
- Manufacturing and quality cost estimates and realistic production unit cost goals have been documented and provided to the P&D budget process.

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- MRL assessment for the Cost Thread
- See CAPE website for tools

Resources

- IEEE 15288.2
- MRL Deskbook Version 2016
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766 Design to Cost
- Should-cost and Affordability Memo, Aug 2011
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- CARD Website and process

F.5 Update Manufacturing and Quality Budget

Manufacturing and Quality Tasks

- Ensure all manufacturing and quality Milestone C risks and issues (i.e., MRL 8) are understood with approved and budgeted mitigation plans in place including:
  - A reasonable budget estimate for achieving required manufacturing and quality capability by the FRP decision point (i.e., MRL 9)
  - Investment required for LRIP and FRP
- Provide manufacturing and quality cost estimates for the P&D budget process (LRIP and FRP) including the following considerations:
  - Ongoing cost reduction initiatives.
  - Manufacturing and quality costs and cost drivers
  - Updated manufacturing and quality learning curves
  - Validation of manufacturing and quality processes (from pilot line) for affordability and executability
  - Results of analyses of manufacturing and quality risks, issues, and the status of mitigations
  - Required facilities, equipment, tooling, test equipment, GFE, etc. for scale-up to LRIP quantity production
  - Results of analyses of the Contractor's proposed manufacturing labor hours and material costs for adequacy, reasonableness, and necessity
  - Recommended manufacturing and quality cost reduction and avoidance initiatives
  - Results of cost performance analyses and trends
  - Manufacturing investment opportunities for future manufacturing improvement and development efforts (See F.3)
  - Funding and budgeting requests for applicable and/or emerging manufacturing and quality initiatives
  - Industrial base investment programs that create, expand, or preserve assured, affordable, robust, and commercially viable manufacturing and quality capabilities and capacities for LRIP and FRP

Metrics

- All manufacturing and quality Milestone C risks and issues (i.e., MRL 8) are understood with approved and budgeted mitigation plans in place including:
  - A reasonable budget estimate for achieving required manufacturing and quality capability by the FRP decision point (i.e., MRL 9)
  - Investment required for LRIP and FRP
- Manufacturing and quality cost estimates have been developed for the P&D budget process (LRIP and FRP) and include:

- Ongoing cost reduction initiatives
- Manufacturing and quality costs and cost drivers
- Updated manufacturing and quality learning curves
- Validated of manufacturing and quality processes (affordability and executability)
- Results and status of mitigations of manufacturing and quality risks and issues
- LRIP scale-up requirements for facilities, equipment, tooling, test equipment, GFE, etc.
- Realistic Contractor proposed manufacturing labor hours and material costs (adequacy, reasonableness, and necessity)
- Detailed manufacturing and quality cost reduction and avoidance initiatives/plans
- Cost performance trends and recommendations as required
- Investment opportunities for future manufacturing improvements and development efforts
- Budgeting requests for emerging manufacturing and quality initiatives
- Industrial base investment programs for commercially viable manufacturing and quality capabilities and capacities for LRIP and FRP

Tools

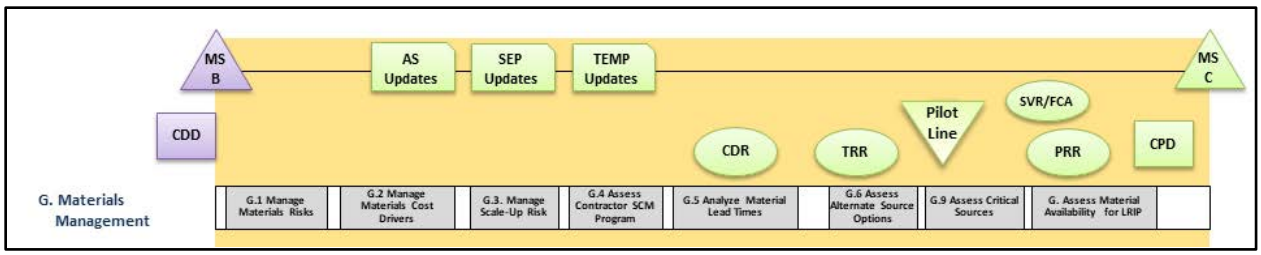
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding Thread
- Technology Readiness Level Assessment Checklist

Resources

- IEEE 15288.2
- Technology Readiness Assessment Guidance, Apr 2011
- Public Law 114-328, §807
- MRL Deskbook Version 2016

G. MATERIALS MANAGEMENT

One of the key elements in a successful program is aggressive materials management and planning. Materials management ranges from basic considerations of maturity and availability to understanding management of the supply chain and to details of GFP, shelf life, security, safety, hazardous materials, storage environment, etc. All program manufacturing and quality materials risks, issues, and opportunities should be assessed based on Contractor data and plans to meet program manufacturing and quality requirements.



The assessment should include analyses for materials fluctuations, rarity, availability, capacity, regulatory issues, ITAR, anti-tamper, and military vulnerability, as well as alternate materials that may mitigate known risks and issues. Additionally, manufacturing and quality risks, issues, and opportunities based on potential materials obsolescence and lack of availability from business climate impacts (e.g., business failures, market changes, political, etc.) should be included in assessments. Results of these assessments should be incorporated into recommended changes and updates for appropriate government/contractor mitigation plans.

For CDR, materials cost drivers must be updated and appropriate management plans implemented for control of all aspects of materials costs (actual and planned) for both the Government and the Contractor. The industrial and manufacturing capability should be assessed to baseline needed industrial capability and to obtain key knowledge on scale-up efforts, and potential supply chain issues. Managing scale-up for EMD should include planning that addresses new manufacturing and quality processes and techniques, meeting delivery dates, critical and long-lead materials, facility, equipment, tooling availabilities and capabilities, tests and demonstrations, conservation of critical and strategic materials, and transportation and security including ITAR considerations. Management also includes planning for mitigation of risks and issues, as well as exploiting opportunities. Manufacturing and quality should assess the Contractor’s materials supply chain for application, implementation, and adherence to industry manufacturing and quality best practices, as well as Contractor’s compliance with Company policies, processes, procedures, and contracts.

The materials and components lead times are extremely critical to both meeting program schedules and defining requirements for long lead and advanced buys. Lead times for defense materials and components can be long and volatile due to various reasons, such as imbalances between capacity and demand, competition from commercial customers, testing cycles, materials availability, budgeting, funding and contracting processes, transportability, workforce issues, etc. All of these can have an impact on capacity, quality, and schedule, thus driving lead times and the program must maintain visibility of the current status and the forecast changes in lead times.

The program's objectives should be to improve capabilities and quality, and reduce costs by maintaining (or improving) schedule, supporting the Industrial Base, and promoting competition by qualification of alternative sources. There many factors that can interfere with these objectives, requiring alternative sources. Natural disasters, such as earthquakes and tsunamis can severely disrupt production operations for many industries as can counterfeit parts and the loss of sources of items or material. Additionally, programs must account for Diminishing Manufacturing Sources and

Material Shortages (DMSMS) to mitigate risks to life-cycle support and viability of the weapon system or equipment. As a resource for this process, the Government Information Data Exchange Program (GIDEP) was established as the central repository within the DOD for all parts discontinuance and counterfeit notices. GIDEP receives notices from manufacturers and participants and distributes alerts to DOD and to private industry.

Future requirements (i.e., Operations and Support phase) for items which represent recurring spare parts requirements and substantial cost for annual buys, require aggressive action to develop alternative sources of supply. These sources ensure continuing part availability and competitive sources for these parts. The process of establishing competitive sources for these parts starts early in the production phase and continues as long as they are in the supply system. Based on pilot line results, manufacturing and quality should validate the identification of critical sources throughout the supply chain. Include sources of key and/or critical subsystems, items, parts, and components, including KCs (KCs), Configuration Items (CIs), and CSIs, required to meet program requirements.

Based on updates to Industrial Capabilities Assessments in support of MS C, manufacturing and quality should assess and verify material availability for LRIP, include availability risks, issues, and mitigations, costs and schedule updates, long-lead procurement risks, mitigation, and status, obsolescence, Supply chain management including first, second, and lower tier suppliers, counterfeit detection and avoidance, physical, cyber, and industrial security, special handling, transportation, storage, and environmental compliance risks and issues, etc. This assessment should consider emerging technology advancements in materials and processes, changes in Government statute, policy, and regulations, changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.), changes in environmental impacts (e.g., natural disasters, etc.), DMSMS, and program plans for P^3I in LRIP.

Successful completion of EMD with a thorough understanding of materials capabilities, capacities, and limitations and the aggressive management of and planning for materials will ensure effective transition to LRIP and Production and Deployment phase.

G.1 Manage Materials Risk

Manufacturing and Quality Tasks

- Analyze the Contractor’s plans to meet manufacturing and quality requirements for maturity of materials by CDR, including:
    - Risks and issues
    - Associated cost drivers (See G.2)
    - Design requirements
    - Configuration Management
    - Materials processes maturity
    - Materials specifications

- Emerging materials
- Cost reduction and avoidance
- Materials availability and lead times
- Environmental factors
- Management of the supply chain
- Counterfeit parts and obsolescence
- Security, required special handling, physical and cyber protection
- Facilities, capital equipment, tooling, and test equipment
- Storage, handling, transportation, etc.

- Based Contractor data, assess all materials for manufacturing and quality risks, issues, and opportunities:
  - Update evaluation of material maturity and availability from TMRR for adequacy to support pilot line
    - Assess validity and maturity of emerging materials for manufacturability
    - Assess maturity in a production environment
  - Update the manufacturing and quality evaluation of lead times including:
    - Long lead materials
    - Impacts to schedule, budget, and critical path, etc.
    - Impacts from fluctuations, availability, capacity, regulatory issues, ITAR, Anti-Tamper, etc.
  - Identify opportunities for alternative materials (to avoid or mitigate known risks and issues)
- Assess and identify manufacturing and quality risks, issues, and opportunities for materials obsolescence and lack of availability based on analyses of the business climate (e.g., business failures, market changes, political, etc.) for the CDR including:
  - Availability from single or sole sources (domestic or foreign), within the NTIB, only from sources that are outside the NTIB, vulnerable to foreign acquisition
  - Disruptive business climate conditions (e.g., natural disasters, strikes, etc.)
  - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
- Develop Government mitigation plans as appropriate (specified in the program SEP) for:
  - Known risks to critical and strategic materials
  - Availability issues to be addressed for pilot line and LRIP builds
- Monitor Contractor mitigation processes and plans as specified in the Contractor SEMP for alignment with the program SEP.
- Analyze and assess the Contractor's Make/Buy process for adequacy and completeness including capabilities, capacities, and processes for:
  - Key and/or critical subsystems, items, parts, and components to include volatility

- Management of the supply chain (including other divisions)
- Vendors to meet quality requirements, schedule and cost targets
- Identification and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
- Management of GFE, GFM, etc.

- Analyze and assess the Contractor's hazardous and special handling, storage, and environmental compliance procedures for risks and issues to include:
  - Regulatory requirements
  - Hazardous materials and handling procedures
  - Security requirements (physical, cyber, industrial, etc.)
  - Transportation, storage, and shelf life
  - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
  - Disposal

Metrics

- Contractor's plans to meet manufacturing and quality requirements for material maturity by CDR have been assessed and recommended approvals, changes, updates, and appropriate government/contractor mitigation plans have been documented for program management for the following:
  - Risks and issues
  - Associated cost drivers (See G.2)
  - Design requirements
  - Configuration Management
  - Materials processes maturity
  - Materials specifications
  - Emerging materials
  - Cost reduction and avoidance
  - Materials availability and lead times
  - Environmental factors
  - Management of the supply chain
  - Counterfeit parts and obsolescence
  - Security, required special handling, physical and cyber protection
  - Facilities, capital equipment, tooling, and test equipment
  - Storage, handling, transportation, etc.

- Based Contractor data, all materials have been assessed for manufacturing and quality risks, issues, and opportunities and recommended changes, updates, and appropriate government/contractor mitigation plans have been documented for program management for:
  - Adequacy of material maturity and availability to support pilot line including:
    - Validity and maturity of emerging materials
    - Use in a production environment

- Capability and capacity to meet required availability (lead times) including:
  - Long lead materials
  - Schedule, budget, and critical path, etc. impacts
  - Fluctuations, regulatory issues, ITAR, Anti-Tamper, etc.
- Opportunities for alternative materials (to avoid or mitigate known risks and issues)

- Based on analyses of the business climate (e.g., business failures, market changes, political, etc.), manufacturing and quality risks, issues, and opportunities for materials obsolescence and availability have been assessed for CDR and the results documented for CDR with recommended mitigations for:
  - Single or sole sources (domestic or foreign), and sources vulnerable to foreign acquisition
  - Disruptive business climate conditions (e.g., natural disasters, strikes, etc.)
  - DMSMS
- Manufacturing and quality inputs to Government materials risks and issues mitigation plans have been provided for:
  - Known risks to critical and strategic materials
  - Availability issues to be addressed for pilot line and LRIP builds
- Contractor manufacturing and quality mitigation processes and plans, as specified in the Contractor SEMP, have been assessed for compliance with the program SEP and recommendations for changes to the SEMP and/or SEP have been documented and provided to program management.
- Contractor's Make/Buy process has been assessed for adequacy and completeness of
- capabilities, capacities, and processes and recommended changes, updates, and appropriate government/contractor mitigation plans have been documented for program management for:
  - Key and/or critical subsystems, items, parts, and components
  - Management of the supply chain (including other divisions)
  - Vendors capability to meet quality requirements, schedule and cost targets
  - Process for counterfeit parts and materials detection and avoidance (e.g., end items, components, parts, or assemblies)
  - Management of GFE, GFM, etc.
- Contractor's hazardous and special handling, storage, and environmental compliance procedures for risks and issues have been assessed for adequacy and completeness and recommended manufacturing and quality changes, updates, and appropriate government/contractor mitigation plans have been documented for CDR to include:
  - Regulatory requirements
  - Hazardous materials and handling procedures
  - Security requirements (physical, cyber, industrial, etc.)
  - Transportation, storage, and shelf life
  - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)

- Disposal

Tools

- DCMA Material Management and Accounting System Audit
- PESHE Assessment/Template
- ISO 14001 Gap Analysis Toolkit
- DMSMS Product Life Cycle Assessment (Consult DLA)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- MRL Assessment Questionnaire for the Materials Thread
- Supply chain Management Risk Assessment Checklist
- Producibility Assessment Worksheet
- TRL Assessment Questionnaire

Resources

- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328, Dec 16
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- ESOH in Acquisition Guide, Apr 2009
- ISO 14001 Environmental Management Systems
- DMSMS Guidebook, SD-22, Sep 2009
- DOD 5000.60 Defense Industrial Capabilities Assessments
- DOD 5000.60H Assessing Defense Industrial Capabilities
- DOD 4140.1-R supply chain Management Regulation
- DoDM 4140.1 DoD supply chain Management Procedures, Feb 2014
- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999

G.2 Manage Materials Cost Drivers

Manufacturing and Quality Tasks

- Based on manufacturing, quality, and unique and/or specialized requirements, specifications, and tolerances, and associated risks and issues; analyze and update manufacturing and quality materials cost drivers for the CDR to include:
  - Contractor plans for materials, materials processes, rates and quantities (including lot buys),
  - Risk mitigation processes (ongoing, identification, reduction, etc.)
  - Supplier Chain (e.g., capability, capacity, quality, etc.)
  - Special handling and training
  - Environmental compliance and training,
  - Materials security (physical, cyber, industrial, etc.)

- Planned subsystems, parts, items, and components (supply chain commodities) to include alternative sources
- Planned rates and quantities for pilot line and LRIP
- Updated "should-cost" analyses and actuals
- Updated materials cost driver uncertainties (based on actuals)
- Cost drivers updates impacted by conservation critical and strategic materials
- Cost drivers for mitigation of supply disruptions
- Updated estimates for the cost of quality
- Updated estimates for the cost of materials testing

- Analyze and update the contractor planning (producibility) with respect to materials cost drivers and associated risks (see G.1) for the CDR to include:
  - Design requirements
  - Configuration management
  - Emerging materials
  - Price stability, cost reduction and avoidance
  - Rates and quantities
  - Materials process maturity including quality processes
  - Materials specifications
  - Materials availability (lead times)
  - Cost reduction and avoidance
  - Environmental factors and compliance
  - Management of supply chain
  - Processes and quality
  - Counterfeit parts avoidance
  - Obsolescence
  - Security, required special handling, physical, cyber, and industrial
  - Facilities, capital equipment, tooling, and test equipment
  - Storage, handling, and transportation, etc.

- Assess and identify manufacturing and quality materials cost drivers based on industrial base analyses of the business climate (e.g., business failures, acquisitions, market changes, political changes, etc.) for the CDR including:
  - Materials availability only from single or sole sources, foreign sources (only from sources that are outside the NTIB), and sources vulnerable to foreign acquisition
  - Disruptive business climate conditions (e.g., natural disasters, strikes, etc.)
  - Materials subject to Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
  - Materials market stability (commodities)

Metrics

- Based on manufacturing, quality, and unique and/or specialized requirements, specifications, and tolerances, and associated risks and issues, manufacturing and quality has assessed materials cost drivers and documented recommended updates and changes to cost drivers risk and issue mitigation plans for the CDR on the following:
    - Contractor plans for materials, materials processes, rates, and quantities
    - Risk mitigation processes (ongoing, identification, reduction, etc.)
    - Supplier Chain (e.g., capability, capacity, quality, etc.)
    - Special handling and training
    - Environmental compliance and training,
    - Materials security (physical, cyber, industrial, etc.)
    - Planned subsystems, parts, items, and components (supply chain commodities) to include alternative sources
    - Planned rates and quantities for pilot line and LRIP
    - Updated “should-cost” analyses and actuals
    - Updated materials cost driver uncertainties (based on actuals)
    - Cost drivers updates impacted by conservation critical and strategic materials
    - Cost drivers for mitigation of supply disruptions
    - Updated estimates for the cost of quality
    - Updated estimates for the cost of materials testing
- Contractor planning with respect to materials cost drivers and associated risks (see G.1) has been assessed and based on the results manufacturing and quality recommendations, changes, and updates have been documented for the CDR to include:
    - Design requirements
    - Configuration management
    - Emerging materials
    - Price stability, cost reduction and avoidance
    - Rates and quantities
    - Materials process maturity including quality processes
    - Materials specifications
    - Materials availability (lead times)
    - Cost reduction and avoidance
    - Environmental factors and compliance
    - Management of supply chain
    - Processes and quality
    - Counterfeit parts avoidance
    - Obsolescence
    - Security, required special handling, physical, cyber, and industrial
    - Facilities, capital equipment, tooling, and test equipment
    - Storage, handling, and transportation, etc.

- Manufacturing and quality has participated in and provided support for assessments and analyses of the industrial base business climate materials cost drivers (e.g., business failures, acquisitions, market changes, political changes, etc.) and has provided documented recommendations and changes on the following:
    - Materials availability (e.g., single or sole sources, foreign sources, and sources vulnerable to foreign acquisition)
    - Business climate conditions (e.g., natural disasters, strikes, etc.)
    - Market changes from technological evolution
    - Business changes (e.g., political, etc.)
    - Materials subject to Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
    - Materials market stability (commodities)

Tools

- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Cost, Schedule Control Systems Criteria (CSCSC)
- MRL assessment for the Material Management Thread
- Producibility Assessment

Resources

- Cost/Schedule Control System Criteria
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328, Dec 16
- MRL Deskbook Version 2016

G.3 Manage Scale-Up Risk

Manufacturing and Quality Tasks

- Analyze and update materials producibility assessments, manufacturing processes, techniques, procedures, capacity, and availability to meet program requirements (scale-up for pilot line, LRIP, and FRP) and assess materials risks, issues, and opportunities including:
    - New materials (to the industry, to the program, to the suppliers)
    - Supply chain and/or source capability and capacity
    - Source criticality and fragility (e.g., sole or single sources, foreign sources, domestic foreign-owned, etc.)
    - Workforce (e.g., knowledge, availability, etc.)
    - Lead times for required quantities (un-proven suppliers)

- Rates that are higher and/or lower than typical
- Introduction of counterfeit materials
- Obsolescence due to product improvements and market/technology changes
- Regulatory requirements and impacts (e.g., US law, ITAR, environmental, REACH concerns, etc.)
- Testing aspects throughout the production processes and supply chain
- Security (e.g., special handling, physical, cyber, industrial, etc.)
- Facilities, equipment, and tooling
- Transportation, storage, and handling

- Update and ensure manufacturing and quality plans for CDR address scale-up risks, issues, and opportunities to include:
  - Manufacturing processes, techniques, and procedures (including special handling)
  - Meeting schedule
  - Addressing impacts from critical and long-lead time materials
  - Addressing facility, equipment, and tooling availability (acquisition and/or scheduling)
  - Cost models, drivers, and schedules
  - Manufacturing and quality materials alternatives
  - Required testing
  - Conservation of critical and strategic materials
  - Workforce
  - DMSMS
  - Counterfeit avoidance
  - Supply disruption
  - Regulatory requirements and impacts (e.g., environmental, HAZMAT, etc.)
  - Security (e.g., special handling, physical, cyber, industrial, etc.)
  - Transportation, storage, and handling

Metrics

- Manufacturing and quality have assessed, updated, and/or validated materials producibility, manufacturing processes, techniques, procedures, capacity, and availability assessments for the capability to meet program scale-up requirements and materials risks, issues, and opportunities results have been documented in the Manufacturing Strategy and Plan and Quality Strategy and Plan (for CDR) for pilot line, LRIP, and FRP including:
  - New materials (to the industry, to the program, to the suppliers)
  - Supply chain and/or source capability and capacity
  - Source criticality and fragility (e.g., sole or single sources, foreign sources, domestic foreign-owned, etc.)
  - Workforce (e.g., knowledge, availability, etc.)
  - Lead times for required quantities (un-proven suppliers)
  - Rates that are higher and/or lower than typical
  - Introduction of counterfeit materials

  - Obsolescence due to product improvements and market/technology changes
  - Regulatory requirements and impacts (e.g., US law, ITAR, environmental, REACH concerns, etc.)
  - Testing aspects throughout the production processes and supply chain
  - Security (e.g., special handling, physical, cyber, industrial, etc.)
  - Facilities, equipment, and tooling
  - Transportation, storage, and handling

- Program Manufacturing Strategy and Plan and Quality Strategy and Plan (See L.2 and I.2) have been updated to mitigate and/or eliminate risks and issues and address opportunities for pilot line, LRIP, and FRP material scale-up requirements to include:

  - Manufacturing processes, techniques, and procedures (including special handling)
  - Schedule
  - Impacts from critical and long-lead time materials
  - Facility, equipment, and tooling availability (acquisition and/or scheduling)
  - Cost models, drivers, and schedules
  - Manufacturing and quality materials alternatives
  - Testing
  - Conservation of critical and strategic materials
  - Workforce
  - DMSMS
  - Counterfeit avoidance
  - Supply disruption
  - Regulatory requirements and impacts (e.g., environmental, HAZMAT, etc.)
  - Security (e.g., special handling, physical, cyber, industrial, etc.)
  - Transportation, storage, and handling

Tools

- Cost and Lead Time Worksheet
- Producibility Assessment Worksheet
- Manufacturing Readiness Assessment Materials Thread
- ManTech Strategic Plan

Resources

- EC 1907/2006, Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
- MRL Deskbook Version 2016
- MRL Users Guide
- DoD Directive 4200.15, ManTech
- Air Force Technology Development and Transition Strategy Guidebook, Nov 2010

G.4 Assess Contractor supply chain Management (SCM) Program

Manufacturing and Quality Tasks

- Assess the contractor's materials supply chain Management (SCM) program for implementation and adherence to industry manufacturing and quality best practices to include:
  - Manufacturing management standards (e.g., AS6500, MIL-STD-896A, etc.)
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)
  - Configuration management
  - Systems Engineering standards (e.g., IEEE 15288, etc.)
- Assess the contractor's materials supply chain Management (SCM) program for:
  - Management of suppliers and sub-tier materials manufacturing processes and procedures, especially suppliers performing key and/or critical materials manufacturing processes impacting KCs
  - Implementation and compliance to security processes, plans, and procedures for materials including:
    - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
    - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
  - Materials special handling, storage, safety, and environmental compliance procedures to include:
    - Regulatory requirements
    - Hazardous materials and handling procedures
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal
  - Materials supplier sourcing processes for:
    - Supplier evaluation, qualification, approval, re-qualification, and removal
    - Management of sole or single sources, foreign sources, domestic foreign-owned, etc.
    - Management of capabilities and capacities
  - Development of strategic partnerships with vendors and suppliers
  - Materials sub-contract management for:
    - Monitoring sub-tier compliance to manufacturing and quality contractual requirements
    - Monitoring sub-tier processes (e.g., configuration management, parts management, obsolescence, counterfeit parts management, electro-static discharge program, etc.)
    - Communications (e.g., two-way flow of quality data, requirements, forecasting data, etc.)

6004 ▪ Materials data (e.g. testing, analyses, storage, and traceability, etc.)
6005 ▪ Quality program implementation (e.g., SPC, process capabilities, predictive
6006 indicators, variability reduction, etc.)

6007 o Materials procurement processes for:

6008 ▪ Specification of requirements (e.g., drawings, revisions, packaging, kitting,
6009 identification, etc.)
6010 ▪ Specification of quality standards and metrics
6011 ▪ Scheduling, quantities, etc.
6012 ▪ Supplier assistance programs
6013 ▪ Monitoring and evaluations
6014 ▪ Deficiencies and corrective actions (i.e. FRACAS)

6015 o Internal logistics and inventory management processes for materials including:

6016 ▪ Production scheduling, kitting, identification, etc.
6017 ▪ Pre- and post-production storage, scheduling, kitting, packaging, environmental,
6018 security, etc.
6019 ▪ Transportation methods, special handling, packaging, environmental controls,
6020 identification and tracking, etc.
6021 ▪ Vendor Managed Inventory (e.g., quality, schedule, quantity, packaging, kitting,
6022 identification and tracking, etc.)

6023 o Integration of supply chain risks and issues for KCs, security, compliance, sourcing
6024 (counterfeit, obsolescence, etc.), and procurement into the joint contractor's Risk, Issue,
6025 and Opportunity System

6026 • Assess the contractor manufacturing and quality materials processes for compliance with or
6027 adherence to Company policy, process, and contracts, utilizing DCMA support (requires a
6028 Letter of Delegation) to include:

6029 o Implementation of industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
6030 o Performing first article/qualification(s) (i.e., AS9103)
6031 o SCM of interdependencies
6032 o Sourcing to minimize risks, criticality, and obsolescence
6033 o Supplier qualification, approval, and monitoring processes to include

6034 ▪ Suppliers with known risks
6035 ▪ Supplier parts usage and sources (i.e., GIDEP prohibited)

6036 o Processes for data flow (two-way)

6037 ▪ Program reviews, milestones, and metrics
6038 ▪ Demand Planning
6039 ▪ Quality, safety, technical, and inspection requirements and changes
6040 ▪ Key and critical characteristics

6041 o Make or buy decision analysis processes

- Counterfeit and DMSMS management processes
- Inventory management
- FRACAS process
- Security processes
- ESOH management
- Material waiver process (should only be utilized in limited circumstances)
- Implementation of supply chain Management oversight processes
  - Vendor survey requirements
  - Identification and management of risks, issues, and opportunities
  - Surveillance

- Ensure assessments of critical first, second, and lower tier supply chain for compliance to purchase order/subcontract quality, manufacturing/ production, engineering and software requirements are completed.
- Initiate SCM planning for EMD, production, developmental and operational test, and life-cycle sustainment.

Metrics

- Contractor's materials SCM program has been assessed for implementation and adherence to industry manufacturing and quality best practices with documented changes and recommendations provided to program management on the following:
  - Manufacturing management standards (e.g., AS6500, MIL-STD-896A, etc.)
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)
  - Configuration management
  - Systems Engineering standards (e.g., IEEE 15288, etc.)
- Contractor's materials SCM program has been assessed for specific manufacturing and quality requirements, processes, and procedures with documented recommendations and changes provided to program management on the following:
  - KCs (KCs) management, including suppliers and sub-tier materials manufacturing processes and procedures
  - Compliance with security processes, plans, and procedures for materials including:
    - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
    - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
  - Special handling, storage, safety, and environmental compliance for materials to include:
    - Regulatory requirements
    - Hazardous materials and handling
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal

- Supplier sourcing processes for:
  - Supplier evaluation, qualification, approval, re-qualification, and removal
  - Management of sole or single sources, foreign sources, domestic foreign-owned, etc.
  - Management of capabilities and capacities
- Vendor and supplier strategic partnerships
- Contract management for sub-tier including:
  - Compliance monitoring for manufacturing and quality contractual requirements
  - Process monitoring (e.g., configuration management, parts management, obsolescence, counterfeit parts management, electro-static discharge program, etc.)
  - Communications (e.g., two-way flow of quality data, requirements, forecasting data, etc.)
  - Materials data management (e.g. testing, analyses, storage, and traceability, etc.)
  - Quality (e.g., SPC, process capabilities, predictive indicators, variability reduction, etc.)
- Materials procurement including:
  - Requirements (e.g., drawings, revisions, packaging, kitting, identification, etc.)
  - Quality standards and metrics
  - Scheduling, quantities, etc.
  - Supplier assistance programs
  - Monitoring and evaluations
  - Deficiencies and corrective actions (i.e. FRACAS)
- Internal logistics and inventory management including:
  - Production scheduling, kitting, identification, etc.
  - Pre- and post-production storage, scheduling, kitting, packaging, environmental, security, etc.
  - Transportation methods, special handling, packaging, environmental controls, identification and tracking, etc.
  - Vendor Managed Inventory (e.g., quality, schedule, quantity, packaging, kitting, identification and tracking, etc.)
- Integration of supply chain risks and issues for KCs, security, compliance, sourcing (counterfeit, obsolescence, etc.), and procurement into the joint contractor's Risk, Issue, and Opportunity System

- Utilizing DCMA support, contractor's manufacturing and quality materials processes have been assessed for compliance with or adherence to Company policies, processes, procedures, and contracts with documented recommendations and changes provided to program management on the following for CDR:
  - Company adherence to industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
  - First article inspections and qualification(s) (i.e., AS9103)

- SCM of interdependencies
- Sourcing to minimize risks, criticality, and obsolescence
- Supplier qualification (approval and monitoring) including
  - Suppliers with known risks
  - Supplier parts usage and sources (i.e., GIDEP prohibited)
- Management of data flow (two-way)
  - Program reviews, milestones, and metrics
  - Demand Planning
  - Quality, safety, technical, and inspection requirements and changes
  - Key and critical characteristics
- Make or buy decision analysis
- Counterfeit and DMSMS management
- Inventory management
- FRACAS
- Security
- ESOH management
- Material waivers
- Implementation of SCM oversight including:
  - Vendor survey requirements
  - Identification and management of risks, issues, and opportunities
  - Surveillance

- Assessments of critical first, second, and lower tier supply chain for compliance to purchase order/subcontract quality, manufacturing/ production, engineering and software requirements have been completed and are documented for CDR.
- Program SCM planning for the Manufacturing and Quality Strategies and Plans has been documented to include EMD, production, developmental and operational test, and life-cycle sustainment for CDR.

Tools

- AS5553 supply chain Assessment
- DCMA Material Management and Accounting System Audit
- Manufacturing Readiness Assessment using the Material thread

Resources

- AS6500, Manufacturing Management Systems
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016s

- AS9103 Variation Management of Key Characteristics
- AS9133, Qualification Procedure for Aerospace Standard Parts
- ISO 9001:2015, Quality Management System
- MIL-STD-896A, Manufacturing Quality Program
- AS5553, Counterfeit Electronics Parts
- IEEE 15288.2, System and Software Engineering, 2015
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.02, Enclosure 14
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

G.5 Analyze Material Lead Times

Manufacturing and Quality Tasks

- Perform an analysis of contractor's manufacturing and quality schedule and quantities for sub-systems, items, and components to meet program IMP/IMS and critical path requirements.
- Analyze results of assessments of contractor and key supply chain to ensure identification of manufacturing and quality risks, issues, and opportunities associated with scheduling procurement of materials (e.g., sub-systems, items, and components) to include:
    - Long-lead Items
    - Lead time fluctuations
    - Impacts from single or sole sources, sources that are outside the NTIB, and sources vulnerable to foreign acquisition
    - Business climate conditions (e.g., acquisitions and mergers, natural disasters, strikes, policies and political changes, etc.)
    - Market changes (e.g., technological changes and obsolescence, workforce, etc.)
    - Impacts from scale-up
    - Impacts from regulatory issues, ITAR, Anti-Tamper, etc.
- Assess pilot line and LRIP procurement requirements (e.g., schedule and quantities).
- Ensure government manufacturing and quality funding supports contractor schedule and procurement requirements.
- Ensure mitigation plans are developed and implemented for all identified procurement risks and issues for CDR.

Metrics

- Contractor's manufacturing and quality schedule and quantities for sub-systems, items, and components have been assessed for meeting program schedule and critical path requirements and recommendations and changes have been documented for the contractor plans and/or the IMP/IMS and provided for CDR.
- Contractor and key supply chain assessment results have been analyzed and document for CDR manufacturing and quality risks, issues, and opportunities associated with scheduling procurement of materials (e.g., sub-systems, items, and components) including:
    - Long-lead Items
    - Lead time fluctuations
    - Impacts from single or sole sources, sources that are outside the NTIB, and sources vulnerable to foreign acquisition
    - Business climate conditions (e.g., acquisitions and mergers, natural disasters, strikes, policies and political changes, etc.)
    - Market changes (e.g., technological changes and obsolescence, workforce, etc.)
    - Impacts from scale-up
    - Impacts from regulatory issues, ITAR, Anti-Tamper, etc.
- Pilot line and LRIP procurement requirements for schedule and quantities have been assessed and documented for CDR.
- Government manufacturing and quality funding support for the contractor schedule and procurement requirements has been verified and confirmed for CDR.
- Mitigation plans have been developed and are in place for mitigation of all procurement risks and issues for CDR.

Tools

- Cost and Lead Time Estimating Worksheet

Resources

- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- MRL Deskbook Version 2016

G.6 Assess Alternate Source Options

Manufacturing and Quality Tasks

- Analyze the contractor's manufacturing and quality sourcing plans, policies, and procedures (e.g., make/buy, alternate sources, etc.) for subsystems, items, and components for:
    - Meeting qualification requirements
    - Contingency planning (e.g., capacity, economic/political impacts, disaster impacts, etc.)
    - Competitive sources (e.g., dual source, GFE, etc.)

- Costs (e.g., per unit, investment, storage and handling, etc.)
- Materials with environmental or ESOH concerns
- Vulnerability mitigation for single, sole, foreign, foreign-owned domestic, fragile, critical, etc.
- Materials only available outside the NTIB
- Quality, schedule, transportation, fulfillment, etc.
- Hazardous materials
- Difficulty to obtain and/or process materials
- Meeting Government requirements for support of the NTIB
- Counterfeit detection and prevention (including GIDEP data)

- Based on manufacturing and quality analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, develop recommendations for alternate sources and options for pilot line, LRIP, and O&S including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Ensure alternate materials sources and/or materials mitigate current risks and issues and/or do not introduce new risks and issues to the program.
- Ensure contractor's alternate manufacturing and quality sourcing plans, policies, and procedures are consistent with program plans for program plans for Product Improvement (P^3I).
- Ensure continuing parts and materials availability for future requirements (i.e., Operations and Support phase) by assessing the supply chain for its long term viability and competitive sourcing.

Metrics

- Contractor's manufacturing and quality sourcing plans, policies, and procedures (e.g., make/buy, alternate sources, etc.) have been assessed and document recommended updates and changes to subsystems, items, and components for:
  - Meeting qualification requirements
  - Contingency planning (e.g., capacity, economic/political impacts, disaster impacts, etc.)
  - Competitive sourcing (e.g., dual source, GFE, etc.)
  - Costs (e.g., per unit, investment, storage and handling, etc.)
  - Materials with environmental or ESOH concerns
  - Mitigation for sources that are single, sole, foreign, foreign-owned domestic, fragile, critical, etc.
  - Materials only available outside the NTIB
  - Quality, schedule, transportation, etc.

- Hazardous materials
- Materials that are difficult to obtain and/or process materials
- Materials to meet Government requirements for supporting the NTIB
- Detection and prevention of counterfeit parts (using GIDEP data, etc.)

- Manufacturing and quality recommendations to minimize risks and issues, and exploit opportunities, through alternate sources and options for pilot line and LRIP have been documented for program management to include:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - DMSMS
- Contractor's proposed alternate materials sources and/or materials have been assessed for mitigation of current risks and issues and/or do not introduce new risks and issues to the program with results documented for program management.
- Contractor's alternate manufacturing and quality sourcing plans, policies, and procedures have been assessed to be are consistent with program plans for P^3I.
- Continuing parts and materials availability have been assessed for capability and capacity of the supply chain and proposed alternate competitive sources to meet future requirements (i.e., O&S phase).

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit

Resources

- DFAR 15.407-2 Make or Buy Programs
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- Contractor Purchasing System Review (CPSR) Guidebook, May 2017
- MRL Deskbook Version 2016
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material

G.7 Assess Critical Sources

Manufacturing and Quality Tasks

- Based on pilot line results, review and update assessment of the contractor's Make/Buy process for adequacy and completeness including capabilities, capacities, and processes for: (See G.1)

- Key and/or critical subsystems, items, parts, and components to include volatility
- Management of the supply chain (including other divisions)
- Vendors to meet quality requirements, schedule and cost targets
- Identification and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
- Management of GFE, GFM, etc.

- Conduct an assessment of the Bill of Materials for LRIP to include:
  - Make/buy process and decisions
  - Identification of key and/or critical items, parts and components
  - Identification of risks, issues, and opportunities
- Ensure identification and management of critical sources throughout the supply chain including:
  - All configuration items (CIs)
  - All CSIs
  - All KCs
- Based on pilot line results, update manufacturing and quality assessments and validation of materials to meet program requirements and mitigation progress on materials risks, issues, and opportunities delineated in the Manufacturing Strategy and Plan and Quality Strategy and Plan (pre-CDR, See G.3) for LRIP, and FRP including:
  - Materials producibility, manufacturing processes, techniques, procedures
  - Source availability, capacity, and capability
  - Source criticality and fragility (e.g., sole or single sources, foreign sources, domestic foreign-owned, etc.)
  - Counterfeit detection and avoidance
  - Security (physical, cyber, industrial, anti-tamper, etc.)
  - ITAR
  - Surveillance (program and/or DCMA)
- Based on pilot line results, review and update the Manufacturing Strategy and Plan and Quality Strategy and Plan (from CDR) for changes to the contractor's:
  - Materials planning and control systems
  - Bill of Materials and make/buy decisions
  - Materials processes and procedures
  - Facilities, equipment, tooling
  - Tests, test facilities and equipment
- Based on pilot line assessments and results, ensure required material maturity has been proven and validated for LRIP, including:
  - Properties and characteristics
  - Material producibility, predictability, manufacturability, etc.

Metrics

- Based on pilot line results, contractor's Make/Buy process has been reviewed for adequacy and completeness and updates and recommended changes have been documented for PRR, including capabilities, capacities, and processes for: (See G.1)
    - Key and/or critical subsystems, items, parts, and components to include volatility
    - Management of the supply chain (including other divisions)
    - Vendors to meet quality requirements, schedule and cost targets
    - Identification and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
    - Management of GFE, GFM, etc.
- Assessment of the LRIP Bill of Materials has been conducted and recommendations and changes documented for PRR to include:
    - Make/buy decisions
    - Changes to delineation of key and/or critical items, parts and components
    - Delineation and mitigation of risks and issues
    - Exploitation plans for opportunities and investments (Government, contractor, and supply chain)
- Critical sources throughout the supply chain have been delineated and documented for PRR to include:
    - All configuration items (Cis)
    - All CSIs
    - All KCs
- Manufacturing and quality assessments and validation of materials to meet program requirements and mitigation progress on materials risks, issues, and opportunities have been conducted and changes and recommendations have been documented in Manufacturing Strategy and Plan and Quality Strategy and Plan for LRIP, and FRP including the following:
    - Materials producibility, manufacturing processes, techniques, procedures
    - Source availability, capacity, and capability
    - Source criticality and fragility (e.g., sole or single sources, foreign sources, domestic foreign-owned, etc.)
    - Counterfeit detection and avoidance
    - Security (physical, cyber, industrial, anti-tamper, etc.)
    - ITAR
    - Surveillance (program and/or DCMA)
- Changes have been documented in the program's Manufacturing Strategy and Plan and Quality Strategy and Plan based on pilot line and changes in the contractor's:
    - Materials planning and control systems
    - Bill of Materials and make/buy decisions

- Materials processes and procedures
- Facilities, equipment, tooling
- Tests, test facilities and equipment

- Based on pilot line assessments and results, capability, capacity, and adequacy of materials to support the LRIP has been proven and validated and the results documented for PRR, including:
  - Properties and characteristics
  - Material producibility, predictability, manufacturability, etc.

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit

Resources

- DFAR 15.407-2 Make or Buy Programs
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- Contractor Purchasing System Review (CPSR) Guidebook, May 2017
- MRL Deskbook Version 2016, Materials Management thread
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328, Dec 16
- MRL Deskbook Version 2016

G.8 Assess Material Availability for LRIP

Manufacturing and Quality Tasks

- Based on updates to Industrial Capabilities Assessments (See D.5 in support of MS C), assess and verify material availability for LRIP, including the following considerations:
  - Availability risks, issues, and mitigations (including for FRP)
  - Costs and schedule
  - Long-lead procurement risks and mitigation
  - Obsolescence
  - Long lead procurements
  - Supply chain
  - Effective supply chain management processes (including first, second, and lower tier suppliers as necessary)
  - Counterfeit detection and avoidance
  - Security (physical, cyber, industrial, anti-tamper, etc.)
  - Make/Buy decisions
  - Special handling, transportation, storage, and environmental compliance risks and issues

- GFE, GFF, etc.

- Based on manufacturing and quality analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, assess and verify material availability for LRIP, including the following considerations:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)

- Assess materials availability to for contractor's manufacturing and quality materials plans to meet program plans for P^3I in LRIP.

Metrics

- Based on updates from the Industrial Base Assessments, material availability has been assessed and the capability to meet LRIP requirements has been documented for PRR including:
  - Availability from Industrial Base sources including risk and issue mitigations
  - Ability to meet costs and schedule
  - Obsolescence plans are in place.
  - Procurements of long lead materials
  - Effective supply chain management processes in place with assessment of critical first tier supply chain completed
  - Adequacy of supply chain to support LRIP with assessment of critical second and lower tier supply chain completed
  - Counterfeit detection and avoidance
  - Security (physical, cyber, industrial, anti-tamper, etc.)
  - Completed Make/Buy decisions.
  - Special handling, transportation, storage, and environmental compliance mitigations in place
  - All GFE, GFF, etc.

- Based on manufacturing and quality analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, recommendations for materials sourcing and options for LRIP have been documented for PRR including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)

- Materials sources and/or materials have been assessed to mitigate current risks and issues, do not introduce new risks and issues to the program for LRIP, and have been documented for PRR.
- Contractor's manufacturing and quality materials sourcing plans, policies, and procedures have been assessed and changes and/or recommendations for consistent with program plans for P^3I for LRIP have been documented for PRR.

Tools

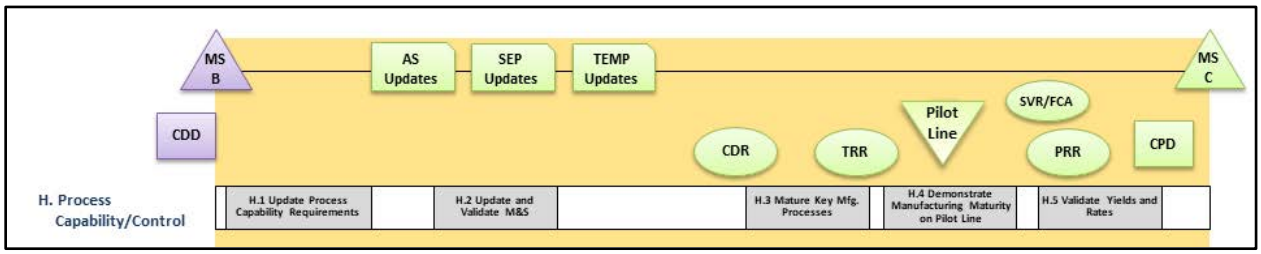
- MRL Assessment Questionnaire for the Materials Thread
- Supply chain Management Risk Assessment Checklist
- DCMA Material Management and Accounting System Audit

Resources

- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- MRL Deskbook Version 2016

H. PROCESS CAPABILITY/CONTROL

Manufacturing and quality process capability and control should be an integral part of any development program. Manufacturing and quality efforts should lead to a producible system with the objective of achieving effective and efficient manufacturing processes with process controls in order to satisfy program requirements with consistent and repeatable products at minimum manufacturing costs.



In preparation for CDR, previously identified manufacturing and quality process capabilities should be refined and updated based on data collected and the contractor's plans, processes, and procedures to identify the process capabilities required for the system. During the development process, additional studies at the system, subsystem, item, and component levels will be conducted to define the appropriate level of process capability and control. A thorough knowledge of a contractor's and supply chain's process capabilities is critical to developing a successful system. Process capabilities and data must be understood, measured, controlled, and documented, and process capability information must be up-to-date.

Program manufacturing and quality personnel should have an understanding of the contractor's Modeling and Simulation (M&S) tools and or products, as well as the industry state-of-the-art and best practices manufacturing and production M&S. The contractor should have and be utilizing manufacturing and quality M&S tools which must be validated for applicability, adequacy, and consistency. Additionally, program manufacturing and quality must assess and understand the correlation of demonstration results with M&S results and ensure M&Ss are updated to reflect maturity of manufacturing and quality systems, systems performance, and capability.

During the EMD phase the contractor will conduct pilot line demonstrations that will include testing and analysis to ensure products meet the program requirements. These products will be built on pilot lines. This means all of the key production realism elements (e.g., equipment, personnel skill levels, facilities, materials, components, work instructions, processes, tooling, temperature, cleanliness, lighting, etc.) required to manufacture products (e.g., items, subsystems, or systems) meet requirements for low-rate production and have been incorporated into the demonstrations. The processes used on the pilot lines should be evaluated to understand the difficulties and quantify the risks to be mitigated for LRIP. Results of the pilot lines and the associated assessments should be incorporated in to the appropriate M&Ss to provide an up-to-date, accurate M&S of the system.

Pilot line demonstrations of system and subsystem manufacturing and quality processes, and production line manufacturing and quality data for components and items provide opportunity to collect up-to-date data for yield and rate analyses. These analyses should be used to validate all manufacturing and quality learning curves for the system and subsystems to include evaluation of yields and rates against pilot line and LRIP targets, goals, and projections for rate production.

These assessments and demonstrations should provide an understanding of the contractor's process capabilities, M&S tools, and yields and rates, and support program manufacturing and quality planning, resource loading, facilities management, etc. for future phases.

H.1 Update Process Capability Requirements

Manufacturing and Quality Tasks

- Analyze process capability index (C_{pk}) goals for each key manufacturing process throughout the supply chain for support to manufacturing and quality program goals.
    - Review contractor and supply chain processes, process control plans, process yields, and Process Failure Modes and Effects Analyses (PFMEAs) for identification of appropriate key and/or critical manufacturing processes and verify the need for and validity of process capability index (C_{pk}) goals and targets
- Utilizing results of the PDR and current program status, update manufacturing and quality process capability risks, issues, and opportunities for the Manufacturing Strategy and Plan and the Quality Strategy and Plan, and the SEP, including:

- KCs
- New equipment and new manufacturing technologies (including ManTech)
- Potential manufacturing and quality cost and schedule impacts
- Producibility
- Tooling and facilities
- ESOH and Safety
- Testing and qualification
- Security
- Environmental, transportation, storage, etc.
- Data management (collection, storage, cyber security, etc.)

- Update and maintain required manufacturing and quality process capability requirements for consistency with product design as design progresses to CDR including producibility, manufacturability, supportability, affordability, etc.
- Ensure system-level manufacturing processes will be demonstrated in a production representative environment by CDR with subsystem, item, and component processes, at a minimum, demonstrated on a pilot line.
  - Ensure subsystems, items, and components manufacturing processes and equipment process capabilities from variability studies and analyses meet pilot line targets
- Continue to collect, monitor, manage, and analyze (or estimate where necessary) process capability data from subsystem, item, and component processes to include:
  - Subsystems, items, and components that are currently or have been previously manufactured for other systems by the supply chain
  - Data collected from supply chain yields, rates, and process capabilities from other similar subsystems, items, components, and prototype builds
- Utilize collected data from manufacture of subsystems, items, and components (e.g., production representative, pilot lines, etc.) to refine process capability requirements.
- Ensure DCMA support and/or external agency support for Government surveillance of and updates to manufacturing and quality process capability requirements is requested and utilized (for the entire supply chain).

Metrics

- Process capability index (C_{pk}) goals for each key manufacturing process throughout the supply chain have been analyzed for support of manufacturing and quality program goals.
  - Contractor and supply chain processes, process control plans, process yields, and PFMEAs have been reviewed for updates and/or identification (inclusion) of key and/or critical manufacturing processes and verification of process capability index (C_{pk}) goals and targets

- Program, contractor, and supply chain manufacturing and quality process capability risks, issues, and opportunities have been assessed and updated in the Manufacturing Strategy and Plan and the Quality Strategy and Plan (and therefore the AS), and the SEP, based on results of the PDR and current program status to include:
    - KCs
    - New equipment and new manufacturing technologies (including ManTech)
    - Potential manufacturing and quality cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - ESOH and Safety
    - Testing and qualification
    - Security
    - Environmental, transportation, storage, etc.
    - Data management (collection, storage, cyber security, etc.)
- Required manufacturing and quality process capabilities are up-to-date and reflect product design and maintained in the Manufacturing and Quality Plans as design progresses to CDR including producibility, manufacturability, supportability, affordability, etc.
- Plans for system-level manufacturing process demonstrations in a production representative environment have been documented and implemented to be conducted and completed by CDR with subsystem, item, and component processes, at a minimum, demonstrated on a pilot line.
    - Variability studies have been conducted and completed on subsystems, items, and components manufacturing processes and equipment process capabilities for CDR and meet pilot line targets
- Process capability data from subsystem, item, and component processes is being collected, monitored, managed, analyzed (or estimated where necessary), and maintained under configuration control to include:
    - Subsystems, items, and components that are currently or have been previously manufactured for other systems by the supply chain
    - Data collected from supply chain yields, rates, and process capabilities from other similar subsystems, items, components, and prototype builds
- Collected data has been utilized to update and refine process capability index requirements (C_{pk}s) and documented in the Manufacturing and Quality Strategies and Plans.
- DCMA support and/or external agency support for Government surveillance of process capability data and support to updates of manufacturing and quality process capability requirements and indices has been requested and is being utilized (for the entire supply chain).

Tools

- Process Capability Study (Cp and Cpk assessment)
- MRL Assessment Checklist for the Process Capability and Control Thread
- AS9100 Quality Management System Assessment
- AS9103 Variation Management Assessment
- AS6500 Manufacturing Management Assessment

Resources

- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- AS9103 Variation Management of Key Characteristics
- AS9145 Requirements for Advanced Product Quality Planning and Production Part Approval Process
- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- MRL Deskbook Version 2016

H.2 Update and Validate Models and Simulations

Manufacturing and Quality Tasks

- Assess contractor Modeling and Simulation (M&S) System prior to product and/or process implementation for the capability to model (product and processes) and assess the system for CDR and pilot line to include:
    - Integration with supply chain M&S Systems
    - Integration with CAD, MRP, scheduling, time standards, work instructions, planning, etc.
    - Yield and rate modeling to predict first pass yields including key design and process attributes
    - Manufacturing ergonomics M&S to ensure human factors considerations are applied in manufacturing
    - Production process M&S addressing material flow, surges, processing times, scrap, rework and repair levels, etc.
    - Supply chain M&S including impacts of disruptions, supplier capabilities and yields, learning curve effects, obsolescence issues, etc.
    - Other tools such as:
        - Value stream mapping completes with all types of information, material, parts, physical processing times, physical movements, wait times, etc.
        - Factory simulations for system production including facility, production lines, transportation, storage, handling, security, etc.
        - Lean Manufacturing, Six-Sigma, etc.

- Capability to evaluate the design and manufacturing processes to meet program manufacturing and quality objectives including quantification of risk and issue mitigation including:
  - Factory floor, process flows, assembly lines, yields/ throughput/variability, cycle times, etc. with estimated quantities of tooling, personnel, and inventory
  - Throughput concurrent with other ongoing production
- Capability to provide estimated yields, rates, cycle times, schedule and cost performance to meet program manufacturing and quality goals
  - Utilize data from production of subsystems, items, and components to validate M&S System
  - Utilize data from production of subsystems, items, and components to identify of manufacturing and quality bottlenecks or constraints
  - Validate manufacturing and quality cycle times achievability

- Assess the results and data from manufacturing and quality demonstrations, tests, production of items and components, etc. by the contractor and supply chain in production representative environment to validate M&S of subsystems, components, and items for CDR, including:
  - A mix of mature hardware, prototypes, and models and simulations
  - Interfaces, integration, and interdependencies
  - Ergonomics
  - Identification of constraints
  - Performance
  - Throughput
  - Sufficient complexity to match the complexity of the system

Metrics

- Contractor M&S System has been assessed prior to product and/or process implementation and documents the capability to model and assess the system for CDR and pilot line to include:
  - Integration and/or utilization of supply chain M&S Systems
  - Integration with other systems (e.g., CAD, MRP, scheduling, time standards, work instructions, planning, etc.)
  - Yield and rate model predictions of first pass yields
  - Manufacturing ergonomics models to include human factors in manufacturing
  - Production process models (e.g., material flow, surges, processing times, scrap, rework and repair levels, etc.)
  - Supply chain models (e.g., impacts of disruptions, supplier capabilities and yields, learning curve effects, obsolescence issues, etc.)
  - Other tools such as:
    - Value stream mapping

        - Factory simulations (e.g., processes, facilities, production lines, transportation, storage, handling, security, etc.)
        - Lean Manufacturing, Six-Sigma, etc.
    - Capability to meet program manufacturing and quality objectives with quantification of risk and issue mitigation
    - Capability to evaluate both the design and supporting manufacturing processes including:
        - Factory floor, process flows, work cells, assembly lines, etc.
        - Yields, throughputs, variability, cycle times, etc.
        - Tooling, personnel, and inventory requirements, etc.
        - Throughput concurrent with other ongoing production
    - Capability to estimate yields, rates, cycle times, schedule and cost performance, etc. to meet program manufacturing and quality goals and utilizing data to:
        - Validate the M&S System
        - Identify of bottlenecks or constraints
        - Validate cycle times
- Results and data from manufacturing and quality demonstrations, tests, production of items and components, etc. by the contractor and supply chain in production representative environment have been assessed and validation M&S of subsystems, components, and items has been documented for CDR, to include the following factors:
    - Mature hardware, prototypes, and models and simulations
    - Interfaces, integration, and interdependencies
    - Ergonomics
    - Constraints
    - Performance
    - Throughput
    - Complexity (reflecting system complexity)

Tools

- MRL Assessment Checklist for the Process Capability and Control Thread
- System Capabilities Analytic Process (SCAP)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)

Resources

- AS6500, Manufacturing Management Program, NOV 2014
- MIL-HDBK-896A
- Modeling and Simulation Guidance for the Acquisition Workforce, Oct 2008

- MRL Deskbook Version 2016

H.3 Mature Key Manufacturing Processes

Manufacturing and Quality Tasks

- Based on contractor, supply chain, Government IPT, and Government contracting personnel interactions, define and document the appropriate manufacturing and quality production representative and pilot line environments to be placed on contract, and utilized for process demonstrations and maturations, verifications and validations, qualifications, first articles, etc.
    - Ensure provisions for Government surveillance of contractor and supply chain "proof-of-builds" and/or "product/process walkthroughs" are included
- For CDR, assess demonstrations of manufacturing and quality processes in an environment with as much production realism as possible, considering the maturity of the design throughout the supply chain including:
    - Equipment (e.g., accuracy, calibration, age and condition, suitability, capacity, reliability)
    - Workforce (i.e., training, skills, and certifications)
    - Human factors (i.e., noise, vibrations, ergonomics)
    - Environmental conditions (i.e. temperature, humidity, air quality)
    - Testing and test equipment
    - Capability to meet the cost, schedule, and performance requirements
    - Estimates of costs, yields, rates, etc.
- Assess risks, issues, and impacts of the manufacturing environment (i.e., production representative) on manufacturing and quality processes and develop recommended mitigation plans for both the contractor and the supply chain for CDR.
- Collect data from process demonstrations and production of components and items in a production representative environment throughout the supply chain to support verification, validation, and authentication of M&S for CDR.
    - Ensure data is under configuration control
- Update status of the comprehensive Manufacturing and Quality Plans based on demonstrations of manufacturing and quality processes in a production representative environment for CDR
    - Include all manufacturing and quality risks and issues
    - Utilize Process Failure Modes and Effects Analyses (PFMEAs) on all manufacturing and quality processes
    - Update plans for achieving pilot line process capability targets
- Ensure key manufacturing and quality processes are sufficiently mature by conducting a system-level MRL assessment in support of CDR.

- System-level target should utilize MRL 7 criteria and metrics
- Subsystem, item, and components targets should utilize MRL 8 and/or MRL 9 criteria and metrics

Metrics

- Manufacturing and quality production representative and pilot line environments have been documented and placed on contract, and are being used for process demonstrations and maturations, verifications and validations, qualifications, first articles, etc.
  - Provisions for DCMA or program surveillance of contractor and supply chain "proof-of-builds" and/or "product/process walkthroughs" are on contract
- Demonstrations of manufacturing and quality processes in a production representative environment, at a minimum, or a more mature environment based on the maturity of the design, have been assessed throughout the supply chain and document implementation for CDR of mature processes in accordance with industry best practices, including those for:
  - Equipment (e.g., accuracy, calibration, age and condition, suitability, capacity, reliability)
  - Workforce (i.e., training, skills, and certifications)
  - Human factors (i.e., noise, vibrations, ergonomics)
  - Environmental conditions (i.e. temperature, humidity, air quality)
  - Testing and test equipment
  - Capability to meet the cost, schedule, and performance requirements
  - Estimates of costs, yields, rates, etc.
- Risks, issues, and impacts of the manufacturing environment (e.g., production representative, etc.) on manufacturing and quality processes have assessed and recommended mitigation plans developed and documented for both the contractor and the supply chain for CDR.
- Data has been collected from process demonstrations and production of components and items in a production representative environment throughout the supply chain and documented as supporting verification, validation, and authentication of M&S for CDR.
  - Data is under configuration control
- Manufacturing and Quality Plans have been updated based on demonstrations of manufacturing and quality processes in a production representative environment for CDR including:
  - All manufacturing and quality risks and issues
  - PFMEAs on all manufacturing and quality processes
  - Updated plans to achieve pilot line process capability targets
- A system-level MRL assessment has been conducted to confirm key manufacturing and quality processes are sufficiently mature by CDR.
  - System-level meets MRL 7 target (criteria and metrics)
  - Subsystem, item, and components meet MRL 8 and/or MRL 9

Tools

- MRL Assessment using Process Capability and Control Thread
- Production Part Approval Process (PPAP)
- Process Capability Assessment

Resources

- AS6500, Manufacturing Management Program, NOV 2014
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- DoDI 5000.02
- MRL Deskbook Version 2016
- ISO 9000

H.4 Demonstrate Manufacturing Maturity on Pilot Line

Manufacturing and Quality Tasks

- Assess the progress and status of pre-CDR mitigations (i.e., production representative environment) for risks, issues, and impacts during pilot line demonstrations of manufacturing and quality processes, procedures, and schedules.
    - Update or develop mitigation plans for LRIP
- Assess demonstrations of manufacturing processes in an environment with all of the key production realism elements required to manufacture production configuration items, subsystems or systems that meet design requirements in low-rate production (i.e., pilot line) including:
    - Equipment (e.g., accuracy, calibration, age and condition, suitability, capacity, reliability)
    - Personnel skill levels
    - Facilities, storage and handling, waste disposal, etc.
    - Hazmat
    - Security and safety
    - Materials and components
    - Work instructions and processes (e.g., cleaning, heat treating, ESD protection, clean rooms, etc.)
    - Tooling
    - Testing and test equipment
    - Environmental conditions (e.g., temperature control, cleanliness, lighting etc.)
    - Costs, yields, rates, etc.
- Collect data from pilot line demonstrations of manufacturing and quality processes and production line manufacturing and quality processes for components and items to support verification, validation, and authentication of system-level M&S for PRR and Milestone C.

- Verify that the contractor conducts process capability studies that meet program targets (C_{pk}s) to include:
  - All manufacturing processes for KCs and critical characteristics
  - Process capability studies conducted throughout the supply chain
- Based on process capability targets and pilot line results, update the comprehensive Manufacturing and Quality Plans for P&D to
  - Maintain currency of manufacturing and quality M&S
  - Maintain all manufacturing and quality risks, issues, and mitigations status
  - Update PFMEAs for all manufacturing and quality processes from pilot line changes
  - Update plans for achieving LRIP process capability targets in P&D
- Ensure key manufacturing and quality processes are sufficiently mature by conducting a MRL assessment to support PRR and Milestone C.
  - System-level target should utilize MRL 8 criteria and metrics
  - Subsystem, item, and components targets should utilize MRL 9 criteria and metrics
- Ensure Government surveillance of contractor and supply chain key and/or critical manufacturing processes for compliance to best practices or AS6500 (depending on contract).
- Ensure all policies, procedures, processes, work instructions, data, plans, metrics, tooling, equipment and documentation are under program configuration management and control.

Metrics

- Progress of production representative environment mitigations for risks, resolution of issues, and associated impacts have been assessed and status and completeness has been documented during pilot line demonstrations of manufacturing and quality processes, procedures, and schedules.
  - Mitigation plans for ongoing risks and issues (i.e., LRIP) have been updated and documented.
- Demonstrations of manufacturing and quality processes have been assessed for impacts and documented with data collected for capability studies (See H.4) in a pilot line environment with all elements required to manufacture items, subsystems or systems (configuration controlled) that meet design requirements in LRIP including:
  - Equipment (e.g., accuracy, calibration, age and condition, suitability, capacity, reliability)
  - Personnel skill levels
  - Facilities, storage and handling, waste disposal, etc.
  - Hazmat
  - Security and safety
  - Materials and components
  - Work instructions and processes (e.g., cleaning, heat treating, ESD protection, clean rooms, etc.)

  - Tooling
  - Testing and test equipment
  - Environmental conditions (e.g., temperature control, cleanliness, lighting etc.)
  - Costs, yields, rates, etc.

- Data collected from pilot line demonstrations and production line processes supports verification, validation, and authentication of system-level M&S for PRR and Milestone C.
- Contractor and supply chain process capability data has been collected and analyzed, and meets program pilot line targets (C_{pk}s) including:
  - All processes for KCs and critical characteristics
  - Supply chain process capabilities for subsystems, items, and components
- The comprehensive Manufacturing and Quality Plans for P&D have been updated based on process capability targets and pilot line results including:
  - Manufacturing and quality M&S
  - Manufacturing and quality risks, issues, and mitigations status
  - Updated PFMEAs for all manufacturing and quality process changes
  - Updated plans to achieve LRIP process capability targets in P&D
- An MRL assessment has been conducted and documented to meet targets to support PRR and Milestone C:
  - System-level target meets MRL 8 criteria and metrics
  - Subsystem, item, and components targets meets MRL 9 criteria and metrics
- DCMA is providing Government surveillance of contractor and supply chain key and/or critical manufacturing processes for compliance to best practices or AS6500 (depending on contract).
- Program configuration control system includes, tracks, and documents all policies, procedures, processes, work instructions, data, plans, metrics, tooling, equipment and documentation (i.e., CDRLs).

Tools

- Pilot Line Demonstration and Assessment

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- DoD 5000.02
- MRL Deskbook Version 2016

H.5 Validate Yields and Rates

Manufacturing and Quality Tasks

- Collect up-to-date data from system and subsystem pilot line demonstrations of manufacturing and quality processes, and production line manufacturing and quality data for components and items as the basis for yield and rate analyses to validate "as is" status.
    - Rate of quality processes (actual time to complete) vs. planned
    - Quality data actuals vs. estimated
    - Quality process yield actuals vs. planned
    - Changes in processes (actual vs. planned)
    - Cost of quality actuals vs. desired
- Validate all manufacturing and quality learning curves for the system and subsystems based on pilot line results, contractor and supply chain improvements, program progress to date to include:
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
    - Planning and scheduling
    - Throughput (yield and rates)
    - Labor efficiency and ergonomics
    - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
    - Materials handling, transportation, and storage (including WIP)
    - Supply chain changes
    - Standardization and common processes
- As a potential impact on yields and rates, validate completeness of all related risk mitigation activities or acceptance of these risks (included in the joint Risk, Issue, and Opportunity Management Process), including:
    - Key and critical manufacturing processes including embedding software (KCs)
    - Supply chain, materials and sourcing, including multiple
    - Facilities, tooling, and equipment
    - Testing, test equipment, and in-process tests
    - System security, safety, and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability, obsolescence, and sustainment
- Evaluate all yields and rates from pilot line and lower level production against pilot line and LRIP targets, goals, and projections.
    - Validate achievement of targets (e.g., pilot line, LRIP, etc.)
    - Refine yields and rates required for LRIP
    - Based on results of analyses develop and implement improvement plans as required

Metrics

- Up-to-date data from system and subsystem pilot line demonstrations of manufacturing and quality processes, and production line manufacturing and quality data for components and items has been collected and documented in the program configuration controlled management system as the basis for yield and rate analyses to validate “as is” status including:
    - Rate of quality processes (actual time to complete) vs. planned
    - Quality data actuals vs. estimated
    - Quality process yield actuals vs. planned
    - Changes in processes (actual vs. planned)
    - Cost of quality actuals vs. desired
- All manufacturing and quality learning curves for the system and subsystems based on collected and documented pilot line results, contractor and supply chain improvement results, and program progress to date have been updated and include:
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
    - Planning and scheduling
    - Throughput (yield and rates)
    - Labor efficiency and ergonomics
    - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
    - Materials handling, transportation, and storage (including WIP)
    - Supply chain changes
    - Standardization and common processes
- Risk mitigation activities have been validated as satisfactory (or program has accepted these risks) and have been analyzed and the documented impacts on yields and rates are acceptable, including:
    - Key and critical manufacturing processes including embedding software (KCs)
    - Supply chain, materials and sourcing, including multiple
    - Facilities, tooling, and equipment
    - Testing, test equipment, and in-process tests
    - System security, safety, and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability, obsolescence, and sustainment
- All yields and rates from pilot line and lower level production products have been validated to meet pilot line targets:
    - Analyses support or indicate achievability of LRIP targets, goals, and projections with refinements as required
    - Improvement plans have been developed and implemented, as required

Tools

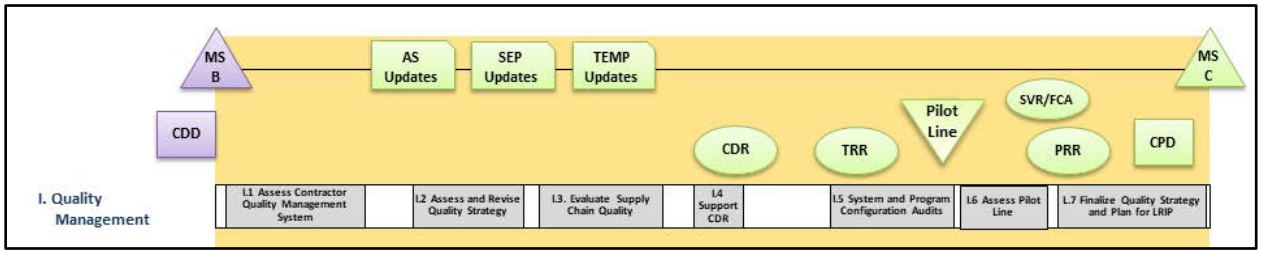
- Yield Rate Assessment

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- AS9103 Variation Management of Key Characteristics
- MRL Deskbook Version 2016

I. QUALITY MANAGEMENT

An effective quality management system is required for operationally safe, suitable and effective weapon systems. A quality management system should be compliant with industry standards ISO 9001 or AS9100 and is foundational to producing products that meet contractual requirements. The quality system ensures the as-delivered configuration is the same as the as-designed and as-tested configuration. The quality system serves as the management and control function, requiring controls over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. It also requires monitoring and measuring of processes and products to ensure they conform to requirements. An effective quality system is absolutely critical to ensuring delivered products meet all of the requirements of the approved design.



Most contractors have Quality Management Systems (QMSs) certified to industry standards (best practices) and should not need assessment for compliance as ongoing audits are part of the certification process. Program should assess that the contractor's QMS supports and aligns with Program strategy, objectives, goals, and the contract. This will involve the use of process audits as to whether the contractor's and supply chain activities, resources, and behaviors are being managed efficiently and effectively including participation of DCMA, KCs control and management, use of acceptance testing, application of Statistical Process Controls (SPC), etc. which are more than just evaluations of the sequential steps and interactions of a process within the QMS. Similarly, these audits should be conducted on the supply chain as necessary.

The Manufacturing and Quality Strategies should require quality assessments of the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a

pilot line, prior to Milestone C. Revision to the quality strategy, plans, and objectives may be required based on the results of process audits and quality assessments.

For CDR, initial product baseline documentation for quality, included in the Quality Strategy and Plans, should be sufficient, complete, and adequate to enable inspections and testing of all components, hardware, and embedded software throughout the supply chain. The system-level CDR assesses the system design as captured in product specifications for each subsystem, item, and component in the system's initial product baseline, and helps ensure that each has been captured in the detailed design and quality documentation. Assessment of the allocated baseline against the initial product baseline should assure that quality parameters (e.g., tolerance, process capability indices, etc.) for considerations such as weight, power, cooling, etc. have been appropriately specified in the detailed design. This includes drawings and specifications with tolerances and test points under configuration control for all KCs, CSIs, and CAIs having been completed.

A system-level Functional Configuration Audit (FCA) should be conducted to assess performance of the system against the functional baseline, and may be conducted in conjunction with the system-level System Verification Review (SVR). Quality and quality personnel should be an integral element in both the FCA and the SVR. The main difference between the two activities is that a system-level FCA focuses primarily on verification of the functional baseline, while SVR assesses system functionality as well as other details to include program readiness to proceed into the Production and Deployment phase. This includes assessments for quality of all program, contractor, and supply chain policies, processes, and procedures.

The system-level FCA should assess the collected data, test results, analysis results, and M&S output and accuracy of the system after completion of development testing and pilot line, and verifies that actual system performance satisfies quality requirements. For quality requirements that cannot be completely verified during pilot line, tests or simulations using approved methods can provide valid data that LRIP performance will be met with acceptable risks.

The SVR should address all changes or additions generated since CDR to ensure the as-tested product on the pilot line includes all Engineering Change Proposals, specification change notices and revisions, interface control changes, and all manufacturing and quality process changes.

As the pilot line environment incorporates all key equipment, personnel skill levels, materials, components, work instructions, tooling, etc. required to manufacture the product, quality analyses should be performed during pilot lines to provide verification and validation of actual yields, rates, and costs to be realized during LRIP. The environment should utilize production processes forecasted to be used in LRIP. Based on quality analyses of program, contractor, and supply chain, quality assessments of maturity, quality analyses of affordability and quality costs, quality risks, issues, and opportunities, all demonstrate that the manufacturing and quality processes and capabilities required for production have matured with high confidence of success in building production configuration products in the P&D phase.

The combination of a robust quality management system and advanced quality and defect prevention practices are critical to successful program execution, and it is mandated under Federal Acquisition Regulation (FAR) Part 46.202-4.

I.1 Assess Contractor Quality Management System

Manufacturing and Quality Tasks

- Assess the contractor's corporate strategic vision, objectives, policies, plans, processes, and procedures for alignment to the contracted program needs and industry best practices (e.g., AS9100, ISO 9000, etc.) for quality both in-house and in suppliers' facilities to include:
    - Established quality policy, at the highest level in the company, based on industry best practices, which commits to continuously improving processes and exceeding customer expectations
    - Organizational direction and values regarding quality are communicated throughout the supply chain
    - Management provides structures and resources supporting full implementation of the quality management system
    - Management solicits quantitative and qualitative feedback on the effectiveness and efficiency of quality management system and takes actions based on that feedback
    - Procedures for internal reviewing of the quality management system periodically with goals and objectives throughout the organization for customer satisfaction, and continuous improvement
    - Procedures independent reporting channels for quality functions and audits
    - Management accountability with emphasis on quality results and customer satisfaction
- Conduct a process audit of the contractor's QMS including assessment of:
    - Quality processes and supply chain quality including:
        - Role and participation of DCMA (Contractor and supply chain)
        - KCs control and management
        - Acceptance testing including software
        - In-process and final inspection functionality
        - Statistical process controls, rates, and yields (and management of same)
        - Execution of and adherence to quality plans including control plans and quality improvement plans
        - Certification processes (e.g., flight safety, man-ratings, etc.)
        - Continuous process improvement results
        - Software quality assurance results
        - Data storage, management, and security (physical and cyber)
        - Management of safety, environmental, transportation, storage, etc.
        - Use of COTS items, GOTS items, and NDIs

        - GFE/GFP management (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
        - Internal and supply chain audits and verification results
    - Processes for management, control, and monitoring of KPPs, KSAs, and KCs, CSIs, and CAIs, and their integration into the QMS.
    - FRACAS processes for sufficiency and adequacy including results of dispositions (i.e., material review boards and processes)
    - QMS impacts on tasks, costs, schedules, and outcomes
    - QMS compliance to standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
    - Planning, integration, and execution of the Risk, Issue, and Opportunity Management System processes
- Request DCMA support and assistance to assess adequacy and completeness of contractor and supply chain QMSs application to system, subsystems, items, and components.

Metrics

- Contractor's and supply chain Quality Management Systems (QMSs) have been analyzed and assessed for alignment to contracted program needs and industry best practices, including:
    - An established quality policy, at the highest level in the company, based on industry best practices, which commits to continuously improving processes and exceeding customer expectations
    - An process established for communication of organizational direction and values regarding quality throughout the supply chain
    - Management structures and resources supporting full implementation of the quality management system
    - Management solicitation of, and action on, quantitative and qualitative feedback on the effectiveness and efficiency of quality management system
    - Procedures for periodic internal review of the quality management system with established goals and objectives throughout the organization for customer satisfaction and continuous improvement
    - Procedures for independent reporting of quality functions and audits
    - Management accountability with emphasis on quality results and customer satisfaction
- Results from the above analyses of corporate strategic vision, objectives, policies, plans, processes, and procedures have been documented in the Acquisition Strategy (AS), Manufacturing and Quality Plans, the SEP, program documentation for CDR, and other appropriate program documentation.
- Process audits (adequacy and sufficiency) of the contractor's and supply chain QMSs have been conducted and results documented for updates to the Quality Strategy and Plan (See I.2) including:

- Role and participation of DCMA (Contractor and supply chain)
- Control and management of KCs, CSIs, and CAIs
- Acceptance testing including software
- Effectiveness of in-process and final inspections
- Application and effectiveness of statistical process controls
- Management of processes for measurement of rates and yields
- Execution of and adherence to quality plans including control plans and quality improvement plans
- Certification processes (e.g., flight safety, man-ratings, etc.)
- Continuous process improvements and results
- Software quality assurance and results
- Data storage, management, and security (physical and cyber)
- Safety, environmental, transportation, storage, etc. management, processes, and procedures
- For use of COTS items, GOTS items, and NDIs
- Management, control, and security of GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
- Internal and supply chain audits, verification of results, and any subsequent corrective actions
- Processes for management, control, and monitoring of Key Performance Parameters (KPPs), KSAs, and KCs, CSIs, and CAIs, and their integration into the QMS.
- FRACAS processes for sufficiency and adequacy including results of dispositions (i.e., material review boards and processes)
- Impacts on tasks, costs, schedules, and outcomes
- Compliance to standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
- Risk, Issue, and Opportunity Management System processes for planning, integration, and execution with the QMS

- DCMA support and assistance has been requested and the Letter of Delegation has been accepted for assessment of adequacy and completeness of contractor and supply chain QMSs application to system, subsystems, items, and components.

Tools

- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread

Resources

- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016

- AS9145 Requirements for Advanced Product Quality Planning and Production Part Approval Process
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016
- MIL-HDBK-896A
- DoD Risk, Issue, and Opportunity Management Guide, Jun 2015

I.2 Assess and Revise Quality Strategy

Manufacturing and Quality Tasks

- Update and revise the program Quality Management Strategy based on the contractor's QMS, and quality strategy and plans to include:
    - The contractor's strategy and plan to address compliance to established industry standards and best practices (e.g., AS9100, ISO 9000, etc.)
    - Alternatively the contractor's quality management strategy and plans should address:
        - Leadership responsibilities and requirements
        - Quality management system requirements and planning
        - Support and resource management requirements
        - Operational requirements (e.g., risk management, design and development, purchasing, etc.)
        - Risks, issues, and opportunities
        - Performance evaluation including measurement, analysis, and improvement requirements
- Update and revise the program Quality Management Strategy and Plan based on the results from process audits (adequacy and sufficiency) of the contractor's and supply chain QMSs conducted (See I.1).
- Develop required contract modifications or updates to ensure alignment of contractor with program Quality Management Strategies and Plans based on results of quality audits conducted. (See I.1)
- Manufacturing and quality should conduct internal audits at planned intervals to ensure the program quality management system conforms to the program's requirements and is effectively implemented and maintained.
- Manufacturing and quality should review and revise program quality objectives for adequacy and sufficiency at the appropriate levels, and for the appropriate processes to meet program objectives. The quality objectives should take into account applicable requirements and be:
    - Consistent with the quality policy
    - Measurable
    - Monitored
    - Communicated
    - Updated, as appropriate

- Manufacturing and quality should verify and update the program Quality Management Strategy and Quality Plan to ensure they include:
    - All required quality technologies and processes (state of the art), unique product quality requirements, metrics, and the frequency of review
    - Compliance with FAR 52.246-11, Higher-Level Contract Quality Requirements
    - The quality aspects of contractor compliance to industry best manufacturing practices (i.e., AS6500)
    - Management, measurement, and control of key and critical characteristics and processes
    - Addresses use of and appropriate quality requirements for COTS items, GOTS items, and non-developmental items (NDIs) and their incorporation into the contractor's QMS (i.e., shock and vibe requirements beyond normal COTS design envelope)
    - Requirements for supply chain:
        - Focused supplier quality management requirements
        - Quality management planning
        - Use of best practices and standards (e.g., AS9100, ISO 9000, etc.)
        - Metrics and review frequency
        - Solutions, tools, techniques, and procedures
        - Use of Government furnished quality and testing equipment and assets
    - Appropriate agreements, delegations and contracts with other agencies, e.g. the DCMA and/or DLA throughout the supply chain
    - Software and firmware development quality assurance and configuration management
- Manufacturing and quality should assess the program's quality management system, at planned intervals for continuing suitability, adequacy, effectiveness, and alignment with the strategic direction of the program. The assessment should include:
    - Status of actions from previous assessments
    - Changes in external and internal issues that are relevant to the QMS
    - Performance and effectiveness of the QMS, including:
        - Extent to which quality objectives have been met
        - Process performance and conformity of products
        - Nonconformities and corrective actions
        - Monitoring and measurement results
        - Audit results
        - Performance of the supply chain
    - Adequacy of resources
    - Effectiveness of actions taken to address risks, issues, and opportunities
    - Opportunities for improvement

Metrics

- Program Quality Management Strategy has been updated based on assessments of the contractor's QMS, and contractor quality strategy and plans to include:
    - The contractor's strategy and plan to address compliance to established industry standards and best practices (e.g., AS9100, ISO 9000, etc.)
    - Alternatively, the contractor's quality management strategy and plans to address:
        - Leadership responsibilities and requirements
        - Quality management system requirements and planning
        - Support and resource management requirements
        - Operational requirements (e.g., risk management, design and development, purchasing, etc.)
        - Risks, issues, and opportunities
        - Performance evaluation including measurement, analysis, and improvement requirements
- Program Quality Management Strategy and Plan has been revised based on the results from process audits (adequacy and sufficiency) of the contractor's and supply chain QMSs.
    - Recommended contract modifications or updates have been submitted to program management to ensure alignment of contractor with program Quality Management Strategies and Plans with program strategies and plans
- Manufacturing and quality have conducted internal audits as planned and documented the program quality management system effective implementation, conformance, and support of the program's requirements, or corrective actions, as appropriate.
- Manufacturing and quality have reviewed, documented, and will maintain documentation on the adequacy and sufficiency of program quality objectives to meet program objectives. The quality objectives take into account applicable requirements and are:
    - Consistent with the quality policy
    - Measurable
    - Monitored
    - Communicated
    - Updated, as appropriate
- Manufacturing and quality have verified and updated where necessary the program Quality Management Strategy and Quality Plan ensuring inclusion of:
    - All required quality technologies and processes (state of the art), unique product quality requirements, metrics, and the frequency of review
    - Compliance with FAR 52.246-11, Higher-Level Contract Quality Requirements
    - The quality aspects of contractor compliance to industry best manufacturing practices (i.e., AS6500)
    - Management, measurement, and control of key and critical characteristics and processes

- Appropriate quality requirements for COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS (i.e., shock and vibe requirements beyond normal COTS design envelope)
- Requirements for supply chain:
  - Focused supplier quality management requirements
  - Quality management planning
  - Use of best practices and standards (e.g., AS9100, ISO 9000, etc.)
  - Metrics and review frequency
  - Solutions, tools, techniques, and procedures
  - Use of Government furnished quality and testing equipment and assets
- Appropriate agreements, delegations and contracts with other agencies, e.g., the DCMA and/or the Defense Logistics Agency (DLA) throughout the supply chain
- Software and firmware development quality assurance and configuration management

- Manufacturing and quality have assessed and documented the program's quality management system for continuing suitability, adequacy, effectiveness, and alignment with the strategic direction of the program including:
  - Status of actions from previous assessments
  - Changes in external and internal issues that are relevant to the QMS
  - Performance and effectiveness of the QMS, including:
    - Extent to which quality objectives have been met
    - Process performance and conformity of products
    - Nonconformities and corrective actions
    - Monitoring and measurement results
    - Audit results
    - Performance of the supply chain
  - Adequacy of resources
  - Effectiveness of actions taken to address risks, issues, and opportunities
  - Opportunities for improvement

Tools

- Acquisition Strategy Template
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- DSMC Acquisition Strategy Guide, Dec 1999
- AFMC Instruction 63-145 Manufacturing and Quality (Draft)

- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- FAR 52.246-11, Quality
- MRL Deskbook Version 2016
- DAG Chapter 14.3.1.3.6 Quality Plans

I.3 Evaluate supply chain Quality

Manufacturing and Quality Tasks

- Ensure that the contractor supplier management system for subsystems, items, and components requires QMS processes and procedures are in alignment with industry best practices (e.g., AS9100, ISO 9000, etc.) to include elements such as:
    - Management responsibility requirements
    - Quality management system requirements
    - Resource management requirements
    - Product Realization requirements (e.g., risk management, design and development, purchasing, etc.)
    - Risks, issues, and opportunities
    - Measurement, analysis, and improvement requirements
- Assess the contractor's supply chain management system capabilities for performance of manufacturing and quality processes and procedures in accordance with industry best manufacturing practices (i.e., AS6500) including:
    - Effectiveness of prime and subcontractor communications and interactions to include:
        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Design and engineering changes traceability and compliance
        - Quality data exchange, analysis, storage, and traceability processes
        - The joint Risk, Issue, and Opportunity Management System
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions and program feedback
    - KCs and critical characteristics (CSIs and CAIs) management
    - Supplier risk, issue, and opportunity, and mitigation management processes for quality (e.g., technical, schedule, material, facility, scale-up, financial impacts, etc.)
    - Make/buy processes for supplier quality performance and impacts
    - Qualification, approval, and removal processes for suppliers, monitoring and tracking of supplier performance, and periodic re-assessment
    - Utilization of processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)

- Verification of suppliers processes and procedures to control quality, including suppliers performing key and/or critical manufacturing processes and changes to those processes
- Process control plans for variability reduction
- Statistical control of process capabilities (i.e., C_{pk}s)
- Production process verification
- Predictive indicators to provide early detection of potential quality problems
- Subsystem, item, and component First Article Inspections (FAIs) and First Article Tests (FATs)
- Continuous manufacturing surveillance and effective metrics to monitor, evaluate, verify, improve processes, and prevent defects

- Collect and analyze supply chain quality data from the production representative environment for subsystems, items, and components and utilize analyses results to develop recommended improvement plans.
- Ensure control plans are in place for management of KCs.
- Ensure development of test and inspection plans underway for EMD prototypes.

Metrics

- Contractor's supplier management system for subsystems, items, and components has been assessed and results document QMS processes and procedures compliance with industry best practices (e.g., AS9100, ISO 9000, etc.) to include elements such as:
  - Management responsibility requirements
  - Quality management system requirements
  - Resource management requirements
  - Product Realization requirements (e.g., risk management, design and development, purchasing, etc.)
  - Risks, issues, and opportunities
  - Measurement, analysis, and improvement requirements
- Contractor's supply chain management system has been assessed and the results document compliance with industry best manufacturing practices (i.e., AS6500) including:
  - Effective prime and subcontractor communications and interactions including:
    - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
    - Design and engineering changes traceability and compliance
    - Quality data exchange, analysis, storage, and traceability processes
    - The joint Risk, Issue, and Opportunity Management System
    - Responses, status, and reports for cost, schedule, and performance actuals
    - Corrective and preventative actions and program feedback
  - Management of KCs and critical characteristics (CSIs and CAIs)

  - Risk, issue, and opportunity, and mitigation management processes for quality (e.g., technical, schedule, material, facility, scale-up, financial impacts, etc.)
  - Make/buy processes that include supplier quality performance
  - Supplier management and monitoring that includes qualification, approval, performance, and removal processes with periodic re-assessment
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
  - Suppliers processes and procedures for control of quality, key and/or critical manufacturing processes, and changes
  - Process control plans for variability reduction
  - Statistical control of process capabilities (i.e., C_{pk}s)
  - Production process verification
  - Use of predictive indicators to provide early detection of potential quality problems
  - FAIs and FATs for subsystems, items, and components
  - Manufacturing surveillance and effective metrics to monitor, evaluate, verify, continuously improve processes, and prevent defects
- Quality data from the supply chain for production representative subsystems, items, and components has been collected and analyzed and recommended improvement plans have been developed and documented.
- Control plans for management of KCs have been completed and are in place, and are being tracked by the contractor.
- Test and Inspection plans are being developed and documented for EMD prototypes.

Tools

- Supplier QA Questionnaire
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread
- AS6081 Counterfeit Electronic Parts; Avoidance Protocol, Distributors

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- Risk, Issue, and Opportunity Guide, Jun 2015
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition, Sep 2016
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel, Jul 2014
- MRL Deskbook Version 2016

I.4 Support Critical Design Review (CDR)

Quality Tasks

- Ensure Quality Strategy and Plan, including initial product baseline documentation for quality, is sufficient, complete, and adequate to enable inspections and testing of components, hardware, and embedded software.
    - Ensure all KCs, CSIs, and CAIs have completed drawings and specifications with tolerances and test points under configuration control
    - Ensure all product data essential for component quality has been released
- For CDR, provide quality inputs on program, contractor, and supply chain implementation status of industry best practices (e.g., ISO 9000, AS9100, and other standards on quality management and quality management systems).
- Ensure all quality design trade studies and assessments are completed and incorporated into the design for CDR.
    - Ensure quality enhancement efforts ongoing for optimized integrated system (e.g. Design for Inspection and Testability, Design for Six Sigma, etc.)
- Ensure all subsystem, item, and component CDRs are complete and the results impacting quality available for the system CDR.
    - Analyze the results of design maturity assessments (See E.6) including all appropriate reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.) for closure or approval of quality related risks, issues, and opportunities
- Ensure quality inputs to the schedule (IMP/IMS) are up-to-date and are executable with acceptable risks.
- Ensure quality plans, activities, and processes are executable within the existing quality budget to support the approved initial product baseline and critical path.
- Ensure all key and critical manufacturing processes process control plans, have been analyzed, updated, and approved for the capability to meet design tolerances.
- Analyze contractor quality plans for materials, facilities, equipment, test facilities and equipment, and tooling to support the pilot line requirements.
- Analyze the contractor FRACAS for adequacy to meet needs based on the Quality Plan.
- Analyze quality plans for adequacy and capability of achieving manufacturing readiness level 8 by initial production.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality management, ESOH, etc.) for quality risks, issues, and opportunities and appropriate mitigation plans.
- Analyze the assessments of adequacy and completeness of quality requirements validation activities (See E.6) which included prototypes and demonstrations in a representative environment at the system, subsystem, item, and component levels for design maturity.
    - Include demonstrations of quality processes in a representative environment

- Include demonstrations of quality processes for KCs, CSIs, and CAIs

- Provide quality inputs to the Life Cycle Support Plan for CDR.
- Ensure contractor quality management systems for manufacturing and quality metrics and data collection and tracking to the component level are in place and functional.
- Ensure the TEMP incorporates all subsystems, items, and components into plans for tests, test facilities, and test equipment.
- Ensure the quality considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
  - Parts and Materials (Management) Plan (PMP)
  - Configuration Management Plan (CMP)
  - Software Development Plan (embedded software)
  - Quality Assurance Plan
  - PPP
  - SEMP
  - TEMP
- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure quality design improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (See E.4).
- Provide up-to-date cost of quality inputs to the program budget and the CARD.
  - Update and allocate quality (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure adequacy and completeness of mitigation activities for mitigation of quality risks, issues, and opportunities in the joint Government/ contractor Risk, Issue, and Opportunity Management System, including quality risks to:
  - Key and critical manufacturing processes including embedding software
  - Materials and sourcing
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and hazardous materials management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment

Metrics

- Quality Strategy and Plan, including initial product quality baseline, has been documented for CDR as sufficient, complete, and adequate to enable inspections and testing of components, hardware, and embedded software.
    - All KCs, CSIs, and CAIs have completed drawings and specifications with tolerances and test points under configuration control
    - All product data essential for component quality has been released
- Quality inputs on program, contractor, and supply chain implementation status of industry best practices (e.g., ISO 9000, AS9100, and other standards on quality management and quality management systems) has been documented and provided for CDR.
- All quality design trade studies and assessments have been completed and the results have been documented into the design for CDR.
    - Continuous quality enhancement efforts are in place and monitored
- All subsystem, item, and component CDRs are complete and all results impacting system quality are documented and available for CDR.
    - Documented results from all design maturity reviews with closures and/or acceptances of quality related risks, issues, and opportunities are included
- Quality inputs to the schedule (IMP/IMS) are documented up-to-date and executable with acceptable risks.
- Quality plans, activities, and processes have been analyzed and are executable within the existing quality budget and the results support the approved initial product baseline and critical path.
- All key and critical manufacturing processes process control plans, have been analyzed, updated, and approval documented for the capability to meet design tolerances for CDR
- Contractor quality plans have been analyzed for materials, facilities, equipment, test facilities and equipment, and tooling and document the capability to support the pilot line.
- Contractor FRACAS has been analyzed for adequacy and documented to meet needs based on the program Quality Plan.
- Contractor and Government Quality Plans have been analyzed and the results document the adequacy and capability to achieve manufacturing readiness level 8 by initial production.
- Contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality management, ESOH, etc.) have been conducted and the results analyzed and document required mitigation plans for quality risks, issues, and opportunities.
- Adequacy and completeness of quality requirements validation activities (See E.6) which included prototypes and demonstrations in a representative environment at the system, subsystem, item, and component levels have been analyzed and assessed for design maturity and results provided for CDR.

- Demonstrations included quality processes in a representative environment
- Demonstrations included quality processes for KCs, CSIs, and CAIs

- Quality inputs to the Life Cycle Support Plan have been developed and documented for CDR.
- Contractor quality management systems for manufacturing and quality metrics and data collection and tracking to the component level have been assessed for adequacy, are documented as in place and functional.
- Tests, test facilities, and test equipment for all subsystems, items, and components have been documented in the TEMP for CDR.
- Contractor's quality plans and inputs are up-to-date and approved for CDR, including:
  - Parts and Materials (Management) Plan (PMP)
  - Configuration Management Plan (CMP)
  - Software Development Plan (embedded software)
  - Quality Assurance Plan
  - PPP
  - SEMP
  - TEMP
- Subsystem, item, and component quantity estimates have been analyzed and updated based on program system requirements, component yield and rate data, and prototype demonstrations and provided as input for CDR.
- Quality design improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (See E.4).
- Up-to-date cost of quality inputs have been documented and provided for the program budget and for the CARD.
  - Updated and allocated quality cost models to subsystem, item, and component levels have been included, and track against targets
- Adequacy and completeness of quality risk mitigation activities have been assessed and documented in the joint Government/ contractor Risk, Issue, and Opportunity (RIO) Management System, including quality risks to:
  - Key and critical manufacturing processes including embedding software
  - Materials and sourcing
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and hazardous materials management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)

- Manufacturing capability obsolescence
- Manufacturing capability sustainment

Tools

- Critical Design Review Checklist

Resources

- AS65000
- Defense Acquisition Guide (DAG) Chapter 3-3.3.5 Critical Design Review
- IEEE 15288.2
- MRL Deskbook Version 2016

I.5 System and Program Configuration Audits

Quality Tasks

- Ensure quality personnel participate in and support program, contractor, and supply chain system audits to be performed in accordance with the process focused requirements in AS9101 for (but not limited to):
  - Risk, Issue, and Opportunity System
  - Supply chain management system
  - Development test operations and evaluations
  - Quality Management System
  - Development (hardware and software)
  - Production control
  - Security (physical and cyber)
  - ESOH
  - Hazardous and/or special materials
  - Human Machine Interface
  - EVM system
  - Transportation, handling, and storage
  - Workforce management
  - Facilities
  - Documentation and data management
- Ensure quality personnel participation in, inputs to, and support of the Functional Configuration Audit (FCA) to include:
  - Support to program and the contractor agreements that development is complete and data from development tests (DTs), analyses, and simulations are sufficient to achieve performance goals
  - Provide quality input to:
    - Verification of performance to the baseline

        - The verification traceability documentation for each manufacturing and quality requirement
        - The validity and the completeness of embedded software and associated documentation
    - Verify all approved engineering change proposals (ECP), requests for deviation, and requests for waiver impacting manufacturing and quality have been incorporated into the Manufacturing and Quality Plans
    - Verification that all KCs, CSIs, and CAIs are identified, managed, and included in the Verification Cross-Reference Matrix (VCRM)
    - Ensure quality provides support to verification activities and tasks to include:
        - Ensuring each requirement listed in the VCRM is traceable and has been verified with test data, analysis, and/or inspection
        - Ensuring demonstration manufacturing and quality processes to provide the capability to satisfy TPMs, KPPs and KSAs thresholds
        - Review of acceptance test reports and deficiencies with root cause and closed corrective actions
- Ensure quality participates in the Change Configuration Boards (CCBs) to ensure changes are in accordance with program direction, program Quality Strategy, and are consistent with industry quality standards and best practices, supplier instructions, processes and procedures, etc.
- Participate in and support the System Verification Review (SVR) including:
    - Provide verification that all manufacturing and quality CDR action items have been closed and any corrective actions have been successfully completed
    - Provide quality inputs on:
        - Verification of requirements from all system, subsystem, item, and component quality test data and analyses
        - Verification of performance to the function baseline based on quality data
        - Verification through analysis of quality data the adequate management and integrity of all critical program information (CPI) (e.g., performance data, yield and rate data, etc.)
        - Verification that quality risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
        - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available quality test data, analysis, and inspection
        - Required certification activities
        - Support and maintenance analyses for incorporation into the LCSP
        - Risks of operational test failures during IOT&E
    - Provide quality inputs to:
        - Ensure adequate quality processes and quality metrics are in place

- Analysis of contractor' s SEMP for appropriate incorporation of quality activities and data collection, analysis, and storage
- Detailed planning and schedules with required resources for proceeding into LRIP and IOT&E
- Updates of the SEP and contractor's SEMP for the production and deployment (P&D) phase
- The CARD for up-to-date cost of quality inputs
- The LCSP
- The TEMP (i.e., up-to-date)
- The Configuration Management Plan (CMP) (i.e., up-to-date)

Metrics

- Quality personnel have participated in and supported program, contractor, and supply chain system audits (IAW AS9101) that document meeting the process focused requirements for (but not limited to):
  - Risk, Issue, and Opportunity System
  - Supply chain management system
  - Development test operations and evaluations
  - Quality Management System
  - Development (hardware and software)
  - Production control
  - Security (physical and cyber)
  - ESOH
  - Hazardous and/or special materials
  - Human Machine Interface
  - EVM system
  - Transportation, handling, and storage
  - Workforce management
  - Facilities
  - Documentation and data management
- Quality personnel have supported and participated in, and provided inputs to the FCA to include:
  - Documented support to program and the contractor agreements that development is complete and data from development tests (DTs), analyses, and simulations are sufficient to achieve performance goals
  - Documented quality inputs to:
    - Verification of performance to the baseline
    - The verification traceability documentation for each manufacturing and quality requirement

7668 ▪ The validity and the completeness of embedded software and associated
7669 documentation

7670 o Verification that all approved ECPs, requests for deviation, and requests for waiver
7671 impacting manufacturing and quality have been documented in the Manufacturing and
7672 Quality Plans
7673 o Verification that all KCs, CSIs, and CAIs have been identified, managed, and
7674 documented, and are included in the Verification Cross-Reference Matrix (VCRM)
7675 o Documented input to verification activities and tasks which included:

7676 ▪ Each requirement's (listed in the VCRM) traceability and verification with test data,
7677 analysis, and/or inspection
7678 ▪ Demonstrations of manufacturing and quality processes for meeting TPMs, KPPs and
7679 KSAs thresholds
7680 ▪ Review of acceptance test reports and deficiencies with root cause and closed
7681 corrective actions

7682 • Quality personnel continue to support and participate in CCBs to ensure quality changes are
7683 in accordance with program direction, program Quality Strategy, and are consistent with
7684 industry quality standards and best practices, supplier instructions, processes and procedures,
7685 etc.
7686 • Quality personnel have participated in and provided documented inputs to the SVR
7687 including:

7688 o Verification that all manufacturing and quality CDR action items have been closed and
7689 any corrective actions have been successfully completed
7690 o Quality inputs on:

7691 ▪ Verification of requirements from all system, subsystem, item, and component
7692 quality test data and analyses
7693 ▪ Verification of performance to the function baseline based on quality data
7694 ▪ Verification through analysis of quality data the adequate management and integrity
7695 of all CPI (e.g., performance data, yield and rate data, etc.)
7696 ▪ Verification that quality risks are included in the Risk, Issue, and Opportunity
7697 Management process and mitigation plans
7698 ▪ Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds)
7699 based on all available quality test data, analysis, and inspection
7700 ▪ Required certification activities status
7701 ▪ Support and maintenance analyses results for incorporation into the LCSP
7702 ▪ Risks of operational test failures during IOT&E

7703 o Quality inputs that ensure adequate quality processes and quality metrics are in place
7704 o Results of analyses of contractor' s SEMP for appropriate incorporation of quality
7705 activities and data collection, analysis, and storage
7706 o Quality inputs to detailed planning and schedules with required resources for proceeding
7707 into LRIP and IOT&E

- Updates of the SEP and contractor's SEMP for the production and deployment (P&D) phase
- Updates to the:
  - CARD for the cost of quality
  - LCSP
  - TEMP
  - CMP
  - SEP

Tools

- Functional Configuration Audit checklist

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- AS9101 Quality Management Systems – Audit Requirements for Aviation, Space, and Defense Organizations
- IEEE 15288.2
- ISO 9000
- Defense Acquisition Guide (DAG) Chapter 3-3.3.6 System Verification Review/System Configuration Audit

I.6 Assess Pilot Line

Manufacturing and Quality Tasks

- Assess contractor and supply chain pilot lines and demonstrations for quality verification and validation efforts including:
  - Quality processes and procedures including continuous improvement efforts
  - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)
  - Quality and process controls in place (e.g. plans, audits, process capabilities (C_{pk}s), Statistical Process Control (SPC), FRACAS, etc.)
  - Adequacy and completeness of acceptance and qualification testing for LRIP
  - All quality instructions, sequencing, in-process tests, and test procedures (including those in work instructions)
  - Quality scheduling and control
  - Quality model and simulations
  - Quality workforce capabilities
  - Implementations of quality technologies

- Tooling, work holding fixtures, jigs, etc. for inspection and test
- Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
- Quality processes for transportation, storage, and handling equipment
- Potential requirements for additional quality tools, equipment, and software
- Safety of quality processes and procedures
- Quality of ESOH processes and procedures
- Quality of security processes, procedures, capabilities, and compliance
- Impacts from direct and indirect infrastructure
- Mitigation results of quality and adequacy of risks and issues resolutions
- Quality costs (and impacts to schedule and performance)
- Quality of materials' sources and selections
- Quality of embedded software (integration)

- Analyze quality processes performed during the pilot lines operations, (including simulations) to include:
  - Rate of quality processes (actual time to complete) vs. planned
  - Quality data actuals vs. estimated
  - Quality process yield actuals vs. planned
  - Changes in processes (actual vs. planned)
  - Cost of quality actuals vs. desired
- Assess process control plans, including all plans for process control of key and critical processes, for adequacy and completeness on the pilot line.
- Assess all work instructions for required quality outputs (e.g., data, in-process inspections and tests, process capability indices, etc.) based on build-to documentation and information gathered during the pilot line.
  - Verify updated work instructions, processes, drawings, etc.
  - Include KCs and their control plans
- Assess quality outputs from the pilot line and demonstrations for adequacy and completeness and validate:
  - All Production Process Verifications (PPVs) performed
  - Implementation of manufacturing technology solutions (including ManTech)
  - Attainability of KCs (will be capable and under process control for LRIP)
  - Data collected for the Variability Reduction program
    - Data should demonstrate progress to metrics
    - Include updates based on process improvements
  - All FAIs and FATs against specifications, drawings, models, etc.
  - Continuous improvement plans.
    - Include assessment of quality targets (gaps)

- Provide quality input for a Letter of Delegation to DCMA for support to, witness of, and assessment of demonstrations, pilot line operations, FAIs and/or FATs, etc.

Metrics

- Quality assessments of contractor and supply chain pilot lines and demonstrations have been conducted and the results document verification and validation of the following for the program Quality Strategy and Plans and the PRR:
  - Quality processes and procedures including continuous improvement efforts
  - Quality surveillance and quality data collection and analyses (including supply chain data)
  - Quality and process controls in place
  - Adequacy and completeness of acceptance and qualification testing for LRIP
  - All quality instructions, sequencing, in-process tests, and test procedures
  - Quality scheduling and control
  - Quality model and simulations
  - Quality workforce capabilities
  - Implementations of quality technologies
  - Tooling, work holding fixtures, jigs, etc. for inspection and test
  - Test equipment and test facilities (including STE/SIE)
  - Quality processes for transportation, storage, and handling equipment
  - Potential requirements for additional quality tools, equipment, and software
  - Safety of quality processes and procedures
  - Quality of ESOH processes and procedures
  - Quality of security processes, procedures, capabilities, and compliance
  - Impacts from direct and indirect infrastructure
  - Mitigation results of quality and adequacy of risks and issues resolutions
  - Quality costs (impacts to schedule and performance)
  - Quality of materials' sources and selections
  - Quality of embedded software (integration)
- Pilot line quality process results, including simulations, have been analyzed and utilized for recommended updates to plans and targets including:
  - Rate of quality processes (actual time to complete)
  - Quality data targets
  - Process yields
  - Process changes
  - Cost of quality
- Assessments of pilot line process control plans, including all plans for process control of key and critical processes, for adequacy and completeness have been conducted and results utilized to recommend updates to plans, process capability indices (C_{pk}s), SPC processes, FRACAS processes, and other metrics, etc.

- All work instructions have been assessed for required quality outputs incorporating all up-to-date build-to documentation and information gathered during the pilot line and recommended changes documented and provided to Configuration Management.
    - Include KCs and their control plans
- Quality outputs from the pilot line and demonstrations have been assessed for adequacy and completeness and document validation of:
    - All PPVs
    - Implementation of manufacturing technology solutions (including ManTech)
    - Attainability of KCs (will be capable and under process control for LRIP)
    - Data collected for the Variability Reduction program
        - Data should demonstrate progress to metrics
        - Include updates based on process improvements
    - All FAIs and FATs against specifications, drawings, models, etc.
    - Continuous improvement plans.
        - Include assessment of quality targets (gaps)
- A Letter of Delegation has been approved and provided to DCMA for support to, witness of, and assessment of demonstrations, pilot line operations, FAIs and/or FATs, etc.

Tools

- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 Quality Systems – Requirements for Aviation, Space, and Defense Organizations, Sep 2016
- AS9145 Requirements for Advanced Product Quality Planning and Production Part Approval Process
- ISO 9001:2015, Quality Management System
- MRL Deskbook Version 2016
- MIL-HDBK-896A
- DoD Risk, Issue, and Opportunity Management Guide, Jun 2015

I.7 Finalize Quality Strategy and Plan for LRIP

Manufacturing and Quality Tasks

- Based on analyses of quality processes performed for the pilot line, verify and validate the quality processes capability for LRIP (including simulations) and update the Quality Strategy and Plan accordingly to include:
  - Rate of quality processes (actual time to complete) vs. planned
  - Quality data actuals vs. estimated
  - Quality process yield actuals vs. planned
  - Changes in processes
  - Cost of quality actuals vs. desired
  - Potential requirements for additional equipment
  - Continuous improvement process and requirements
- Ensure process control plans, including all plans for process control for key and critical processes, are updated from pilot line and in place for LRIP.
- Verify Quality Strategy and Plan are updated based on all build-to documentation from the pilot line, including KCs and critical characteristics and their control plans for LRIP.
  - Include updates based on process capability data collected for those processes affecting KCs and critical characteristics
  - Include process stability data for key and critical processes and provide estimates for those with insufficient data
- Adjust Quality Strategy and Plan based on validated data collected for the Variability Reduction program
  - Data should indicate progress to metrics
  - Include updates based on process improvements
- Update Quality Strategy and Plan to include all First Article Inspections and First Article Tests (completed with plans in place to correct findings).
- Ensure that the Quality Strategy and Plan for LRIP requires:
  - Includes Letter of Delegations for DCMA support at the appropriate levels of the supply chain
  - Adequate acceptance and qualification testing
  - Continuous collection and periodic review of quality data to identify areas for improvement (i.e., Continuous Process Improvement (CPI)).
  - Supplier risk and issue mitigation planning complete and being implemented
  - Periodic supplier process control verification and validation
  - Periodic assessment of Variability Reduction processes
  - Implementation of Six Sigma, lean manufacturing processes, etc.

- Based on contractor's manufacturing and quality system verification and validation efforts, including pilot line and demonstrations, and direct and indirect infrastructure, update the Program Quality Strategy and Plan (i.e., AS6500) including:
  - Quality processes including continuous improvement efforts
  - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)
  - All quality instructions, sequencing, in-process tests, and procedures (including those in work instructions)
  - Process capabilities (C_{pk}s) and process control plans
  - Quality scheduling and control
  - Quality model and simulations
  - Quality workforce capabilities
  - Implementations of quality technologies
  - Tooling, work holding fixtures, jigs, etc. for inspection and test
  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment validation in accordance with plans)
  - Quality processes for transportation, storage, and handling equipment
  - Safety of quality processes and procedures
  - Quality of ESOH processes and procedures
  - Quality of security processes, procedures, capabilities, and compliance
  - Mitigation results of quality and adequacy of risks and issues resolutions
  - Quality costs (and impacts to schedule and performance)
  - Quality of materials' sources and selections
  - Quality of embedded software (integration)
- Based on quality analyses of program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, develop recommendations for sourcing and options for LRIP including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages
- Ensure contractor's quality plans, policies, and procedures are consistent with program plans for program Plans for Product Improvement for LRIP.
- Based on pilot line operations, demonstrations, and simulations, update all quality risks, issues, and mitigation plans for LRIP.
- Ensure mitigations of current risks and issues are on track and/or do not introduce new risks and issues to the program for LRIP.

- Based on the results of the Pilot Line build, finalize the Technical Data Package (TDP) including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Metrics

- Pilot line quality processes have been analyzed and the results document verification and validation of LRIP quality processes capability. Quality Strategy and Plan has been updated accordingly including:
  - Rate of quality processes
  - Quality data
  - Process yields
  - Process changes
  - Cost of quality
  - Requirements for additional equipment
  - Requirements for continuous process improvement
- Assessments of process control plans, including all plans for process control of key and critical processes, for adequacy and completeness have been conducted and results utilized to recommend updates to LRIP plans, process capability indices (C_{pk}s), SPC processes, FRACAS processes, and other metrics, etc.
- LRIP Quality Strategy and Plan have been updated:
  - Based on all build-to documentation from the pilot line, to include all KCs and their control plans for LRIP:
    - Process capability updates
    - Process stability estimates (if data insufficient)
  - Based on validated data collected for the Variability Reduction program
    - Data depicts progress to metrics
    - Updates include process improvements
  - To include results of all FAIs and FATs
    - Plans in place to correct findings
- Based on contractor's manufacturing and quality system verification and validation efforts, including pilot line and demonstrations, and direct and indirect infrastructure, the updated LRIP Quality Strategy and Plan documents and includes:
  - Letters of Delegation for DCMA support at the appropriate levels of the supply chain
  - Requirements for acceptance and qualification testing
  - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)

- Quality processes including CPI with continuous quality data collection and periodic reviews
- Mitigation results of quality and adequacy of risks and issues resolutions
  - Up-to-date supplier risk and issue mitigation plans and actions
- Periodic supplier process control verification and validation
- Periodic assessment of Variability Reduction processes
- Implementation of Six Sigma, lean manufacturing processes, etc.
- All quality instructions, sequencing, in-process tests, and procedures (including those in work instructions)
- Process capabilities (C_{pk}s) and process control plans
- Quality scheduling and control
- Quality model and simulations
- Quality workforce capabilities
- Implementations of quality technologies
- Tooling, work holding fixtures, jigs, etc. for inspection and test
- Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment validation in accordance with plans)
- Quality processes for transportation, storage, and handling equipment
- Safety of quality processes and procedures
- Quality of ESOH processes and procedures
- Quality of security processes, procedures, capabilities, and compliance
- Quality costs (and impacts to schedule and performance)
- Quality of materials' sources and selections
- Quality of embedded software (integration)

- Recommendations for sourcing and options for LRIP have been developed and documented based on quality analyses of program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages
- Contractor's quality plans, policies, and procedures have been assessed and recommendations and changes have been documented to maintain consistency with program P^3I plans for LRIP.
- All updated quality risks, issues, and mitigation plans have been documented and provided for the joint program/Contractor Risk, Issue, and Opportunity Management System for LRIP.
  - Mitigations of current risks and issues are assessed to be on track and do not introduce new risks and issues to the program for LRIP

- Based on the results of the pilot line and demonstrations, final quality input to the TDP has been provided, including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Tools

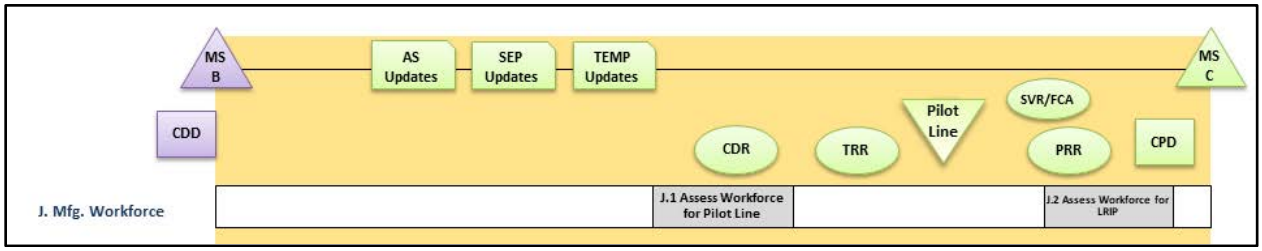
- Acquisition Strategy Template
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A
- DSMC Acquisition Strategy Guide, Dec 1999
- AFMC Instruction 63-145 Manufacturing and Quality (Draft)
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- FAR 52.246-11, Quality
- MRL Deskbook Version 2016
- DAG Chapter 14.3.1.3.6 Quality Plans

J. MANUFACTURING WORKFORCE

Workforce skills identification and plans provide inputs to program planning. Workforce planning should align the skills required to the scope of the effort required to develop, field, and sustain the system. To determine the scope of the manufacturing and quality workforce plans necessary for the system during EMD, the following considerations should be analyzed and understood, including the Work Breakdown Structure (WBS), the contractor's make/buy plans and manufacturing and quality plans, processes, and procedures, the risks, issues, and opportunities and associated plans, the IMP/IMS, and other supporting resources.



A comprehensive assessment of contractor manufacturing plans for system development is necessary to understand the requirements for workforce skills, capabilities, training, and certifications. In

support of pilot line workforce requirements, contractor plans should be assessed for human resource policies, processes, and procedures, forecasts for the number of workers, skills and capabilities, etc. Additionally, the current training, certifications, and education, sourcing availability and stability, demographics of the contractor and supply chain should be evaluated for adequacy, as well as their capability and capacity to expand the workforce, through hiring, training, and certification, for pilot line and LRIP.

Based on contractor execution of the pilot line and the manufacturing and quality workforce results, update the program workforce plans contained in the Manufacturing and Quality Strategies for required skills, capabilities, training, and certifications for LRIP in the P&D phase.

J.1 Assess Workforce for Pilot Line

Manufacturing and Quality Tasks

- Assess the contractor's Manufacturing and Quality Plans for manufacturing, quality, and supporting pilot line workforce requirements for adequacy and capacity to meet program requirements and schedule including:
  - Human resource policies, processes, and procedures to include forecasting and scheduling
  - Number of workers by category by schedule
  - Skillsets and capabilities by category by schedule
  - Current level and forecasting for training, certifications, and education
  - Capacity and capability to train, certify, etc.
  - Labor regulations, relations, union agreements, etc.
  - Labor Sourcing – internal and external
  - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
  - Demographics (e.g., citizenship, retirement eligibility, etc.)
  - Security
- Assess contractor's facility and personnel statistics (e.g., turnover, accidents, ESOH violations, etc.) and Manufacturing and Quality Plans for manufacturing and quality workforce risks, issues, and opportunities.

Metrics

- Contractor's Manufacturing and Quality Plans has been assessed and documents the adequacy and capacity of manufacturing, quality, and supporting pilot line workforce to meet program requirements and schedule, and/or recommended changes, including:
  - Human resource policies, processes, and procedures to include forecasting and scheduling
  - Number of workers by category by schedule

  - Skillsets and capabilities by category by schedule
  - Current level and forecasting for training, certifications, and education
  - Capacity and capability to train, certify, etc.
  - Labor regulations, relations, union agreements, etc.
  - Labor Sourcing – internal and external
  - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
  - Demographics (e.g., citizenship, retirement eligibility, etc.)
  - Security
- Contractor's facility and personnel statistics and Manufacturing and Quality Plans have been assessed for manufacturing and quality workforce risks, issues, and opportunities with results and recommendations documented for the joint Risk, Issue, and Opportunity Management Plan.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS6500, Manufacturing Management Systems
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- Manufacturing Resource Planning (MRP II)

J.2 Assess Workforce for LRIP

Manufacturing and Quality Tasks

- Based on pilot line results, assess the updated contractor's Manufacturing and Quality Plans for manufacturing, quality, and supporting LRIP and FRP workforce scale-up requirements for adequacy and capacity to meet program requirements and schedule including updates to the following:
    - Human resource policies, processes, and procedures to include forecasting and scheduling
    - Number of workers by category by schedule
    - Skillsets and capabilities by category by schedule
    - Current level and forecasting for training, certifications, and education
    - Capacity and capability to train, certify, etc.
    - Labor regulations, relations, union agreements, etc.
    - Sourcing – internal and external
    - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
    - Demographics (e.g., citizenship, retirement eligibility, etc.)
    - Security
- Update contractor's facility and personnel statistics (e.g., turnover, accidents, ESOH violations, etc.) for manufacturing and quality workforce risks, issues, and opportunities.

Metrics

- Based on pilot line results, the updated contractor's Manufacturing and Quality Plans for manufacturing, quality, and supporting LRIP and FRP scaled-up workforce has been assessed and documents the adequacy and capacity to meet program requirements and schedule, and/or recommended updates to the following:
    - Human resource policies, processes, and procedures to include forecasting and scheduling
    - Number of workers by category by schedule
    - Skillsets and capabilities by category by schedule
    - Current level and forecasting for training, certifications, and education
    - Capacity and capability to train, certify, etc.
    - Labor regulations, relations, union agreements, etc.
    - Sourcing – internal and external
    - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
    - Demographics (e.g., citizenship, retirement eligibility, etc.)
    - Security

- Contractor's updated facility and personnel statistics and Manufacturing and Quality Plans have been assessed for manufacturing and quality workforce risks, issues, and opportunities with results and recommendations documented for the joint Risk, Issue, and Opportunity Management Plan.

Tools

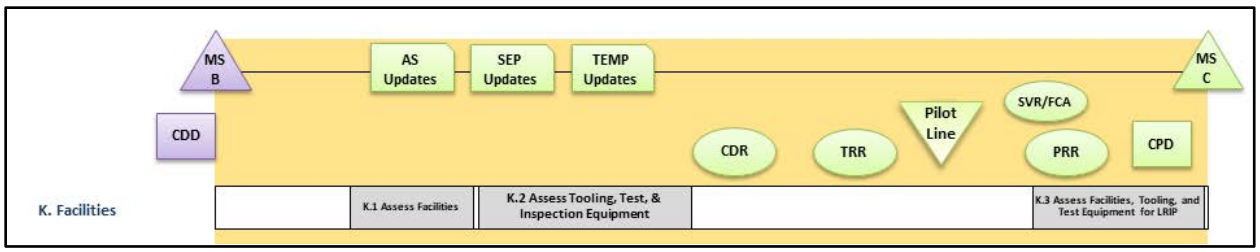
- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS6500, Manufacturing Management Systems
- AS9100 Quality Systems – Requirements For Aviation, Space, And Defense Organizations, Sep 2016
- ISO 9001:2015, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MRL Deskbook Version 2016

K. FACILITIES

Based upon the results of PDR and program progress during early EMD, manufacturing and quality personnel should assess the contractor and supply chain facility and tooling plans developed for the pilot line and LRIP. This should include pre-CDR assessments of proposed production (e.g., pilot line, LRIP, FRP, etc.) facilities, and an update to the Manufacturing and Quality Strategies and Plans for EMD and future phases.



Based on the system design and results of assessments of existing assets, new facilities, tools, and equipment may be required to meet rates and schedules. Additionally, depending on final CDR design, new materials, new technologies, new processes, and new tooling and equipment may be required. The program and the contractor(s) need to address the assessment results, current and known future facility workload (i.e., other programs), and any new requirements, and plan accordingly for the capability and capacity to develop, produce, maintain, and support the program throughout the supply chain.

The assessments conducted for EMD should include subcontractors and key suppliers identified in the contractor's Manufacturing Management Plan, which should include tooling and facilities plans with utilization, and any relocation/consolidation considerations, schedules, and requirements for manufacturing maturity. These assessments should be conducted on-site and can be included as part of the MRL assessment. These should include all "special test equipment" and "special tooling" as defined in FAR 2.101 in assessments conducted.

The results of these assessments should identify and document risks, issues, and opportunities arising from facility and tooling shortfalls and document the required planning for mitigation. Prior to CDR and pilot line, the program Tooling Plan for facilities, tooling, equipment, and test equipment (part of the Manufacturing and Quality Strategies and Plans) should be finalized along with the associated risk and issue mitigation actions. Final validation of manufacturing and quality plans must be accomplished prior to CDR, prior to execution of a pilot line.

Facilities, tooling, equipment, and test equipment requirements, resource requirements, and schedules should be re-assessed based on results of pilot line demonstrations and assessments for LRIP and FRP. Using the actual data collected from pilot line assess equipment capability, capacity, and availability for scale-up. Additionally, assess manufacturing and quality operations and environmental requirements, floor space utilization and expansion requirements, facility data requirements, and equipment maintenance requirements for LRIP and FRP. Focused attention on facilities, tooling, equipment, and test equipment in EMD will decrease risk and can be a major factor in avoiding or preventing cost overruns and schedule delays for LRIP and FRP.

K.1 Assess Facilities

Manufacturing and Quality Tasks

- Identify facility and resource requirements by phase and schedule (e.g., pilot line, LRIP, and FRP) to include the following:
  - Current facility availability, capacity (including surge), capitalization plan, and expansion potential
  - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and scale-up
  - Floor space requirements (including feeding, storage, transportation, re-work, work-in-process, etc.) and expansion
  - Manufacturing facility data requirements (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
  - Maintenance requirements (facilities and spares)
- Assess contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and required resources for pilot line and plan for LRIP to include:
  - Current and future facility availability and capacity
  - Equipment capability, capacity, and availability (machines, processes, storage, etc.)
  - Floor space requirements (including feeding, storage, transportation, re-work, work-in-process, etc.) and planned expansion
  - Maintenance requirements (facilities and spares)

Metrics

- Facility requirements have been assessed by phase and schedule (e.g., pilot line, LRIP, and FRP) and documents the following for CDR:
  - Current facility availability, capacity (including surge), capitalization plan, and expansion potential
  - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and scale-up
  - Floor space requirements (including feeding, storage, transportation, re-work, work-in-process, etc.) and expansion
  - Manufacturing facility data capability and capacity (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
  - Maintenance requirements (facilities and spares)
- Contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and resources for pilot line and LRIP have been assessed and the results and recommendations documented for CDR including:
  - Current and future facility availability and capacity
  - Equipment capability, capacity, and availability (machines, processes, storage, etc.)

- Current floor space (including feeding, storage, transportation, re-work, work-in-process, etc.) and required expansion
- Maintenance requirements (facilities and spares)

Tools

- Manufacturing Readiness Level (MRL) Assessment Questionnaire, Facilities thread
- DCMA Production Planning and Control Risk Assessment Checklist
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist

Resources

- DoDI 5000.02
- AS6500, Manufacturing Management Systems
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- DCMA-INST-204 Manufacturing and Production
- Risk, Issue, and Opportunity Management Guide
- MRL Deskbook Version 2016
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting

K.2 Assess Tooling, Test, and Inspection Equipment

Manufacturing and Quality Tasks

- Develop manufacturing and quality equipment, tooling, test and inspection equipment maintenance strategy:
  - Include processes and procedures in accordance with industry best practices (i.e., AS9100)
  - Include objectives and requirements for tooling, testing, funding, resources, and scheduling
- Update the TMRR Tooling Plan for:
  - Tooling and Special Test Equipment/Special Inspections Equipment requirements for development (i.e., pilot line ramp up to LRIP, ramp up to FRP)
    - Limited quantity or soft tooling
    - Rate quantity or hard tooling
    - Necessary only for development (pilot)
    - Necessary only for production (LRIP/FRP)
    - Necessary for Operations and Sustainment support
    - Available government assets (GFE)
  - Tooling used for the development or production of supplies or parts or to the performance of particular functions for the program to include:

        - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
        - Requirements for identification, calibration, frequency, and traceability to international or national measurement standards
        - Requirements for collection, monitoring, and maintenance of data and a register for validation purposes
        - Requirements for safeguarding from adjustments, damage, or deterioration
    - Use and application of single or multipurpose integrated specialized test equipment (STE/SIE) (e.g., engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items, assemblies of equipment including inter-connected or interdependent, foundations and similar improvements, etc.)
    - Use and application of GFE, COTS, etc.
    - Tooling and STE/SIE test and validation plans (including demonstrations)
- Ensure that production tooling and test equipment design and development efforts are underway.
- Perform a manufacturing and quality assessment of the contractor's and supply chain tooling, test, and inspection equipment resources provided for:
    - Suitability for the specific type of monitoring and measurement activities required
    - Maintenance and accountability to required standards with appropriate documentation
- Assess contractor and supply chain demonstrations of tooling and STE/SIE for subsystems, item, and components in the appropriate production environment (e.g., representative, pilot line, production line) for functionality, sufficiency, and capacity.

Metrics

- Manufacturing and quality has developed an equipment, tooling, test and inspection equipment maintenance strategy to be implemented in the Tooling Plan for CDR, to include:
    - Processes, procedures, and demonstrations that implement industry best practices (i.e., AS9100)
    - Policy, objectives, goals, and desired outcomes for tooling, testing, funding, resourcing, and scheduling
- The TMRR Tooling Plan has been updated for CDR and documented in the Manufacturing and Quality Plans to include:
    - Detailed requirements for tooling and STE/SIE for pilot line ramp up to LRIP and LRIP ramp to FRP (e.g., soft, hard, development, production, O&S, GFE, etc.)
    - Detailed requirements for:
        - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
        - Identification, calibration, frequency, and traceability to international or national measurement standards

    - Collection, monitoring, and maintenance of data and a register for validation purposes
    - Safeguarding from adjustments, damage, or deterioration
    - single or multipurpose integrated STE/SIE
    - Use and application of COTS, etc.
    - Test and validation plans (including demonstrations)

- Production tooling and test equipment design and development efforts have been approved and are underway.
- Contractor's and supply chain tooling, test, and inspection equipment resources have been assessed for adequacy and completeness and results document for CDR:
    - Suitability for the specific type of monitoring and measurement activities required
    - Maintenance and accountability to required standards with appropriate documentation maintained as evidence of fitness for purpose
- Contractor and supply chain demonstrations of tooling and STE/SIE for subsystems, item, and components in the appropriate production environment (e.g., representative, pilot line, production line) have been assessed for functionality, sufficiency, and capacity and document completion of validation plans.

Tools

- DCMA Production Planning and Control Risk Assessment Checklist
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- Rough Cut Capacity Planning Spreadsheet
- Material Requirements Planning
- Capacity Requirements Planning Assessment Worksheet
- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Manufacturing Resource Planning (MRPII)
- Manufacturing Readiness Level (MRL) Assessment Questionnaire, Facilities thread
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- AS9100
- ISO 9000
- FAR Part 2, §2.101 Definitions
- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- Manufacturing Resource Planning (MRP II)
- DCMA-INST-204 Manufacturing and Production
- MRL Deskbook Version 2016

K.3 Assess Facilities, Tooling, and Test Equipment for LRIP

Manufacturing and Quality Tasks

- Based on pilot line demonstrations and assessments, assess facilities, facilities resource requirements, and facilities schedules for LRIP and FRP to include the following:
    - Current facilities availability, capacity (including surge), and expansion requirements
    - Facilities capitalization plan
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and scale-up
    - Manufacturing operations and environmental requirements (e.g., noise, lighting, vibrations, temperature, humidity, cleanliness, dust, foreign object detection (FOD), etc.)
    - Floor space utilization (including processes and requirements for feeding, storage, transportation, re-work, work-in-process, etc.) and expansion requirements
    - Manufacturing facility data requirements (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
    - Manufacturing equipment maintenance requirements (facilities, spares, and frequency)
- Assess contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and required facilities resources for LRIP and FRP to include:
    - Current and future facility availability and capacity
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and requirements for additional resources
    - Environmental and manufacturing operations (regulatory and program) requirements (e.g., noise levels, lighting levels, vibration and isolation, temperature and humidity control, cleanliness requirements, FOD and preventions requirements, etc.)
    - Floor space utilization (including processes and requirements for feeding, storage, transportation, re-work, work-in-process, etc.) and expansion requirements
    - Maintenance requirements (facilities and spares)
- Support assessments of manufacturing work place safety for compliance with applicable statutes, regulations, and policies.
- Assess results of manufacturing and quality equipment, tooling, test and inspection equipment maintenance strategy demonstration and adequacy on the pilot line for:
    - Processes and procedures implementation according to industry best practices (i.e., AS9100)
    - Tooling, testing, resources, and scheduling meeting requirements
- In accordance with validation plans, validate tooling and STE/SIE based pilot line demonstrations and results.
- Based on pilot line demonstrations and results, update the program Tooling Plan for LRIP to include:

- Tooling and STE/SIE requirements for ramp up to LRIP and FRP (e.g., soft, hard, development, production, O&S, GFE, etc.)
- Updated detailed requirements for:
  - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
  - Identification, calibration, frequency, and traceability to international or national measurement standards
  - Collection, monitoring, and maintenance of data and a register for validation purposes
  - Safeguarding from adjustments, damage, or deterioration (physical security)
  - Digital safeguarding from tampering (cyber security)(i.e., Additive Manufacturing software and firmware)
  - Tooling and STE/SIE test, validation maintenance, and re-validation plans
- Use and application of single or multipurpose integrated STE/SIE
- Use and application of GFE, COTS, etc.

- Ensure that LRIP tooling, inspection, and test equipment efforts are complete, and FRP tooling and test equipment efforts are underway.
- Based on pilot line demonstrations and results, update the manufacturing and quality assessment of the contractor's and supply chain tooling, test, and inspection equipment LRIP resources for:
  - Suitability for the specific type of monitoring and measurement activities required
  - Maintenance and accountability to required standards with appropriate documentation
- Based on pilot line demonstrations and results, update the assessment of contractor and supply chain tooling and STE/SIE for subsystems, item, and components in the appropriate production environment (e.g., production line for LRIP or FRP) for functionality, sufficiency, and capacity.

Metrics

- Facilities, facilities resource requirements, and facilities schedules have been assessed with recommended changes and updates implemented. Based on pilot line demonstrations and implementation of changes, manufacturing facilities have been assessed as adequate for LRIP with plans are in place for transition to FRP including:
  - Current facilities availability and capacity (including surge) with expansion requirements
  - Facilities capitalization plan
  - Equipment capability, capacity, and availability (machines, processes, storage, etc.) with scale-up
  - Manufacturing operations and environmental conditions (e.g., power, noise, lighting, vibrations, temperature, humidity, cleanliness, FOD, dust, etc.)
  - Floor space utilization (including processes and requirements for feeding, storage, transportation, re-work, work-in-process, etc.) with expansion requirements

- Manufacturing facility data capability and capacity (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
- Manufacturing equipment maintenance (facilities, spares, and frequency)

- Contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and required facilities resources have been assessed for adequacy and completeness for LRIP and FRP and recommended changes and updates have been documented for:
  - LRIP and future FRP facility availability and capacity
  - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and requirements for additional and/or future resources
  - Environmental and manufacturing operations (regulatory and program) requirements (e.g., noise levels, lighting levels, vibration and isolation, temperature and humidity control, cleanliness requirements, FOD and preventions requirements, etc.)
  - Floor space utilization (including processes and requirements feeding, storage, transportation, re-work, work-in-process, etc.) and expansion requirements
  - Maintenance requirements (facilities and spares)
- Work place safety has been assessed, with manufacturing and quality support, for compliance with applicable statutes, regulations, and policies and required changes have been documented and implemented.
- Equipment, tooling, test and inspection equipment maintenance strategy has been demonstrated on the pilot line and results assessed as adequate and/or recommendations and changes documented in the Manufacturing and Quality Plans for:
  - Implementation of processes and procedures according to industry best practices (i.e., AS9100)
  - Meeting requirements for tooling, testing, resources, and scheduling
- Based pilot line demonstrations and results, tooling and STE/SIE has been validated In accordance with validation plans and results and/or recommended changes have been documented in the Quality Plan and implemented.
- Based on pilot line demonstrations and results, the program Tooling Plan for LRIP has been assessed and updated for necessary changes including:
  - Tooling and STE/SIE requirements for ramp up to LRIP and FRP (e.g., soft, hard, development, production, O&S, GFE, etc.)
  - Updated detailed requirements for:
    - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
    - Identification, calibration, frequency, and traceability to international or national measurement standards
    - Collection, monitoring, and maintenance of data and a register for validation purposes
    - Safeguarding from adjustments, damage, or deterioration (physical security)

        - Digital safeguarding from tampering (cyber security)(i.e., Additive Manufacturing software and firmware)
        - Tooling and STE/SIE test, validation maintenance, and re-validation plans
    - Use and application of single or multipurpose integrated STE/SIE (e.g., engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items, assemblies of equipment including inter-connected or interdependent, foundations and similar improvements, etc.)
    - Use and application of GFE, COTS, etc.
- LRIP tooling, inspection, and test equipment efforts, proven on a pilot line, have been assessed, are complete and/or additional requirement identified for LRIP
    - FRP tooling and test equipment efforts are underway, and documented up-to-date in the Tooling Plan, the IMP/IMS, and the TEMP.
- Based on pilot line demonstrations and results, contractor's and supply chain tooling, test, and inspection equipment LRIP resources have been assessed and recommended changes and updates have been documented for:
    - Capability to perform the specific type of monitoring and measurement activities required by the program
    - Meeting required standards for maintenance and accountability with appropriate documentation
- The assessment of contractor and supply chain tooling and STE/SIE has been updated for all subsystems, items, and components with results of demonstrations for functionality, sufficiency, and capacity in the appropriate production environments. Recommendations for changes and additional updates have been documented.
    - Incomplete or insufficient demonstrations of capability are documented for independent assessment according to statute

Tools

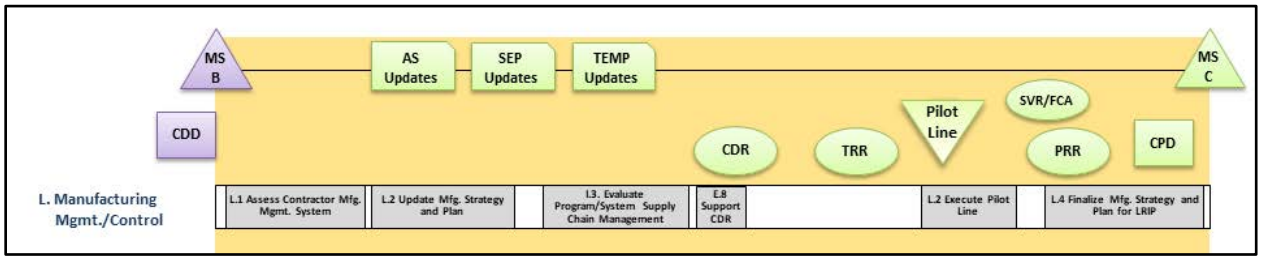
- DCMA Production Planning and Control Risk Assessment Checklist
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- Rough Cut Capacity Planning Spreadsheet
- Material Requirements Planning
- Capacity Requirements Planning Assessment Worksheet
- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Manufacturing Resource Planning (MRPII)
- Manufacturing Readiness Level (MRL) Assessment Questionnaire, Facilities thread
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- FAR Part 2, §2.101 Definitions
- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- Manufacturing Resource Planning (MRP II)
- DCMA-INST-204 Manufacturing and Production
- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- MRL Deskbook Version 2016
- Public Law 114-328

L. MANUFACTURING MANAGEMENT/CONTROL

The Manufacturing Strategy and Plan are major aspects of development, test, initial production, and other activities essential for program success. With the potential for a new contractor or contractors responsible for engineering and manufacturing development through completion of pilot line production, updated manufacturing and quality strategies will be required. This begins with an assessment of the contractor(s), and their supply chain(s), manufacturing plans for adequacy and alignment with the program Acquisition Strategy (AS).



Manufacturing is a complex combination of resources consisting of facilities, materials, machines, manpower, methods, measurement systems, and capital that are utilized in converting or transforming raw materials and component parts into end products. The contractor must have an effective combination of people and systems in order to plan for, monitor, and control these manufacturing resources, as well as a well-structured manufacturing management system. This requires effective implementation of industry best practices. Assessment of the contractor's manufacturing management system (and quality management system) should be performed against the recognized industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.).

Many acquisition programs experience difficulties in smoothly transitioning from development to production and fielding supportable systems. Assessments of the contractor's manufacturing strategy and planning should ensure adequacy and sufficiency of their manufacturing planning and capability

to perform the final design and manufacturing work scope to achieve production. These should include processes, procedures, and work instructions encompassing the supply chain and supply chain communications, KCs control and management, management, control, and monitoring of KPPs, KSAs, CSIs, and CAIs, process control plans, control or avoidance of obsolescent items, high-risk sources, counterfeit parts and materials, etc. Additionally, the government requires implementation of cyber threat protection measures and manufacturing control systems which include safeguarding manufacturing and quality information, designed in systems protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security. Implementing all of these protections and controls is the basis for maintaining the currency of the program Manufacturing Strategy and Plans.

For CDR, initial product baseline documentation for manufacturing, included in the Manufacturing Strategy and Plans, should be sufficient, complete, and adequate to enable manufacture of all components and hardware with embedded software throughout the supply chain on a pilot line.

At CDR manufacturing capability and capacity of the contractor and supply chain are assessed for the system design for each subsystem, item, and component in the system's initial product baseline. This assessment should include all key and critical manufacturing processes, and their process control plans, for definition, characterization, and currency to the detailed design, and the capability to meet requirements. Additionally, the assessments should include contractor plans for meeting schedule, rates, yields, long-lead procurement requirements, demonstration requirements, safety and security, test, etc. on a pilot line.

The Government and contractor designated pilot lines should be assessed for production realism and affordability in production of the system, subsystem, items, and components. Verification and validation of contractor and supply chain manufacturing plans, processes, and procedures should be analyzed during the demonstrations. Additionally, process control plans, work instructions, facilities, tooling, manufacturing data output, etc. should be included. Based upon these assessments and demonstrations, the Manufacturing Strategy and Plan should be updated, and the Technical Data Package should be finalized for LRIP

L.1 Assess Contractor Manufacturing Management System

Manufacturing and Quality Tasks

- Assess the contractor’s Manufacturing Management Strategy and Plan for:
  - Incorporation of industry and government manufacturing and quality best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
  - Compliance with policy directives and regulations
  - The Risk, Issue and Opportunity Management plans

- Development and incorporation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
- Development and incorporation of system required technologies (and constraints)
- Requirements and schedules for manufacturing development projects
- Design feasibility, methodology, and producibility initiatives
- Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
- Management of key and critical characteristics
- Configuration management and control
- Costs and schedule requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
- Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues
- Management of the supply chain
- Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
- Processes and process capability control requirements
- Workforce needs, capabilities, training, certifications, availability, etc.
- Facilities, Tooling, and Test Equipment (including GFE and assets) requirements
- Acceptance testing
- Environmental, security, and safety requirements

- Assess and audit (where necessary) the contractor's Manufacturing Management System (MMS) capability to perform the final design and manufacturing work scope in accordance with industry best practices (e.g., AS6500, AS9100, ISO 9000, etc.) and program policies, objectives, and goals including:
  - Effective implementation and integration of the QMS processes throughout the MMS and supply chain to include (See I.1):
    - Organization direction, values, policies, and procedures
    - Management commitment, resources, communications, feedback, and accountability
  - Effectiveness of program and contractor communication and interaction processes to include:
    - Cost, schedule, and performance requirements and timely notification of changes
    - Manufacturing data management processes (to include responses, status, and reports for cost, schedule, and performance actuals)
    - Integration of risk, issue, and opportunity management processes
    - Failures, corrective, and preventative actions, communication processes
    - Specification and production of prototypes
  - Design analyses for manufacturing to include:
    - Producibility and manufacturing feasibility
    - Failure mode analyses

- KCs

- Risk, issue, and opportunity management processes (to include quality, technical, schedule, material, facility, scale-up, financial impacts, and audits if necessary, etc.)
- Processes, procedures, and work instructions for the following:
  - KC control, management, and inclusion in the Technical Data Package (TDP)
  - Management, control, and monitoring of Key Performance Parameters (KPPs), Key System Attributes (KSAs), and KCs, CSIs, and CAIs
  - Process control plans including statistical process controls, rates, yields, and management of process capabilities (C_{pk}s)
  - Make/buy (to include performance and impacts)
  - Control or avoidance of items and components that could become obsolete or are from a diminishing or fragile manufacturing source
  - Control or avoidance of sources that are sole, single, foreign, or vulnerable to interruption, interference, or compromise
  - Prevention and/or detection of counterfeit parts and materials (See AS5553 and AS6174)
  - Continuous process improvement (CPI)
  - Effective metrics management to include monitoring, evaluating, and verifying
  - Conduct of Process Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
  - Support of the FRACAS and the associated corrective actions (i.e., manufacturing process changes)
- Supply chain management system that tracks and reports supplier performance and supplier quality assessment processes
- A system for manufacturing verification that verifies the proposed production processes, tooling, and test equipment meet program requirements (including Special Tooling and Special Test Equipment)
- Systematic manufacturing self-assessments and supply chain assessments to measure progress in manufacturing maturation and risk and issue reduction
- MRL assessments throughout the supply chain and independent assessments as required by statute.
- Manufacturing management processes including roles and responsibilities for:
  - Materials management and control, including availability and lead-times
  - Data storage, management, and security (physical and cyber)
  - Safety, environmental, transportation, storage, etc.
  - COTS items, GOTS items, and NDIs
  - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
- Production Process Verifications (PPVs) that verify manufacturing processes, tooling, and equipment are statistically capable of producing required parts and assemblies

- Variability Reduction (VR) plan for incorporation of mature processes and techniques
- Manufacturing software and firmware management processes and integration (including the program Software Development Plan (SDP), and Software Configuration Management Plan (SCMP)
- Manufacturing processes for inclusion of in-process and acceptance tests encompassing:
  - Prototypes, first articles, hardware, software, and firmware
  - First Article Inspections (FAIs)/First Article Tests (FATs)
  - Test procedures including test equipment
  - Quality plans including control plans and quality improvement plans (included in the TEMP)

- Assess the contractor's MMS processes for the management, execution, and maintenance of the Integrated Master Plan and Integrated Master Schedule (IMP/IMS).
  - Include MMS impacts on critical path, schedule, costs, and outcomes
- Assess the contractor's MMS for capability to support a Life-Cycle Support Plan (if required) which includes planning for production, developmental and operational test, deployment, and life-cycle sustainment.
- Verify the contract and the subcontractor management plan includes right of access for both the contractor and the Government to supplier facilities and documentation, where applicable.
- Request DCMA support and assistance to assess in conducting assessments and audits of contractor and supply chain MMSs.

Metrics

- The contractor's Manufacturing Management Strategy and Plan have been assessed and the results document the inclusion of the following for use in updating appropriate program documentation (See L.2):
  - Incorporation of industry and government manufacturing and quality best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
  - Compliance with policy directives and regulations
  - The Risk, Issue and Opportunity Management plans
  - Development and incorporation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
  - Development and incorporation of system required technologies (and constraints)
  - Requirements and schedules for manufacturing development projects
  - Design feasibility, methodology, and producibility initiatives
  - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
  - Management of key and critical characteristics
  - Configuration management and control
  - Costs and schedule requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path

- Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues
- Management of the supply chain
- Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
- Processes and process capability control requirements
- Workforce needs, capabilities, training, certifications, availability, etc.
- Facilities, Tooling, and Test Equipment (including GFE and assets) requirements
- Acceptance testing
- Environmental, security, and safety requirements

- Contractor's Manufacturing Management System (MMS) has been assessed for the capability to perform the final design and manufacturing work in accordance with industry best practices and program policies, objectives, and goals; the assessment results are documented in program Manufacturing Strategy, Plans, and other program processes and procedures, and include the following:
  - Documented implementation and integration of the QMS processes throughout the MMS and supply chain to include (See I.1):
    - Organization direction, values, policies, and procedures
    - Management commitment, resources, communications, feedback, and accountability
  - Verified implementation of effective program and contractor communication and interaction processes to include:
    - Cost, schedule, and performance requirements and timely notification of changes
    - Manufacturing data management processes (to include responses, status, and reports for cost, schedule, and performance actuals)
    - Integration of risk, issue, and opportunity management processes
    - Failures, corrective, and preventative actions, communication processes
    - Specification and production of prototypes
  - Documented design analyses for manufacturing including analyses for:
    - Producibility and manufacturing feasibility
    - Failure modes
    - KCs and associated manufacturing processes
  - Documented risk, issue, and opportunity management and mitigation processes (to include quality, technical, schedule, material, facility, scale-up, financial impacts, and audits if necessary, etc.)
  - Documented and implemented processes, procedures, and work instructions for:
    - KC control, management, and inclusion in the Technical Data Package (TDP)
    - Management, control, and monitoring of KPPs, KSAs, and KCs, CSIs, and CAIs
    - Process control plans including statistical process controls, rates, yields, and management of process capabilities (C_{pk}s)

- Make/buy (to include performance and impacts)
- Control or avoidance of items and components that could become obsolete or are from a diminishing or fragile manufacturing source
- Control or avoidance of sources that are sole, single, foreign, or vulnerable to interruption, interference, or compromise
- Prevention and/or detection of counterfeit parts and materials (See AS5553 and AS6174)
- Continuous process improvement (CPI)
- Effective metrics management to include monitoring, evaluating, and verifying
- Conduct of Process Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
- Support of the FRACAS and the associated corrective actions (i.e., manufacturing process changes)

- A functional supply chain management system that tracks and reports supplier performance and supplier quality assessment processes
- A system for manufacturing verification that is in place and documents proposed production processes, tooling, and test equipment that meet program requirements (including Special Tooling and Special Test Equipment)
- Documented systematic process for manufacturing self-assessments and supply chain assessments to measure progress in manufacturing maturation and risk and issue reduction
- Documented process for performing MRL assessments throughout the supply chain and independent assessments as required by statute.
- Documented manufacturing management processes including roles and responsibilities for:

  - Materials management and control, including availability and lead-times
  - Data storage, management, and security (physical and cyber)
  - Safety, environmental, transportation, storage, etc.
  - COTS items, GOTS items, and NDIs
  - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)

- Documented systematic application of PPVs ongoing to verify manufacturing processes, tooling, and equipment are statistically capable of producing required parts and assemblies
- Documented VR plan for application of mature processes and techniques
- Documented management processes for manufacturing software and firmware, and integration (including the program SDP, and SCMP)
- Documented manufacturing processes for in-process and acceptance tests that encompass:

  - Prototypes, first articles, hardware, software, and firmware
  - FAIs and FATs

        - Test procedures (including test equipment)
        - Quality plans including control plans and quality improvement plans (in the TEMP)

- Contractor's MMS processes for the management, execution, and maintenance of the IMP and IMS have assessed and approved.
    - MMS impacts on critical path, schedule, costs, and outcomes have been included
- Contractor's MMS has been assessed and the results document the capability to support a Life-Cycle Support Plan.
- Contract and the subcontractor management plan have been verified to include the right of access for both the contractor and the Government to supplier facilities and documentation, when necessary.
- DCMA support and assistance in conducting assessments and audits of contractor and supply chain MMSs has requested through a Letter of Delegation

Tools

- Manufacturing Readiness Level (MRL) Assessment Questionnaire for the Manufacturing Management and Control thread
- AS6500 Manufacturing Management Assessment
- Material Management and Accounting System Audit

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- DFAR 242.72 Contractor Material Management and Accounting System
- MRL Deskbook Version 2016
- AS9100, Quality Management System, Sep 2016
- AS5553, Counterfeit Electronic Parts, 2013
- AS6174, Counterfeit Material, 2012
- IEEE 15288, Systems and Software Engineering, 2015
- Public Law 114-328

L.2 Update Manufacturing Strategy and Plan

Manufacturing and Quality Tasks

- Update the manufacturing inputs to the program Manufacturing Strategy and Plan (government) for EMD based on the results of assessment of the contractor's Manufacturing Strategy and Plans and to include:
    - Implementation of industry and government manufacturing and quality best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
    - Requirements for compliance with policy directives and regulations

- Requirements for the EMD AS and RFP
- Government IB risk and issue mitigation plans (complementary to contractor plans)
- The joint Risk, Issue and Opportunity Management plans
- Implementation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
- Implementation of system required technologies (and constraints)
- Requirements and schedules for implementing ManTech projects
- Requirements for Intellectual Property management and control, and impacts to the TDP
- Results of producibility initiatives
- Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
- Management of key and critical characteristics
- Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
- Updates to requirements for program management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
- Updates to requirements for and approach to program management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
  - Including DCMA and DLA support and data
- Updates for schedule contingencies, variances, and risks
- Updates to program plans and methodologies for prototypes, competitive or dual sources, co-production, etc.
- Updates to program requirements for process capability control
- Additional program workforce requirements for program personnel capabilities, SMEs, training, certifications, availability, etc.
- Updates to program GFE and assets requirements for facilities, tooling, and test equipment
- Manufacturing updates for the program Manufacturing Plan and schedule (IMP/IMS) for integration of independent or Service testing (DoD)
- Updates to manufacturing requirements for environmental, security, and safety

- Based on results of assessments of the contractor's MMS and plans for security, provide updated manufacturing inputs to:
  - Program Manufacturing Strategy and Plan for industrial security and anti-tamper including risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Program security (physical, digital, and cyber) strategies, plans, processes, and procedures (e.g., SSE, COMSEC, and PPP)

- Based on results of assessments and audits, update manufacturing inputs to manufacturing requirements in the Life-Cycle Support Plan for the program and updates the program Manufacturing Strategy accordingly.
- Based on results of assessments of the contractor's MMS and plans, provide manufacturing updates for the program Manufacturing Strategy and AS to include appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, etc.) for support and inputs.
- Based on results of assessments provide updates to manufacturing inputs for the program Configuration Management Plan.
- Based on results of assessments of the contractor's Manufacturing Management Plan (MMS) and program/technical plans, provide manufacturing recommendations for required contract modifications or updates to ensure alignment of contractor with program Manufacturing Management Strategy and Plans (See I.1 and L.1).
- Based on monitoring of post-PDR manufacturing and quality mitigation measures, provide manufacturing updates for the program Manufacturing Strategy to address status or completion of all mitigation measures for all gaps, risks, and issues (See E.6).

Metrics

- Updated manufacturing inputs to the Program Manufacturing Strategy and Plan (government) for EMD have been documented and provided based on the results of assessments of the contractor's Manufacturing Strategy and Plans including:
  - Implementation of industry and government manufacturing and quality best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
  - Requirements for compliance with policy directives and regulations
  - Requirements for the EMD AS and RFP
  - Plans for Government IB risk and issue mitigation (complementary to contractor plans)
  - Plans for the joint Risk, Issue and Opportunity Management System
  - Implementation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
  - Implementation of system required technologies (and constraints)
  - Requirements and schedules for implementing ManTech projects
  - Requirements for Intellectual Property management and control, and impacts to the TDP
  - Results of producibility initiatives
  - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
  - Management of key and critical characteristics
  - Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
  - Requirements for program management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)

  - Requirements for and approach to program management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
    - Including DCMA and DLA support and data
  - Schedule contingencies, variances, and risks
  - Program plans and methodologies for prototypes, competitive or dual sources, co-production, etc.
  - Program requirements for process capability control
  - Additional program workforce requirements for program personnel capabilities, SMEs, training, certifications, availability, etc.
  - Program GFE and assets requirements for facilities, tooling, and test equipment
  - Manufacturing updates for the Program Manufacturing Plan and schedule (IMP/IMS) for integration of independent or Service testing (DoD)
  - Requirements for manufacturing environmental, security, and safety
- Updated manufacturing inputs have been provided from documented results of assessments of the contractor's MMS and plans for security including updates to:
  - Program Manufacturing Strategy and Plan for industrial security and anti-tamper including risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Program security (physical, digital, and cyber) strategies, plans, processes, and procedures (e.g., SSE, COMSEC, and PPP)
- Updated manufacturing inputs have been provided from documented results of assessments and audits for manufacturing requirements in the Life-Cycle Support Plan for the program, and update the Program Manufacturing Strategy accordingly.
- Up-to-date manufacturing inputs have been provided for and documented in the Program Configuration Management Plan.
- Manufacturing recommendations for required contract modifications or updates have been documented and provided to Program management to ensure alignment of contractor with Program Manufacturing Management Strategy and Plans (See I.1 and L.1).
- Monitoring of post-PDR manufacturing and quality mitigation measures is ongoing and has provided documented manufacturing updates for the Program Manufacturing Strategy that address status of all mitigation measures (See E.6).
- Manufacturing updates have been documented and provided for the Program Manufacturing Strategy and AS to include appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, etc.) for support and input.

Tools

- Acquisition Strategy Template
- Manufacturing Readiness Level (MRL) assessment questionnaire using Manufacturing Management/Control thread

Resources

- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- ISO 9000
- Acquisition Plan Preparation Guide, Jan 2009
- DSMC Acquisition Strategy Guide, Dec 1999w
- MRL Deskbook Version 2016
- DoDI 5000.02
- Service specific policies and regulations (i.e., AFI 63-145)
- DoDI 5000.02, Enclosure 14 Cybersecurity
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- IEEE 15288, Systems and Software Engineering, 2015
- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

L.3 Evaluate Program/System supply chain Management

Manufacturing Tasks

- Ensure that the contractor supply chain management system for subsystems, items, and components requires MMS processes and procedures are in alignment with industry best practices (i.e., AS6500) to include elements such as:
    - Manufacturing Management System
    - Design Analysis for Manufacturing including producibility analyses, KCs, and Failure Mode Effects Analyses (DFMEA and PFMEA)
    - Manufacturing Risk Identification including manufacturing feasibility and MRL assessments, and Production Readiness Reviews
    - Manufacturing Planning including:
        - Supply chain and material management
        - Manufacturing technology development
        - Manufacturing cost
        - Modeling and simulations
        - Manufacturing system verification
        - Manufacturing workforce
        - Tooling, test equipment and facilities
    - Manufacturing Operations Management including:

- Production Scheduling and Control
- Manufacturing Surveillance
- Continuous Improvement
- Process Control Plans
- Process Capabilities
- PPVs
- FAIs and FATs
- Sub-tier supplier management
- Sub-tier supplier quality

- Assess the contractor's supply chain management system capabilities for performance of manufacturing processes and procedures including:
  - Effectiveness of contractor, supplier, and sub-tier communications and interactions including:
    - Flow down of cost, schedule, and performance requirements to sub-tier suppliers and timely notification of changes
    - Design and engineering changes traceability and compliance
    - Manufacturing data exchange, analysis, storage, and traceability processes
    - The joint Risk, Issue, and Opportunity Management System
    - Responses, status, and reports for cost, schedule, and performance actuals
    - Corrective and preventative actions and feedback
  - KCs and critical characteristics (CSIs and CAIs) management
  - Supplier and sub-tier risk, issue, and opportunity mitigation management processes for manufacturing (e.g., schedule, material, facility, scale-up, financial impacts, etc.)
  - Make/buy processes for supplier and sub-tier manufacturing capability, capacity, performance, and impacts
  - Qualification, approval, re-qualification, and removal processes for suppliers, monitoring and tracking of supplier performance, and periodic re-assessment
  - Supplier and sub-tier manufacturing assistance and mentoring program
  - Utilization of processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
  - Verification of suppliers and sub-tier manufacturing processes and procedures, especially suppliers performing key and/or critical manufacturing processes
  - Manufacturing process control plans
  - Appropriate application of statistical control techniques for manufacturing
  - Predictive processes and systems to provide early detection of manufacturing issues (e.g., tooling wear indicators, tracking, predictive and preventative maintenance, etc.)
  - Continuous manufacturing surveillance and effective metrics

- Collect and analyze supply chain manufacturing data from the subsystems, items, and component production to:
  - Develop and recommend manufacturing process improvements

- Meet planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)

- Assess the supply chain for manufacturing security processes, plans, and procedures including:
  - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)

- Assess the supply chain for implementation and compliance with Program manufacturing processes and requirements for:
  - Configuration Management
  - ESOH
  - Environmental, safety, hazardous materials, waste handling, etc.
  - Testing, qualifications, and certifications (e.g., TEMP, etc.)
  - The LCSP
  - Facilities and tooling (GFE/GFP)

- Request DCMA perform Government surveillance of supplier and sub-tier compliance to manufacturing management program contract requirements.

Metrics

- Contractor's supply chain (for subsystems, items, and components) MMS processes and procedures have been assessed for implementation of industry best practices, with documented recommendations for changes if necessary, for the following elements (See AS6500):
  - Manufacturing Management System
  - Design Analysis for Manufacturing
    - Producibility analyses
    - KCs
    - Failure Mode Effects Analyses (DFMEA and PFMEA)
  - Manufacturing Risk Identification
    - Manufacturing feasibility assessments
    - MRL assessments
    - Production Readiness Reviews
  - Manufacturing Planning including supply chain:
    - Materials management
    - Manufacturing technology development
    - Manufacturing cost
    - Modeling and simulations
    - Manufacturing system verification
    - Manufacturing workforce

        - Tooling, test equipment and facilities
    - Manufacturing Operations Management including:
        - Production Scheduling and Control
        - Manufacturing Surveillance
        - Continuous Improvement
        - Process Control Plans
        - Process Capabilities
        - PPVs
        - FAIs and FATs
        - Sub-tier supplier management
        - Sub-tier supplier quality
- Contractor's supply chain management system has been assessed for specific capabilities in performance of manufacturing processes and procedures and documented for adequacy, completeness, and sufficiency including:
    - Communications effectiveness for contractor, supplier, and sub-tier interactions including:
        - Flow down of cost, schedule, and performance requirements to sub-tier suppliers and timely notification of changes
        - Design and engineering changes traceability and compliance
        - Manufacturing data exchange, analysis, storage, and traceability processes
        - The joint Risk, Issue, and Opportunity Management System
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions and feedback
    - Management of KCs and critical characteristics (CSIs and CAIs)
    - Mitigation management processes for supplier and sub-tier risks, issues, and opportunities for manufacturing (e.g., schedule, material, facility, scale-up, financial impacts, etc.)
    - Make/buy processes for supplier and sub-tier manufacturing capability, capacity, performance, and impacts
    - Processes for qualification, approval, re-qualification, and removal of suppliers, monitoring and tracking of supplier performance, and periodic re-assessment
    - Supplier and sub-tier manufacturing assistance and mentoring program
    - Processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
    - Processes and procedures for verification of suppliers and sub-tier manufacturing, especially suppliers performing key and/or critical manufacturing processes
    - Manufacturing process control plans
    - Application of statistical control techniques for manufacturing
    - Predictive processes and systems to provide early detection of manufacturing issues (e.g., tooling wear indicators, tracking, predictive and preventative maintenance, etc.)

- Continuous manufacturing surveillance and effectiveness of metrics

- Supply chain manufacturing data has been collected from the subsystems, items, and component production and has been assessed with recommendations provided for:
  - Manufacturing process improvements
  - Meeting and/or improving planned rates and schedules
- Supply chain has been assessed for manufacturing security processes, plans, and procedures and results document compliance with Program requirements including:
  - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
- Supply chain has been assessed for implementation of Program manufacturing processes and document compliance with Program requirements and/or recommendations for updates for:
  - Configuration Management
  - ESOH
  - Environmental, safety, hazardous materials, waste handling, etc.
  - Testing, qualifications, and certifications (e.g., TEMP, etc.)
  - The LCSP
  - Facilities and tooling (GFE/GFP)
- DCMA Letter of Delegation has been sent for performance of Government surveillance of supplier and sub-tier compliance to manufacturing management program contract requirements.

Tools

- Supply Chain Assessment

Resources

- DoD supply chain Management Guide, March 2016
- AS6500, Manufacturing Management Program, Nov 2014
- AS9100 QUALITY SYSTEMS – REQUIREMENTS FOR AVIATION, SPACE, AND DEFENSE ORGANIZATIONS, SEP 2016
- ISO 9001 Quality Management Systems
- IEEE 15288.2, System and Software Engineering, 2015
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- AS5553 Counterfeit Electronic Parts
- DFARS 252.246-7008, Sources of Electronic Parts
- DoDI 5000.02, Enclosure 14
- MIL-STD-882
- NIST 800-82 Guide to Industrial Control Systems Security

- AS6174
- DFARS 252.228-7001, Ground and Flight Risk
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

L.4 Support CDR

Manufacturing and Quality Tasks

- For CDR, provide manufacturing inputs on Program, contractor, and supply chain implementation status of industry best practices (i.e., AS6500).
- Ensure initial product baseline documentation for manufacturing is sufficient, complete, and adequate to enable component manufacturing, hardware fabrication and software implementation to proceed.
    - Ensure all KCs, CSIs, and CAIs have completed drawings and specifications under configuration control
    - Ensure all product data essential (e.g., drawings, specifications, etc.) for component manufacturing has been released
- Ensure all manufacturing design trade studies and manufacturing producibility assessments are completed and incorporated into the design for CDR.
    - Ensure manufacturing producibility process enhancement efforts ongoing for optimized integrated system (e.g. Design for Manufacturability, Design for Assembly, etc.)
- Ensure all subsystem, item, and component CDRs are complete, with any open manufacturing action items and associated risks understood, and the results available for the system CDR.
- Ensure manufacturing input to the schedule (IMP/IMS) is up-to-date and is executable with acceptable risks.
- Ensure manufacturing plans, activities, and processes are executable within the existing manufacturing budget to support the approved initial product baseline and critical path.
- Ensure all key and critical manufacturing processes, including process control plans, have been defined, characterized, updated for the detailed design, and the capability to meet requirements has been determined.
- Assess manufacturing plans for adequacy and capability to achieve manufacturing readiness level 8 by initial production.

- Assess plans for long-lead procurement requirements and incorporate results into procurement plans.
- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Analyze the assessments of adequacy and completeness of manufacturing requirements validation activities (e.g., prototypes and demonstrations in the appropriate environment) of the system, subsystem, item, and component levels for manufacturing maturity including:
    - Demonstrations of manufacturing processes in the appropriate environment (for the product level)
    - Demonstrations of manufacturing processes for KCs, CSIs, and CAIs
- Provide manufacturing inputs to the LCSP for CDR.
- Ensure contractor manufacturing management systems for manufacturing metrics, data collection, and tracking to the component level are in place and functional.
- Ensure the manufacturing considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - Safety Plan
    - ESOH, environmental, and security plans
    - PPP
    - SEMP
    - TEMP
- Ensure the contractor's SEMP incorporates all Program requirements, certification requirements, interfaces and interdependencies, etc. to support manufacturing of subsystems, items, and components.
- Provide up-to-date manufacturing inputs to the Program budget and the CARD.
    - Update and allocate manufacturing and quality (production) cost models to subsystem, item, and component levels, and track against targets
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) to ensure identification of manufacturing risks, issues, and opportunities with associated mitigation plans.
- Ensure adequacy and completeness of mitigation activities for mitigation of manufacturing risks, issues, and opportunities in the joint Government/ contractor Risk, Issue, and Opportunity (RIO) Management System, including:
    - Key and critical manufacturing processes including embedding software

- Materials and sourcing
- Supply chain including multiple sources
- Production rates and yields
- Facilities
- Special tooling development
- Tests and demonstrations
- Security (physical and cyber)
- System safety, ESOH, and hazardous materials management
- Schedule (i.e., IMP/IMS)
- Manufacturing capability obsolescence
- Manufacturing capability sustainment

- Assess contractor production control and materials planning systems for adequacy to support pilot line.
- Assess contractor make/buy decisions and BOM sufficiency to support pilot line.
- Assess contractor manufacturing processes and procedures for materials, facilities, equipment, test facilities and equipment, and tooling to support the pilot line.
- Ensure the Manufacturing Strategy and Plan are updated based on the all assessments, audits, demonstrations, tests, etc. and the results conducted to date.

Metrics

- Manufacturing inputs on Program, contractor, and supply chain implementation status of industry best practices (i.e., AS6500) have been documented and provided for CDR.
- Initial product baseline documentation has been assessed for CDR and documents the completeness and adequacy to allow component manufacturing, hardware fabrication and software implementation to proceed.
  - All KCs, CSIs, and CAIs have completed drawings and specifications under configuration control
  - All product data essential (e.g., drawings, specifications, etc.) for component manufacturing has been released
- All manufacturing design trade studies and manufacturing producibility assessments results have been reviewed for adequacy and completeness and are documented in the design for CDR.
  - Manufacturing producibility process enhancement efforts are ongoing for the optimized integrated system (e.g. Design for Manufacturability, Design for Assembly, etc.)
- All subsystem, item, and component CDRs have been completed:
  - Open manufacturing action items are tracked and monitored in the joint RIO System
  - All risks understood with mitigation plans documented, in progress, and status available for the system CDR

- Manufacturing has provided up-to-date and executable inputs for the schedule and the critical path for the IMP/IMS with acceptable risks.
- Manufacturing plans, activities, and processes have been assessed and documented as executable within the existing manufacturing budget in support of the approved product baseline and critical path.
- All key and critical manufacturing processes, including process control plans, have been documented to include characterization, up-to-date detailed design, and capability and capacity to meet Program requirements.
- Manufacturing plans to achieve manufacturing readiness level 8 by initial production have been assessed for adequacy and are documented in the Program Manufacturing Plan.
- Long-lead procurement requirements and plans have been assessed and results have been incorporated into the Manufacturing Plan.
- Results from prototype demonstrations (e.g., component yield and rate data) have been analyzed and updates to subsystem, item, and component quantity estimates to meet Program system requirements have been documented in the Manufacturing Plan for CDR.
- Manufacturing requirements validation activities (e.g., prototypes and demonstrations in the appropriate environment of the system, subsystem, item, and component levels) have been assessed and the results document the manufacturing maturity. Assessments included:
    - Demonstrations of manufacturing processes in the appropriate environment (for the product level)
    - Demonstrations of manufacturing processes for KCs, CSIs, and CAIs
- Manufacturing inputs to the LCSP have been documented and provided CDR.
- Contractor manufacturing management systems for manufacturing metrics, data collection, and tracking to the component level have been assessed, are in place and functional, and the results document adequacy and sufficiency for CDR and pilot line.
- Contractor's plans and inputs have been assessed for manufacturing considerations and aspects, are documented up-to-date, and have been approved for CDR, including the following plans:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - Safety Plan
    - ESOH, environmental, and security plans
    - PPP
    - SEMP
    - TEMP
- Contractor's SEMP has been assessed and documentation shows incorporation of all Program requirements, certification requirements, interfaces and interdependencies, etc. for manufacturing of subsystems, items, and components in support of CDR.

- Up-to-date manufacturing inputs have been provided for the Program budget and the CARD.
    - Manufacturing and quality (production) cost models have been updated and document allocation and tracking to subsystem, item, and component levels
- Contractor and key supply chain assessment results have been analyzed and document adequacy and completeness of identification and mitigation activities and plans for manufacturing risks, issues, and opportunities with associated mitigation plans in the joint Government/ contractor Risk, Issue, and Opportunity (RIO) Management System, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security (physical and cyber)
    - System safety, ESOH, and hazardous materials management
    - Schedule (i.e., IMP/IMS)
    - DMSMS
    - Manufacturing sustainment
- Contractor's capability, capacity, and adequacy to support the pilot line has been assessed and the results documented for CDR to include the following:
    - Production control systems
    - Materials planning systems
    - Make/buy decisions
    - Bill of Materials
    - Manufacturing processes and procedures
    - Materials
    - Facilities, equipment, tooling
    - Tests, test facilities and equipment
- Manufacturing Strategy and Plan have been updated for CDR based on the all assessments, audits, demonstrations, tests, etc. and the results conducted to date.

Tools

- Critical Design Review Checklist

Resources

- AS6500, Manufacturing Management Program, Sep 2016
- Defense Acquisition Guide (DAG) Chapter 3-3.3.5 Critical Design Review
- IEEE 15288.2, System and Software Engineering, 2015

- MRL Deskbook Version 2016

L.5 Execute Pilot Line

Manufacturing and Quality Tasks

- Assess the contractor designated pilot lines for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:
  - Manufacturing readiness for manufacture of equipment
  - Materials, components, and tooling availability,
  - Adequacy of workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
  - Capability to meet design requirements for LRIP
  - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
  - Capability and capacity to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule
- Ensure contractor and supply chain manufacturing plans, processes, and procedures are demonstrated, verified, and validated on the pilot line in accordance with industry best practices (i.e., AS6500) to include the following:
  - Continuous process improvement efforts
  - Manufacturing surveillance, data collection, and analyses (including supply chain data for items and components)
  - Manufacturing process controls in place (e.g. plans, process capabilities (C_{pk}s), Statistical Process Control (SPC), etc.)
  - Adequacy and completeness of acceptance processes for LRIP
  - All manufacturing work instructions, sequencing, and in-process tests (including quality test points and procedures)
  - Manufacturing scheduling, work flow, and optimization
  - Manufacturing resource planning, and scheduling
  - Physical and functional interfaces
  - Manufacturing models and simulations
  - Manufacturing workforce capabilities, skills, and training
  - Implementations of manufacturing technologies including ManTech
  - Tooling, work holding fixtures, jigs, etc.
  - Manufacturing equipment and facilities (including GFE, etc.)
  - Manufacturing processes for movement, storage, and handling equipment
  - Manufacturing safety processes and procedures
  - Manufacturing ESOH processes and procedures
  - Manufacturing security processes, procedures, capabilities, and compliance
  - Impacts from direct and indirect infrastructure

- Mitigation results for manufacturing risks and issues resolutions
- Manufacturing cost changes (and impacts to schedule and performance)
- Adequacy of materials sources and selections
- Integration (manufacturing processes) of embedded software

- Analyze manufacturing processes performed during the pilot lines operations, (including simulations) to include:
  - Rate of manufacturing processes (actual time to complete) vs. planned
  - Manufacturing data actuals vs. estimated
  - Process yield actuals vs. planned
  - Changes in processes (actual vs. planned)
  - Cost of manufacturing actuals vs. desired
- Assess process control plans, including all plans for process control of key and critical processes, for adequacy and completeness on the pilot line.
- Assess all work instructions for required outputs and changes based on build-to documentation and information gathered during the pilot line.
  - Verify updated work instructions, processes, drawings, etc.
  - Include KCs, Critical Manufacturing Processes, and their control plans
- Assess manufacturing output from the pilot line for adequacy and completeness and validate:
  - All Production Process Verifications (PPVs) performed
  - Attainability of KCs (will be capable and under process control for LRIP)
  - Manufacturing data collected for the Variability Reduction program
    - Data should demonstrate progress to metrics
    - Include updates based on process improvements
  - All FAIs and FATs against specifications, drawings, models, etc.
  - Requirements for design changes and process changes identified during pilot line operations, testing, and qualification
- Capture the results of manufacturing processes, demonstrated on a pilot line, as inputs to the system MRL assessment, PRR, and to the Industrial Base Capabilities Considerations that are required for Milestone C.
- Based on the results of the Pilot Line build, finalize the Technical Data Package including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.
- Provide manufacturing input for a Letter of Delegation to DCMA for support to, witness of, and assessment of demonstrations, pilot line operations, FAIs and/or FATs, etc.

Metrics

- Contractor designated pilot lines have been assessed and documented in an MRL assessment and/or for PRR for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:
  - Manufacturing readiness for manufacture of equipment
  - Materials, components, and tooling availability,
  - Adequacy of workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
  - Capability to meet design requirements for LRIP
  - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
  - Capability and capacity to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule
- Contractor and supply chain manufacturing plans, processes, and procedures have been demonstrated on a pilot line and the results documented in the Program management information system and/or Contract Data Requirements List (CDRL) to validate industry best practices were followed to include:
  - Continuous process improvement efforts
  - Manufacturing surveillance, data collection, and analyses (including supply chain data for items and components)
  - Manufacturing process controls in place (e.g. plans, process capabilities (C_{pk}s), Statistical Process Control (SPC), etc.)
  - Adequacy and completeness of acceptance processes for LRIP
  - All manufacturing work instructions, sequencing, and in-process tests (including quality test points and procedures)
  - Manufacturing scheduling, work flow, and optimization
  - Manufacturing resource planning, and scheduling
  - Physical and functional interfaces
  - Manufacturing models and simulations
  - Manufacturing workforce capabilities, skills, and training
  - Implementations of manufacturing technologies including ManTech
  - Tooling, work holding fixtures, jigs, etc.
  - Manufacturing equipment and facilities (including GFE, etc.)
  - Manufacturing processes for movement, storage, and handling equipment
  - Manufacturing safety processes and procedures
  - Manufacturing ESOH processes and procedures
  - Manufacturing security processes, procedures, capabilities, and compliance
  - Impacts from direct and indirect infrastructure
  - Mitigation results for manufacturing risks and issues resolutions
  - Manufacturing cost changes (and impacts to schedule and performance)
  - Adequacy of materials sources and selections

- Integration (manufacturing processes) of embedded software

- Manufacturing processes performed during the pilot lines operations, (including simulations) were assessed for actuals against plans and the results documented for:
  - Rates
  - Manufacturing data
  - Process yields
  - Changes in processes
  - Costs of manufacturing
- Process control plans, including all plans for process control of key and critical processes, have been assessed on the pilot line and the results document adequacy and completeness for PRR and LRIP.
- Based on build-to documentation and information gathered during the pilot line, all work instructions have been assessed and updated for required outputs and changes and results documented for PRR.
  - Updated work instructions, processes, drawings, etc. have been verified completeness and accuracy
  - KCs, Critical Manufacturing Processes, and their control plans have been validated and documented
- Pilot line output has been assessed for adequacy and completeness and documentation for PRR and LRIP shows verification and validation of:
  - All Production Process Verifications (PPVs)
  - Attainability of KCs (i.e., capable and under process control for LRIP)
  - Variability Reduction program
    - Data demonstrates progress to metrics
    - Includes all process improvements
  - All FAIs and FATs completed (e.g., specifications, drawings, models, etc.)
  - Design and process required by pilot line operations, testing, and qualification
- Results of manufacturing processes, demonstrated on a pilot line, have been documented as manufacturing inputs to the system MRL assessment, PRR, and to the Industrial Base Capabilities Considerations that are required for Milestone C.
- Based on the results of the Pilot Line build, the TDP has been updated and finalized to include all applicable technical data (e.g., models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation, and packaging details).
- Manufacturing input for a Letter of Delegation to DCMA has been provided to obtain support to, witness of, and assessment of demonstrations, pilot line operations, FAIs, or FATs, etc.

Tools

- Manufacturing Readiness Assessment, Material Management thread

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- MIL-HDBK-896A, Manufacturing Management Program Guide
- DoDI 5000.02
- MRL Deskbook Version 2016

L.6 Finalize Manufacturing Strategy and Plan for LRIP

Manufacturing and Quality Tasks

- Update and finalize the Program Manufacturing Strategy and Plan for Production and Deployment (P&D) to include updates for:
    - Results from pilot line and the resulting manufacturing updates
    - Results from FAIs, FATs, and FRACAS activities
    - Findings, results, and direction from the SVR/FCA
    - Final TDP
    - Requirements from the CPD
    - Findings from the MRL assessment
    - Direction and results from a completed PRR (e.g., date, open items, issues, etc.)
    - Requirements for P&D from the RFP
    - The joint Risk, Issue, and Opportunity System
    - Maturity and plans for manufacturing development
    - Manufacturing maturity and plans for system required new technologies
    - Results of pilot line design updates and producibility improvements
    - Results from continuous process improvement efforts
    - Management of Intellectual Property and data rights
    - Actual rates and schedules (includes processes, tooling, make/buy, etc.)
    - Verification and validation of models and simulations
    - Estimates for Learning Curves, LRIP (subsequent ramp-up to rate), surges, etc.
    - Changes to management of KCs and critical characteristics and associated processes
    - Manufacturing inputs on costs, schedule, budgets, affordability requirements, and IMP/IMS critical path
    - Management of materials (e.g., critical and controlled, lead-times, long-lead, sourcing, risks, issues, sole, single, foreign, counterfeit, obsolescence, etc.)
    - DMSMS strategies and plans
    - Use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
    - Finalized process capability requirements

- Requirements for in-process and acceptance tests, test procedures, and test equipment (hardware and software)
- Program and contractor workforce needs, capabilities, training, certifications, availability, etc.
- Changes in contractor facilities, manufacturing equipment and tooling, and test equipment requirements
- Processes and procedures for prevention and/or detection of counterfeit parts and materials
- ESOH, environmental, security, and safety requirements
- Management of ITAR and anti-tamper
- Plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations

- Ensure the Program Manufacturing Strategy for P&D includes industry best manufacturing practices (in accordance with AS6500) to include:
  - Manufacturing Management System
  - Design for Manufacturing including:
    - Producibility analyses
    - KCs
    - Failure Mode Effects Analyses (DFMEA and PFMEA)
  - Manufacturing Risk Identification including:
    - Manufacturing feasibility assessments
    - MRL assessments
    - Production Readiness Reviews
  - Manufacturing Planning including:
    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing costs
    - Modeling and simulations
    - Manufacturing system verification
    - Manufacturing workforce
    - Tooling, test equipment and facilities
  - Manufacturing Operations Management including:
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - PPVs
    - FAIs and FATs

        - Sub-tier supplier management

- Update the Program Manufacturing Management Strategy and Plan for manufacturing management of software and firmware.
- Provide updated manufacturing inputs to the PPP for considerations of contractor compliance, risks, and issues for P&D.
- Update the Program Manufacturing Strategy and Plan for P&D for required agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, National Test Facilities, etc.).
- Update the Manufacturing Strategy and Plan to include the contractual definition and agreement to manufacturing environments for LRIP and Full-Rate Production (FRP).
- Ensure the WBS adequately defines the tasks to be accomplished for LRIP in P&D.
- Based on manufacturing analyses of Program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, develop recommendations for sourcing and options for LRIP including:
    - Emerging technology advancements in materials and processes
    - Changes in Government statute, policy, and regulations
    - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
    - Changes in environmental impacts (e.g., natural disasters, etc.)
    - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Ensure contractor's manufacturing plans, policies, and procedures are consistent with Program plans for Program Plans for Product Improvement (P^3I) for LRIP.
- Based on pilot line operations, demonstrations, and simulations, update all manufacturing risks, issues, and mitigation plans for LRIP.
    - Ensure mitigations of current risks and issues are on track and/or do not introduce new risks and issues to the Program for LRIP.
- Based on the results of the Pilot Line build, finalize the Technical Data Package (TDP) including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Metrics

- Program Manufacturing Strategy and Plan has been updated for P&D and includes and documents the following:
    - Results from pilot line and the resulting manufacturing updates
    - Results from FAIs, FATs, and FRACAS activities
    - Findings, results, and direction from the SVR/FCA
    - Final TDP
    - Requirements from the CPD
    - Findings from the MRL assessment

- Direction and results from a completed PRR (e.g., date, open items, issues, etc.)
- Requirements for P&D from the RFP
- The joint Risk, Issue, and Opportunity System
- Maturity and plans for manufacturing development
- Manufacturing maturity and plans for system required new technologies
- Results of pilot line design updates and producibility improvements
- Results from continuous process improvement efforts
- Management of Intellectual Property and data rights
- Actual rates and schedules (includes processes, tooling, make/buy, etc.)
- Verification and validation of models and simulations
- Estimates for Learning Curves, LRIP (subsequent ramp-up to rate), surges, etc.
- Changes to management of KCs and critical characteristics and associated processes
- Manufacturing inputs on costs, schedule, budgets, affordability requirements, and IMP/IMS critical path
- Management of materials (e.g., critical and controlled, lead-times, long-lead, sourcing, risks, issues, sole, single, foreign, counterfeit, obsolescence, etc.)
- DMSMS strategies and plans
- Use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
- Finalized process capability requirements
- Requirements for in-process and acceptance tests, test procedures, and test equipment (hardware and software)
- Program and contractor workforce needs, capabilities, training, certifications, availability, etc.
- Changes in contractor facilities, manufacturing equipment and tooling, and test equipment requirements
- Processes and procedures for prevention and/or detection of counterfeit parts and materials
- ESOH, environmental, security, and safety requirements
- Management of ITAR and anti-tamper
- Plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations

- Program Manufacturing Strategy for P&D documents the requirements for and the implementation of industry best manufacturing practices including:
  - Manufacturing Management System
  - Design for Manufacturing including:
    - Producibility analyses
    - KCs
    - Failure Mode Effects Analyses (DFMEA and PFMEA)
  - Manufacturing Risk Identification including:

9597 ▪ Manufacturing feasibility assessments
9598 ▪ MRL assessments
9599 ▪ Production Readiness Reviews

9600 o Manufacturing Planning including:

9601 ▪ Supply chain and material management
9602 ▪ Manufacturing technology development
9603 ▪ Manufacturing costs
9604 ▪ Modeling and simulations
9605 ▪ Manufacturing system verification
9606 ▪ Manufacturing workforce
9607 ▪ Tooling, test equipment and facilities

9608 o Manufacturing Operations Management including:

9609 ▪ Production Scheduling and Control
9610 ▪ Manufacturing Surveillance
9611 ▪ Continuous Improvement
9612 ▪ Process Control Plans
9613 ▪ Process Capabilities
9614 ▪ PPVs
9615 ▪ FAIs and FATs
9616 ▪ Sub-tier supplier management

9617 • Program Manufacturing Management Strategy and Plan has been updated and documents
9618 manufacturing management of software and firmware.
9619 • Updated manufacturing inputs have been documented and provided for the PPP for
9620 evaluations of contractor's capability for compliance, risks, and issues for P&D.
9621 • Program Manufacturing Strategy and Plan documents updated requirements for P&D
9622 agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, National Test
9623 Facilities, etc.).
9624 • Manufacturing Strategy and Plan documents the contractual definition of and agreement to
9625 manufacturing environments for LRIP and Full-Rate Production (FRP).
9626 • Contractor WBS has adequately defined and documented the tasks to be accomplished for
9627 LRIP in P&D.
9628 • Recommendations for sourcing and options for LRIP have been developed and documented
9629 based on manufacturing analyses of Program progress and assessments of maturity,
9630 affordability and costs, availability and capability, risks, issues, and opportunities, including:

9631 o Emerging technology advancements in materials and processes
9632 o Changes in Government statute, policy, and regulations
9633 o Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
9634 o Changes in environmental impacts (e.g., natural disasters, etc.)
9635 o Diminishing Manufacturing Sources and Material Shortages (DMSMS)

- Contractor's manufacturing plans, policies, and procedures have been assessed and recommendations and changes have been documented to maintain consistency with Program P^3I plans for LRIP.
- All updated manufacturing risks, issues, and mitigation plans have been documented and provided for the joint Program/Contractor Risk, Issue, and Opportunity Management System for LRIP.
    - Mitigations of current risks and issues are assessed to be on track and do not introduce new risks and issues to the Program for LRIP
- Based on the results of the pilot line and demonstrations, final manufacturing input to the TDP has been provided, including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Tools

- Manufacturing Readiness Level (MRL) Assessment Questionnaire for the Manufacturing Management and Control thread
- AS6500 Manufacturing Management Program Assessment
- Material Management and Accounting System Audit

Resources

- AS6500, Manufacturing Management Program, Sep 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- DFAR 242.72 Contractor Material Management and Accounting System
- MRL Deskbook Version 2016
- AS9100, Quality Management System, Sep 2016
- ASISO5553, Counterfeit Electronic Parts, 2013
- AS6174, Counterfeit Material, 2012
- IEEE 15288, Systems and Software Engineering, 2015

5. Production and Deployment (P&D) Phase

Introduction

Congress and the Government Accountability Office (GAO) are concerned about manufacturing and production. They understand that a lack of attention to this function increases program and system risk and is the major factor in cost overruns and schedule delays. The following items are common production risks that can greatly affect cost, schedule and performance if the program office is not proactive in managing them.

- Unstable requirements and too many engineering changes
- Unstable production rates and quantities
- Insufficient process proofing
- Insufficient material characterization
- Changes in proven materials, processes, subcontractors, vendors, and components
- Lack of producibility consideration
- Configuration management
- Subcontractor management
- Special tooling and test equipment

These risks can occur early in the program's life, not just during production.

Department of Defense Instruction (DoDI) 5000.02, Operation of the Defense Acquisition System, identifies the policies and principles that guide all defense acquisition programs to include the following manufacturing related policy excerpt: "PMs shall provide knowledge about key aspects of a system at key points in the acquisition process. They shall reduce manufacturing risk and demonstrate producibility prior to full-rate production."

For manufacturing, the final acquisition role is to execute the manufacturing plan. This means to execute the plan in a way that reflects the design intent while ensuring repeatable processes and focusing on continuous improvement. Since the very earliest acquisition phases manufacturing has been working on the manufacturing plan and getting ready for production.

At Milestone C, key manufacturing readiness considerations include:

- Industrial base viability
- Design stability
- Process maturity
- Supply chain management
- Quality management
- Facilities
- Manufacturing skills availability

The Milestone C review should provide the status of assessments of manufacturing processes and highlight the steps needed to progress from an Engineering and Manufacturing Development (EMD) manufacturing environment to an Low-Rate Initial Production (LRIP) environment.

For the Full-Rate Production (FRP) decision review Acquisition Strategy update, the Program Management Office (PMO) should identify remaining risks prior to a production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews (PSRs), pre-award surveys, Production Readiness Reviews (PRR) , Industrial Capabilities Assessments (ACA), trade-off studies, tooling plans, make or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or handle remaining risks.

Figure 5-1 shows the P&D manufacturing and quality activities.

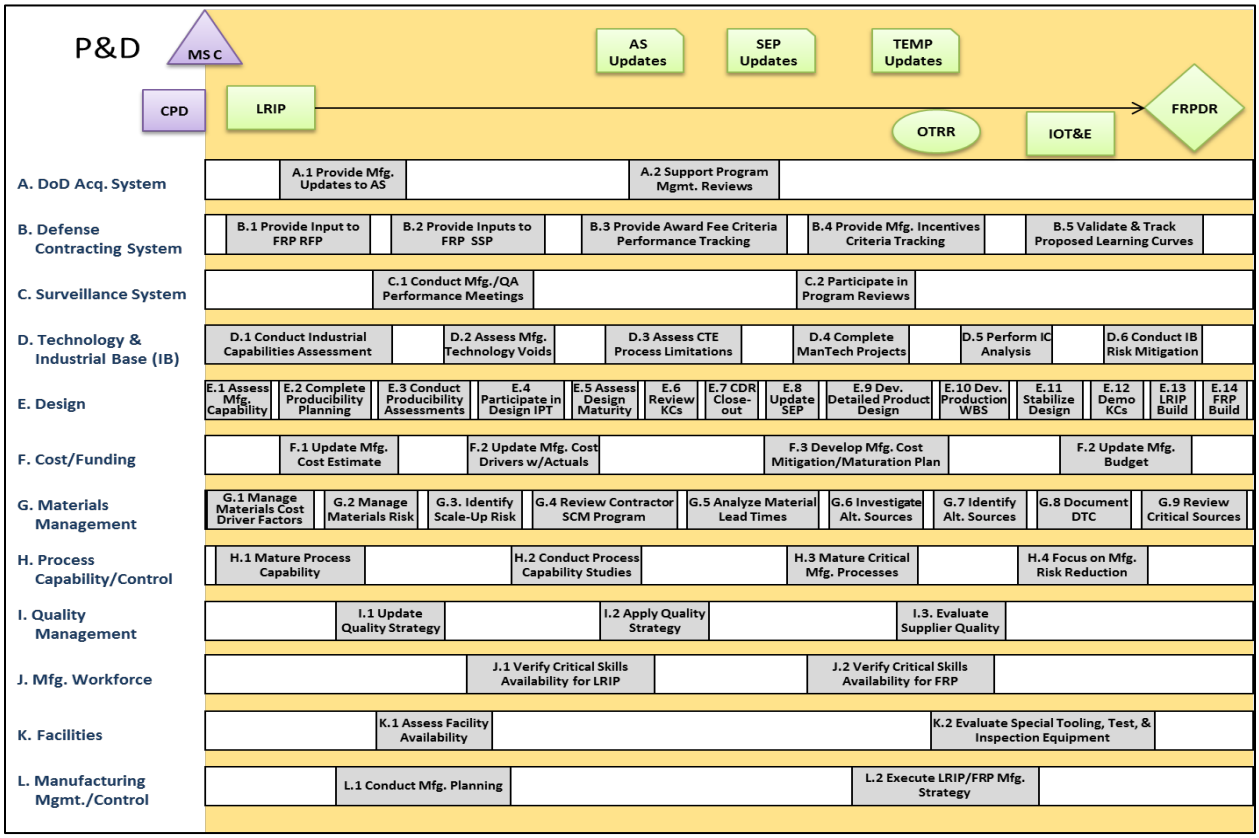


Figure 5-1. P&D Phase Manufacturing and Quality Activities

Specific requirements must be identified for inclusion in the statement of work for the production phase. The particular requirements reflect the areas that have been determined to be of importance, given the acquisition strategy of the program. Typical areas to be considered for inclusion are:

- Manufacturing management systems

- Work measurement
- Manufacturing data (including manufacturing plan updates)
- Initial production facilities
- Production and material control systems
- Manufacturing reporting systems (especially line of balance)
- Control of subcontractors and vendor
- Make or Buy program
- Government Furnished Property
- System audit
- Technical data
- Competition

Incentives may be included to motivate contractors to improve performance and control costs. The benefits attainable through use of multiyear contracting should also be explored.

The purpose of P&D is to produce items for the warfighter that will achieve operational capability and satisfy mission needs. In order to achieve those goals, the items being produced must have achieved design stability, had their technologies matured and their manufacturing processes must be capable, stable and under control. There are essentially two related production efforts during the PD phase: LRIP and FRP. LRIP is often identified as up to 10% of the estimated production volume.

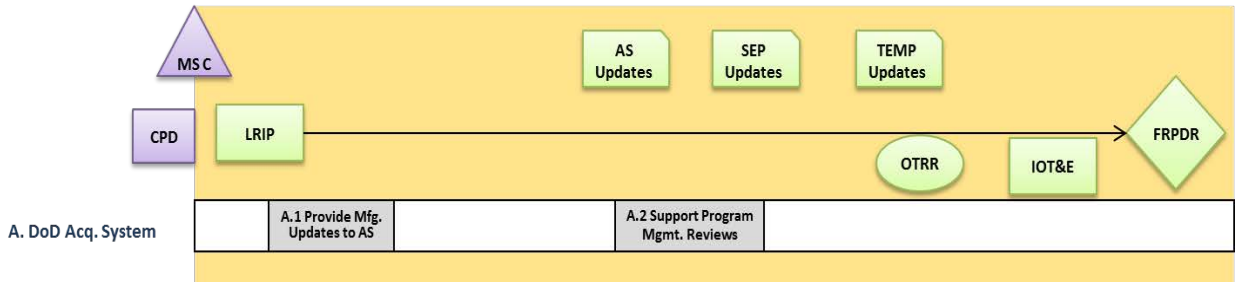
LRIP typically demonstrates the production of articles beyond a pilot line environment. These items are typically built in a pilot line environment. All systems engineering/design requirements should have been met such that there are minimal system changes. Major system design features are stable and have been proven in test and evaluation. Materials are available to meet planned rate production schedules. Manufacturing process capability in a low-rate production environment is at an appropriate quality level to meet design key characteristic tolerances. Production risk monitoring is ongoing. LRIP cost targets have been met, and learning curves have been analyzed with actual data. The cost model has been developed for the FRP environment and reflects the impact of continuous improvement.

P&D phase objectives include all of the following:

- The production of authorized quantities; on time and within budget.
- To conduct technical reviews:
- Integrated baseline review
- Operational test readiness review
- Physical configuration audit
- To create the following documents:
- Acquisition baseline
- Capability Production Document
- Systems Engineering Plan (SEP)

- Test and Evaluation Master Plan (TEMP)
- Programmatic Environmental, Safety and Occupational Health Evaluation (PESHE)Product support elements
- To achieve LRIP
- To achieve FRP
- To refine logistics support plans
- Important Manufacturing Considerations include:
- Complete initial production facilities
- Execute the manufacturing program
- Integrate spares production
- Maintain P
- production surveillance
- Provide and support proposal efforts
- Accomplish Value Engineering
- Support technical reviews
- Accomplish second sourcing/component breakout
- Complete Industrial Preparedness Planning
- Plan for the system transition/deployment/support
- Develop inputs to key documents

A. DEPARTMENT OF DEFENSE (DOD) ACQUISITION SYSTEM



The Milestone C Decision will generally be either an LRIP or Limited Deployment and Operational Test decision followed by an FRP or Full Deployment Decision (FDD). The initial production decision, based primarily on developmental testing results and usually also informed by an operational assessment, commits the resources (i.e., authorizes proceeding to award the contract(s)) required to enter production and begin deployment of the product. Evidence from testing that the product design is stable is the critical consideration for this decision. The commitment to enter production is very expensive and difficult to reverse.

Acquisition Strategy (AS)

At the end of the EMD, all of the information necessary to plan the detailed manufacturing operations for the system should have been available. This information should be described in a

manufacturing plan covering the issues of manufacturing organization, make or buy planning, subcontract management, resources and manufacturing capability, and the detailed fabrication and assembly planning. The plan should also describe the types of GFP required and the specific need dates for it. The contractor management control systems, including those for configuration management, the control of subcontractors and manufacturing performance evaluation should be described in sufficient detail for the program management office to determine their expected utility. The plan developed should also include consideration of the potential requirements for industrial preparedness planning, including surge capability during the production phase and the post production phase requirements for support to employment of the system in combat situations. The development of this formal manufacturing plan contributes value to the program from two standpoints. The primary benefit accrues from the fact that the contractor has to crystallize the manufacturing planning to a point where it can be described in the detail required. The secondary benefit is the usability the plan provides to the program management office personnel. It serves as a basis for a structured review of the contractor approach, the expected cost of the production phase effort, and a fuller assessment of manufacturing risk. Where such a plan is not developed during the EMD Phase there is often unnecessarily high cost and schedule turbulence at the front end of and indeed throughout the production phase. Also, if there is no detailed plan in place there can be no effective Program Office monitoring, assessing, scheduling review, testing, etc. In effect there is no production program.

Program Management Reviews

Sources of data used to inform industrial and manufacturing readiness include: technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

A.1 Provide All Manufacturing Updates to Acquisition Strategy

Manufacturing and Quality Tasks

- Validate production quantities per year and the total planned production quantity.
- Finalize and validate the Production Plan.
- Ensure manufacturing risk assessments, configuration audits, production schedule reviews and production deliveries and events (including long lead, and multiple suppliers) are on the Program Schedule.
- Ensure all industrial base and any manufacturing/production risks and mitigation efforts are scheduled, funded and actively worked.
- Ensure specific breakout efforts for each major component or sub-system are being worked.
- Ensure the Manufacturing/Quality Organization or Lead is being effectively utilized.
- Validate all remaining or developing IB constraints, how they are being managed, and the plan and schedule for future assessments.

- Estimate any risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule.
- Validate the Manufacturing Management System and the Quality Management Systems being used in production and ensure they are minimizing cost, schedule, and performance risks throughout the product life cycle.
- Validate the make-or-buy approach and maintain access to competitive suppliers.
- Maintain and keep current a list of critical items and their sources.
- Ensure/verify all manufacturing processes have been effectively demonstrated in a manufacturing environment appropriate to the type of production that this program requires.
    - The manufacturing environment should incorporate all of the key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in rate production
    - To the maximum extent practical, the environment should utilize the same rate manufacturing processes scheduled to be used in production
    - The Acquisition Strategy should thoroughly describe the production phase planning to assess and demonstrate that the manufacturing processes/capabilities required for production have been matured to a high enough level of confidence to ensure producing production configuration products in the production phase
- Ensure the Milestone C Acquisition Strategy reflects planned efforts that results in completion of manufacturing development and demonstrates:
    - No significant manufacturing risks
    - All manufacturing processes are under control
    - An approved Capability Production Document (CPD)
    - Adequate and efficient manufacturing capability
    - Produces the minimum quantity necessary to provide production or production-representative articles for Initial Operational Test and Evaluation (IOT&E)
    - Establishes an initial production baseline for the system
    - Provides for an orderly increase in the production rate for the system
    - Permits the collection of statistical process control data
- Ensure the Acquisition Strategy addresses the approach to making production rate and quantity changes in response to contingency needs. Consider these items in developing the strategy:
    - Technology and Industrial Base, including small business
    - Design
    - Cost and Funding
    - Materials
    - Process Capability and Control
    - Quality Management
    - Manufacturing Personnel

- Facilities
- Manufacturing Management

Metrics

- Have scheduled production quantities per year and the total planned production quantity been validated? Have these quantities been approved by all effected parties such as Testing, Contracting, Engineering, Manufacturing Planning, Subcontract Management, etc.?
- Has the Production Plan been finalized and validated?
- Have you ensured that all manufacturing risk assessments, configuration audits, production schedule reviews and production deliveries and events (including long lead, and multiple suppliers) are on the Program Schedule?
- Have you ensured that all industrial base and all remaining manufacturing/production risks and mitigation efforts are scheduled, funded and are being actively worked?
- Have you ensured there are specific breakout efforts for each major component or sub-system are being worked?
- Have you ensured the Manufacturing/Quality Organization or Lead is an active member of your team and are being effectively utilized?
- Have you validated all remaining or developing IB constraints, how they are being managed, and the plan and schedule for future assessments?
- Have you ensured all estimates of the risk of industry being unable to provide program design or manufacturing capabilities at your planned cost and schedule?
- Have you validated that the Manufacturing Management System and the Quality Management Systems being used during production and ensured they are minimizing cost, schedule, and performance risks throughout the product life cycle?
- Have you validated the make-or-buy approach and are you maintaining access to competitive suppliers?
- Do you maintain and keep a current list of critical items and their sources?
- Have you ensured/verified that all manufacturing processes have been effectively demonstrated in a manufacturing environment appropriate to the type of production that this program requires?
    - During Production the manufacturing environment should incorporate all of the key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in rate production
    - To the maximum extent practical, the LRIP environment should utilize the same rate manufacturing processes scheduled to be used in production
    - The Acquisition Strategy should thoroughly describe the production phase planning to assess and demonstrate that the manufacturing processes/capabilities required for production have been matured to a high enough level of confidence to ensure producing production configuration products in the production phase

- Have you ensured the Milestone C Acquisition Strategy reflects planned efforts that results in completion of manufacturing development and demonstrates:
    - No significant manufacturing risks
    - All manufacturing processes are under control;
    - An approved Capability Production Document;
    - Adequate and efficient manufacturing capability;
    - Produces the minimum quantity necessary to provide production or production-representative articles for IOT&E;
    - Establishes an initial production base for the system;
    - Provides for an orderly increase in the production rate for the system;
    - Permits the collection of statistical process control data?
- Have you ensured the Acquisition Strategy addresses an adequate approach to making production rate and quantity changes in response to contingency needs?
- Have you considered these items in developing the strategy:
    - Technology and Industrial Base, including small business,
    - Design,
    - Cost and Funding,
    - Materials,
    - Process Capability and Control,
    - Quality Management,
    - Manufacturing Personnel,
    - Facilities,
    - Manufacturing Management?

Tools

- Acquisition Strategy Outline
- Integrated Master Plan/Integrated Master Schedule: Use MicroSoft Project Risk Management Plan Template; SEP Outline
- SEP Outline
    - Manufacturing Plan
    - Quality Assurance Plan
- Test and Evaluation Master Plan Outline
- Life Cycle Sustainment Plan Outline
- AS6500 Manufacturing Management System Checklist
- AS9100 Quality Management System Checklist
- ISO 9001 Quality Management System Checklist
- Manufacturing Readiness Level (MRL) Assessment Checklist
- Technology Readiness Level (TRL) Assessment Checklist

- Industrial Base Assessment Survey Form Defense Contract management Agency (DCMA) Industrial Analysis Center

Resources

- Acquisition Strategy Guide, DSMC, Dec 1999
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- SEP Outline, Apr 2011
- IEEE15288, System and Software Engineering, 2015
- Test and Evaluation Management Guide, Dec 2012
- Life Cycle Sustainment Plan Content Guide
- DoDI 5000.02, Enclosure 2, 6.d., Jan 2017
- AS6500 Manufacturing Management Program
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 Quality Systems – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- MRL Deskbook Version 2016
- Risk, Issue and Opportunity Management Guide, Jun 2015
- TRA Deskbook, Apr 2012
- DoDI 4200.15, Manufacturing Technology (ManTech) Program, Dec 2003
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities, Apr 1996

A.2 Support Program Management Reviews

Sources of data used to inform industrial and manufacturing readiness include: technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

Manufacturing and Quality Tasks

- Identify any actual or potential quality, and/or manufacturing producibility risks associated with the proposed design during any review.
- Recommend mitigation plans for all quality and manufacturing risks identified during any review.
- Analyze all proposed design documentation submitted in support of reviews by applying design for manufacture and design for assembly principles to identify potential producibility risks associated with the proposed design change.
- In Production your key manufacturing readiness considerations include:
    - Industrial base viability,
    - Design stability,

- Change Control
- Manufacturing process maturity,
- Supply chain management,
- Quality management,
- Facilities, and
- Manufacturing skills availability.

- Other sources of industrial and manufacturing readiness data include:
  - Technical reviews and audits,
  - Program Status Reviews,
  - Pre-award surveys,
  - Production Readiness Reviews,
  - Industrial Capabilities Assessments,
  - Trade-off studies,
  - Tooling plans,
  - Make-or-buy plans,
  - Manufacturing plans, and
  - Bills of material.
  - An important output includes actions to reduce or address any remaining risks.

Metrics

- Have you identified any actual or potential quality, and/or manufacturing producibility risks associated with the proposed design during any review?
- Have you any recommend mitigation plans for any quality and/or manufacturing risks that you identified during any review?
- Have you analyzed all proposed design documentation submitted in support of reviews by applying design for manufacture and design for assembly principles to identify potential producibility risks associated with the proposed design change?
- Have you considered these key manufacturing readiness considerations during Production:
  - Industrial base viability,
  - Design stability,
  - Change Control
  - Manufacturing process maturity,
  - Supply chain management,
  - Quality management,
  - Facilities, and
  - Manufacturing skills availability?

- Have you considered these other sources of industrial and manufacturing readiness data during Production:
  - Technical reviews and audits,
  - Program Status Reviews,

- Pre-award surveys,
- Production Readiness Reviews,
- Industrial Capabilities Assessments,
- Trade-off studies,
- Tooling plans,
- Make-or-buy plans,
- Manufacturing plans, and
- Bills of material?

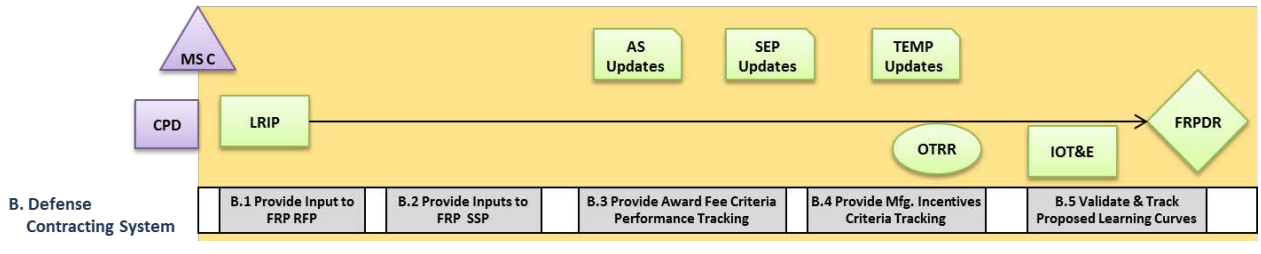
Tools

- Operational Test Readiness Review Checklist
- Production Readiness Review (PRR) Checklist (FRP Decision)
- Manufacturing Readiness Assessment (MRA) Checklist
- Technology Readiness Assessment (TRA) Checklist
- Industrial Base Capability Assessment

Resources

- Test and Evaluation Management Guide, Dec 2012
- AS6500 Manufacturing Management Program
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100 Quality Systems – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- MRL Deskbook Version 2016
- TRA Deskbook, Apr 2012
- Risk, Issue and Opportunity Management Guide, Jun 2015
- IEEE 15288.2, IEEE Standard for Technical Reviews and Audits on Defense Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.7.4 Technical Reviews, and Chapter 12.5 Technical Reviews and Audits
- DODI 5000.60H Defense Industrial Capabilities Assessments

B. DEFENSE CONTRACTING SYSTEM



Specific requirements must be identified for inclusion in the Request for Proposal (RFP)/statement of work for the production phase. The particular requirements reflect the areas that have been

determined to be of importance, given the acquisition strategy of the program. Typical areas to be considered for inclusion are:

- Manufacturing management systems,
- Work measurement,
- Manufacturing data (including manufacturing plan updates),
- Initial production facilities,
- Production and material control systems,
- Manufacturing reporting systems (especially line of balance),
- Control of subcontractors and vendor,
- Make or Buy program,
- Government Furnished Property,
- System audit,
- Technical data, and
- Competition.

B.1. Provide Input to Request for Proposal Full-Rate Production (RFP) (FRP)

(Provide topics, request data, etc. to the following proposal responses that you would expect the contractor to include in their proposals.)

Manufacturing and Quality Tasks

- The following RFP planning data topics should have significant Manufacturing, Industrial Base and Quality inputs.
    - Manufacturing Management Plan.
    - Quality Assurance Management Plan.
    - Producibility Engineering Plan.
    - Manufacturing and Producibility Trade Studies.
    - Manufacturing Technology Investments.
    - Award Fee/Incentive Fee Criteria.
    - Make/Buy Plan.
    - Technical Reviews (MRAs/PRR).
    - Material Availability/Long Lead Procurement Analysis.
    - Technical Data/Manufacturing Data.
    - Process Capability Study.
    - Work Measurement/Learning Curve Analysis.
    - Manufacturing Reporting and Control Systems.
    - Contractor maintained cost data/libraries associated with manufacturing processes and technologies.
    - Contractor maintained Cost of Quality data available.

Metrics

- Have you provided significant Manufacturing, Industrial Base and Quality inputs to these RFP planning data topics?
    - Manufacturing Management Plan.
    - Quality Assurance Management Plan.
    - Producibility Engineering Plan.
    - Manufacturing and Producibility Trade Studies.
    - Manufacturing Technology Investments.
    - Award Fee/Incentive Fee Criteria.
    - Make/Buy Plan.
    - Technical Reviews (MRAs/PRR).
    - Material Availability/Long Lead Procurement Analysis.
    - Technical Data/Manufacturing Data.
    - Process Capability Study.
    - Work Measurement/Learning Curve Analysis.
    - Manufacturing Reporting and Control Systems.
    - Contractor maintained cost data/libraries associated with manufacturing processes and technologies.
    - Contractor maintained Cost of Quality data available.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist, Sep 2016
- ISO 9001, Quality Management System Checklist, Sep 2016
- IEEE 15288, System and Software Engineering, 2015
- IG5315.204-5(b) Section L Guide and Template
- IG5315.204-5(c) Section M Guide and Template

Resources

- AS6500, Manufacturing Management System
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100, Quality Management System, Sep 2016
- ISO9000, Quality Management System, Sep 2016
- IEEE 15288, System and Software Engineering, 2015
- IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- MRL Deskbook Version 2016

B.2. Provide Inputs to Source Selection Plan (SSP) for Full-Rate Production

Capability reviews such as manufacturing capability reviews are a useful tool available during source selections to assess the offerors' capability in selected critical process areas. Capability reviews may be the appropriate means for evaluating program-specific critical processes such as systems engineering, software development, configuration management, etc. The reviews would be useful to supplement process past performance data to ascertain the risks in selecting a given offeror and to assist in establishing the level of government oversight needed to manage the process-associated risks if that offeror is awarded the contract. The trade-off in determining whether or not to do a capability review would be the criticality of the process versus the time and resources to do the review versus the availability, adequacy, and currency of an offeror's process past performance data.

Manufacturing and Quality Tasks

- The following are some of the Manufacturing/Industrial Base/Quality inputs that should be included in a Production Source Selections Plan (SSP). However these are just some of the more universal inputs. Each program should spend significant time in identifying the appropriate inputs for their particular program.
    - Manufacturing Readiness.
    - Investments in advanced manufacturing technology production equipment, processes, and organization of work systems that build on workers' skill and experience, and work force skill development.
    - Tooling, special tooling, special test equipment.
    - Material handling, management, availability.
    - Production capability and efficiency.
    - Quality Management.
    - Subcontractor Management.

Metrics

- Have you made Manufacturing/Industrial Base/Quality inputs in your Production SSP? While these are just some of the more universal inputs. You should spend significant time in identifying the appropriate inputs for your program.
    - Have you made "Manufacturing Readiness" a topic in the SSP?
    - Have you asked the contractor to address "Investments in advanced manufacturing technology production equipment, processes, and organization of work systems that build on workers' skill and experience, and work force skill development" in their response to your RFP?
    - Have you made "tooling, special tooling, special test equipment" a topic the contractor must address in their response to your RFP?
    - Have you made "material handling, management and availability" a topic in your SSP input?
    - Have you made "production capability and efficiency" a topic in your SSP input?

- Have you made "Quality Management" a topic in your SSP input?
- Have you made "Subcontractor Management" a topic in your SSP input

Tools

- Source Selection Plan Template, (see applicable service document)
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- IEEE 15288, System and Software Engineering

Resources

- DoD Source Selection Procedures Memo, Apr 2016
- DoD Source Selection Procedures, Mar 2016
- MIL-HDBK 2450, DoD Handbook for Preparation of Statement of Work, 1996
- Source Selection Plan Guide, Apr 2017
- AS6500, Manufacturing Management System
- AS9100, Quality Management System, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- ISO 9001, Quality Management System
- IEEE 15288, System and Software Engineering, 2015
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- MIL-STD-882, DoD System Safety, May 2012

B.3. Provide Award Fee Criteria Performance Tracking

Contracts should produce measurable performance outcomes that cumulatively contribute to the system Key Performance Parameters (KPP)/Key Systems Attributes (KSAs), to their threshold or objective levels. To motivate the contractor to achieve the desired behavior, appropriate contract incentives (including award fee, incentive fee, award term, and cost sharing) need to be developed to promote and facilitate contractor performance.

Manufacturing and Quality Tasks

- The following lists some of the performance tracking measures that could be used on most production programs. Not all are appropriate to every program and too many on any program can lead to micro management of a program and lower effectiveness and efficiency. However, having some on any program are critical.
  - Producibility packages released (#/%).
  - Materials characterized in production representative environment (#/%).
  - Manufacturing Cost Reduction Efforts.

- Manufacturing Maturation Plan Risks Burned Down.
- Variation/Variability Reduction efforts (initial yield rates/downward trend).
- Manufacturing Processes defined and characterized.
- Quality metric targets (such as SRR reductions).
- Schedule performance.

Metrics

- Have you ensured that the appropriate measures are included on your program?
  - Are you tracking your Producibility Packages released (#/%) against the anticipated total?
  - Are you tracking your Materials Characterized in production representative environment (#/%) against the anticipated total?
  - Are you tracking your Manufacturing Cost Reduction Efforts?
  - Are you tracking your Manufacturing Maturation Plan Risks burned down?
  - Are you tracking your Variation/Variability Reduction Efforts (Initial Yield Rates/Downward Trend)?
  - Are you tracking your Manufacturing Processes Defined and Characterized against the anticipated total?
  - Are you tracking your Quality metric targets (such as SRR reductions) against the anticipated total?
  - Are you tracking your Schedule performance?

Tools

- Award Fee Template, (see applicable service templates)

Resources

- Air Force Award Fee Guide, Oct 2008 (Army and Navy guides available)
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)
- AS6500, Manufacturing Management System
- ISO 9001, Quality Management System, Sep 2016
- MRL Deskbook Version 2016

B.4. Provide Manufacturing Incentives Criteria Tracking

Manufacturing and Quality Tasks

- The following lists some of the manufacturing incentives tracking measures that could be used on most production programs. Not all are appropriate to every program and too many on any program can lead to micro management of a program and lower effectiveness and efficiency. However, having some on any program are critical.

- Organize for/incorporate quality and producibility.
- Develop producibility infrastructure (software tools, training, design guides).
- Investments in modern manufacturing methods and equipment (hardware and software).
- Production cost reductions.
- Quality Improvement goals.

Metrics

- Have you included manufacturing incentives tracking measures on your program? Not all are appropriate to every program and too many on any program can lead to micro management of a program and lower effectiveness and efficiency. However, having some on any program are critical.
  - Have you organized your program for and quality and incorporated producibility?
  - Have you developed producibility infrastructure (software tools, training, design guides) for your program?
  - Have you made investments in modern manufacturing methods and equipment (hardware and software) in your program?
  - Have you incorporated production cost reductions in your program?
  - Have you developed and are you tracking Quality Improvement goals in your program?

Tools

- Award/Incentive Fee Plan

Resources

- Federal Acquisition Regulation (FAR) Subpart 16.4 Incentive Contracts
- DoD/NASA Incentive Contracting Guide
- Award Fee Guide (see service specific guides)
- Society of Automotive Engineers (SAE) AS6500, Manufacturing Management System
- International Organization for Standardization (ISO) 9001, Quality Management System, Sep 2016
- MRL Deskbook Version 2016

B.5. Validate and track proposed Learning Curves

Cost Reduction Initiatives (CRIs) should be formally documented and the documentation must include the baseline ("before" implementation) costs and "after" costs, as well as the nonrecurring costs to implement the initiative.

It is often difficult to distinguish initiatives that are "over and above" the historical learning curves that were already used to estimate the program costs. Historical learning curves usually include some amount of cost reduction initiatives, so the challenge in documenting and estimating the impacts of new CRIs is to determine if they are truly over and above what has been done in the past. Generally,

initiatives that reduce the scope of work can be considered over and above, but ones that improve the efficiency of the work must be more carefully evaluated.

Manufacturing and Quality Tasks

- Significant effort must be initiated determining what should be an appropriate learning curve for the program. The large dollar amounts that go into the production effort for a relatively short period of time make the learning curve an important aspect of any cost reduction effort. Any changes to processes or design or materials at this stage will significantly impact the overall program cost by negating the previous process learning and lowering the curve. To be effective the learning curve must first establish expected cost and time then using the scheduled effort how much each item or lot should cost and how much less each successive item should cost. Without this base lining an effective and accurate learning curve is not possible.
- Establish the learning curve based on appropriate factors such as:
    - Worker learning
    - Supervisor learning
    - Reductions in crowded workstations
    - Tooling improvements
    - Design producibility improvements
    - Improved work methods
    - Improved planning and scheduling
    - Increased lot sizes
    - Reduced engineering change activity
    - Reduction in scrap and rework
    - Better operation sequencing and synchronizations
- Using previous cost models and actuals establish the expected cost of the first items.
- Using the learning curve formula establish how much cost reduction is possible using expected schedule, production amounts, and process times.
- Apply the curve against the program schedule and determine the expected cost reductions.

Metrics

- Based on the above factors:
    - Are your processes stable?
    - Are your materials stable?
    - Is your schedule stable?
    - Can you determine an appropriate learning curve and base line?

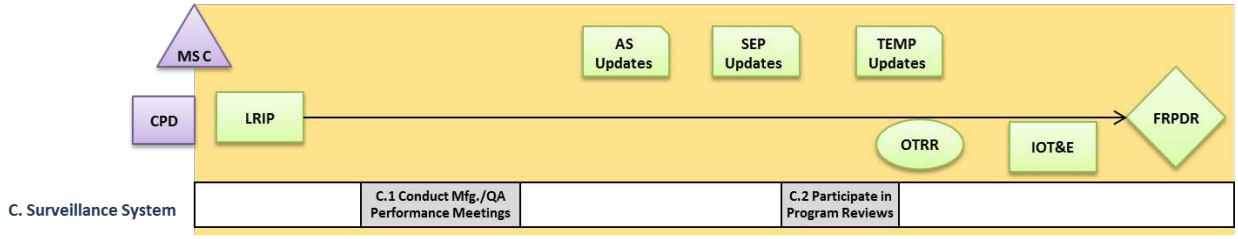
Tools

- Learning Curve Estimator
- Manufacturing Cost Estimating Worksheet

Resources

- IEEE 15288.2, System and Software Engineering, 2015
- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8 Learning Curve
- Learning Curve Methodology for Cost Analysis, Oct 1967

C. SURVEILLANCE SYSTEM



C.1. Conduct Manufacturing/Quality Assurance (QA) Performance Meetings

Compliance to a standard such as ISO 9001 or AS9100, does not, in itself, guarantee product or service quality. These standards are management system standards that identify requirements for processes within an organization, describe expected tasks and outcomes, and explain how the processes and tasks integrate to produce required inputs and outputs. Standards are meant to enable the organization to develop a set of processes that, if done by qualified persons using appropriate tools and methods with appropriate leadership involvement, will enable a capability for delivering high quality products or services.

Product or service quality is achieved through the implementation of a strategic plan to integrate all business and technical functions that result in the consistent application of proven, capable processes within an organization. Managers must ensure that all management systems are working toward the same goals and are not creating conflicting or dysfunctional behavior. Implementing a standard is of little use if the financial system rewards individuals for delivering non-conforming products/services. Because everything a contractor does should be related to the quality of its products or services, a contractor's quality management system should be the basis for integrating all other management systems within an enterprise.

Manufacturing and Quality Tasks

Include quality management as a selection factor and look for the following elements of a quality management system in proposals:

- Effective policies and procedures that encourage the use of the quality system;
- Organizations with defined authorities and responsibilities;

- Objectives to drive people, processes, and the system;
- Method to analyze and resolve quality problems;
- Metrics that reflect desired outcomes;
- Interacting processes to transform inputs into outputs; and
- Records as evidence of what happened.

Evaluate Manufacturing and Quality Impacts of Factors such as:

- Technical Performance
- Production Performance
- Quality Assurance
- *Finance
- *Accounting
- Government Property Control
- Transportation and Packaging
- *Security
- Plant Safety
- Environmental/Energy Compliance
- *Flight Operations/Safety

*Other functional areas should be included in reviews. It is important to understand how these non-manufacturing areas can and will impact the manufacturing function.

Metrics

Have you used quality management as a proposal selection factor and did you find the following elements of a quality management system in the proposals you evaluated?

- Effective policies and procedures that encouraged the use of the quality system;
- Evidence that organizations have defined authorities and responsibilities for quality;
- Written quality objectives and goals to drive people, processes, and the quality system;
- Did you find evidence of methods to be used to analyze and resolve quality problems;
- Established detailed metrics that reflect desired program outcomes;
- Are there interacting processes that will transform inputs into outputs; and
- Are there records that are maintained that establish evidence of what happened.

You should evaluate impact of the following factors on Manufacturing and Quality:

- Technical Performance
- Production Performance
- Quality Assurance
- *Finance
- *Accounting
- Government Property Control
- Transportation and Packaging

- *Security
- Plant Safety
- Environmental/Energy Compliance
- *Flight Operations/Safety

*While all of these are not Manufacturing and Quality factors they can each have a severe impact.

Tools

- DCMA Program Assessment Report

Resources

- DCMA-INST-204 Manufacturing and Production
- DCMA--INST-205, Major Program Support
- DCMA--INST-207, Engineering Surveillance
- DCMA--INST-219, SCM Risk Management
- DCMA--INST-309, Government QA Surveillance Planning
- DCMA--INST-401, Industrial Analysis
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System, 2015
- ISO9001, Quality Management System, 2015
- IEEE 15288.2, Systems and Software Engineering, 2015
- DD 1423, Contract Data Requirements List

C.2. Participate in Program Reviews

The Program Support Assessment (PSA)is conducted to provide insight into current and future program execution through detailed analysis using the "Defense Acquisition Program Support (DAPS) Methodology." OSD system assessment teams apply the DAPS methodology to Major Defense Acquisition Programs (MDAPs) approaching a Defense Acquisition Board (DAB) review. DAPS, however, is also a powerful self-assessment tool for the program manager to use for technical evaluation of a program's systems engineering process details and health.

The DAPS methodology addresses the systems engineering policies set forth by the Defense Acquisition Executive. These policies foster effective systems engineering practices on all programs, helping the program manager attain success in the acquisition and support life cycle. The thorough application of the DAPS methodology can contribute to improved balance of cost, schedule, performance, and risk.

The DAPS Methodology is a guidebook for conducting PSRs that will assist program managers prepare for Milestone A, B, and C decision reviews. It contains a listing of programmatic and

technical areas, sub-areas, and factors, developed to be both broad in scope, as well as specific (detailed) enough to enable application to programs of all types. The DAPS methodology was constructed from numerous documents in the Defense acquisition community, and exploits the expert knowledge of "greybeard" human resources with years of acquisition experience in both government and industry. Sources include the Software Engineering Institute's Capability Maturity Model and Capability Maturity Model Integration, NAVAIR Systems Engineering Technical Resources Handbook, Air Force assessment guidance, Manufacturing Best Practices/Willoughby Templates, OSD Acquisition guidelines and policies, and many subject matter experts from across the DoD community.

Manufacturing and Quality Tasks

- Conduct Production Program Assessments:
    - Technical Performance
    - Production Performance
    - Quality Assurance
    - *Finance
    - *Accounting
    - Government Property Control
    - Transportation and Packaging
    - *Security
    - Plant Safety
    - Environmental/Energy Compliance
    - *Flight Operations/Safety

    *Other functional areas should be included in the reviews. It is important to understand how these non-manufacturing areas can and will impact the manufacturing function.
- Identify, capture, and address any manufacturing concerns identified during testing.

Metrics

Are Manufacturing and Quality personnel participating in the appropriate System Engineering Technical Reviews and Program Management Reviews?. . There are many other reviews that can also be used to get an understanding of how the program is progressing. While your immediate concern is the Manufacturing and Quality area, your insight may provide other technical experts with a valuable perspective and bring out other program aspects that may not be readily visible.

Ensure technical experts in the following areas are available to support your reviews:

- Technical Performance
- Production Performance
- Quality Assurance
- *Finance

- *Accounting
- Government Property Control
- Transportation and Packaging
- *Security
- Plant Safety
- Environmental/Energy Compliance
- *Flight Operations/Safety

Have you identified, captured, and addressed all manufacturing concerns identified during testing?

These issues are of paramount concern at this time. They will frequently lead to design changes to "fix" the problem in production. These are some of the most critical cost and schedule breakers you will have to deal with.

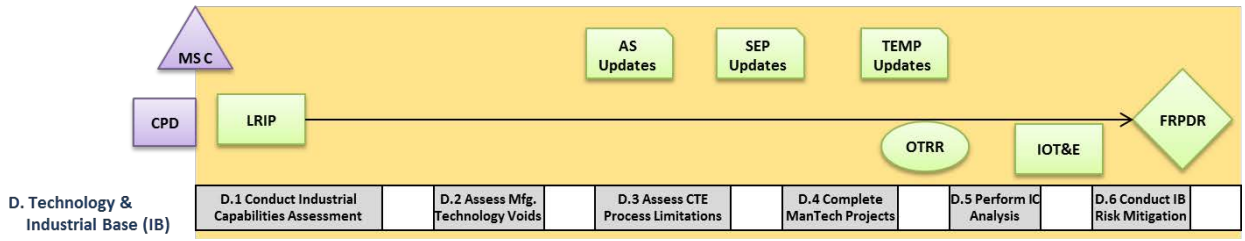
Tools

- DCMA Program Assessment Report

Resources

- DCMA-INST-204 Manufacturing and Production
- DCMA--INST-205, Major Program Support
- DCMA--INST-207, Engineering Surveillance
- DCMA--INST-219, SCM Risk Management
- DCMA--INST-309, Government QA Surveillance Planning
- DCMA--INST-401, Industrial Analysis

D. TECHNOLOGY AND INDUSTRIAL BASE



The EMD Acquisition Strategy should have highlighted the strategy for assessing the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a pilot line environment, prior to Milestone C. The manufacturing environment should incorporate key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in low-rate production. To the maximum extent practical, the environment should utilize rate production processes using production processes forecasted to be used in LRIP.

The Acquisition Strategy should strategically describe the EMD phase planning to assess and demonstrate that the manufacturing processes/capabilities, required for production will have been matured to a level of high confidence for building production configuration products in the P&D phase.

For Milestone C, key manufacturing readiness considerations include:

- industrial base viability
- design stability
- process maturity
- supply chain management
- quality management
- facilities
- manufacturing skills availability

The development of the Acquisition Strategy should include results of industrial base capability (public and private) analysis to design, develop, produce, support, and, if appropriate, restart an acquisition program. This includes assessing manufacturing readiness and effective integration of industrial capability considerations into the acquisition process and acquisition programs ensuring the sufficient maturity before production begins. For applicable products, the Acquisition Strategy should also address the approach to making production rate and quantity changes in response to contingency needs.

Consider these items in developing the strategy:

- Technology and Industrial Base, including small business
- Design
- Cost and Funding
- Materials
- Process Capability and Control
- Quality Management
- Manufacturing Personnel
- Facilities
- Manufacturing Management

Sources of data to inform industrial and manufacturing readiness could include; technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

The Milestone C Acquisition Strategy should provide the status of the assessments of the manufacturing processes highlight needed steps to progress from an EMD manufacturing environment to an LRIP environment.

For the FRP Decision Review Acquisition Strategy update, the Program should identify remaining risks prior to a production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or handle remaining risks.

D.1. Industrial Capabilities (IC) Assessment

The program office should assess the impact of programmatic decisions on the national and international NTIB supporting U.S. defense to satisfy the requirements of 10 USC 2440 and DFAR Subpart 207.1.

Manufacturing and Quality Tasks

Overall Industrial Capabilities Assessments (ICAs) should address critical sub-tier, as well as prime contractor capabilities and should include:

- New and unique capabilities that must be developed or used to meet program needs;
- Identifying DOD investments needed to create new or enhance existing industrial capabilities. This includes any new capability (e.g. skills, facilities, equipment, etc.);
- Identifying new manufacturing processes or tooling required for new technology.
- Funding profiles must provide for up front development of manufacturing processes/tooling and verification that new components can be produced at production rates and target unit costs;
- Identifying exceptions to FAR Part 45, which requires contractors to provide all property (equipment, etc.) necessary to perform the contract;
- Program context in overall prime system and major subsystem level industry sector and market;
- Strategies to address any suppliers considered to be vulnerable;
- Risks of industry being unable to provide new program performance capabilities at planned cost and schedule;
- Alterations in program requirements or acquisition procedures that would allow increased use of non-developmental or commercial capabilities;
- Strategies to deal with product or component obsolescence, given DOD planned acquisition schedule and product life;
- Strategies to address reliability issues (i.e. , tampering, potential interrupted delivery from non-trusted sources, etc.) associated with commercial components for sensitive applications; and

- Strategies to utilize small business, including small disadvantaged business, women- owned small business, veteran-owned small business, service-disabled veteran-owned small business and small businesses located in Historically Underutilized Business Zones.
- Industrial Capability Assessment has been completed and all issues mitigated.
- Industrial capability is in place to support LRIP.
- Industrial capability will be in place to support Production.
- Assess the labor/facility availability by understanding labor contracts and facility leases for the production schedule.
- Industrial capability to support LRIP/Production has been analyzed. Sole/single/foreign sources stability is being assessed/monitored.
- Conduct Logistics analysis.
    - Investigate manufacturing, re-manufacturing, and overhaul opportunities which have high potential impact for reducing life cycle costs and depot operations.
- Assess the impact of programmatic decisions on the national and international technology and industrial base. Overall Industrial Capabilities Assessments (ICAs) should address critical sub-tier, as well as prime contractor capabilities and should include:
    - new and unique capabilities that must be developed or used to meet program needs
    - identify DoD investments needed to create new or enhance existing industrial capabilities. This includes any new capability (e.g. skills, facilities, equipment).
    - identify new manufacturing processes or tooling required for new technology.
    - funding profiles must provide for up front development of manufacturing processes/tooling and verification that new components can be produced at production rates and target unit costs.
- Assess the overall prime system and major subsystem level industry sector and market strategies to address any suppliers considered to be vulnerable
- Assess risks of industry being unable to provide new program performance capabilities at planned cost and schedule
- Assess alterations in program requirements or acquisition procedures that would allow increased use of non-developmental or commercial capabilities
- Assess strategies to deal with product or component obsolescence, given DoD planned acquisition schedule and product life

Metrics

In your overall Industrial Capabilities Assessments (ICAs) have you addressed critical sub-tier, as well as prime contractor capabilities and did you verify that:

- All new and unique capabilities that must be developed or used to meet program needs will be available?
- Did you identify all DOD investments needed to create new or enhance existing industrial capabilities? This includes any new capability (e.g. skills, facilities, equipment, etc.).

- Did you identify all new manufacturing processes or tooling required for new technology?
- Have you ensured that funding profiles provide for up front development of manufacturing processes/tooling and verification that new components can be produced at production rates and target unit costs?
- Did you identify any exceptions to FAR Part 45, which require contractors to provide all property (equipment, etc.) necessary to perform the contract?
- Have you identified all program context in the overall prime system and major subsystem level industry sector and market?
- Have you identified any strategies to address any suppliers considered to be vulnerable?
- Have you identified any risks of industry being unable to provide new program performance capabilities at planned cost and schedule?
- Have you identified any alterations in program requirements or acquisition procedures that would allow increased use of non-developmental or commercial capabilities?
- Have you identified adequate strategies to deal with product or component obsolescence, given DOD planned acquisition schedule and product life?
- Have you identified adequate strategies to address reliability issues (i.e. , tampering, potential interrupted delivery from non-trusted sources, etc.) associated with commercial components for sensitive applications; and
- Have you identified any strategies to utilize small business, including small disadvantaged business, women- owned small business, veteran-owned small business, service-disabled veteran-owned small business and small businesses located in Historically Underutilized Business Zones?
- Has your Industrial Capability Assessment been completed and all issues mitigated?
- Have you verified that the required industrial capability is in place to support LRIP?
- Have you ensured that the required industrial capability will be in place to support Production?
- Have you assessed the labor/facility availability by understanding labor contracts and facility leases for the production schedule?
- Has the industrial capability to support LRIP/Production been analyzed?
- Are all sole/single/foreign sources stability issues being assessed/monitored?
- Have you conducted a thorough logistics analysis?
    - Have you investigated manufacturing, re-manufacturing, and overhaul opportunities which have high potential impact for reducing life cycle costs and depot operations?
- Have you assessed the impact of programmatic decisions on the national and international technology and industrial base?
- Have you ensured your Industrial Capabilities Assessments (ICAs) address critical sub-tier, as well as prime contractor capabilities and includes:
    - Any new and unique capabilities that must be developed or used to meet program needs?
    - Identity of all DoD investments needed to create new or enhance existing industrial capabilities?

- This includes any new capability (e.g. skills, facilities, equipment).
- Identity of all new manufacturing processes or tooling required for new technology?
- Planned funding profiles which provide for up front development of manufacturing processes/tooling and verification that new components can be produced at production rates and target unit costs?

- Have you assessed the overall prime system and major subsystem level industry sector and market strategies to address any suppliers considered to be vulnerable?
- Have you assessed risks of industry being unable to provide new program performance capabilities at planned cost and schedule?
- Have you assessed alterations in program requirements or acquisition procedures that would allow increased use of non-developmental or commercial capabilities?
- Have you assessed strategies to deal with product or component obsolescence, given DoD planned acquisition schedule and product life?

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- MRL Assessment Checklist for Technology and Industrial Base thread

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 2503, Analysis of the Technology and Industrial Base
- DoDI 5000.60H Defense Industrial Capabilities Assessments
- MRL Deskbook Version 2016

D.2. Manufacturing Technology Voids

The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing and transitioning advanced manufacturing technologies. The manufacturing feasibility assessment should identify high risk manufacturing process areas that may require investments in ManTech or other programs. These investments must be identified early so that these manufacturing capabilities will be matured on time to support rate production.

Manufacturing and Quality Tasks

- Ensure no new ManTech voids have surfaced.
- Evaluate ongoing ManTech efforts and determine if they can be applied to your program.

Metrics

- Have you ensured no new ManTech voids have surfaced?

- Have you evaluated ongoing ManTech efforts to determine if they can be applied to your program in time for Production?

Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- MRL Assessment Checklist for Technology and Industrial Base thread
- TRL Assessment Checklist

Resources

- Defense Production Act, Title III
- DoDD 4200.15, ManTech
- DoDI 5000.02
- MRL Deskbook Version 2016
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- Technology Readiness Assessment Guidance, Apr 2011
- Service ManTech guidance, e.g. Air Force Technology and Transition Strategy Guidebook, Nov 2010

D.3. CTE Process Limitations

If a platform or system depends on specific technologies to meet system operational threshold requirements in development, production, operation, and sustainment, and if the technology or its application is either new or novel, then that technology is considered a critical or enabling technology.

Manufacturing and Quality Tasks

These critical technology elements (CTEs) are evaluated to assess technology maturity.

- Ensure all CTE limitations have been identified and all CTE risks have associated mitigation efforts.

Metrics

- Have you ensured all CTE limitations have been identified and all CTE risks have associated mitigation efforts?

Tools

- Producibility Assessment Worksheet (PAWs)
- Technology Readiness Assessment
- TRL Calculator

- MRL Assessment Checklist for Technology and Industrial Base thread

Resources

- NAVSO P-3687Producibility Systems Guidelines, Dec 1999Technology Readiness Assessment Deskbook, Jul 2009
- Technology Readiness Assessment Guidance, Apr 2011
- DoDI 5000.02, 5d(4)(b)3. And 5d(4)(c)
- Defense Acquisition Program Support Methodology, Ver. 3.0
- MRL Deskbook Version 2016

D.4. ManTech Projects

The ManTech Program focuses on advancing state-of-the-art manufacturing technologies and processes from the research and development environment (laboratory) to the production and shop floor environment. Technologies with generic application required for defense systems and having high technical and financia1 risk characterize the projects with the highest priority for ManTech funding.

Manufacturing and Quality Tasks

ManTech projects demonstrate production application of emerging technologies.

- Ensure primary manufacturing technology efforts are concluding, and improvement efforts are continuing.
- Ensure required manufacturing technology development solutions have been demonstrated in LRIP.
- Validate required manufacturing technology solutions before the FRP decision.

Metrics

- Have you ensured all primary manufacturing technology efforts are concluding, and improvement efforts are continuing?
- Have you ensured all required manufacturing technology development solutions have been demonstrated in LRIP?
- Have you validated all required manufacturing technology solutions before the FRP decision?

Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- MRL Assessment Checklist for Technology and Industrial Base thread
- TRL Assessment Checklist

Resources

- Defense Production Act, Title III
- DoDD 4200.15, ManTech
- DoDI 5000.02
- MRL Deskbook Version 2016
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- Technology Readiness Assessment Guidance, Apr 2011
- Service ManTech guidance, e.g. Air Force Technology and Transition Strategy Guidebook, Nov 2010

D.5. IC Analysis

Industrial Base Assessments are conducted using a standardized questionnaire which they send out to companies of interest and they complete the survey. After the survey has been completed a small team visits the company to follow-up on the questions and to get a tour of the facilities.

Manufacturing and Quality Tasks

- The ICA questionnaire addresses some of the following IB considerations:
    - Suppliers name, location, etc.
    - Company Ownership (public or private)
    - Facility Size and other facility information
    - Sales and sales backlog
    - Distribution or Sales Mix (% government vs commercial)
    - DOD Programs Supported
    - Significance of Current Program to overall sales
    - Maturity of product technology
    - Production Status
- Industry Status (consolidations, rising or falling market, etc.)
- Unique or Critical Manufacturing Processes
- Technology Issues (Obsolescence, etc.)
- Vendor or Supply Chain issues
- Industrial Base Risks
- Production Rate
- Ensure all Industrial Capabilities risk has been identified and all IC risks have associated mitigation efforts.

Metrics

- Did the ICA addresses the following IB considerations?
    - Suppliers name, location, etc.
    - Company Ownership (public or private)

  - Facility Size and other facility information
  - Sales and sales backlog
  - Distribution or Sales Mix (% government vs commercial)
  - DOD Programs Supported
  - Significance of Current Program to overall sales
  - Maturity of product technology
  - Production Status

- Did the ICA address Industry Status (consolidations, rising or falling market, etc.)?
- Did the ICA address Unique or Critical Manufacturing Processes?
- Did the ICA address Technology Issues (Obsolescence, etc.)?
- Did the ICA address Vendor or Supply Chain issues?
- Did the ICA address Industrial Base Risks?
- Did the ICA address Production Rate?
- Have you insured all Industrial Capabilities risk have been identified and all IC risks have associated mitigation efforts?

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- MRL Assessment Checklist for Technology and Industrial Base thread

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 2503, Analysis of the Technology and Industrial Base
- DoDI 5000.60H Defense Industrial Capabilities Assessments
- MRL Deskbook Version 2016

D.6. IB Risk Mitigation

Manufacturing and Quality Tasks

- Develop potential alternate sources as necessary.
- Ensure needed sources are available, multi-sourcing where cost-effective or necessary to mitigate risk.
- Industrial capability available to support modifications, upgrades, surge and other potential manufacturing requirements.

Metrics

- Have you developed potential alternate sources as necessary?
- Have you ensured needed sources will be available, multi-sourcing where cost-effective or necessary to mitigate risk?

- Have you ensured sufficient industrial capability will be available to support modifications, upgrades, surge and other potential manufacturing requirements?

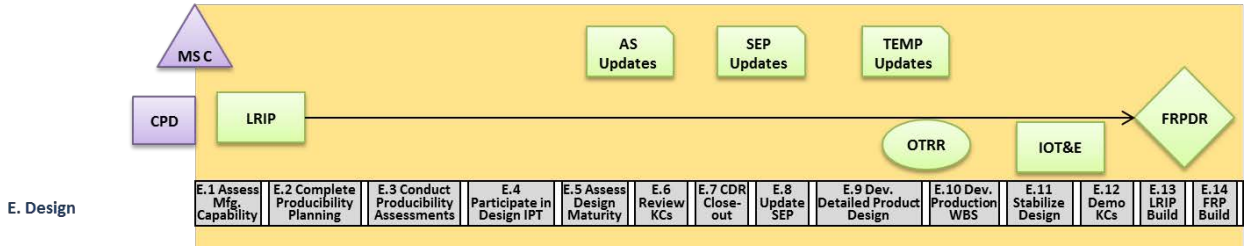
Tools

- Manufacturing/QA Risk Mitigation Plan (no Template available)

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions, Apr 1996
- MRL Deskbook Version 2016, Chapter 5.2 Development of a Manufacturing Maturation Plan

E. DESIGN



E.1. Manufacturing Capability

The development of the Acquisition Strategy should include results of industrial base capability (public and private) analysis to design, develop, produce, support, and, if appropriate, restart an acquisition program. This includes assessing manufacturing readiness and effective integration of industrial capability considerations into the acquisition process and acquisition programs. For applicable products, the Acquisition Strategy should also address the approach to making production rate and quantity changes in response to contingency needs. Consider these items in developing the strategy:

- Technology and Industrial Base, including small business,
- Design,
- Cost and Funding,
- Materials,
- Process Capability and Control,
- Quality Management,
- Manufacturing Personnel,
- Facilities, and
- Manufacturing Management.

Manufacturing and Quality Tasks

- Ensure the contractors' manufacturing capability covers:
  - All required manufacturing processes and techniques,
  - All design producibility risks.
  - Manufacturing capability has a high probability of meeting delivery dates.
  - Manufacturing capability provides for minimal impact of critical and long-lead time material.
  - Manufacturing capability ensures all production equipment will be available.
  - Manufacturing capability provides accurate production unit cost goals.
  - Capability includes cost and production schedule estimates updated with actuals to support management reviews.
  - All alternatives have adequate manufacturing feasibility and cost and schedule impact analyses that support trade-offs.
  - Capability includes recommendations for anticipated production testing and demonstration efforts.
  - Prior producibility improvements analyzed for effectiveness during LRIP.

Metrics

- Have you checked the contractors' manufacturing capability to ensure it covers:
  - All required manufacturing processes and techniques?
  - All design producibility risks?
  - The necessary manufacturing capability that has a high probability of meeting delivery dates? Level?
  - The necessary manufacturing capability that provides for minimal impact of critical and long-lead time material?
  - The necessary manufacturing capability that ensures all production equipment will be available?
  - The necessary manufacturing capability that provides accurate production unit cost goals?
  - The necessary manufacturing capability that includes cost and production schedule estimates updated with actuals to support management reviews?
  - Have you ensured that all alternatives have adequate manufacturing feasibility and cost and schedule impact analyses that support trade-offs?
  - The necessary manufacturing capability includes recommendations for anticipated production testing and demonstration efforts?
  - Have you ensured all prior producibility improvements have been analyzed for effectiveness during LRIP?

Tools

- Manufacturing Readiness Assessment Checklist, Design thread
- Design for Manufacturing and Assembly (DFMA) Assessment

- Design for Six Sigma
- Design of Experiments
- Robust Design
- Tolerance Design
- Design Failure Modes and Effects Analysis (DFMEA)
- Process Failure Modes and Effects Analysis (PFMEA)

Resources

- MRL Deskbook Version 2016
- Principles and Guidelines for Design for Manufacturing and Assembly, July 2014
- Design for Six Sigma Memory Jogger
- Taguchi Robust Design/Six Sigma Guide
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis

E.2. Producibility Planning Completed

Producibility is an engineering function directed toward generating a design which is compatible with the manufacturing capability of the proposed factory floor. It is often considered the most important determinant of product cost, due to the effect on both production and sustainment costs. The Technology Development contract should have required that the contractor develop a Producibility Plan and producibility criteria to guide the design effort. The plan should describe specifically what activities will be accomplished in each phase, the responsible organization, and the management controls that will be established to ensure successful accomplishment. The Program Management Office should review the plan with a focus on the realism, completeness and clarity of the planning accomplished by the contractor. Formal submission of the plan may be required by the contract or may be reviewed at the contractor facility.

Producibility criteria should reflect a blending of general criteria (such as minimum parts count) and specific criteria applicable to the type of equipment being developed. The producibility program will be effective if the design engineers understand and apply the producibility design criteria. Each competing design needs to be evaluated from a producibility standpoint. Producibility evaluations will serve as a basis for estimating the likely manufacturing cost and assessing the level of manufacturing risk of the system. Results of these assessments should support the development of specific contractual provisions for the EMD phase.

Ignoring producibility can lock the acquisition program into design solutions which can only be accomplished at unnecessarily high levels of production cost or design changes which can entail substantial technical, cost and schedule risk during production.

Manufacturing and Quality Tasks

- As the design evolves its producibility should be subjected to regular review.
- Contractor's detailed producibility trade studies used knowledge of key design characteristics and related manufacturing process capability.
- All producibility improvements implemented into system design and specifications.
- Known producibility issues have been resolved and pose minimum risk for LRIP and no risk for FRP.
- Contractor's producibility enhancement efforts (e.g. DFX) completed for optimized integrated system.
- Contractor's design producibility evaluated for such factors as:
    - Liberal tolerances (dimensions, mechanical, electrical);
    - Use of materials that provide optimum machinability, formability and weldability;
    - Shapes and forms designed for castings, stampings, extrusions, etc., that provide maximum economy;
    - Inspection and test requirements that are the minimum needed to assure desired quality and maximum usage of available and standard inspection equipment;
    - Assembly by efficient, economical methods and procedures; and
    - Minimized requirements for complex or expensive manufacturing tooling or special skills.

Metrics

- Have you regularly reviewed the producibility of the evolving design?
- Have you reviewed the contractor's detailed producibility trade studies to ensure they used knowledge of key design characteristics and the related manufacturing process capability?
- Ave you ensured that all producibility improvements have been implemented into the latest system design and specifications?
- Have all known producibility issues been resolved and ensured they impose minimum risk for LRIP and no risk for FRP?
- Have you ensured the contractor's producibility enhancement efforts (e.g. DFX) have been completed for optimized integrated system?
- Have you evaluated the contractor's design producibility efforts for such factors as:
    - Liberal tolerances (dimensions, mechanical, electrical);
    - Use of materials that provide optimum machinability, formability and weldability;
    - Shapes and forms designed for castings, stampings, extrusions, etc., that provide maximum economy;
    - Inspection and test requirements that are the minimum needed to assure desired quality and maximum usage of available and standard inspection equipment;
    - Assembly by efficient, economical methods and procedures; and
    - Minimized requirements for complex or expensive manufacturing tooling or special skills?

Tools

- Producibility Engineering and Planning (PEP) Data Item Description

Resources

- IEEE15288.2, System and Software Engineering, 2015
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999
- MIL-HDBK-727, Design Guidance for Producibility, Apr 1984
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center, Sep 1993
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning (PEP)

E.3. Producibility Assessments

DOD policy on major system acquisitions makes producibility considerations a requirement prior to the start of Technology Development. The Alternative Systems Review should have included producibility assessments of the design concepts. Producibility assessments and engineering should be a part of the ongoing systems engineering process. DoDI 5000.02 states that "design for producibility" shall be a part of the Engineering and Manufacturing Development phase. DODD 5000.01 states that the PM shall “reduce manufacturing risk and demonstrate producibility” prior to FRP.

History has demonstrated that as the complexity of systems increases, so does the acquisition cost. Therefore, producibility programs are necessary as a management means for assuring that practicality is addressed and that the cost increases associated with the growing complexity of systems are minimized. It should be recognized that the producibility analysis accomplished by the PMO must be performed by a team of specialists assembled from the program office: and supporting organizations. One functional organization cannot possibly accomplish the total producibility effort without assistance from other functional organizations. Consequently, the PMO approach to organizing for producibility is of prime importance to a successful defense system.

Manufacturing and Quality Tasks

- Ongoing Producibility Assessments conducted on current efforts including additional efforts if necessary.
    - At the enterprise level (including infrastructure – software tools, design guides, training, and policies).
    - On a product-by-product level (including trade studies, and design principles – reduce part count, use of common parts, ease of assembly, and simplicity of fabrication).
    - Producibility issues/risks discovered in LRIP have been mitigated and pose no significant risk for FRP.

Metrics

- Have you conducted ongoing Producibility Assessments on current efforts including additional efforts if necessary?
- Have these assessments been conducted;
  - At the enterprise level (including infrastructure – software tools, design guides, training, and policies)?
  - On a product-by-product level (including trade studies, and design principles – reduce part count, use of common parts, ease of assembly, and simplicity of fabrication)?
  - Producibility issues/risks discovered in LRIP have been mitigated and pose no significant risk for FRP?

Tools

- Producibility Assessment Worksheet

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- ISO 9001, Quality Management System, 2015
- IEEE15288.2, System and Software Engineering, 2015
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999
- MIL-HDBK-727, Design Guidance for Producibility, Apr 1984
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center, Sep 1993

E.4. Participate in Design IPT

Major programs are organized around core design team, usually comprised of 20-50 of the contractor's best engineers. This core design team makes 90-95% of all critical decisions. If manufacturing is not one of their primary concerns then manufacturing issues will be delegated to secondary teams.

The contractor will follow the government's lead. If the PM, IPT and Technical Director do not ask manufacturing questions then the contractor receives the message that these issues are secondary. In addition, CDRLs, in and of themselves, do not result in effective concrete action nor will they replace effective communication.

Manufacturing and Quality Tasks

- Ongoing Design IPT demonstrates that:
  - Producibility has been assessed and integrated with other design activities.

  - Key and critical manufacturing assembly and test processes have been identified, evaluated and matured.
  - All risks (technology, manufacturing, software development, and sustainment) have been assessed.
  - Metrics and data to assess, monitor, manage and control the transition process have been developed.
  - Manufacturing and quality engineers participate on engineering IPTs.
- Ensure the product design is stable.
  - Design changes are few and generally limited to those required for continuous improvement or in reaction to obsolescence.
- Ensure the pilot-line conditions represent a robust enough production environment to be used to validate LRIP manufacturing needs.

Metrics

- Have the ongoing Design IPT demonstrated that:
  - Producibility has been assessed and integrated with other design activities.
  - Key and critical manufacturing assembly and test processes have been identified, evaluated and matured?
  - All risks (technology, manufacturing, software development, and sustainment) have been assessed?
  - Metrics and data to assess, monitor, manage and control the transition process have been developed?
  - Manufacturing and quality engineers participate on engineering IPTs.
- Have you ensured that the current product design is stable?
- Have you ensured that design changes are few and generally limited to those required for continuous improvement and or in reaction to obsolescence?
- Have you ensured that the pilot-line conditions represent a robust enough production environment to be used to validate LRIP manufacturing needs?

Tools

- Design for Manufacturing and Assembly (DFMA)
- SEP assessment
- Integrated Master Plan/Integrated Master Schedule template
- Manufacturing Readiness Assessment Checklist, Design thread

Resources

- Design for Six Sigma Memory Jogger
- SEP Outline, Apr 2011

- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- MRL Deskbook version 2016

E.5. Assess Design Maturity

DOD acquisition programs face a high risk of failure at the outset of the design process. While some level of risk associated with a new technical concept may be unavoidable, historically this risk has been magnified by the misunderstanding of the industrial design disciplines necessary to turn the concept into a mature product. The government and its contractors must share equal responsibility for this misunderstanding. The contractor's proposal and government source selection process provide the last cost-effective opportunity to ensure application of these critical disciplines during design and the achievement of design maturity.

A mature design meets operational requirements without additional government or contractor intervention - no further field modifications or additional equipment and spares are required to overcome design shortfalls. In the factory, design maturity might be indicated by the tapering off of Engineering Change Proposal (ECP) traffic, once the test phase is underway, if it can be assumed that contract requirements are being met. But what constitutes design maturity at the conclusion of the design effort before entering the formal test phase? This is the question faced at the Critical Design Review (CDR), when a decision to proceed with fabrication of formal test articles must be made, a decision on which this matter of risk hangs.

It must be economically feasible to manufacture a quality product at a specified rate and to deliver end items capable of achieving the performance and reliability inherent in the design.

This design requirement is not always well understood and historically has taken a back seat to the more popular objective of high performance. The results of this neglect have ranged from factory rework rates in excess of 50 percent to the suspension of government acceptance of end items pending major redesign for producibility. A strong producibility emphasis early in design will minimize the time and cost required for successful transition to production.

Manufacturing and Quality Tasks

- Continue design maturity assessments. Ensure that all:
  - Product data required for Pilot-Line component manufacturing completed.
  - Pilot-Line product requirements and features have been defined.
  - Product data essential for subsystem/system Pilot-Line has been released.
  - All enabling/critical components have been demonstrated on the Pilot-Line.
  - Design maturity metrics have been applied to the planned Production Line.

Metrics

- As you continue design maturity assessments. You must ensure that all:
  - Product data required for Pilot-Line component manufacturing is completed?
  - Pilot-Line product requirements and features have been defined?
  - Product data essential for subsystem/system Pilot-Line has been released?
  - All enabling/critical components have been demonstrated on the Pilot-Line?
  - All design maturity metrics have been applied to the planned Production Line?

Tools

- Design for Six Sigma
- Manufacturing Readiness Level Assessment Questionnaire, Design thread

Resources

- DoD MIL-STD 882E, System Safety
- MRL Deskbook version 2016

E.6. Review the contractor's preliminary Key Characteristics (KCs)

The reliability of the as-built product is bounded by the inherent reliability of the design and in the control of quality of key and critical characteristics.

A Key Characteristic (KC) is a feature of a material, process, or part (includes assemblies) whose variation within the specified tolerance has a significant influence on product fit, performance, service life, or manufacturability.

A Critical Characteristic is any feature throughout the life cycle of a Critical Safety Item (CSI), such as dimension, tolerance, finish, material or assembly, manufacturing or inspection process, operation, field maintenance, or depot overhaul requirement that if nonconforming, missing or degraded may cause the failure or malfunction of a CSI. CSIs are parts whose failure could have catastrophic consequences. In general terms, a CSI's failure could cause loss of life, serious injury or permanent disability, loss of a weapon system, or substantial equipment damage.

Manufacturing and Quality Tasks

- Design KCs have been identified and any mitigation plans developed.
- All KCs are controlled in LRIP to appropriate quality levels.

Metrics

- Have you ensured all design KCs have been identified and any necessary mitigation plans developed?

- Have you ensured all KCs are controlled in LRIP to appropriate quality levels for production?
- Process Capability Ratio or Cp
- Demonstrated Process Capability or Cpk

Tools

- MRL Assessment Checklist for Process Capability and Control thread
- Critical to Quality Tree
- Failure Mode and Effects Analysis
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- Technology Readiness Level Assessment Checklist

Resources

- MRL Deskbook Version 2016
- DoD AS6500, Manufacturing Management Program
- AS9100, Quality Assurance Management
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis
- NAVSO P-3687 Producibility System Guidelines, Dec 1999
- Technology Level Assessment Guidance, Apr 2011

E.7 Ensure MFG and Quality Support inputs to Critical Design Review (CDR) have been implemented.

DoDI 5000.02 requires that PMs and their technical staff to, "Develop an affordable and executable manufacturing process during the Engineering and Manufacturing Development (EMD) Phase." The Post-CDR assessment will include a demonstration that the "maturity of critical manufacturing processes has been accomplished. EMD shall end when "manufacturing processes have been effectively demonstrated in a pilot line environment" prior to Milestone C.

The CDR is conducted to ensure that the system under review can proceed into system fabrication, demonstration, and test, and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints. At this time Producibility Engineering activities should be complete.

The CDR assesses the system final design as captured in product specifications for each configuration item in the system (product baseline), and ensures that each product in the product baseline has been captured in the detailed design documentation.

Manufacturing and Quality Tasks

- Typical manufacturing and quality CDR concerns include:

- That the system product baseline has been established and documented to enable hardware fabrication to proceed with proper configuration management.
- Adequate processes and metrics are in place for the program to succeed.
- All the known risks are understood and manageable for testing in support of developmental and operational evaluation objectives.
- The program schedule is executable (technical/cost risks).
- The program is executable with the existing budget and the approved product baseline.
- The detailed design is producible within the production budget.
- The updated Cost Analysis Requirements Description (CARD) is consistent with the approved product baseline.
- The updated cost estimate fits within the existing budget.
- Key product characteristics that have the most impact on system performance, assembly, cost, reliability, and sustainment or safety are identified.
- The critical manufacturing processes that affect the key characteristics have been identified and their capability to meet design tolerances determined.
- Process control plans have been developed for critical manufacturing processes.
- Manufacturing processes have been demonstrated in a production representative environment.
- Detailed trade studies and system producibility assessments are complete.
- Materials and tooling are available to meet LRIP/FRP schedule.
- System production cost models have been updated, allocated to subsystem level, and tracked against targets.
- Long lead procurement plans are in place and the supply chain has been validated.
- All product data essential for component manufacturing has been released.
- Design change traffic does not impact LRIP.

- Major product design features and configuration are stable.
- Physical Configuration Audit (PCA) or equivalent completed.
- Maintenance of production equipment translates to downtime and is accounted for in determining the availability of the equipment and contingency plans.

Metrics

- During the CDR your typical manufacturing and quality concerns include:
  - Have you ensured that the system product baseline has been established and documented to enable hardware fabrication to proceed with proper configuration management?
  - Have you ensured that adequate processes and metrics are in place for the program to succeed?
  - Have you ensured that all the known risks are understood and manageable for testing in support of developmental and operational evaluation objectives?
  - Have you ensured that the program schedule is executable in lite of (technical/cost risks)?
  - Have you ensured that the program is executable within the existing budget and the approved product baseline?

  - Have you ensured that the detailed design is producible within the production budget?
  - Have you ensured that the updated Cost Analysis Requirements Description (CARD) is consistent with the approved product baseline?
  - Have you ensured that the updated cost estimate fits within the existing budget?
  - Have you ensured that key product characteristics that have the most impact on system performance, assembly, cost, reliability, and sustainment or safety have been identified?
  - Have you ensured that the critical manufacturing processes that affect the key characteristics have been identified and their capability to meet design tolerances have been determined?
  - Have you ensured that process control plans have been developed for critical manufacturing processes?
  - Have you ensured that manufacturing processes have been demonstrated in a production representative environment?
  - Have you ensured that detailed trade studies and system producibility assessments have been completed?
  - Have you ensured that all materials and tooling are available to meet LRIP/FRP schedule?
  - Have you ensured that system production cost models have been updated, allocated to subsystem level, and tracked against targets?
  - Have you ensured that long lead procurement plans are in place and the supply chain has been validated?
  - Have you ensured that all product data essential for component manufacturing has been released?
  - Have you ensured that design change traffic does/will not impact LRIP?
- Have you ensured that major product design features and configuration are stable?
- Have you ensured that the Physical Configuration Audit (PCA) or equivalent has been completed?
- Have you ensured that the maintenance of production equipment translates to downtime and is accounted for in determining the availability of the equipment and contingency plans?

Tools

- Critical Design Review Checklist and Assessment

Resources

- DoD Defense Acquisition Guide (DAG) Chapter 3-3.3.5 Critical Design Review

E.8. Update to Systems Engineering Plan (SEP)

Manufacturing and Quality Tasks

The following information sources provide important inputs to the Production &Deployment phase systems engineering process and should contain manufacturing considerations:

- Acquisition Program Baseline;
- Capability Production Document;
- SEP
- Test and Evaluation Master Plan;
- Programmatic Environmental, Safety, and Occupational Health Evaluation (PESHE).
- Product Support Elements.
- Program Schedule (PRR/Production Lot/Phases).
- Technical Risks and Mitigation Planning (Production/Manufacturing/Quality).
- Manufacturing and Quality Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics).
- Planned Activities for the Next Phase (including manufacturing maturity).
- All modifications, upgrades, Diminishing Manufacturing Sources and Material Shortages (DMSMS) and other changes assessed for producibility.
- Technical Review Process (Manufacturing Purposes/Criteria).
- Manufacturing and Quality TPMs/Metrics to be used to identify and manage risks.
- Manufacturing Design Considerations (Include Trade Study Criteria).
- Engineering Tools (such as Producibility/Throughput Analysis, Line of Balance, factory and process modeling and simulation tools, and quality assurance tools) are available and in use.

Metrics

Have you used the following information sources to provide important inputs to the Production and Deployment phase systems engineering process and that they contain manufacturing considerations:

- Acquisition Program Baseline?
- Capability Production Document?
- SEP?
- Test and Evaluation Master Plan?
- Programmatic Environmental, Safety, and Occupational Health Evaluation (PESHE)?
- Product Support Elements?
- Program Schedule (PRR/Production Lot/Phases)?
- Technical Risks and Mitigation Planning (Production/Manufacturing/Quality)?
- Manufacturing and Quality Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)?
- Planned Activities for the Next Phase (including manufacturing maturity)?

- All modifications, upgrades, Diminishing Manufacturing Sources and Material Shortages (DMSMS) and other changes assessed for producibility?
- Technical Review Process (Manufacturing Purposes/Criteria)?
- Manufacturing and Quality TPMs/Metrics to be used to identify and manage risks?
- Manufacturing Design Considerations (Include Trade Study Criteria)?
- Engineering Tools (such as Producibility/Throughput Analysis, Line of Balance, factory and process modeling and simulation tools, and quality assurance tools) are available and in use?

Tools

- SEP Outline
- Manufacturing Plan (included I n the SEP)
- Quality Assurance Plan (included in the SEP)
- Critical to Customer/Critical to Quality Tree
- Producibility Assessment Worksheet

Resources

- DoD TAB B - SEP Outline Version 3.0 - Final V4 (provided by OSD)
- SEP Outline, Apr 2011
- MRL Deskbook Version 2016
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System, 2015
- ISO 9001, Quality Management System, 2015
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy, Dec 1999

E.9 Develop Detailed Production Design

One of the most important elements of any production design is the definition of the manufacturing resources. No matter how good a design may be, it is useless if system or product cannot be built. It is therefore essential that availability of manufacturing resources be a consideration during the design review process. Manufacturing engineers should be a part of each design team to assure adequate consideration of availability of required manufacturing resources.

Manufacturing resources should not be limited to manufacturing methods, but should include materials, capital, manufacturing technology, facilities, qualified labor, and the management structure to effectively integrate them. The successful competitor, of the production phase will depend upon the efficient application of the full spectrum of these resources to the task of fabricating and delivering the defense system design.

Manufacturing and Quality Tasks

- Ensure detailed design drawings, bills of material and product and process specifications are completed by release of design to manufacturing.

- Participate in design reviews to assure that the contractor is complying with the design requirements and meeting the cost/design goals.
- Ensure the final design definition is the result of the performance requirements, the outcomes of the testing accomplished, producibility studies and other design influences.
- Ensure that the design is specified to a very low level of detail so that the required production phase processes and resources can be identified and obtained.
- Design producibility improvements demonstrated in LRIP/FRP.

Metrics

- Have you ensured detailed design drawings, bills of material and product and process specifications are completed by release of design to manufacturing?
- Have you participated in design reviews to assure that the contractor is complying with the design requirements and meeting the cost/design goals?
- Have you ensured the final design definition is the result of the performance requirements, the outcomes of the testing accomplished, producibility studies and other design influences?
- Have you ensured that the design is specified to a very low level of detail so that the required production phase processes and resources can be identified and obtained?
- Have you ensured that design producibility improvements have been demonstrated in LRIP/FRP?

Tools

- Design for Manufacturing and Assembly (DFMA)
- SEP Outline
- Manufacturing Readiness Level Assessment Questionnaire, Design thread

Resources

- SEP Outline, Apr 2011
- MRL Deskbook version 2016

E.10 Develop Production Work Breakdown Structure

The planning, execution and control of the production phase activities require that the work be divided into manageable tasks that are compatible with the existing manufacturing and performance measurement systems. Often, the work breakdown structure (WBS) used during the development phases will not be appropriate for the production phase. Consequently, the contractor should, as a basis for production planning, identify the WBS which is to be used. While this was may differ from the EMD structure, the two should be such that production phase costs can be related to the development WBS. This is critical for those programs which have utilized a design-to-unit production cost management approach during development.

Manufacturing and Quality Tasks

- Develop the Production WBS to ensure planning, execution and control of the production phase activities are compatible with the existing manufacturing and performance measurement systems.
    - Ensure the contractor identifies the Production WBS such that production phase costs can be related to the development WBS.

Metrics

- During the development of the Production WBS have you ensured planning, execution and control of the production phase activities are compatible with the existing manufacturing and performance measurement systems?
    - Ensure the contractor identifies the Production WBS such that production phase costs can be related to the development WBS?

Tools

- Work Breakdown Standard review

Resources

- MIL-STD-881 Work Breakdown Standard

E.11 Design Stability

For the FRP Decision Review Acquisition Strategy update, the Program should identify remaining risks prior to a production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make- or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or handle remaining risks.

Manufacturing and Quality Tasks

- Product design and features during the Critical Design Review support a production decision.
    - Design change traffic should be minimal.
- Detailed design of all product features and interfaces is complete.
    - All product data essential for product manufacturing has been released.
- Final material selection completed and evaluated for producibility.
- Product specifications/build-to packages are matured to the same level as the design.
- LRIP/FRP Build-to Packages are complete.

- System design has been validated through operational testing of LRIP items.
- Design change traffic is limited.
- Ensure the design efforts achieve effective and efficient manufacturing processes with the necessary process controls to satisfy requirements and minimize manufacturing costs.
- Ensure the design of the system facilitates the timely and affordable manufacture, assembly, and delivery of a quality product to the customer.

Metrics

- Have you ensured that the product design and features during the Critical Design Review support a production decision?
    - Have you verified that design change traffic minimal?
- Have you ensured that the detailed design of all product features and interfaces is completed?
    - Have you verified that all product data essential for product manufacturing has been released?
- Have you verified that final material selection has been completed and evaluated for producibility?
- Have you verified that product specifications/build-to packages are matured to the same level as the design?
- Have you verified that LRIP/FRP Build-to Packages are complete?
- Have you verified that system design has been validated through operational testing of LRIP items?
- Have you verified that design change traffic is limited?
- Have you verified/ensured that the design efforts achieved effective and efficient manufacturing processes with the necessary process controls to satisfy requirements and minimize manufacturing costs?
- Have you verified/ensured that the design of the system facilitates the timely and affordable manufacture, assembly, and delivery of a quality product to the customer?

Tools

- Design for Six Sigma
- Critical Path Template
- Manufacturing Readiness Level Assessment Questionnaire, Design thread

Resources

- DoD MIL-STD 882E, System Safety
- DoDI 4245-.7-M, Willoughby Templates, Chapter 3 – Design
- MRL Deskbook version 2016

E.12 Key Characteristics Proven

The manufacturing strategy should include the criteria for determining which production processes will require proofing and the timing of such proofing activity. These processes are often identified during a manufacturing risk assessment or during the design as Key Characteristics. Process proofing can make a major contribution to risk reduction, but it may involve cost and/or potential schedule impacts during the development phase. Maturing manufacturing processes should be documented in a formal Manufacturing Maturation Plan.

Manufacturing and Quality Tasks

- Manufacturing processes re-assessed as needed for capability to test and verify potential influence on Operations and Support.
- Potential KC risk issues have been identified and mitigated on pilot-line.
- Key Characteristics are attainable based upon pilot-line demonstrations.
- Process producibility improvements ongoing.
- All KCs are controlled in FRP to appropriate quality levels.

Metrics

- Have you ensured that manufacturing processes are being re-assessed as needed for capability to test and verify potential influence on Operations and Support?
- Have you ensured that potential KC risk issues have been identified and mitigated on the pilot-line?
- Have you ensured that Key Characteristics are attainable based upon pilot-line demonstrations?
- Have you ensured that process producibility improvements are ongoing?
- Have you ensured that all KCs are controlled in FRP to appropriate quality levels?
- Process Capability Ratio or Cp
- Demonstrated Process Capability or Cpk

Tools

- MRL Assessment Checklist for Process Capability and Control thread
- Critical to Quality Tree
- Failure Mode and Effects Analysis
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist

Resources

- DoD AS6500, Manufacturing Management Program
- AS9100, Quality Assurance Management
- MRL Deskbook Version 2016

- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis
- NAVSO P-3687 Producibility System Guidelines, Dec 1999

E.13 LRIP Build

The Milestone C review should provide the status of assessments of manufacturing processes and highlight the steps needed to progress from an EMD manufacturing environment to an LRIP environment.

Manufacturing and Quality Tasks

- LRIP describes the initial production effort needed to reduce the government's exposure in transitioning to FRP. It usually begins at the end of the EMD phase and often transitions from a pilot line to an LRIP then FRP production capability. To reduce risk during LRIP, manufacturing personnel must ensure that:
    - new technologies are mature and ready to transition into the production units
    - the detailed system design is complete with few engineering changes, and none that impact form, fit or function
    - all manufacturing processes are capable and under statistical control, and there are no producibility risks
    - a complete definition of the fabrication and assembly tasks and they are transferred to the general factory work force
    - detailed work instructions exist and a closely controlled system for changes to the documents used in the factory, such as drawings and process specifications
    - required production planning documentation are based on a stable design, quantity requirements and delivery schedule
    - engineering changes are controlled to minimize disruption to production documentation and planned manufacturing schedules
- Participate in the PCA which is usually conducted around the time of the FRP Decision. The PCA examines the actual configuration of an item being produced and confirms that:
    - the manufacturing processes,
    - quality control system,
    - measurement and test equipment,
    - and training are adequately planned, tracked, and controlled.

    And that the related design documentation matches the item as specified in the contract
- Ensure affordable and executable manufacturing process have been developed and demonstrated/proven. The PCA demonstrated that the maturity of critical manufacturing processes has been accomplished.
- Ensure all manufacturing processes have been effectively demonstrated during LRIP.

Metrics

- Have you ensured that:
  - New technologies are mature and ready to transition into the production units?
  - The detailed system design is complete with few engineering changes, and none that impact form, fit or function?
  - All manufacturing processes are capable and under statistical control, and there are no producibility risks?
  - A complete definition of the fabrication and assembly tasks and they are transferred to the general factory work force?
  - Detailed work instructions exist and a closely controlled system for changes to the documents used in the factory, such as drawings and process specifications?
  - Required production planning documentation are based on a stable design, quantity requirements and delivery schedule?
  - Engineering changes are controlled to minimize disruption to production documentation and planned manufacturing schedules?
- You must participate in the PCA which is usually conducted around the time of the FRP Decision.
- During the PCA you must examine the actual configuration of an item being produced and confirm that:
  - The manufacturing processes,
  - quality control system,
  - Measurement and test equipment, and training are adequately planned, tracked, and controlled?
  - And the related design documentation matches the item as specified in the contract?
- Have you ensured affordable and executable manufacturing process have been developed and demonstrated/proven?
- Has the PCA demonstrated that the maturity of critical manufacturing processes has been accomplished?
- Have you ensured all manufacturing processes have been effectively demonstrated during LRIP?

Tools

- Production Verification Test
- Production Part Approval Process (PPAP) Checklist
- Manufacturing Readiness Level Assessment, Design thread
- Integrated Master Plan/Integrated Master Schedule assessment

Resources

- AS6500, Manufacturing Management System

- DCMA Instruction 302, First Article and Production Lot Testing, Jan 2015
- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- DoDI 5000.02
- IEEE 15288.2, System and Software Engineering, 2015
- MRL Deskbook Version 2016
- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide, Oct 2005

E.14 FRP Build

For the FRP Decision Review Acquisition Strategy update, the program should identify remaining risks prior to a production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make- or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or handle remaining risks.

Manufacturing and Quality Tasks

- FRP is the highest level of production readiness. Manufacturing personnel must ensure that:
  - engineering/design changes are few and generally limited to quality and cost improvements
  - system, components or items are in FRP and meet all engineering, performance, quality and reliability requirements
  - manufacturing process capability is at the appropriate quality level
  - all materials, tooling, inspection and test equipment, facilities and manpower are in place and have met FRP requirements
  - rate production unit costs meet goals, and funding is sufficient for production at required rates
  - lean practices are well established and continuous process improvements are ongoing
  - there are no significant manufacturing risk
  - manufacturing processes should be under statistical control if quantities warrant
- Identify remaining risks prior to FRP production go-ahead decision. Key considerations should include:
  - industrial base viability,
  - design stability,
  - process maturity,
  - supply chain management,
  - quality management, and
  - facilities and manufacturing skills availability.

- Sources of this data could include:
- technical reviews and audits,
- Program Status Reviews,
- pre-award surveys,
- Production Readiness Reviews,
- Industrial Capabilities Assessments,
- trade-off studies,
- tooling plans,
- make-or-buy plans,
- manufacturing plans,
- and bills of material.

Important outputs include actions to reduce or handle remaining risks.

- A follow-on, tailored, PRR may be appropriate in the Production and Deployment phase for the prime contractor and major subcontractors if:
  - Changes from the EMD phase and during the production stage of the design, in either materials or manufacturing processes, occur,
  - Production start-up or re-start occurs after a significant shutdown period,
  - Production start-up with a new contractor, or
  - Relocation of a manufacturing site.

Metrics

- During FRP, manufacturing personnel must ensure the highest level of production readiness:
  - Have you ensured that engineering/design changes are few and generally limited to quality and cost improvements?
  - Have you ensured that system, components or items are in FRP and meet all engineering, performance, quality and reliability requirements?
  - Have you ensured that manufacturing process capability is at the appropriate quality level?
  - Have you ensured that all materials, tooling, inspection and test equipment, facilities and manpower are in place and have met FRP requirements?
  - Have you ensured that rate production unit costs meet goals, and funding is sufficient for production at required rates?
  - Have you ensured that lean practices are well established and continuous process improvements are ongoing?
  - Have you ensured that there are no significant manufacturing risks?
  - Have you ensured that manufacturing processes should be under statistical control if quantities warrant?
- Have you identified any remaining risks prior to the FRP production go-ahead decision?
- Have your considerations included:

- industrial base viability?
- design stability?
- process maturity?
- supply chain management?
- quality management?
- facilities and manufacturing skills availability?

- Did you include the following sources for this data:
  - technical reviews and audits?
  - Program Status Reviews?
  - pre-award surveys?
  - Production Readiness Reviews?
  - Industrial Capabilities Assessments?
  - trade-off studies?
  - tooling plans?
  - make-or-buy plans?
  - manufacturing plans?
  - and bills of material?

Do your considerations of this data include actions to reduce or handle any remaining risks?

- Have you considered a follow-on, tailored, PRR as entry criteria before entering the Production and Deployment phase for the prime contractor and major subcontractors?
- This follow-on PRR might be appropriate if any of the following factors are present.
  - Do you anticipate changes from the EMD phase and during the production stage of the design, in either materials or manufacturing processes?
  - Do you anticipate production start-up or re-start occurring after a significant shutdown period?
  - Do you anticipate production start-up with a new contractor?
  - Do you anticipate relocation of a manufacturing site?

Tools

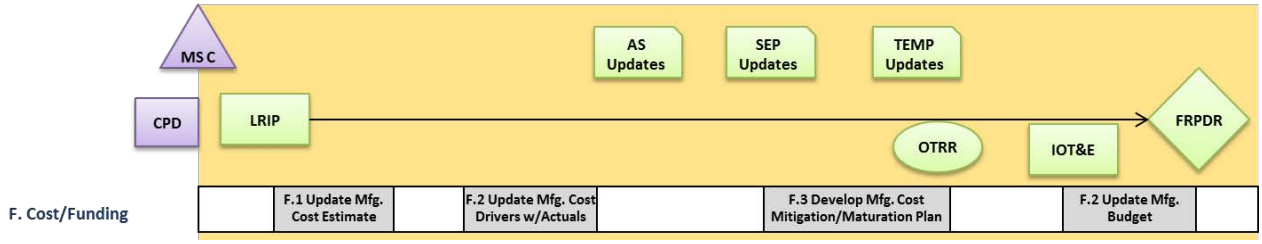
- Production Verification Test
- Production Part Approval Process (PPAP) Checklist
- Manufacturing Readiness Level Assessment, Design thread
- Integrated Master Plan/Integrated Master Schedule assessment

Resources

- AS6500, Manufacturing Management System
- DCMA Instruction 302, First Article and Production Lot Testing, Jan 2015
- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- DoDI 5000.02

- IEEE 15288.2, System and Software Engineering, 2015
- MRL Deskbook Version 2016
- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide, Oct 2005

F. COST/FUNDING



F.1 Update Manufacturing Cost Estimates

Manufacturing cost estimates for the production phase are normally based on the assumption that the design is complete, that the manufacturing processes are known, and manufacturing operations will be accomplished as planned. Any deviation from these assumptions could cause a growth in cost. As such, time and conformance measures can give some indication of potential or real cost aberrations since there is normally a direct correlation between late delivery or conformance problems and cost. In addition, the following measures may also indicate the existence of cost problems:

- Scrap and rework rates,
- Percentage of out-of-station work,
- Supplier quality problems,
- Engineering change volume,
- Yield rates on manufacturing operations, and
- Reliability growth profiles.

Manufacturing and Quality Tasks

- The initial manufacturing cost estimate has been updated to reflect the final definition of the system design and the completed manufacturing approach.
- These manufacturing cost estimates should be based upon application of detailed manufacturing standards to the operations to be performed and adjusted, as necessary, by realization factors and/or learning curves to develop the time phased manufacturing cost.
- If the contractor does not have a system for development and application of labor standards, strong consideration should be given to including a contract requirement for Work Measurement in the LRIP/FRP phase contract.
- FRP cost model updated with results of LRIP build.

Metrics

- Have you updated the initial manufacturing cost estimate to reflect the final definition of the system design and the completed manufacturing approach?
- Have your updated manufacturing cost estimates been based upon application of detailed manufacturing standards to the operations to be performed and adjusted, as necessary, by realization factors and/or learning curves to develop the time phased manufacturing cost?
- If the contractor does not have a system for development and application of labor standards, have you considered including a contract requirement for Work Measurement in the LRIP/FRP phase contract?
- Has your FRP cost model been updated with the results of LRIP build?

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Readiness Level assessment for the Cost Thread
- See CAPE website for tools

Resources

- MRL Deskbook Version 2016
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766 Design to Cost
- Should-cost and Affordability Memo, Aug 2011
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- CARD Website and process

F.2 Manufacturing Cost Drivers have been updated with actuals

The cost to manufacture a weapon system or equipment results from a combination of the design, the physical facility, and the five M's (manpower, materials, methods, measurements, and machines) used to build the design and the management efficiency of the operation. As such, the manufacturing cost for a product should be viewed within the context of the factory in which the product will be built. Three other very significant cost factors will need to be identified to support the estimating activity, and these are rate, quantity and efficiency.

Manufacturing and Quality Tasks

- Manufacturing costs rolled up to system/subsystem level and tracked against targets.

- Detailed trade studies and engineering change requests supported by cost estimates.
- Cost reduction and avoidance strategies implemented.
- Costs have been analyzed using pilot-line actuals and updated into manufacturing cost estimates to ensure target costs are achievable.
- Manufacturing cost analysis support proposed changes to requirements or configuration.
- All cost models updated with results of pilot line build.
- LRIP cost goals met and learning curve analyzed with actual data.

Metrics

- Have your manufacturing costs been rolled up to the system/subsystem level and tracked against targets?
- Have you ensured that all detailed trade studies and engineering change requests are supported by cost estimates?
- Have you ensured that cost reduction and avoidance strategies implemented?
- Have you ensured that costs have been analyzed using pilot-line actuals and updated into manufacturing cost estimates to ensure target costs are achievable?
- Have you ensured that manufacturing cost analysis support all proposed changes to requirements or configuration?
- Have you ensured that all cost models have been updated with results of pilot line build?
- Have you ensured that LRIP cost goals have been met and that learning curves are analyzed with actual data?

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Readiness Level assessment for the Cost Thread
- See CAPE website for tools

Resources

- MRL Deskbook Version 2016
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766 Design to Cost
- Should-cost and Affordability Memo, Aug 2011
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- CARD Website and process

F.3 Develop Manufacturing Cost Mitigation/Maturation Plan

Production cost and production cost estimates change over time. In the early acquisition phases, cost estimating is probably based on analogy. That is, you compare the cost of the proposed new system with that of a similar system that you have experience with and have cost information on. At this point the estimate is not very accurate as the basis of the estimate is may only resemble the final product and much may change as you develop the new system thus driving changes in the cost model. Then as the program matures and moves through the acquisition life cycle, more and more is learned about the final product to the point you may move from analogy to parametric cost estimating. Parametric cost estimating uses a statistical analysis of two or more similar systems to develop cost estimating relationships. Again, as the program matures and more is known about the system as it transitions from development towards production, the cost estimating methodology moves towards engineering estimates. Engineering estimates are derived by summing detailed cost estimates of the individual work packages and adding appropriate burdens. Engineering estimates are usually determined by a contractor's industrial engineers, price analysts, and cost accountants.

The final and most accurate cost estimating technique is the use of actuals. Actual cost estimating method uses the actual cost of the previous production lot adjusted for inflation, labor saving, material cost, technology changes and other factors. It generally comes at the end of the developmental cycle. An actual cost is a cost sustained in fact, on the basis of costs actually incurred and recorded in accomplishing the work performed within a given time period, as distinguished from forecasted or estimated costs.

Manufacturing and Quality Tasks

- Manufacturing cost models should include:
  - The ability to be used in design trades to assess the cost impacts of specific design changes, alternative production processes or process improvements;
  - The ability to incorporate the current, actual manufacturing costs into the production cost estimate; and
  - The ability to support Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs.)
- Develop Manufacturing Maturation Plans for any areas assessed that do not comply with the appropriate manufacturing readiness criteria.
- Touch labor efficiency analyzed to meet production rates and elements of inefficiency identified with plans in place for reduction.

Metrics

- Do your manufacturing cost models include:
  - The ability to be used in design trades to assess the cost impacts of specific design changes, alternative production processes or process improvements?

  - The ability to incorporate the current, actual manufacturing costs into the production cost estimate?
  - The ability to support Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs)?
- Have you developed Manufacturing Maturation Plans for any areas assessed that do not comply with the appropriate manufacturing readiness criteria?
- Have you analyzed all touch labor efficiency to meet production rates and elements of inefficiency identified with plans in place for reduction?

Tools

- Parametric, Engineering and Actual estimating
- CARD - Cost Analysis Requirements Description (see CAPE website for tools)
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding Thread
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan (no template available)

Resources

- 10 USC Sec. 2334 Independent Cost Estimation and Cost Analysis
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- Public Law 114-328, §807, Cost, Schedule and performance of major defense acquisition programs
- CARD - Cost Analysis Requirements Description Template (See CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide, Sep 1992
- DODI 5000.73 Cost Analysis Guidance and Procedures
- MRL Deskbook Version 2016

F.4 Update Manufacturing Budget

Manufacturing and Quality Tasks

- Cost reduction initiatives ongoing.
- Program has reasonable budget estimate for FRP.
- Manufacturing costs and cost drivers associated with design alternatives considered in trade-off process.
- Update manufacturing cost drivers for "Should-Cost" models.
- Program has met their budget estimate for MRL 8 by MS C.
- All outstanding MRL 9 risk areas understood with approved mitigation plans in place.
- Program has reasonable budget estimate for reaching MRL 9 by the FRP decision point.

- Estimate includes investment for LRIP and FRP.
- Assess the affordability and executability of the manufacturing processes.
- Determine the risks to affordably install and execute required manufacturing processes for each identified prototype.
- Analyze the identified risks.
- Integrate the individual risks identified for each prototype into a cumulative assessment of the ability to affordably install and execute the proposed manufacturing processes.
- Document and provide the cumulative assessment of the ability/risk to affordably install and execute the proposed manufacturing processes.
- Analyze of the adequacy, reasonableness and necessity of contractor-proposed manufacturing labor hours and material costs.
- Recommend quality and manufacturing cost reduction initiatives.
- Provide accurate cost performance versus target analysis and assessment of identified trends.
- Analyze the quality, manufacturing and production cost data against cost targets, and identify trends.
- Identify and provide quality, and manufacturing cost/funding estimates and recommendations on emerging requirements.
- Identify manufacturing investment opportunities and develop investment roadmaps for achieving the manufacturing development efforts.
- Develop funding and budgeting request for quality and manufacturing initiatives.
    - Identify emerging quality and manufacturing initiatives.
    - Develop program estimates for applicable quality and manufacturing initiatives.
- Develop and manage industrial base investment programs that create, expand or preserve assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense.
- Cost models validated against actual FRP cost.
- FRP cost goals met.
- Production budgets sufficient for production at required rates and schedule to support funded program.

Metrics

- Do you have Cost reduction initiatives that are ongoing?
- Have you ensured that the program has reasonable budget estimates for FRP.
- Have you ensured that the manufacturing costs and cost drivers associated with the design alternatives were considered in trade-off process?
- Have you updated manufacturing cost drivers for "Should-Cost" models?
- Have you ensured that the program has met their budget estimate for MRL 8 by MS C?
- Have you ensured that all the outstanding MRL 9 risk areas are understood with approved mitigation plans in place?

- Have you ensured that the program has reasonable budget estimates for reaching MRL 9 by the FRP decision point?
- Have you ensured that the estimate includes investment for LRIP and FRP?
- Have you assessed the affordability and executability of the manufacturing processes?
- Have you determined the risks to affordably install and execute required manufacturing processes for each identified prototype?
- Have you analyzed the identified risks?
- Have you integrated the individual risks identified for each prototype into a cumulative assessment of the ability to affordably install and execute the proposed manufacturing processes?
- Have you documented and provided the cumulative assessment of the ability/risk to affordably install and execute the proposed manufacturing processes?
- Have you analyzed the adequacy, reasonableness and necessity of contractor-proposed manufacturing labor hours and material costs?
- Have you recommend quality and manufacturing cost reduction initiatives?
- Have you provided an accurate cost performance versus target analysis and assessment of identified trends?
- Have you analyzed the quality, manufacturing and production cost data against cost targets, and identified trends?
- Have you identified and provided quality, and manufacturing cost/funding estimates and recommendations based on emerging requirements?
- Have you identified manufacturing investment opportunities and developed investment roadmaps for achieving the manufacturing development efforts?
- Have you developed funding and budgeting requests for quality and manufacturing initiatives?
    - Have you identified emerging quality and manufacturing initiatives?
    - Have you developed program estimates for applicable quality and manufacturing initiatives?
- Have you developed and managed industrial base investment programs that create, expand or preserve assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense?
- Have your cost models been validated against actual FRP cost?
- Have your FRP costs and goals met?
- Are your production budgets sufficient for production at required rates and schedule to support the funded program?

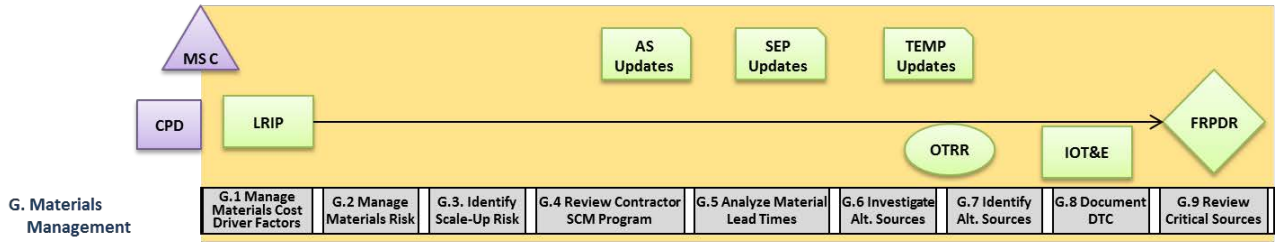
Tools

- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding Thread
- Technology Readiness Level Assessment Checklist

Resources

- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011
- Public Law 114-328, §807

G. MATERIALS MANAGEMENT



G.1. Update/Manage Materials Cost Driver Factors

Manufacturing and Quality Tasks

- Update cost drivers based on:
  - Design requirements
  - Material specifications and tolerances
  - Projected rates/quantities (lot buys)
  - Price stability
  - Material maturities demonstrated on pilot-line build.
  - Material specifications approved.
  - Materials proven and validated during EMD as adequate to support LRIP/FRP.
  - Material specification is stable.
- Material is controlled to specification in LRIP.
  - Methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials.

Metrics

- Have you updated cost drivers based on:
  - Design requirements?
  - Material specifications and tolerances?
  - Projected rates/quantities (lot buys)?
  - Price stability?
  - Material maturities demonstrated on pilot-line build?
  - Material specifications that are approved?
  - Materials proven and validated during EMD as adequate to support LRIP/FRP?
  - Material specifications that are stable?

- Have you validated that material is controlled to specification in LRIP?
    - Have you verified methods for conserving all critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials?

Tools

- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Cost, Schedule Control Systems Criteria (CSCSC)
- MRL assessment for the Material Management Thread
- Producibility Assessment

Resources

- DoD Cost/Schedule Control System Criteria
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328, Dec 16
- MRL Deskbook Version 2016

G.2. Manage Materials Risk

The area of component and material lead time is extremely critical to meeting program schedules and defining long lead and advanced buy requirements. The program office should maintain continuing visibility of the current status of and the forecast changes in lead times.

Manufacturing and Quality Tasks

- Availability issues addressed to meet LRIP/FRP builds.
- All long lead procurement risk identified and mitigated.
- Obsolescence plan in place.
- Availability issues addressed to meet FRP builds.
- Long lead procurement initiated for LRIP/FRP.
- Effective supply chain management process in place.
- Assessment of critical first tier supply chain completed.
- Supply chain adequate to support LRIP/FRP.
- Assessment of critical second and lower tier supply chain completed.
- Critical make/buy decisions have been assessed.
- Contractor’s make/buy decisions for all key and/or critical components analyzed.
- Make/buy decisions analyzed for ability of selected manufacturers, whether in factory or at vendor facility, to meet quality requirements, schedule and cost targets.
- Material availability risks minimalized.
- All special handling/storage/environmental compliance risks/issues mitigated.

- All new materials have been characterized in a factory environment.
- All government-furnished equipment (GFE)/facilities/materials/property
- Materials proven and validated as adequate to support FRP.

Metrics

- Have you addressed all availability issues to meet LRIP builds?
- Have you identified and mitigated all long lead procurement risk?
- Do you have an obsolescence plan in place?
- Have you addressed all availability issues to meet FRP builds?
- Has long lead procurement been initiated for LRIP/FRP?
- Do you have an effective supply chain management process in place?
- Have you completed an assessment of the critical first tier supply chain?
- Is your supply chain adequate to support LRIP/FRP?
- Have you completed an assessment of the critical second and lower tier supply chain?
- Have all critical make/buy decisions been assessed?
- Have you analyzed the contractor's make/buy decisions for all key and/or critical components?
- Have you analyzed the make/buy decisions for the ability of selected manufacturers, whether in factory or at vendor facility, to meet quality requirements, schedule and cost targets?
- Have you minimalized material availability risks?
- Have you mitigated all special handling/storage/environmental compliance risks/issues?
- Have all new materials been characterized in a factory environment?
- Have all GFE/F/M/P been identified?
- Have all materials been proven and validated as adequate to support FRP?

Tools

- DCMA Material Management and Accounting System Audit
- PESHE Assessment/Template
- ISO 14001 Gap Analysis Toolkit
- DMSMS Product Life Cycle Assessment (Consult Defense Logistics Agency (DLA)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- MRL Assessment Questionnaire for the Materials Thread
- Supply Chain Management Risk Assessment Checklist
- Producibility Assessment Worksheet
- TRL Assessment Questionnaire

Resources

- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- ESOH in Acquisition Guide, Apr 2009
- ISO 14001 Environmental Management Systems

- DMSMS Guidebook, SD-22, Sep 2009
- DOD 5000.60 Defense Industrial Capabilities Assessments
- DOD 5000.60H Assessing Defense Industrial Capabilities
- DOD 4140.1-R Supply Chain Management Regulation
- DoDM 4140.1 DoD Supply Chain Management Procedures, Feb 2014
- MRL Deskbook Version 2016
- Technology Readiness Assessment Guidance, Apr 2011
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999

G.3. Identify Scale-Up Risk

Manufacturing and Quality Tasks

As early as technology development, key knowledge must be obtained on critical manufacturing processes, production scale-up efforts, and potential supply chain issues. Risk considerations should include:

- Manufacturing processes and techniques not currently available;
- Design producibility risks;
- Probability of meeting delivery dates;
- Potential impact of critical and long-lead time material;
- Production equipment availability;
- Production unit cost goal realism;
- Cost and production schedule estimates to support management reviews;
- Manufacturing feasibility and cost and schedule impact analyses to support trade-offs among alternatives;
- Recommendations for anticipated production testing and demonstration efforts; and
- Methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials.
- All manufacturing processes and techniques are currently available and used on pilot-line.
- There are no design producibility risks.
- There are no production manpower constraints.
- There are no capacity constraints.
- There is a high probability of meeting delivery dates.
- Potential impact of critical and long-lead time material is minimal.
- There are no production equipment availability issues.
- Production unit cost goal realism verified on pilot-line.
- All cost and production schedule estimates support management estimates.
- Manufacturing feasibility and cost and schedule impact analyses support all trade-offs among alternatives.
- Supply chain is stable and adequate to support FRP.

- Recommendations for anticipated production testing and demonstration efforts implemented.
- Special handling procedures applied in production representative environment.
- Special handling procedures developed and annotated on work instructions for pilot line incorporated into production line.
    - Special handling procedures applied in production representative environment.
- All special handling procedures demonstrated.
- Special handling issues pose no significant risk for LRIP/FRP.
- Special handling procedures applied in LRIP environment.
- Special handling procedures demonstrated in LRIP.
- Special handling issues pose no significant risk for FRP.
- Special handling procedures effectively implemented in FRP.
- All work instructions contain special handling provisions as required.
- Material is controlled to specification in FRP.

Metrics

Have you obtained key knowledge on critical manufacturing processes, production scale-up efforts, and potential supply chain issues? You should include the following risk considerations:

- Have you identified any manufacturing processes and techniques that are not currently available?
- Have you identified any design producibility risks?
- Have you identified a high probability of meeting delivery dates?
- Have you identified the potential impact of critical and long-lead time material?
- Have you identified any production equipment availability issues?
- Have you verified that all production unit cost goals are realistic?
- Have you verified that all cost and production schedule estimates support management reviews?
- Have you verified that all manufacturing feasibility and cost and schedule impact analyses that supports trade-offs among alternatives?
- Have you verified all recommendations for anticipated production testing and demonstration efforts?
- Have you validated all methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials?
- Have you verified that all manufacturing processes and techniques are currently available and used on pilot-line?
- Have you verified that there are no design producibility risks?
- Have you verified that there are no production manpower constraints?
- Have you verified that there are no capacity constraints?
- Have you verified that there is a high probability of meeting delivery dates?
- Have you verified that the potential impact of critical and long-lead time material is minimal?
- Have you verified that there are no production equipment availability issues?

- Have the production unit cost goal realism been verified on the pilot-line?
- Do all cost and production schedule estimates support management estimates?
- Do manufacturing feasibility and cost and schedule impact analyses support all trade-offs among alternatives?
- Is the supply chain stable and adequate to support FRP?
- Have the recommendations for anticipated production testing and demonstration efforts been implemented?
- Have special handling procedures been applied in a production representative environment?
- Have special handling procedures been developed and annotated on work instructions for the pilot line been incorporated into the production line instructions?
    - Have the special handling procedures been applied in the production representative environment?
- Have all special handling procedures been demonstrated?
- Have you verified that special handling issues pose no significant risk for LRIP/FRP?
- Have special handling procedures been applied in the LRIP environment?
- Have special handling procedures been demonstrated in LRIP?
- Have you verified that special handling issues pose no significant risk for FRP?
- Have special handling procedures been effectively implemented in FRP?
- Do all work instructions contain special handling provisions as required?
- Have you verified that material is controlled to specification in FRP?

Tools

Cost and Lead Time Worksheet
Producibility Assessment Worksheet
Manufacturing Readiness Assessment Materials Thread
ManTech Strategic Plan

Resources

Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
MRL Deskbook Version 2016
MRL Users Guide
DoD Directive 4200.15, ManTech
Air Force Technology Development and Transition Strategy Guidebook, Nov 2010

G.4. Review Contractor Supply Chain Management (SCM) Program

The DoD has many supply chains and these chains are a multibillion- dollar business. However, many SCM best practices have not been incorporated into the DOD supply chain uniformly because the DOD supply chain is a conglomeration of different supply chains managed under different organizational structures. Some of these supply chains have a logistics view and some have an

acquisition view. In many cases, these different supply chains are linked only by the fact that they provide supplies to DOD personnel. Because the DOD supply chain is enormous, making it even slightly more efficient could result in tremendous cost savings.

Manufacturing and Quality Tasks

- Review SCM for:
  - Strategic partnerships exist with vendors and suppliers.
  - Stronger collaboration of information (especially forecasting data).
  - Reducing lead times on the critical path.
  - Reducing variability.
  - Supply Chain Planning.
  - Demand Planning.
  - Vendor Managed Inventory.
  - Supplier Management.
  - Procurement.
  - Strategic Sourcing.
  - Warehouse Management.
  - Transportation Management.
  - Order Fulfillment.
  - Contract Management.
- Effective supply chain management process in place.
  - Assessment of critical first tier supply chain completed.
- Supply chain adequate to support LRIP/FRP.
  - Assessment of critical second and lower tier supply chain completed.
- Supply chain proven and supports FRP requirements.

Metrics

- Have you reviewed SCM for the following considerations?
  - Have you verified that strategic partnerships exist with vendors and suppliers?
  - Have you verified strong collaboration of information (especially forecasting data)?
  - Have you verified reductions in lead times on the critical path?
  - Have you verified reductions in variability?
  - Have you verified ongoing Supply Chain Planning?
  - Have you verified ongoing Demand Planning?
  - Have you verified Vendor Managed Inventory levels?
  - Have you verified ongoing Supplier Management?
  - Have you verified strong Procurement policies and procedures?
  - Have you verified ongoing Strategic Sourcing?
  - Have you verified ongoing Warehouse Management?

- Have you verified ongoing Transportation Management?
- Have you verified ongoing Order Fulfillment?
- Have you verified ongoing Contract Management?

- Have you verified that an effective supply chain management process is in place?
  - Have you completed an assessment of the critical first tier supply chain?
- Have you verified that the supply chain is adequate to support LRIP/FRP?
  - Have you completed an assessment of the critical second and lower tier supply chain?
- Have you verified that the supply chain has been proven and supports FRP requirements?

Tools

- AS5553 Supply Chain Assessment
- DCMA Material Management and Accounting System Audit
- Manufacturing Readiness Assessment using the Material thread

Resources

- AS6500, Manufacturing Management Systems
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS9100, Quality Management Systems
- ISO 9001, Quality Management Systems
- IEEE 15288.2, System and Software Engineering, 2015
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- AS9103 Variation Management of Key Characteristics
- AS9133, Qualification Procedure for Aerospace Standard Parts
- AS5553, Counterfeit Electronics Parts
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.02, Enclosure 14
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

G.5. Analyze Materials Lead Time

Production lead time is the time interval between when the item is put under contract and the initial delivery of the first unit(s). Defense systems typically exhibit lead time volatility due to the

complexity of the product and complexity of the acquisition process. Lead time analysis begins with the customers' need date. The start date for contractor activity is normally based on a setback from the customers' need date. The setback is dictated by the operation flow times and the material, component and tooling lead times. Often these lead times can be very long (over a year) and may require long lead funding. Lead times may include the time it takes to place orders for long lead materials, components and tooling, transportation time for those items, receiving/inspection, fabrication, assembly, inspection and testing, packaging and shipping. It will also include the wait time in the systems as work-in-progress as the item sits in a cue waiting for the next operation. In a complex manufacturing/assembly process with several different production paths, the critical path will dictate the lead time, which will be the longest path.

When the lead time is in error, two possible problems exist. If the lead time estimate is excessive, the funds requirement will be established unnecessarily early. This may lead to an overstatement of the lead-time funding requirement and could result in funds being drawn unnecessarily from other areas of need. If the lead time estimate is understated, specific contractor activities could experience a start date that will not support the required delivery date without the expenditure of premium effort, resulting in higher than necessary program cost or even potential schedule slippage. The impact of lead time variations on a particular program can be minimized but requires management attention. Tools like JIT, Supplier Partnerships, Lean, Six Sigma and Theory of Constraints can be used to minimize the cycle time.

Manufacturing and Quality Tasks

- No potential Long Lead Items issues.
- Analyze lead time fluctuations do not impact schedule.
- Ensure government funding is aligned with contractor long lead requirements.
- Long lead procurement initiated for LRIP/FRP.
- Long lead procurement initiated for FRP.
- Availability issues pose no significant risk for FRP.
- Long term agreements in place where practical.

Metrics

- Have you verified that there are no potential Long Lead Items issues?
- Have you verified that an analysis of lead time fluctuations does not impact schedule?
- Have you ensured government funding is aligned with contractor long lead requirements?
- Have you verified that long lead procurement has been initiated for LRIP/FRP?
- Have you verified that long lead procurement initiated for FRP?
- Have you verified that material availability issues pose no significant risk for FRP?
- Have you verified that long term agreements are in place where practical?

Tools

- Cost and Lead Time Estimating Worksheet

Resources

- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide, Oct 2005
- MRL Deskbook Version 2016, Materials Management thread

G.6. Investigate Alternate Source Options – primarily a contractor function

Parts management is a design strategy that seeks to reduce the number of unique or specialized parts used in a system (or across systems) to reduce the logistic footprint and lower total life-cycle costs. In addition, it also will enhance the reliability of the system and mitigate parts obsolescence because of Diminishing Manufacturing Sources and Material Shortages. Parts management is an important design consideration and should be used whenever parts are not defined based on open systems design interfaces or commercial off-the-shelf (COTS) items.

A part is one piece, or two or more pieces joined together, that is not normally subject to disassembly without destruction or impairment of intended design use. A part is the lowest configuration item of the system design that would be implemented and verified. Parts are defined in performance-based terms by their form, fit, function, and interfaces.

The parts management strategy should cover the entire life cycle of a system and be based on the fundamental systems engineering processes. The parts management strategy should also be evaluated at technical reviews, in particular, the Preliminary Design Review and Critical Design Review.

The SEP should address the parts management strategy, including the need for a parts management plan. A parts management plan typically includes the following:

- Specification of parts selection criteria based on objectives in the Acquisition Strategy Report and overall support strategy,
- Identification of a preferred parts list,
- Definition of the processes for conducting trade-off analysis, parts selection, inclusion of configuration identification status and related change decisions in the technical baseline, and approval and
- documentation of non-preferred parts, and
- Discussion of how parts management considerations will flow down to suppliers.

Parts selection should be based on trade-off and cost-benefit analyses that are conducted in accordance with the program's parts strategy and management plan, as derived from the overall acquisition and sustainment strategies. Selected parts should be documented in a parts list, which is under configuration management of the overall technical baseline.

Manufacturing and Quality Tasks

- Understand quality, and manufacturing recommendations for the Diminishing Manufacturing Sources and Material Shortages (DMSMS) plan.
- Understand contractor's analysis of the Government and Industry Data Exchange Program (GIDEP) database for configuration items that are susceptible to DMSMS issues.
- Review contractor's DMSMS recommendations for the program risk management plan.

Metrics

- Do you understand the quality, and manufacturing recommendations for the DMSMS) plan?
- Do you understand the contractor's analysis of the GIDEP database for configuration items that are susceptible to DMSMS issues?
- Have you reviewed contractor's DMSMS recommendations for the program risk management plan?

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit
- Make or Buy Plans

Resources

- DFAR 15.407-2 Make or Buy Programs
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- Contractor Purchasing System Review (CPSR) Guidebook, May 2017
- MRL Deskbook Version 2016, Materials Management thread
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material

G.7. Work with contractor to identify Alternate Sources

Manufacturing and Quality Tasks

- Single/Sole/Foreign Sources identified.
- Potential alternative sources identified.
- Qualification plans in place.

Metrics

- Have you identified Single/Sole/Foreign sources?
- Have you identified potential alternative sources?
- Do you have qualification plans in place?

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit
- Make or Buy Plans

Resources

- DFAR 15.407-2 Make or Buy Programs
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- Contractor Purchasing System Review (CPSR) Guidebook, May 2017
- MRL Deskbook Version 2016, Materials Management thread
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material

G.8. Document Design to Cost (DTC)

The Design to Cost (DTC) approach was created in the mid-1970's as a cost cutting initiative. The underlying objective of DTC was to identify cost drivers early in the systems life cycle so that trade-off decisions could be considered and ways to mitigate those costs identified. DTC accomplished this by making cost a design parameter by constraining design options to a fixed cost limit. The focus of DTC at that time was on designing the system to minimize development and production costs for a particular performance level with little or no attention given to reducing operating and support (O&S) costs.

DTC is a management concept that historically emphasized cost-effective design (minimizing cost while achieving performance) and targeting an Average Unit Procurement Cost (AUPC). DTC concentrates on the contractors' activities associated with tracking/controlling costs and performing cost-performance analyses/tradeoffs. Cost as an Independent Variable (CAIV) came along in 1996 and refocused DTC to consider cost objectives for the total life cycle of the program and to view CAIV with the understanding it may be necessary to trade off performance to stay within cost objectives and constraints. DTC is now those actions that are undertaken to meet cost objectives through explicit design activities. DTC has fallen into disuse since the development of CAIV and the emphasis on fixed price production contracts.

Manufacturing and Quality Tasks

- Analyze costs using pilot-line system/sub-system actuals to ensure target costs are achievable.
- Update cost models with design requirements, material specifications and pilot-line results.

Metrics

- Have you analyzed costs using pilot-line system/sub-system actuals to ensure target costs are achievable?
- Have you updated cost models with design requirements, material specifications and pilot-line results?

Tools

- Cost Estimate (based on actuals)

Resources

- GAO-09-3SP GAO Cost Estimating and Assessment Guide, Mar 2009
- MIL-HDBK-766, Design to Cost, Aug 1989
- Dept. of Army Design to Cost Handbook, Jan 1990
- DFAR 207.103(B)(i)(i), Apply design to cost principles

G.9. Review Critical Sources

Lead times for defense materials and components can be long and volatile. There are various reasons for this situation, such as:

- Imbalances between capacity and demand;
- Competition from commercial suppliers;
- Poor quality and lack of process improvement;
- Production bottlenecks;
- Long testing cycles;
- Raw materials not available;
- Long contracting process;
- Lack of funding;
- Transportation; and
- Labor issues.

Lead times are severely impacted by capacity limitations. As orders increase beyond existing capacity, the contractor has the option to increase capacity or to add new orders to backlog. For a contractor with a reasonably steady demand and no capacity expansion, increasing backlog increases lead time. When these lead time increases are communicated to customers, their response to the lead time is to issue orders immediately to ensure material availability. With constant capacity, these new orders must also be added to backlog, which must then be reflected in increased lead time. As this self-fueling process, often called the lead time capacity syndrome, continues, a relatively small increase in demand can result in extremely large increases in lead times.

Some commodities, like electronics, have long lead times. In the case of electronics, especially space qualified electronics it is the testing that makes the items have a long lead issue. Steady- state life

testing is performed to demonstrate the quality and reliability of devices by subjecting them to specified operational conditions over an extended period of time. The standard steady- state life test is 1,000 hours for many items. Corrosion testing can take up to 240 hours, and burn-in testing could be as long as 700 hours. Many space qualified electronic devices have a lead time measured in months, often due to testing requirements and lack of competition.

Natural disasters, such as the earthquake and tsunami that hit Japan in 2011 displaced nearly half a million people and severely disrupted production operations in Japan for many industries. The impact to production was so severe that automobile production for Toyota, Honda and Nissan were all slowed down, even at U.S. plants due to the lack of parts.

The area of component and material lead time is extremely critical to meeting program schedules and defining long lead and advanced buy requirements. The program office should maintain continuing visibility of the current status of and the forecast changes in lead times.

Manufacturing and Quality Tasks

- Verify LRIP/FRP material availability.
- Conduct an assessment of the LRIP/FRP bill of materials using pilot-line activity.
    - Identify key and/or critical components in the LRIP/FRP Bill of Materials (BOM).
    - Analyze key and/or critical components in the LRIP/FRP BOM for potential issues.
- Validate material maturity based on pilot-line.
    - Validate that the properties and characteristics of the material to be used for the LRIP/FRP system meet requirements.
    - Determine that the material's properties and manufacturing characteristics are predictable.
    - Assess the properties of the material for basic manufacturability.
- Develop mitigation strategies for quality and manufacturing related supply chain counterfeit and anti-tamper and related exportability risks.
- Conduct an assessment of the materials planning systems. Identify materials planning systems being employed by the contractor or facility.
- Update Critical Suppliers List.
- Program is in FRP with no significant material availability issues.

Metrics

- Have you verified LRIP/FRP material availability?
- Have you conducted an assessment of the LRIP/FRP bill of materials using pilot-line activity?
    - Have you identified key and/or critical components in the LRIP/FRP BOM?

  - Have you analyzed key and/or critical components in the LRIP/FRP BOM for potential issues?
- Have you validated material maturity based on pilot-line actuals?
  - Have you validated that the properties and characteristics of the material to be used for the LRIP/FRP system meet requirements?
  - Have you determined that the material's properties and manufacturing characteristics are predictable?
  - Have you assessed the properties of the material for basic manufacturability?
- Have you developed mitigation strategies for quality and manufacturing related supply chain counterfeit and anti-tamper and related exportability risks?
- Have you conducted an assessment of the materials planning systems. Have you identified the materials planning systems being employed by the contractor or facility?
- Have you updated the Critical Suppliers List?
- Have you verified that the program is in FRP with no significant material availability issues?

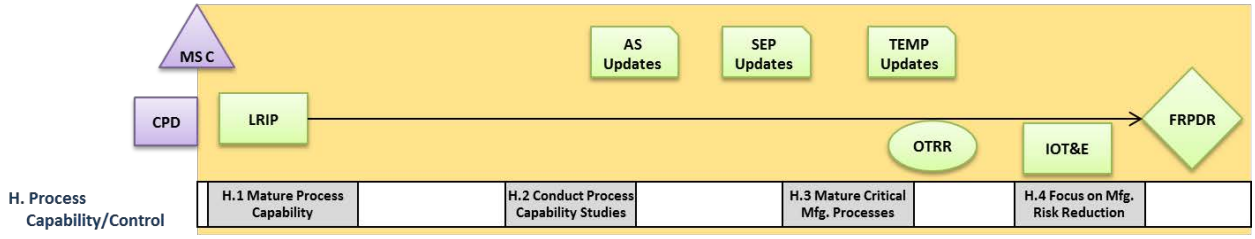
Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit

Resources

- DFAR 15.407-2 Make or Buy Programs
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- Contractor Purchasing System Review (CPSR) Guidebook, May 2017
- MRL Deskbook Version 2016, Materials Management thread
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328, Dec 16
- MRL Deskbook Version 2016

H. PROCESS CAPABILITY/CONTROL



H.1. Identify Required Process Capability

The purpose of the P&D Phase is to produce items for the warfighter that achieve operational capability and satisfy mission needs. In order to achieve those goals the items being produced must have achieved design stability, had their technologies matured and their manufacturing processes must be capable, stable and under control. There are essentially two related production efforts during the P&D phase: LRIP and FRP. LRIP is often identified as up to 10% of the estimated production volume.

LRIP typically demonstrates the production of articles beyond a pilot line environment. These items are typically built in a pilot line environment. All systems engineering/design requirements should have been met such that there are minimal system changes. Major system design features are stable and have been proven in test and evaluation. Materials are available to meet planned rate production schedules. Manufacturing process capability in a low-rate production environment is at an appropriate quality level to meet design key characteristic tolerances. Production risk monitoring is ongoing. LRIP cost targets have been met, and learning curves have been analyzed with actual data. The cost model has been developed for FRP environment and reflects the impact of continuous improvement.

It is essential to fully understand present and future process capabilities to ensure that, as new or improved processes mature, they can be readily introduced into manufacturing with no detrimental effects to producibility. Predicting future capabilities is especially important in markets like the electronics industry where product or process obsolescence forces the rapid development and use of new technology. Future process capabilities in this context means more than advanced, new processing techniques. It also means being cognizant of processes used by competitors or manufacturers in different industries and adapting those processes if, and when, it is appropriate.

Manufacturing and Quality Tasks

- Models/simulation verified by LRIP build, assists in management of LRIP, and determines that FRP requirements can be met.

- Ensure manufacturing process documentation is being developed concurrently with the product specification to ensure the design is producible, supportable, and affordable.
- Ensure models/simulation were used to determine system constraints and identify improvement opportunities.
- Verify models/simulation with pilot-line builds.
    - Results used to improve process and determine that LRIP/FRP requirements can be met.
- Ensure manufacturing processes were demonstrated on a pilot-line.
    - Continue collecting or estimating process capability data.
- Ensure manufacturing processes have been verified for LRIP/FRP on a pilot-line.
    - Process Capability data from pilot line meets target.
- Verify process capability requirements have been refined.
- Models/simulation verified by FRP build.
- Production simulation models used as a tool to assist in management of FRP.

Metrics

- Have you verified that the LRIP Models/simulation assists in management of LRIP, and demonstrates that the FRP requirements can be met?
- Have you ensured that manufacturing process documentation is being developed concurrently with the product specification to ensure the design is producible, supportable, and affordable?
- Have you ensured models/simulation were used to determine system constraints and identify improvement opportunities?
- Have you verified the models/simulation with pilot-line builds?
    - Have you used the results to improve process and determine that LRIP/FRP requirements can be met?
- Have you ensured that manufacturing processes were demonstrated on a pilot-line?
    - Have you continued collecting or estimating process capability data?
- Have you ensured manufacturing processes have been verified for LRIP/FRP on a pilot-line?
    - Have you verified that the Process Capability data from pilot line meets target?
- Have you verified process capability requirements have been refined?
- Have you verified models/simulation by the FRP build?
- Have you verified production simulation models used as a tool to assist in management of FRP?

Tools

- MRL Assessment using Process Capability and Control Thread
- Critical to Quality Tree

Resources

- Capability-Based Assessment (CBA) Handbook, Mar 2014
- MRL Deskbook Version 2016

H.2. Initiate Process Capabilities Studies

Manufacturing Process Capability Analysis determines the available manufacturing capacity and its capability to produce the desired end item without special controls. It is a critical activity in producibility analysis. This normally includes analysis of the degree of process variability, the causes of variability and the definition of methods to reduce it.

Manufacturing and Quality Tasks

- Manufacturing processes are stable, adequately controlled, capable, and have achieved program LRIP objectives.
- Evaluate yields and rates from pilot-line actuals against production targets and the results are used to feed improvement plans.
- Validate pilot-line actuals support production targets.
- Refine yields and rates required to begin LRIP using pilot-line results. Update ongoing improvement plans.
- Ensure key processes are identified and their status briefed at all major reviews.

Metrics

- Have you verified that manufacturing processes are stable, adequately controlled, capable, and have achieved program LRIP objectives?
- Have you evaluated yields and rates from pilot-line actuals against production targets and the results are used to feed improvement plans?
- Have you validated that pilot-line actuals support production targets?
- Have you verified and refined yields and rates required to begin LRIP using pilot-line results?
- Have you updated ongoing improvement plans?
- Have you ensured key processes are identified and their status briefed at all major reviews?

Tools

- MRL Assessment using Process Capability and Control Thread
- Process Capability Studies (Cp and Cpk assessment)
- Producibility Assessment Worksheet (PAWs)
- Six Sigma Worksheet
- First Pass Yield Estimates Worksheet

Resources

- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program, May 2008

- DoD Continuous Process Improvement Transformation Guide, May 2006
- Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
- MRL Deskbook Version 2016

H.3. Mature Critical Manufacturing Processes

DoDI 5000.02 requires that Program Managers and their technical staff; "Develop an affordable and executable manufacturing" process during the EMD Phase. The Post-CDR assessment will include a demonstration that the "maturity of critical manufacturing processes has been accomplished. EMD shall end when "manufacturing processes have been effectively demonstrated in a pilot line environment" **prior to Milestone C**.

Manufacturing and Quality Tasks

- Manufacturing processes are stable, adequately controlled, capable, and have achieved program FRP objectives.
- Manufacturing Process Demonstration includes the development of affordable and executable manufacturing processes, the completion of system fabrication, production of test articles so that you can demonstrate system integration, interoperability, supportability, safety and utility.
- Additional processes requirements may include such items as cleaning, heat treatment, clean room controls, controlled testing and special handling (i.e., personal grounding requirements for electronic components).
- All processes must be identified in the design documentation.
- Processes that contributed manufacturing risk to the program must be proofed on the pilot-line.
    - Ensure that the pilot-line process can repeatedly produce conforming hardware within the cost and time constraints of the production phase.
    - Evaluate expected pilot-line process yields for each critical process and indicate the statistical or other method used to maintain control of process performance.
    - Ensure proofing is accomplished in an environment that simulates actual production conditions (typically a pilot-line environment).
    - These pilot-line conditions include the physical facilities, personnel and manufacturing documentation.
    - It may also be necessary for the contractor to establish training and certification programs for the shop personnel to ensure that the pilot-line process capabilities can be attained on a recurring basis.
    - Environmental and safety regulations and standards are an integral part of the production planning and are compliant with federal, state, and industry standards and laws. Their effects on the cost of production operations are known.

Metrics

- Have you verified that manufacturing processes are stable, adequately controlled, capable, and have achieved program FRP objectives.
- Have you verified that Manufacturing Process Demonstration includes the development of affordable and executable manufacturing processes, the completion of system fabrication, production of test articles so that you can demonstrate system integration, interoperability, supportability, safety and utility.
- Have you verified that additional processes requirements may include such items as cleaning, heat treatment, clean room controls, controlled testing and special handling (i.e., personal grounding requirements for electronic components).
- Have you verified that all processes must be identified in the design documentation.
- Have you verified that processes that contributed manufacturing risk to the program must be proofed on the pilot-line.
    - Have you ensured that that the pilot-line process can repeatedly produce conforming hardware within the cost and time constraints of the production phase?
    - Have you evaluated the expected pilot-line process yields for each critical process and indicate the statistical or other method used to maintain control of process performance?
    - Have you ensured that proofing is accomplished in an environment that simulates actual production conditions (typically a pilot-line environment)?
    - Have you verified that pilot-line conditions include the physical facilities, personnel and manufacturing documentation?
    - Have you verified that it may be necessary for the contractor to establish training and certification programs for the shop personnel to ensure that the pilot-line process capabilities can be attained on a recurring basis?
    - Have you verified that environmental and safety regulations and standards are an integral part of the production planning and are compliant with federal, state, and industry standards and laws and their effects on the cost of production operations are known?

Tools

- MRL Assessment using Process Capability and Control Thread
- Production Part Approval Process (PPAP)
- Process Capability Assessment

Resources

- MRL Deskbook Version 2016
- DoDI 5000.02

H.4. Focus on Manufacturing Risk Reduction

DOD has increased management focus on manufacturing and quality management throughout the program phases. There are significant costs associated with the manufacturing effort. These costs, to

a great degree, are inherent in the design. As a design evolves, certain costs become essentially fixed. Given the objective of minimizing cost and the existence of projections that indicate limited dollars are available for future manufacturing effort, it is vital that PMs identify costs at the point when they are being fixed. Understanding the cause and effect relationships between these early decisions provides the justification for early assessments.

Manufacturing and Quality Tasks

- Variability experiments conducted to show FRP impact and potential for continuous improvement.
- EMD typically includes the demonstration of production prototype articles or engineering development models. These items are typically built in a pilot-line environment.
- When the industrial capabilities are in place and the prototype items achieve their requirements as validated through testing, then the program can exit EMD and enter LRIP/Production.
- LRIP yield and rate targets achieved.
- Yields and rates required to begin FRP refined using LRIP results. Yield improvements ongoing.
- FRP yield and rate targets achieved.
- Yield improvements ongoing.
- Process capability goes beyond machine capability. Ensure it also includes the effects of changes in:
    - workers,
    - materials,
    - fabrication methods,
    - tooling and equipment,
    - set-up, and other process conditions.

Metrics

- Have you conducted variability experiments to show FRP impact and the potential for continuous improvement?
- Did EMD include the demonstration of production prototype articles or engineering development models? Were these items built in a pilot-line environment?
- Were the industrial capabilities in place and the did the prototype items achieve their requirements as validated through testing, before the program exited EMD and entered LRIP/Production?
- Were the LRIP yield and rate targets achieved?
- Were the yields and rates required to begin FRP refined using LRIP results? Are yield improvements ongoing?
- Were FRP yield and rate targets achieved? Are yield improvements ongoing?
- Does process capability extend beyond machine capability? Have you ensured it also includes the effects of changes in:

- workers,
- materials,
- fabrication methods,
- tooling and equipment,
- set-up, and other process conditions?

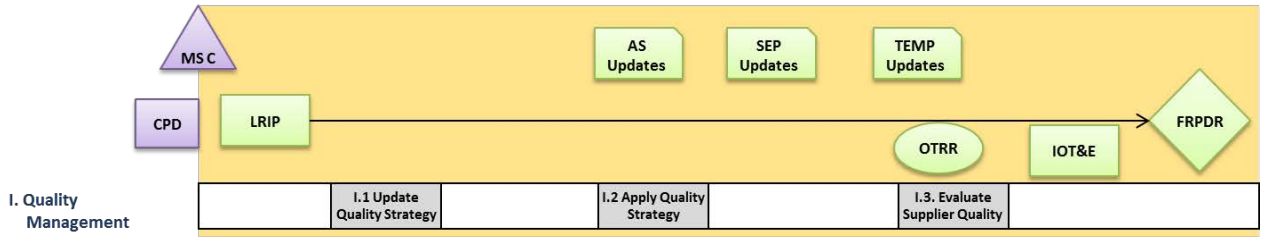
Tools

- LRIP demonstrated
- FRP demonstrated

Resources

- AS6500 Manufacturing Management Program
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- DoDI 5000.02
- MRL Deskbook Version 2016, Process Capability and Control thread

I. QUALITY MANAGEMENT



I.1. Update Quality Strategy based on pilot-line results

Examine a program to determine if the design is ready for production and if the prime contractor and major subcontractors have accomplished adequate production planning without incurring unacceptable risks that will breach thresholds of schedule, performance, cost, or other established criteria. The Production Readiness Review examines risk; it determines if production or production preparations identify unacceptable risks that might breach thresholds of schedule, performance, cost, or other established criteria. The review evaluates the full, production-configured system to determine if it correctly and completely implements all system requirements. The review determines whether the traceability of final system requirements to the final production system is maintained.

At this review, the Integrated Product Team (IPT) should review the readiness of the manufacturing processes, the quality management system, and the production planning (i.e., facilities, tooling and test equipment capacity, personnel development and certification, process documentation, inventory management, supplier management, etc.). A successful review is predicated on the IPT's determination that the system requirements are fully met in the final production configuration, and that production capability forms a satisfactory basis for proceeding into LRIP and FRP.

The program manager should convene a PRR of the prime contractor and major subcontractors, as applicable. The PRR(s) should be conducted in an iterative fashion, concurrently with other technical reviews, such as the CDR, during the EMD phase. Periodic production readiness assessments should be conducted during System Capability and Manufacturing Process Demonstration to identify and mitigate risks as the design progresses. The 'final' PRR should occur at the completion of the EMD phase and the start of the Production and Deployment phase. The final PRR should assess the manufacturing and quality risk as the program proceeds into LRIP and FRP.

Manufacturing and Quality Tasks

Ensure the following quality of design attributes are represented as Key Performance Parameters:

- Performance,
- Reliability,
- Availability, and
- Maintainability
- Government-furnished information (GFI) is confirmed by the PMO to meet system requirements and to be available, complete, and supportable.

Metrics

Have you ensured the following quality of design attributes are represented as Key Performance Parameters?

- Performance,
- Reliability,
- Availability, and
- Maintainability
- GFI is confirmed by the PMO to meet system requirements and to be available, complete, and supportable?

Tools

- Acquisition Strategy Template
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread

Resources

- DSMC Acquisition Strategy Guide, Dec 1999
- AFMC Instruction 63-145 Manufacturing and Quality (Draft)
- AS9100, Quality Management System – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- FAR 52.246-11, Quality

- MRL Deskbook Version 2016
- DAG Chapter 14.3.1.3.6 Quality Plans

I.2. Apply Quality Strategy

For the FRP Decision Review Acquisition Strategy update, the Program Management Office should identify remaining risks prior to a production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality strategy/management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make- or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or handle remaining risks.

Manufacturing and Quality Tasks

- Quality targets verified on LRIP line.
- Continuous quality improvement ongoing.
- Establish quality targets.
- Collect and analyze quality data from the pilot-line and use results to feed improvement plans.
- Assess quality targets against pilot-line. These results feed continuous quality improvements.
- Quality targets verified on FRP line.
- Planned non-developmental item (NDI) or COTS items have been determined to meet program system performance and sustainment requirements through a defined acceptance process.

Metrics

- Have you verified quality targets on the LRIP line?
- Are continuous quality improvement activities ongoing?
- Have you established quality targets?
- Have you collected and analyzed quality data from the pilot-line and used the results to feed improvement plans?
- Have you assessed quality targets against the pilot-line? Did you use these results to feed continuous quality improvements?
- Have you verified quality targets on the FRP line?
- Have you determined the planned NDI or COTS items meet program system performance and sustainment requirements through a defined acceptance process?

Tools

- ISO 9001 QMS Audit Checklist

- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread

Resources

- AS9100, Quality Management System – Aerospace, Sep 2016
- AS9145 Requirements for Advanced Product Quality Planning and Production Part Approval Process
- ISO 9001, Quality Management System, Sep 2016
- MRL Deskbook Version 2016
- MIL-HDBK-896A
- DoD Risk, Issue, and Opportunity Management Guide, Jun 2015

I.3. Conduct Supplier Quality

Compliance to a standard such as ISO 9001 (available for purchase), or AS9100, does not, in itself, guarantee product or service quality. These standards are management system standards that identify requirements for processes within an organization, describe expected tasks and outcomes, and explain how the processes and tasks integrate to produce required inputs and outputs. Standards are meant to enable the organization to develop a set of processes that, if done by qualified persons using appropriate tools and methods with appropriate leadership involvement, will enable a capability for delivering high quality products or services.

Product or service quality is achieved through the implementation of a strategic plan to integrate all business and technical functions that result in the consistent application of proven, capable processes within an organization. Managers must ensure that all management systems are working toward the same goals and are not creating conflicting or dysfunctional behavior. Implementing a standard is of little use if the financial system rewards individuals for delivering non-conforming products/services. Because everything a contractor does should be related to the quality of its products or services, a contractor's quality management system should be the basis for integrating all other management systems within an enterprise.

Manufacturing and Quality Tasks

- Ensure acceptance testing of supplier products is adequate to begin FRP.
- Ensure supplier products have completed qualification testing and first article inspection.
- Ensure acceptance testing of supplier products is adequate to begin LRIP/FRP.
- Ensure Key Characteristics are being managed.
- Continuous quality improvement ongoing.

Metrics

- Have you ensured acceptance testing of supplier products is adequate to begin FRP.

- Have you ensured supplier products have completed qualification testing and first article inspection.
- Have you ensured acceptance testing of supplier products is adequate to begin LRIP/FRP.
- Have you ensured Key Characteristics are being managed.
- Have you ensured continuous quality improvements are ongoing.

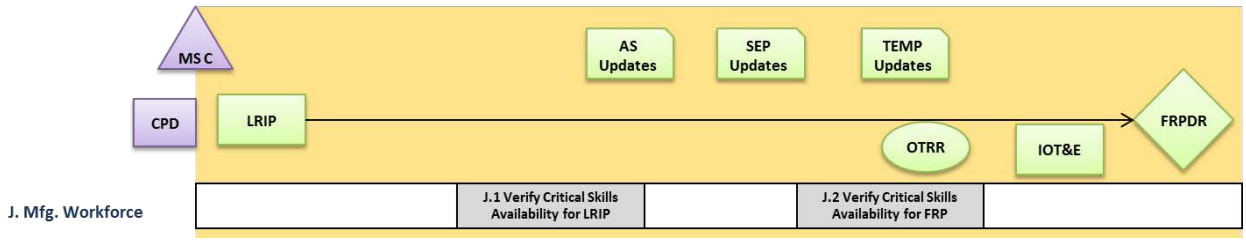
Tools

- Supplier QA Questionnaire
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread

Resources

- AS9100, Quality Management System – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- MRL Deskbook Version 2016
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, Jan 2017
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition, Sep 2016
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel, Jul 2014
- MRL Deskbook Version 2016

J. MANUFACTURING WORKFORCE



For either the LRIP or FRP Decision Review Acquisition Strategy update, the Program should identify remaining risks prior to the production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or handle remaining risks. Provide an assessment of manufacturing processes, including critical skills availability, and highlight the steps needed to progress from an EMD

manufacturing environment to an LRIP environment and to an FRP environment.

J.1. LRIP/FRP Critical Skills Availability (Prime and Sub level) verified using Pilot-Line experience

Manufacturing and Quality Tasks

- Identify LRIP/FRP manufacturing workforce resource requirements using pilot-line actuals.
    - Ensure required workforce availability forecast by monthly requirement against the LRIP/FRP schedule.
    - Ensure workforce training requirements forecast against the LRIP/FRP schedule.
    - Review any union agreements to ensure workforce/schedule compatibility.
- Plans have been developed to achieve LRIP/FRP requirements.
- Plans are updated to achieve LRIP workforce requirements.
- LRIP/FRP workforce is trained in a pilot line environment.

Metrics

- Have you identified LRIP/FRP manufacturing workforce resource requirements using pilot-line actuals?
    - Have you ensured required workforce availability forecast by monthly requirement against the LRIP/FRP schedule?
    - Have you ensured workforce training requirements are forecast against the LRIP/FRP schedule?
    - Have you reviewed any union agreements to ensure workforce/schedule compatibility?
- Have plans been developed to achieve LRIP/FRP requirements?
- Have plans been updated to achieve LRIP workforce requirements?
- Has the LRIP/FRP workforce been trained in a pilot line environment?

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis

- Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis (
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS6500, Manufacturing Management Systems
- AS9100, Quality Management System, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- Manufacturing Resource Planning (MRP II)

J.2. LRIP Critical Skills Availability (Prime and Sub level) verified for Production

Manufacturing and Quality Tasks

- Manufacturing workforce resource requirements identified for LRIP/FRP.
    - Required workforce availability forecast by monthly requirement against the LRIP schedule.
    - Workforce training requirements forecast against the LRIP schedule.
    - Review any union agreements to ensure workforce/schedule compatibility.
- Plans developed to achieve LRIP requirements.
- Plans updated to achieve FRP workforce requirements.
- LRIP personnel trained on pilot-line where possible.
- LRIP personnel requirements met.
- Implement plan to achieve FRP workforce requirements.
- FRP personnel requirements met.
- Production workforce skill sets maintained due to attrition of workforce.

Metrics

- Have manufacturing workforce resource requirements been identified for LRIP/FRP?
    - Are the required workforce availability forecast by monthly requirement against the LRIP schedule?
    - Are the workforce training requirements forecast against the LRIP schedule?
    - Have you reviewed any union agreements to ensure workforce/schedule compatibility?
- Have you developed plans to achieve LRIP requirements?
- Have you updated plans to achieve FRP workforce requirements?
- Have you ensured LRIP personnel are trained on pilot-line where possible?
- Have you ensured LRIP personnel requirements are met?
- Have you implemented a plan to achieve FRP workforce requirements?
- Have FRP personnel requirements been met?

- Have production workforce skill sets been maintained based on attrition of workforce?

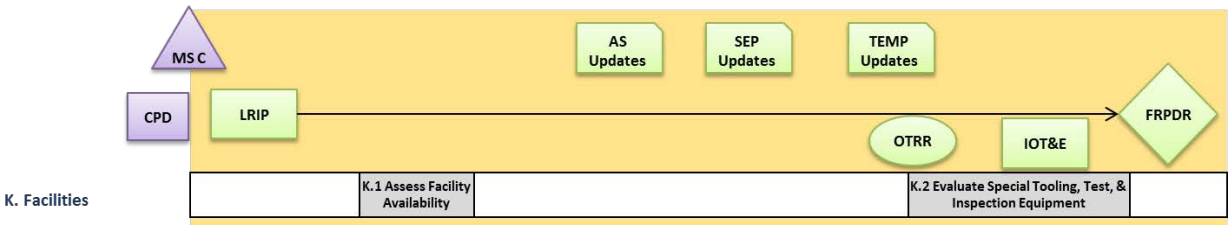
Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- AS6500, Manufacturing Management Systems
- AS9100, Quality Management System, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- Manufacturing Resource Planning (MRP II)

K. FACILITIES



Among the critical elements to be defined during EMD phase are the manufacturing processes which will be utilized to build the system. The sequence of manufacturing processes begins with the receipt of the raw material, where special handling and storage may be required. Additional processes requirements may include such items as cleaning, heat treatment, clean room controls, controlled testing and special handling (i.e., personal grounding requirements for electronic components). Identification of all processes must be a part of the design documentation. Where the selected processes contribute manufacturing risk to the program, the processes should be proofed during EMD. The purpose of proofing is to ensure that the process can repeatedly produce conforming

hardware within the cost and time constraints of the production phase. It is important that the proofing be accomplished in an environment that simulates actual production conditions (typically a pilot line environment). These conditions include the physical facilities, personnel and manufacturing documentation. It may also be necessary for the contractor to establish training and certification programs for the shop personnel to ensure that the process capabilities can be attained on a recurring basis.

The production facilities and equipment planning include all key functional groups that play a role in production operations.

K.1. Facility Availability (Prime and Sub level)

One of the most important elements of any production design is the definition of the manufacturing resources. No matter how good a design may be, it is useless if system or product cannot be built. It is therefore essential that availability of manufacturing resources be a consideration during the design review process. Manufacturing engineers should be a part of each design team to assure adequate consideration of availability of required manufacturing resources.

Manufacturing resources should not be limited to manufacturing methods, but should include materials, capital, manufacturing technology, facilities, qualified labor, and the management structure to effectively integrate them. The successful competitor, of the production phase will depend upon the efficient application of the full spectrum of these resources to the task of fabricating and delivering the defense system design.

Manufacturing and Quality Tasks

- Facility requirements identified for LRIP and Production using pilot-line actuals.
    - Facility requirements include the following:
        - Machine/Process availability.
        - Machine/Process floor space requirements (including feeding/storage/WIP/maintenance requirements).
        - Surge capability/requirements.
        - Pilot-Line to LRIP to Production Ramp-Up requirements.
        - Include critical Tooling/Special Tooling/Special Test Equipment requirements.
        - Include Soft/Limited and Hard/Durable Tooling needs.

These requirements should be time phased against the schedule to ensure they will meet the program's needs.

- Pilot-line facilities and capability demonstrated to fulfill LRIP/FRP requirements.
- Manufacturing facilities identified and plans developed to produce LRIP build.
- Manufacturing facilities adequate to begin LRIP.
- All tooling, test and inspection equipment proven in LRIP and requirements identified for FRP.

- Manufacturing equipment maintenance schedule demonstrated.
- Plans in place to support transition to FRP.
- Production facilities in place and capacity demonstrated to meet maximum FRP requirements.
- The choice of facilities is flexible enough to accommodate growth and avoid relocation of production operations that could negatively affect the transition to FRP.
- The choice of investment in new facilities factors in the impact of government changes in inventory objectives that often result in sustained low production rates for the life of the program.
- Contingency planning is considered in the manufacturing facility planning effort.
- Validate the physical layout of the production facilities dedicated to the program, including the flow of material, components, and product. Answer the following:
    - Does the layout plan maximizes efficiency, safety, and productivity and an encourage an environment that emphasizes cost-reduction?
    - Were computer-aided manufacturing tools used to design the manufacturing plant layout?
    - What was the process for determining the plant layout?
    - What internal disciplines within the company participated in the effort?
    - Does the program plan to use the "just-in-time" material supply approach?
    - How does this affect the plant layout?
    - How will the manufacturing facility accommodate growth or decreases in production rates?

Metrics

- Have you identified facility requirements for LRIP and Production using pilot-line actuals?
- Have you ensured that facility requirements include the following:
    - Machine/Process availability?
    - Machine/Process floor space requirements (including feeding/storage/WIP/maintenance requirements)?
    - Surge capability/requirements?
    - Pilot-Line to LRIP to Production Ramp-Up requirements?
    - Critical Tooling/Special Tooling/Special Test Equipment requirements?
    - Include Soft/Limited and Hard/Durable Tooling needs?

These requirements should be time phased against the schedule to ensure they will meet the program's needs

- Have pilot-line facilities and capability been demonstrated to fulfill LRIP/FRP requirements?
- Have manufacturing facilities been identified and plans developed to produce LRIP build?
- Have you insured manufacturing facilities are adequate to begin LRIP?
- Have all tooling, test and inspection equipment been proven in LRIP and all requirements identified for FRP?

- Has the manufacturing equipment maintenance schedule been demonstrated?
- Have plans been put in place to support transition to FRP?
- Are production facilities in place and capacity demonstrated to meet maximum FRP requirements?
- Is the choice of facilities flexible enough to accommodate growth and avoid relocation of production operations that could negatively affect the transition to FRP?
- Does the choice of investment in new facilities factor in the impact of government changes in inventory objectives that often result in sustained low production rates for the life of the program?
- Has contingency planning been considered in the manufacturing facility planning effort?
- Have you validated the physical layout of the production facilities dedicated to the program, including the flow of material, components, and product?
- In validating the manufacturing facility planning effort did you consider the following:
    - Does the layout plan maximizes efficiency, safety, and productivity and an encourage an environment that emphasizes cost-reduction?
    - Were computer-aided manufacturing tools used to design the manufacturing plant layout?
    - What was the process for determining the plant layout?
    - What internal disciplines within the company participated in the effort?
    - Does the program plan to use the “just-in-time” material supply approach?
    - How does this affect the plant layout?
    - How will the manufacturing facility accommodate growth or decreases in production rates?

Tools

- Manufacturing Readiness Level Assessment Questionnaire, Facilities thread
- DCMA Production Planning and Control Risk Assessment Checklist
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist

Resources

- DoDI 5000.02
- AS6500, Manufacturing Management Systems
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016
- DCMA-INST-204 Manufacturing and Production
- Risk, Issue, and Opportunity Management Guide

K.2. Special Tooling, Test, and Inspection Equipment

Special tooling and test equipment required for a program can be very expensive and take a long time to develop and procure. The general guidelines for planning for tooling and test equipment need to be established and established early. The issues include contractor investment, the level of rate tooling

and test equipment to be utilized, the transition from limited life to rate tools and the degree of similarity between production test equipment and depot test equipment to be required. Also, guidelines for calibrating and maintaining tools and test equipment need to be set forth.

Manufacturing and Quality Tasks

- Evaluate all documentation used to manage and account for Tooling, Special Tooling (ST), and Special Test Equipment (STE).
    - Documents directing tooling policy for proposed Tooling, ST and STE development including:
        - Limited/Soft Tooling
        - Durable/Hard Tooling
        - ST/STE needed for development and manufacture only.
        - ST/STE having possible mission support utility.
        - Already available government assets.
- Tooling, Test and Inspection equipment proven on pilot-line and additional requirements identified for LRIP/FRP.
- Proven tooling, test and inspection equipment in place to support maximum FRP.
- The program ensures that adequate production test infrastructure, resources, and facilities are available.
- Planned equipment maintenance schedule achieved.
- Production tooling and STE/special inspection equipment (SIE) design and development efforts underway.
- Manufacturing equipment maintenance strategy developed and demonstrated on pilot-line.

Metrics

- Have you evaluated all documentation used to manage and account for tooling, ST/STE.
    - Did you evaluate documents directing tooling policy for proposed Tooling, ST and STE development including:
        - Limited/Soft Tooling?
        - Durable/Hard Tooling?
        - ST/STE needed for development and manufacture only?
        - ST/STE having possible mission support utility?
        - Already available government assets?
- Have Tooling, Test and Inspection equipment been proven on pilot-line and any additional requirements identified for LRIP/FRP?
- Is proven tooling, test and inspection equipment in place to support maximum FRP?
- Did the program ensure that adequate production test infrastructure, resources, and facilities are available?
- Did you achieve the planned equipment maintenance schedule?

- Are Production Tooling and STE/SIE design and development efforts underway?
- Have manufacturing equipment maintenance strategy been developed and demonstrated on the pilot-line?

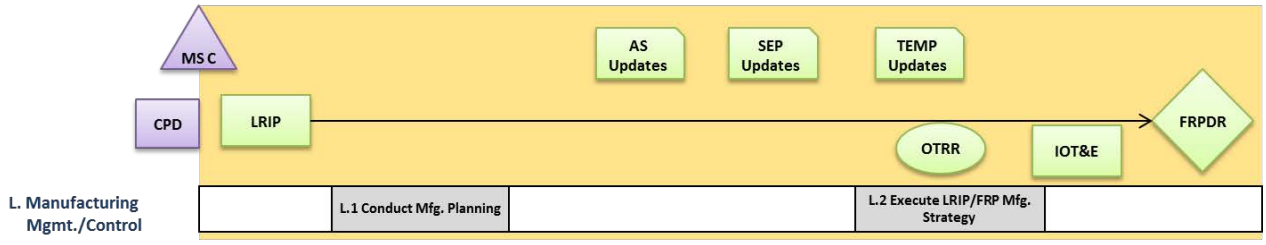
Tools

- DCMA Production Planning and Control Risk Assessment Checklist
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- Rough Cut Capacity Planning Spreadsheet
- Material Requirements Planning
- Capacity Requirements Planning Assessment Worksheet
- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Manufacturing Resource Planning (MRPII)
- Manufacturing Readiness Level (MRL) Assessment Questionnaire, Facilities thread
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- FAR Part 2, §2.101 Definitions
- AS6500, Manufacturing Management System, Sep 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016
- Manufacturing Resource Planning (MRP II)
- DCMA-INST-204 Manufacturing and Production

L. MANUFACTURING MANAGEMENT/CONTROL



L.1. Manufacturing Planning

Manufacturing involves the process of transforming raw materials into finished products. This transformation is accomplished through the use of contractor resources which can include basic raw materials, to expensive facilities, human skills, machines and capital investments. The purpose of manufacturing planning is the identification of these resources and their integration into a structure that provides the capability to achieve production objectives. The PM and the system contractor(s) need to identify the actions to develop that structure. The issue of manufacturing risk assessment and

its application to the planning process must be described. Risk assessment is intended to identify gaps in capabilities so that the PM can identify investment strategies allocate resources against those risks and gasp. Risk assessment, one of the PM's significant manufacturing tasks during development - is an element which is required to be addressed throughout the acquisition life cycle and during the various technical reviews and in the milestone review process. The primary manufacturing planning and scheduling challenge to the PM involves measuring the qualitative and quantitative manufacturing resources required for production.

Manufacturing and Quality Tasks

- Manufacturing plan updated for FRP.
  - All of the information necessary to plan the detailed manufacturing operations for the system should be available to the contractor.
  - This information must be described in a contractor's manufacturing plan covering:
    - Manufacturing organization including who is responsible, organization charts, points of contact.
    - Manufacturing Management System including how materials and parts are ordered, structure order for parts and components, and track a project to produce the end item.
    - How all manufacturing risks are being tracked and mitigated.
  - Manufacturing Management Program describing manufacturing strategy including:
    - Program manufacturing time-phased schedule,
    - Manpower Plan,
    - Industrial facilities capacity assessment,
    - Surge and Mobilization capacity assessment,
    - Manufacturing risk assessment,
    - Capital investment commitment,
  - Manufacturing Program Planning including:
    - Producibility Program Plan,
    - Make-or-Buy Criteria including considerations used in making decisions
  - Conservation of critical/strategic materials
  - Reduction of critical forms and parts (reducing foreign dependency)
  - Capacity to support normal production needs, surge, mobilization
  - Risk reduction
  - Second-sourcing of critical components including critical safety items
  - Standardization of components and parts
  - Trade-off analyses are documented and provide an optimized solution that is the basis for the production planning effort.
    - The analyses are based on established modeling tools and factor in the current capabilities and experience of the contractor.
    - Cost optimization is a significant factor.

- The production plan provides for scheduled and unscheduled maintenance with little disruption to the production schedule.

- Subcontractor/Supplier Management including,
  - List of proposed major/critical subs and suppliers including products
  - Locations
  - Make/Buy decisions and BOM complete to support FRP.
- Make/buy decisions are consistent with contractor policy and reflect a rationale that meets the planned schedule and offers the best value to the government.
  - Data used to determine supplier capacity and capability to meet program needs
  - Data used to support second sourcing decisions and to define supplier risk
  - Supplier management methodology/process/tracking
- Manufacturing Methods and Production Flow including:
  - Advanced or unique manufacturing technology required to produce components or end items including tools and processes requiring proofing or demonstration to minimize high risk or critical operations
  - Effective production control system in place to support FRP.
  - Production flow utilizing a “goes-into” chart, tree chart, to portray the planned process of fabrication and assembly in terms of key operational points. This includes lead times from procurement of raw material to delivery of end product.
  - The acquisition of production tooling and equipment is based on a schedule that represents reasonable acquisition lead times, installation and setup, training, etc., that is coordinated with the overall schedule and presents contingency plans that address any schedule risks.
  - Identify production, test, or inspection stations which have bottleneck potential and identify corrective action
  - Plant flow of major in-plant manufacturing operations including operation, equipment, and location
  - Identify expected process yields for each process and indicate statistical or other method used to maintain control
  - During LRIP or Production obtain and evaluate processes using process control system
  - A detailed allocation of production space and equipment is described, along with the factors used in developing the plan.
  - The status of design and acquisition of production equipment is tracked in the schedule. Equipment cost, efficiency, and availability are reflected in the planning process.
- Tooling, ST and STE
  - The program verifies procedures for ensuring functional compliance and calibration of all tooling and test equipment.

- Productivity Improvement
  - All manufacturing risks mitigated.
- Industrial Materials Management including:
  - Critical forms and parts
  - Strategic and critical materials
  - Diminishing Manufacturing Sources and Materials Shortages
  - Material planning systems proven in LRIP and sufficient for FRP.
  - Requests for Special Priorities Assistance
  - Scrap management and reclamation
  - Material planning systems validated on FRP build.
- Manufacturing Management Data
  - Cost of work scheduled, cost of work performed, and the actual cost of work performed in hours
  - Cause, corrective action, and means of follow-up to attain planned performance
- Manufacturing Audits including checklists and other criteria used by the prime to conduct audits of the contractor and supplier operations. Include audit summaries and corrective actions.
- Labor Relations including:
  - Location of facilities performing program work
  - Each union representing workers at the facility locations, type and number of workers
  - Expiration date of union's labor management agreement.
  - History of last 3 negotiations
  - Components supplied by each facility location
  - Contingency plan listing possible alternate suppliers
- The plan should also describe:
  - All GFP required and specific need dates.
- The contractor has established procedures for management of company and government-furnished information assets that support the needs of the program.
- All contractor management control systems, including those for configuration management and the control of subcontractors and manufacturing performance evaluation.
- The identification and planned use of existing contractor assets and government-owned resources are supported by the confirmed availability of the resources. Resource sharing between programs is on a non-competing basis.
  - The plan should also include industrial preparedness planning, including surge capability during the production phase and the post production phase requirements for support to employment of the system in combat situations.
  - Have you updated the Manufacturing Plan for FRP?

- Have you ensured that all of the information necessary to plan the detailed manufacturing operations for the system is available to the contractor?
- Have you ensured this information is described in a contractor's manufacturing plan covering:
  - Manufacturing organization including who is responsible, organization charts, points of contact, etc.?
  - Manufacturing Management System including how materials and parts are ordered, structure order for parts and components, and track a project to produce the end item?
  - How all manufacturing risks are being tracked and mitigated?
- Have you verified the Manufacturing Management Program describes manufacturing strategy including:
  - Program manufacturing time-phased schedule?
  - Manpower Plan?
  - Industrial facilities capacity assessment?
  - Surge and Mobilization capacity assessment?
  - Manufacturing risk assessment?
  - Capital investment commitment?
- Have you verified the Manufacturing Program Planning includes:
  - A Producibility Program Plan?
  - Make-or-Buy Criteria including these types of considerations used in making decisions:
- Conservation of critical/strategic materials?
- Reduction of critical forms and parts (reducing foreign dependency)?
- Capacity to support normal production needs, surge, mobilization?
- Risk reduction?
- Second-sourcing of critical components including critical safety items?
- Standardization of components and parts?
- Have you verified that Trade-off analyses are documented and provide an optimized solution that is the basis for the production planning effort?
  - That analyses are based on established modeling tools and factor in the current capabilities and experience of the contractor?
  - That cost optimization is a significant factor?
  - That the production plan provides for scheduled and unscheduled maintenance with little disruption to the production schedule?
- Have you verified Subcontractor/Supplier Management includes,
  - List of proposed major/critical subs and suppliers including products?
  - Locations?
  - Make/Buy decisions and BOM complete to support FRP?

- Make/buy decisions are consistent with contractor policy and reflect a rationale that meets the planned schedule and offers the best value to the government?
- Data used to determine supplier capacity and capability to meet program needs?
- Data used to support second sourcing decisions and to define supplier risk?
- Supplier management methodology/process/tracking?

- Have you validated Manufacturing Methods and Production Flow to include:
  - Advanced or unique manufacturing technology required to produce components or end items including tools and processes requiring proofing or demonstration to minimize high risk or critical operations?
  - Effective production control system in place to support FRP?
  - Production flow utilizing a “goes-into” chart, tree chart, to portray the planned process of fabrication and assembly in terms of key operational points? This includes lead times from procurement of raw material to delivery of end product.
  - Is the acquisition of production tooling and equipment based on a schedule that represents reasonable acquisition lead times, installation and setup, training, etc., that is coordinated with the overall schedule and presents contingency plans that address any schedule risks?
  - Identify production, test, or inspection stations which have bottleneck potential and identify corrective action?
  - Plant flow of major in-plant manufacturing operations including operation, equipment, and location?
  - Identify expected process yields for each process and indicate statistical or other method used to maintain control?
  - During LRIP or Production obtain and evaluate processes using process control system?
  - A detailed allocation of production space and equipment is described, along with the factors used in developing the plan?
  - The status of design and acquisition of production equipment is tracked in the schedule. Equipment cost, efficiency, and availability are reflected in the planning process?
- Have you validated Tooling, ST and STE?
  - Did you verify program procedures for ensuring functional compliance and calibration of all tooling and test equipment?
- Have you validated Productivity Improvement efforts?
  - Have all manufacturing risks been mitigated?
- Have you validated Industrial Materials Management including:
  - Critical forms and parts?
  - Strategic and critical materials?
  - Diminishing Manufacturing Sources and Materials Shortages?

- Material planning systems proven in LRIP and sufficient for FRP?
- Requests for Special Priorities Assistance?
- Scrap management and reclamation?
- Material planning systems validated on FRP build?

- Have you validated Manufacturing Management Data including;
  - Cost of work scheduled, cost of work performed, and the actual cost of work performed in hours?
  - Cause, corrective action, and means of follow-up to attain planned performance?
- Have you validated that Manufacturing Audits including checklists and other criteria used by the prime to conduct audits of the contractor and supplier operations include audit summaries and corrective actions?
- Have you reviewed Labor Relations activity to ensure a smooth transition in to LRIP and FRP to include:
  - Location of facilities performing program work?
  - Each union representing workers at the facility locations, and type and number of workers?
  - Expiration date of union's labor management agreement?
  - History of last 3 negotiations?
  - Components supplied by each facility location?
  - Contingency plan listing possible alternate suppliers?
- Have you evaluated the Manufacturing Plan for FRP to ensure it also describes:
  - All GFP required and specific need dates?
  - The contractor has established procedures for management of company and GFI assets that support the needs of the program?
- All contractor management control systems, including those for configuration management and the control of subcontractors and manufacturing performance evaluation?
- The identification and planned use of existing contractor assets and government-owned resources are supported by the confirmed availability of the resources. Resource sharing between programs is on a non-competing basis?
  - Does your evaluation of the Manufacturing Plan for FRP also include industrial preparedness planning, including surge capability during the production phase and the post production phase requirements for support to employment of the system in combat situations?

Tools

- Acquisition Strategy Template
- Manufacturing Readiness Level (MRL) assessment questionnaire using Manufacturing Management/Control thread

- AS6500 assessment

Resources

- Acquisition Plan Preparation Guide, Jan 2009
- DSMC Acquisition Strategy Guide, Dec 1999
- MRL Deskbook Version 2016
- AS6500, Manufacturing Management System, Sep 2016
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016
- DoDI 5000.02
- Service specific policies and regulations (i.e., AFI 63-145)
- DoDI 5000.02, Enclosure 14 Cybersecurity
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- IEEE 15288, Systems and Software Engineering, 2015
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations

L.2. Conduct LRIP/FRP Manufacturing Strategy using Pilot-Line actuals

Manufacturing and Quality Tasks

- Manufacturing Planning accomplished during EMD supports LRIP/FRP Manufacturing Strategy and Risk Reduction efforts.
- All manufacturing risks tracked and mitigated for LRIP.
- LRIP/FRP Manufacturing Plan developed incorporates Pilot-Line results.
- Manufacturing planning included in Initial Manufacturing Planning Strategy.
- Manufacturing risks integrated into risk mitigation plans.
- Develop LRIP/FRP work instructions and validate with pilot-line experience.
- Effective production control system in place to support LRIP.
- Make/Buy decisions and BOM complete for production build.
- Material planning systems in place for production build.
- FRP Manufacturing plan updated with LRIP actuals.
- Key manufacturing risks are identified and assessed with approved mitigation plans in place.
- Production work instructions finalized.
    - Labor standards are considered a key aspect of production planning and important in workforce projection. These standards also are considered when planning facilities and equipment to ensure efficient utilization rates and overall productivity of the workforce.
- Effective production control system in place to support FRP.
- All manufacturing risks mitigated for FRP.

- Make/Buy decisions and BOM complete to support FRP.
- Material planning systems proven on LRIP for FRP build.
- Strategy should address production and rate issues such as process capabilities and proofing, factory layout, availability of tooling, lead-times, etc.

Metrics

- Have you evaluated the Manufacturing Planning accomplished during EMD to ensure it supports LRIP/FRP Manufacturing Strategy and Risk Reduction efforts?
- Have tracked and mitigated all manufacturing risks for LRIP?
- Have you ensured the LRIP/FRP Manufacturing Plan developed uses Pilot-Line results?
- Did you include manufacturing planning in your Initial Manufacturing Planning Strategy?
- Did you integrate all manufacturing risks into risk mitigation plans?
- Did you ensure LRIP/FRP work instructions were developed and validated with pilot-line experience?
- Did you ensure effective production control systems are in place to support LRIP.
- Did you validate that Make/Buy decisions and the BOM were complete for the production build?
- Did you validate that Material Planning systems are in place for the production build?
- Did you ensure the FRP Manufacturing plan was updated with LRIP actuals?
- Did you validate that all key LRIP/FRP manufacturing risks are identified and assessed with approved mitigation plans in place?
- Did you validate that all Production work instructions have been finalized?
    - Did you consider labor standards a key aspect of production planning and their importance in workforce projection? Did you also consider these standards when planning facilities and equipment to ensure efficient utilization rates and overall productivity of the workforce?
- Did you ensure effective production control system are in place to support FRP?
- Did you ensure all manufacturing risks are mitigated for FRP?
- Have you made sure all Make/Buy decisions and the BOM are complete to support FRP?
- Have you ensured the Material Planning Systems were proven on LRIP for the FRP build?
- Have you ensured the Manufacturing Strategy addresses production and rate issues such as process capabilities and proofing, factory layout, availability of tooling, lead-times, etc.?

Tools

- Manufacturing Readiness Assessment, Material Management and Control thread
- AS6500 Manufacturing Management Program Assessment
- Material Management and Accounting System Audit

Resources

- AS6500 Manufacturing Management Program

- MIL-HDBK-896A, Manufacturing Management Program Guide
- DoDI 5000.02
- MRL Deskbook Version 2016
- DFAR 242.72 Contractor Material Management and Accounting System

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6. Operations and Support (O&S) Phase

Introduction

As stated in DoD Instruction (DoDI) 5000.02, "The purpose of the O&S phase is to execute the product support strategy, satisfy materiel readiness and operational support performance requirements, and sustain the system over its life cycle (to include disposal)." The Defense Acquisition Guidebook (DAG) Chapter 4, provides guidance on the development and execution of activities that support the sustainment of weapon systems.

The O&S phase has two major efforts, Sustainment and Disposal. The Life Cycle Sustainment Plan (LCSP), prepared by the Program Manager (PM) and approved by the Milestone Decision Authority (MDA), is the basis for the activities conducted during this phase.

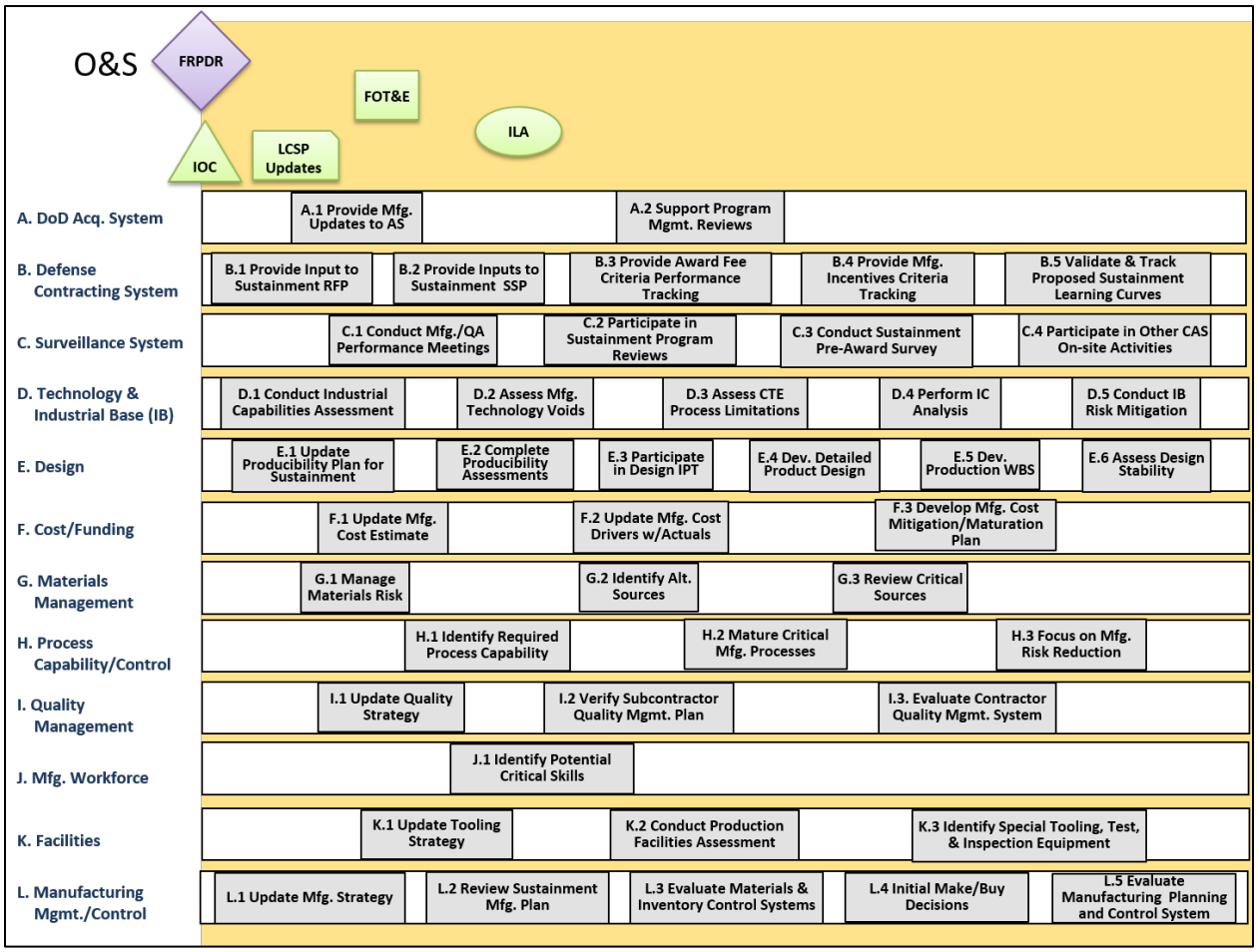


Figure 6.1. O&S Phase Manufacturing and Quality Activities

- Sustainment: During this phase, the Program Manager will deploy the product support package and monitor its performance according to the LCSP. The LCSP may include time-phased transitions between commercial, organic, and partnered product support providers. The Program Manager will ensure resources are programmed and necessary IP deliverables and associated license rights, tools, equipment, and facilities are acquired to support each of the levels of maintenance that will provide product support; and will establish necessary organic depot maintenance capability in compliance with statute and the LCSP.
    - A successful program meets the sustainment performance requirements, remains affordable, and continues to seek cost reductions by applying Should Cost management and other techniques throughout the O&S phase. Doing so requires close coordination with the war-fighting sponsor (i.e., user), resource sponsors, and materiel enterprise stake holders, along with effective management of support arrangements and contracts. During O&S, the Program Manager will measure, assess, and report system readiness using sustainment metrics and implement corrective actions for trends diverging from the required performance outcomes defined in the Acquisition Program Baseline (APB) and LCSP.
    - Over the system life cycle, operational needs, technology advances, evolving threats, process improvements, fiscal constraints, plans for follow-on systems, or a combination of these influences and others may warrant revisions to the LCSP. When revising the LCSP, the Program Manager will revalidate the supportability analyses and review the most current product support requirements, senior leader guidance, and fiscal assumptions to evaluate product support changes or alternatives and determine best value.
- Disposal: The O&S phase ends when the program is at the end of its useful life, the system will be demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment.

Key Program Phase Reviews, Documentation and Activities

The O&S phase begins after the production or deployment decision and is based on an MDA-approved **Life Cycle Sustainment Plan (LCSP)**. The life cycle sustainment planning begins as early as the Materiel Solution Analysis (MSA) phase and is updated in every phase all the way through the O&S phase. The LCSP helps the PM to develop a complete and detailed product support package, resulting in product support arrangements. The package consists of product support elements needed to achieve sustainment requirements and the set of arrangements that programs establish with organic and commercial sustainment providers. The backbone of the product support package is the Integrated Product Support (IPS) Elements as detailed in the IPS Element Guidebook. These 12 elements can be grouped into three buckets that cover the full range of life cycle functions:

- Life cycle management
    - Product Support Management
    - Supply Support

- Packing, Handling, Storage, and Transportation (PHST)
- Maintenance Planning and Management

- Technical management
  - Design Interface
  - Sustaining Engineering
  - Technical Data
  - Computer Resources

- Infrastructure management
  - Support Equipment
  - Training and Training Support
  - Manpower and Personnel
  - Facilities and Infrastructure.

A major focus during the sustainment effort of the Operations and Support (O&S) phase is identifying root causes and resolutions for safety and critical readiness degrading issues. These efforts include participating in Trade Studies and decision making relative to changes to the product support package, process improvements, modifications, upgrades, and future increments of the system. All these changes need to consider the operational needs and the remaining expected service life, Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, and Joint or service commonality.

- Program Documentation
  - Capability Development Document (CDD)
  - System Safety Analysis
  - Programmatic Environmental, Safety and Occupational Health Evaluation (PESHE)
  - National Environmental Policy Act (NEPA) and NEPA Compliance Schedule
  - Systems Engineering Plan (SEP)
  - Life Cycle Sustainment Plan (LCSP)
  - Reliability Centered Maintenance Analysis

- Independent Logistics Assessment
- Requests for Proposals (RFPs)
- Source Selection Plans (SSPs)

Manufacturing and Quality O&S Objectives

During the Production and Deployment phase and into the Operations and Support phase, program offices collect service use data, user feedback, failure reports and discrepancy reports in order to assess sustainment performance. Based on user feedback, there is often a series of product improvements which are defined and executed. This could happen as a result of a Pre-Planned Product Improvement, Value Engineering proposal, or modifications/upgrades to meet warfighter

needs. When the product is competitive with similar products, these improvements are often driven by the action of competitors. The challenge in this phase of the cycle is to integrate these changes into the production system with minimum disruption and cost. The changes introduced reflect both improvements in the ability of the product to meet the original design objective and extensions of capability to meet increased or broadened performance objectives.

Manufacturing considerations during the O&S phase should include the following:

- Continued production of units being fielded
- Updates/Product Improvements often tied to block upgrades
- Changes to the supply chain
- Items maturing (Diminishing Manufacturing and Diminishing Suppliers (DMSMS)/Obsolescence/Counterfeit Parts)
- Changes to rate and quantity of items being produced, need to ensure a source of supply
- Items manufactured for spare parts (different configurations)
- Improvements to a contractor's Manufacturing Management System or Quality Management System
- Impacts of Continuous Process Improvement (CPI) due to Lean/Six Sigma/TOC or other improvement activities
- Environmental considerations (ESOH/OSHA/NEPA and PESHE), requirements and risks
- Need to be able to maintain fielded items (Data/Technical information availability)
- Manage Total Life Cycle costs/Affordability (Manufacturing/QA elements)
- End of life management (Demil and Disposal)

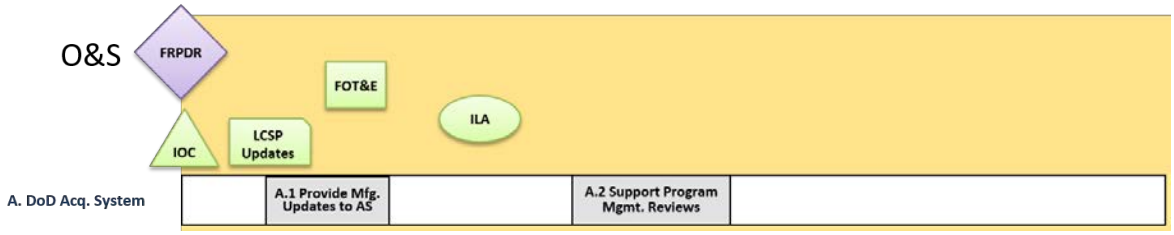
The O&S phase often overlaps with the Production and Deployment phase for many years, since O&S activities begin when the first system is fielded and production can run for many years after IOC. O&S ends when a system is demilitarized and disposed of. Manufacturing and QA activities often change as production sometimes moves from a prime contractor to government owned and operated facilities, such as depots and Maintenance, Repair and Overhaul (MROs) facilities. Key activities during this phase include:

- Continuation of Full Rate Production
- PBL implementation continues
- Updates to the Sustainment contract
- Updates to Intel/Counter Intelligence products
- Disposal and Demil at the end of its useful life

A. DD ACQUISITION SYSTEM

Sustainment planning, including the requirements in 10 U.S.C. 2337 must be an integral element of the capability requirements and acquisition process from inception. The Program Manager, with the support of the Product Support Manager (PSM), will:

- Develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and lead to a product support package to achieve and sustain warfighter requirements.
- Initiate system modifications, as necessary, to improve performance and reduce ownership costs, consistent with the limitations prescribed in 10 U.S.C. 2244a.
- Begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components, as required by DoD Manual 4160.28-M, with sufficient lead time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.



The LCSP will be updated at each milestone and specified decision points to reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

The Program Manager will integrate the product support design into the overall design process, and assess enablers that improve supportability, such as diagnostics and prognostics, for inclusion in the system performance specification. As the design matures, the Program Manager will ensure that life-cycle affordability is a factor in engineering and sustainment trades.

The following information sources provide important inputs to the O&S phase systems engineering process and should contain manufacturing considerations:

- Systems Engineering Plan (SEP)
- PESHE
- LCSP

Manufacturing/Quality tasks during the O&S phase are generally focus on producing spare parts/ subsystems/ systems to keep the production articles operating and initiating system modifications, to improve performance and reduce ownership costs.

Manufacturing should help develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and leads to a product support package that will achieve and sustain warfighter requirements.

- Manufacturing should begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components with sufficient lead time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.
- Manufacturing should initiate/support system modifications, as necessary, to improve performance and reduce ownership costs.
- Manufacturing will also be concerned about several related issues to include:
    - Diminishing Manufacturing Sources and Material Shortages
    - Obsolescence
    - Counterfeit Parts
    - Corrosion Prevention and Control
- Manufacturing should provide updates that reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

A.1 Provide Manufacturing Updates to the Acquisition Strategy

Manufacturing and Quality Tasks

- Manufacturing inputs for the O&S phase should evolve from the P&D phase. Sustainment requirements will be finalized to support sustainment contracts and LCSP.
    - Support the development of the Product Support Package.
- Tasks associated with the 12 product support elements in the Product Support Package are:
    - Product Support Management
    - Design Interface
    - Sustaining Engineering
    - Maintenance Planning and Management
    - Supply Support
    - Support Equipment
    - Technical Data
    - Training and Training Support
    - Manpower and Personnel
    - Facilities and Infrastructure
    - Packaging, Handling, Storage and Transportation (PHS&T)
    - Computer Resources
- Support the development of the Plan
- Support the development of the Product Support Strategy
- Support the development of the Product Support Requirements
- Manufacturing inputs include:
    - Manufacturing support to system and product support package design trades.

- Manufacturing support to test and evaluation (T&E) planning.
- Manufacturing support in defining performance metrics for product support contracts and organic support requirements.
- Manufacturing support to logistics requirements, workload estimates, and logistics risk assessment.
- Manufacturing support to integrate the product support design into the overall design process, and assess enablers that improve supportability, such as diagnostics and prognostics, for inclusion in the system performance specification.
- Manufacturing support helps ensure that life-cycle affordability is a factor in engineering and sustainment trades.

- Manufacturing tasks during the O&S phase include producing spare parts/subsystems/systems to keep the production articles operating and initiating system modifications, to improve performance and reduce ownership costs.
  - Manufacturing should help develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and leads to a product support package that will achieve and sustain warfighter requirements.
  - Manufacturing should help to assess field R&M data to evaluate the impact of manufacturing/QA activities on field failures. Assess using Failure Modes and Effects Analysis (FMEA) and Process Failure Modes and Effects Analysis (PFMEA).
  - Manufacturing should begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components with sufficient lead time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.
  - Manufacturing should initiate/support system modifications, as necessary, to improve performance and reduce ownership costs.
  - Manufacturing should support cost estimating associated with system modifications.
  - Manufacturing will also be concerned about several related issues to include:

- Diminishing Manufacturing Sources and Material Shortages
- Obsolescence
- Counterfeit Parts
- Corrosion Prevention and Control
- Manufacturing should provide updates that reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

Metrics

- Manufacturing and quality inputs to Program Management's Risk, Issue, and Opportunity (RIO) processes have been provided and documents industrial base, manufacturing technology, quality, software, and engineering related risks/issues, etc.

- Manufacturing and quality Program workforce requirements have been documented and provided to Program Management.
- Manufacturing and quality management requirements have been documented and provided to Program Management for use in assessing contractor plans to meet sustainment objectives.
    - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of manufacturing and quality data)
    - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
    - Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) requirements
    - Human safety and health
    - Hazardous materials management and pollution prevention
    - Interoperability requirements
    - Key Performance Parameters (KPPs) (i.e., Key Product and Process Characteristics)
    - Parts, materials, and processes (PM&P)
    - Security parameters (physical and cyber) for both hardware and software
    - Supportability and sustainment
    - Use of commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and government-furnished equipment (GFE) (including diminishing manufacturing sources)
- Analyses have been accomplished and document the completeness and adequacy of manufacturing and quality aspects and requirements included in contractor's:
- Plans for processes and metrics included in System Engineering Management Plan (SEMP)
- Plans for budget and schedule including identification of cost and schedule drivers (with impacts on the critical path)
- Software development strategy and plans (to include functionality, adequacy, testing, etc.)
- Technology maturation plans
- Follow-on Test and Evaluation (FOT&E) approaches
- Development, qualification, and acceptance testing approaches including consideration for Non-Developmental Items (NDI), COTS, and reuse items
- Modeling and Simulation plans to include design, production, processes, costing, etc.

Tools

- AS6500 Manufacturing Management System Checklist
- AS9100 Quality Management System Checklist
- ISO 9001 Quality Management System Checklist
- Technology Readiness Level (TRL) Assessment Checklist
- Industrial Base Assessment Survey Form Defense Contract Management Agency (DCMA) Industrial Analysis Center
- Product Support Strategy Development Tool, Defense Acquisition University (DAU)
- Life Cycle Sustainment Plan Outline

Resources

- DoDI 5000.02, Operation of the Defense Acquisition System, Jan 2017
- CJS JCIDS 3170.01, JCIDS System
- 10 USC, title 10, Section 2337, Life-cycle Management and Product Support
- AS6500 Manufacturing Management Program
- AS9100 Quality Systems - Aerospace
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes, 2015
- ISO 9001, Quality Management System
- NIST 800-171, June 2015, Controls for Controlled Unclassified information
- MIL-STD-1472, DoD Design Criteria Standard: Human Engineering
- DoD HCI Style Guide, 1994, Human Computer Interaction (HCI)
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities, Apr 1996
- Technology Readiness Assessment Guidance, Apr 2011
- Defense Manufacturing Management Guide for Program Managers, Chapter 12.5.14 In-Service Review
- Guide to Environment, Safety, and Occupational Health (ESOH) in the Systems Engineering Plan (SEP), no date
- Product Support Manager Guidebook, 2016
- Performance Based Logistics (PBL) Guidance, Nov 2011

A.2 Support Program Management Reviews

The only review planned for the O&S phase is a series of Integrated Logistics Assessment (ILA). The ILA is a multi-disciplined product and process assessment to ensure that the fielded system is operationally employed with well-understood and managed risk. This review is intended to characterize in-service technical and operational health of the fielded system by providing an assessment of risk, readiness, technical status, and trends in a measurable form that will substantiate in-service support budget priorities. Normally ISRs occur at numerous points in the O&S phase. It is typically initiated prior to, and in support of, the initiation of the following fiscal year(s) operations and support budget requirements determination process.

During the sustainment effort of the Operations and Support phase, systems engineering processes support in-service reviews including identifying root causes and resolutions for safety and critical readiness degrading issues. This effort includes participating in trade studies and decision making relative to the best resolution (e.g., changes to the product support package, manufacturing process improvements, modifications, upgrades, and future increments of the system), considering the operational needs and the remaining expected service life.

Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, joint or service commonality, etc. may all indicate the need for a system upgrade(s) or process improvements.

- Measure, assess, and report manufacturing readiness.
    - The major review during the O&S phase is the In-Service Review.
    - During O&S reviews, manufacturing should measure, assess, and report manufacturing readiness using metrics and implement corrective actions for trends diverging from the required performance outcomes.
    - Provide input of quality, manufacturing/production, engineering and software related issues, deficiencies and/or risks.
- Manufacturing analysis supports the depot source of repair decision and must include detailed requirements for core depot-level maintenance and repair capabilities, and associated sustaining workloads required to support such requirements.

During O&S, the Program Manager will measure, assess, and report system readiness using sustainment metrics and implement corrective actions for trends diverging from the required performance outcomes defined in the Acquisition Program Baseline and LCSP.

Ensure that sustainment factors are fully considered at all key life-cycle management decision points, and that appropriate measures are taken to reduce O&S costs by influencing system design early in development, developing sound product support strategies, and addressing key drivers of cost.

The program manager should be aware of changing production capability as the transition from production to spare parts provisioning will severely reduce opportunities for future spares procurement if production facilities are changed to accommodate a new product line, material needs change or new tooling for special purpose machines is installed. If extended production runs did not provide a spare parts inventory, the cost of parts produced at a later date can be significantly higher than the original procurement. Conditions which drive up spare parts prices include:

- Smaller order quantity requirements;
- Orders for earlier configuration units which require special documentation;
- Parts requiring special purpose tooling;
- Unique or scarce material requirements;
- Lack of production capability due to a number of factors: Out of business, discontinued facilities, lack of available production capacity, etc.; and
- Special handling, packaging and shipping requirements

Manufacturing & Quality Tasks

- Provide manufacturing and quality assessments in support of the ILA:
    - Assess system hazard
    - Operational readiness impacts from Manufacturing/Quality Assurance (QA) risks

- Impacts to cost and schedule from Manufacturing/QA risks
- Budget estimates in support of future Manufacturing/QA activities
- Assessment of the impact of Manufacturing/QA on reliability, maintainability and operational readiness

Metrics

- Integrated Logistics Assessment Tool, Mar 2017

Tools

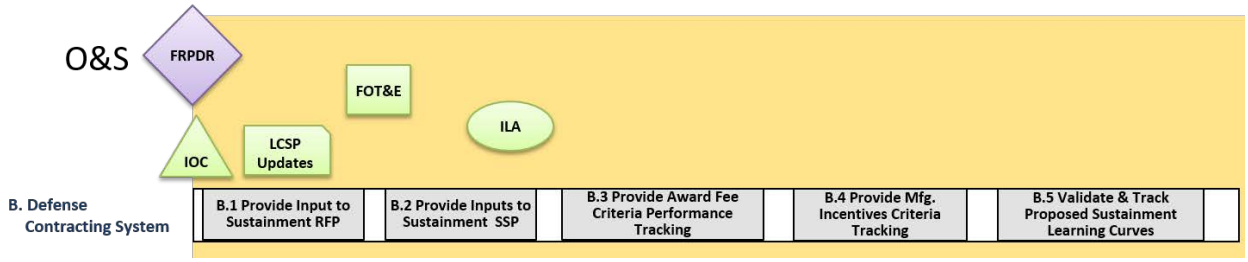
- Life Cycle Sustainment Plan Outline

Resources

- Logistics Assessment Guidebook, Jul 2011
- Logistics Assessment Guidebook Tool, Mar 2017
- AS6500, Manufacturing Management System, 2015
- AS9100, Quality Management System, Sep 2016
- ISO 9001, Quality Management System, Sep 2016

B. DEFENSE CONTRACTING SYSTEM

The RFP is the primary opportunity to make inputs to the Engineering and Manufacturing Development (EMD) contract and should be based on manufacturing and quality risks, issues, and opportunities discovered during Technology Maturation and Risk Reduction (TMRR). Typical areas to be included in the proposal include industry best practices for manufacturing management, quality management, and systems engineering. Other areas such as design and producibility, trade studies, manufacturing and quality technology investments, competition, materials (availability, counterfeit, and/or long-lead), data management, quality processes (capability studies), manufacturing and quality reporting and control, etc. should be addressed by manufacturing and quality. This list and other details should be addressed in the Statement of Work (SOW) and/or the Statement of Objectives (SOO).



B.1 Provide Input to Sustainment Request for Proposal (RFP)

Manufacturing and Quality Tasks

A well-written RFP is absolutely critical to the success of the source selection. There shall be consistency between the requirements documents, Source Selection Plan (SSP), and Request for Proposal (RFP). The acquisition team must ensure a clear linkage between the requirements and evaluation factors to maximize the accuracy and clarity of the RFP.

During O&S, manufacturing should support the Program Manager to revalidate the supportability analyses and review the most current product support requirements, senior leader guidance, and fiscal assumptions to evaluate product support changes or alternatives and determine best value.

- Ensure that manufacturing and quality personnel are included in the Sustainment Request for Proposals (RFPs) writing and review teams. Typical RFPs shall contain the following item:
  - Content for SOW, SOO
  - Contract sections C, L, M, and H
  - System Performance Specification
  - Top-level Schedule
  - Preliminary Work Breakdown Structure (PWBS)
  - Contract Data Requirements List (CDRLs) (Manufacturing/QA)
  - Contract Line Items (CLINs)
- Insert the following into Sustainment RFPs and Contracts (if appropriate).
  - Higher-Level Contract Quality Requirement per Federal Acquisition Regulation (FAR) Part 52
- ISO 9001, AS9100, etc.
  - Manufacturing Management Program
- Not a biAS6500, Manufacturing Management Systems
  - Failure Modes, Effects, and Criticality Analysis (FMECA)
  - Failure Reporting, Analysis, and Corrective Action System (FRACAS)
  - System Safety Military Standard (MIL-STD-882)
  - Material Management and Accounting System (MMAS)
  - Software QA Plan
  - Other (Parts Management Program, Counterfeit Management Program, Configuration Management Program, Integrated Product Support Plan, etc.)
- As a basis for RFP Sustainment requirements and inputs, analyze manufacturing and quality outputs from:
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, feasibility, and manufacturability studies and analyses

- Tooling, facility, and workforce analyses
- Prototype demonstrations and development tests
- Materials analyses
- Make/buy processes and analyses
- Costs and budget analyses
- Market research and analyses
- Modeling and simulations analyses
- Process Capability Studies
- Environmental studies and risks (PESHE)
- Manufacturing and quality processes and data
- Work measurement/learning curve analyses
- Industrial Base studies

- Specify contractual manufacturing and quality requirements for:
  - Content for Statement of Work, Statement of Objectives, and contract sections C, L, M, and H
- DPAS can be a valuable tool for critical programs in obtaining priority support from contractors and subcontractors.
  - The role of manufacturing/quality assurance is to assure the proper Defense Priorities and Allocation System (DPAS) rating is imposed on their program (if a change is required, this will require a major effort to document and support) and then to assure the contractor is effectively using it and flowing it down to suppliers.
  - In cases where military programs are competing for limited resources, or where commercial items are competing with military products, it may be necessary to get the DPAS office to mediate.

When revising the LCSP, the Program Manager will revalidate the supportability analyses and review the most current product support requirements, senior leader guidance, and fiscal assumptions to evaluate product support changes or alternatives and determine best value.

After the Full Rate Production decision, the LCSP will focus on finalizing the sustainment metrics, integrating sustainment considerations with design and risk management activities, and refining the execution plan for the design, acquisition, fielding, and competition of sustainment activities

Metrics

- Most are Go/No-Go, the items are either on contract or not
- Manufacturing Readiness Risk Assessment
- Technology Readiness Assessment (if required)
- Industrial Base Capability Assessment

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes, 2015
- IG5315.204-5(b) Section L Guide and Template
- IG5315.204-5(c) Section M Guide and Template
- Technology Readiness Level (TRL) Assessment Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- ISO 9000, Quality Management System
- ISO/IEC/IEEE 15288, System and Software Engineering IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities, Apr 1996
- Technology Readiness Assessment Guidance, Apr 2011

B.2 Provide Inputs to Sustainment Source Selection Plan (SSP)

Manufacturing and Quality Tasks

A Source Selection Plan (SSP) is required for all best-value, negotiated, competitive acquisitions under FAR Part 15. The Source Selection Authority shall approve the SSP before the final solicitation is issued. The SSP shall include the following (as a minimum):

- Background and Objectives
- Acquisition Strategy
- Source Selection Team (should include Manufacturing/QA)
- Communications
- Evaluation Factors and Sub-factors (should include some Manufacturing/QA)
- Documentation
- Schedule of Events
- Non-governmental personnel
- Source Selection materials management

Manufacturing and QA should provide inputs to the SSP.

- Manufacturing inputs to the Sustainment SSP include:

- Manufacturing/QA evaluation criteria,
- Technical Data Rights and Manufacturing Process Data Rights,
- Intellectual property (IP) deliverables and associated license rights.

Specify how the program will provide for rights, access, or delivery of technical data the government requires for the systems total life cycle sustainment. Include analysis of data needs to implement the product support life cycle strategy including such areas as materiel management, training, Information Assurance protection, cataloging, open architecture, configuration management, engineering, technology refreshment, maintenance/repair within the Technical Order (TO) limits and specifically engineered outside of TO limits, and reliability management.

The Program Manager should describe:

- The overall management approach to managing data acquired with other than unlimited rights.
- The management approach for management data (i.e. data that is not software or technical data). It should include how contractor data needing protection will be identified, marked, and managed.
- How the data deliverables will be reviewed for unjustified or non-conforming markings. It should include the process the program will follow to question or challenge contractor assertions or markings
- The data deliverables specified in the RFP or contract, including the technical data, computer software documentation, and management data items.
- The approach for maintaining the software and its documentation once software maintenance is transferred from the Original Equipment Manufacturer (OEM. It should include the contract provisions being put into place that will allow for a cost-effective migration.
- The degree to which data will be acquired to support future competitions. It should include the logic by which these elements were selected; the alternative solutions considered; and the criteria by which the decision to procure technical data was made.
- The extent to which priced options and associated source selection criteria will be used to acquire additional licenses.
- The intended use of other mechanisms such as deferred ordering, deferred delivery, and the use of withholding or incentives specific to performance in the area of data management.
- How the use of an integrated digital environment and the repository system factors into the data strategy.
- Any required interfaces to government data systems or repositories, and how those requirements will be satisfied.
- The digital format standards to be used and why they were selected. The process (i.e., business case analysis, adherence to DoD Component policy, etc.) used to determine the deliverable form/format for all deliverables should be included.

At the end of its useful life, a system will be demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment.

Life-cycle sustainment for information systems may be provided via multiple approaches, including service level agreements, support agreements, performance work statements, and enterprise services. Where feasible and as approved by the MDA, programs may employ portfolio-level documents to satisfy their LCSP requirements. COTS and GOTS products used as intended will normally be supported via standard warranties and support agreements. Effective life-cycle sustainment requires continuous monitoring to ensure investments are maintained at the right size, cost, and condition, to include vulnerability management, to support warfighter and business missions and objectives.

The necessary intellectual property (IP) deliverables and associated license rights, consistent with and integrated with the program IP Strategy.

COTS and GOTS products used as intended will normally be supported via standard warranties and support agreements. Effective life-cycle sustainment requires continuous monitoring to ensure investments are maintained at the right size, cost, and condition, to include vulnerability management, to support warfighter and business missions and objectives.

Reduced oversight: Generally, contractors prefer less oversight/insight by the government. We can use this desire to trade off personal involvement from Program Management Office (PMO) manufacturing/quality assurance if contractor performance is improved/acceptable. We may also have some influence over the amount of DCMC oversight if contractor performance is acceptable.

Relationship between government and contractor: This may be one of the most critical areas an individual may influence in their day-to-day job. Although senior management creates the overall program environment, personal, professional, and constructive relationships at the working levels can still be cultivated. The PMOmanufacturing/quality assurance manager should strive to create and maintain close teaming arrangements with their counterparts. This will enable better communications and enhanced respect among both parties.

Metrics

- Most are Go/No-Go, the items are either on contract or not
- Manufacturing Readiness Risk Assessment
- Technology Readiness Assessment (if required)
- Industrial Base Capability Assessment

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist

- ISO 9001, Quality Management System Checklist
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes, 2015
- Source Selection Plan Template, USMC
- Technology Readiness Level (TRL) Assessment Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- ISO 9000, Quality Management System
- IG5315.303 Source Selection Plan Guide, Dec 2008
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities, Apr 1996
- Technology Readiness Assessment Guidance, Apr 2011

B.3 Provide Award Fee/Incentive Fee Criteria Performance Tracking

Performance Tracking within the SOO/SOW and RFP should focus on technical and business measures that will help to assure program success (cost, schedule and performance). Cost performance measures should focus on affordability and total life cycle costs, schedule performance measures should focus on the Integrated Master Plan/Schedule. Adherence to both may be found in an Earned Value Management (EVM) if required. Technical performance should be assessed using technical measures that are derived from the Measures of Effectiveness (MOEs), Key Performance Parameters (KPPs), Measures of Performance, and Technical Performance Measures (TPMs). Manufacturing and QA related TPMs should support the achievement of Sustainment Supportability Measures.

Manufacturing and Quality Tasks

Manufacturing and Quality personnel should support an integrated product support capability implementing the program's mix of government and industry providers supported by appropriate analyses as included in 10 U.S.C. 2337 – Life-cycle management and product support that focuses on:

- Maximize competition and make the best possible use of available Department of Defense and industry resources at the system, subsystem, and component levels; and
- Maximize value to the DoD by providing the best possible product support outcomes at the lowest operations and support cost.

Manufacturing and QA personnel should be working to identify cost, schedule and technical performance measures. Technical Performance Measures are often derived from mission needs or Measures of Effectiveness, Key Performance Parameters, and Measures of Performance. These

measures can then be related to and tracked by an Earned Value Management system (if applicable), and the Integrated Master Plan/Schedule.

Award Fee/Incentive Fee: An award fee or incentive fee is intended to motivate the contractor's performance in those areas critical to program success. While the overall Award Fee process and final rating is not controlled by manufacturing/quality assurance, we may own specific sections and usually have a great deal of control over what items we want to include as criteria. We also control the evaluations for those sections and can use this authority as a basis for communicating our concerns to our contractor counterparts as well as rewarding them for doing well.

Potential Manufacturing/QA Award Fee Criteria could include:

- Customer Responsiveness
  - Customer Fulfillment Rate (on time/schedule)
  - Throughput Time
  - Manufacturing Cycle Time
- Quality
  - First Pass Yield/Scrap/Rework and Repair Rates
  - Supplier Quality Yield Rates
  - Field Data (Warranty/Mean Time Between Failure) (Technical performance)
  - Cost of Quality (affordability)
- In-Plant
  - OSHA Compliance
  - Inventory Reduction
  - Overall Equipment Effectiveness

Metrics

- Technical Performance Measures
- Schedule Performance Measures
- Cost Performance Measures

Tools

- Award Fee Template, Annex B of the Air Force Award Fee Guide
- Quality Function Deployment excel template
- Requirements Roadmap worksheet

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- ISO 9000, Quality Management System

- Award Fee Guide, various Army, Navy and Air Force
- Quality Function Deployment, Dr. Akao
- Guidebook for the Acquisition of Services, Jun 2012 (Chapter 4.3.1 Automated Requirements Roadmap Tool)

B.4 Provide Manufacturing Incentives Criteria Tracking

Manufacturing and Quality Tasks

Manufacturing should provide appropriate analyses support in developing an integrated product support capability implementing the program's mix of government and industry providers by focusing on the twelve Integrated Support Elements listed below:

- Product Support Management
- Supply Support
- Packaging, Handling, Storage and Transportation
- Maintenance Planning and Management
- Design Interface
- Sustaining Engineering
- Technical Data
- Computer Resources
- Facilities and Infrastructure
- Manpower and Personnel
- Support Equipment
- Training and Training Support

Manufacturing and Quality personnel should support an integrated product support capability implementing the program's mix of government and industry providers supported by appropriate analyses as included in 10 U.S.C. 2337.

Competition, or the option of competition, at the prime and subcontract levels for large and small businesses, and system and sub-system levels.

Plan for Corrosion Prevention and ontrol (CPC) in systems engineering and life cycle sustainment as required by DoDI 5000.67. Product support planning, especially maintenance planning and sustaining engineering, will incorporate appropriate mitigation of CPC risks inherent in the design to meet sustainment requirements.

The LCSP will focus on ensuring operational supportability and verifying performance.

Mean Down Time. The average total downtime required to restore an asset to its operational capability, measures the effectiveness of the supply chain and support infrastructure (e.g., customer wait time, logistics response time, retrograde time). It is an important element in assessing a system's

affordability across its life cycle and identifies constraints and opportunities of a system's product support strategy and product support arrangements.

The Acquisition Strategy should promote sufficient program stability to encourage industry to invest, plan, and bear their share of the risk. However, the strategy should not compel the contractor to use independent research and development contracts, except in unusual situations where there is a reasonable expectation of a potential commercial application.

All of the great quality improvement tools and producibility initiatives will make no difference if the contractor is not properly motivated to employ those tools or make producibility changes. For many years it has been suspected that a contractor can make more profit in the short term by producing defective products that we pay him to fix, than he would if he fixed the system and prevented the defects. In that light, some suggestions for specific incentives an individual Manufacturing or Quality Assurance Manager may have include award fee, reduced oversite, lab resources, bully pulpit, increased review of critical suppliers/processes, government/contractor relationships.

Metrics

- Life Cycle Sustainment Plan
- Competition
- Corrosion Prevention
- Mean Down Time
- Industry Investments
- Producibility

Tools

- Life Cycle Sustainment Plan Outline

Resources

- Life Cycle Sustainment Plan Content Guide, June 2010

B.5 Validate and Track Proposed Sustainment Learning Curves

Manufacturing and Quality Tasks

A successful program meets the sustainment performance requirements, remains affordable, and continues to seek cost reductions by applying should-cost management and other techniques throughout the O&S phase. Doing so requires close coordination with the warfighting sponsor (i.e., user), resource sponsors, and materiel enterprise stake holders, along with effective management of support arrangements and contracts.

Manufacturing should help the program meet the sustainment performance requirements, remain affordable, and continues to seek cost reductions by applying should-cost management and other techniques throughout the O&S phase. At the Full-Rate Production Decision or Full Deployment Decision, the LCSP will focus on how sustainment performance is measured, managed, assessed, and reported; and the actions to adjust the product support package to ensure continued competition and cost control while meeting warfighter mission requirements.

During Full-Rate Production, manufacturing should focus on how sustainment performance will be measured, managed, assessed, and reported; and the necessary actions to adjust the product support package to ensure continued competition and cost control while meeting warfighter mission requirements. After Initial Operational Capability (IOC), the LCSP is the principle document governing the system's sustainment. Programs will update the plan whenever there are changes to the product support strategy, or every 5 years, whichever occurs first, supported by appropriate analyses, sustainment metrics, sustainment costs, system components or configuration (hardware and software), environmental requirements, and disposal plans or costs.

Manufacturing should support programs to update the plan whenever there are changes to the product support strategy, or every 5 years, whichever occurs first, supported by appropriate analyses, sustainment metrics, sustainment costs, system components or configuration (hardware and software), environmental requirements, and disposal plans or costs. Use performance-based payment events as effective Manufacturing /quality measures. This activity involves the assessment of how efficiently the contractor is producing products, primarily through the evaluation of work measurement data. It also includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.

- During production and into sustainment, manufacturing should support performance-based payment events such as award fees, manufacturing/production incentives, and learning curve analysis.

Manufacturing/quality activity sometimes involves the use of the "bully pulpit" of the PMO and the role we have in encouraging the contractors to continually improve their processes and products. The manufacturing/quality assurance managers have numerous opportunities to do this, such as during teleconferences, Program Management Reviews, Fact Findings, etc. Also note this is not confined to contractors - we can encourage internal improvements at depots and within the PMOs.

Metrics

- [TBD]

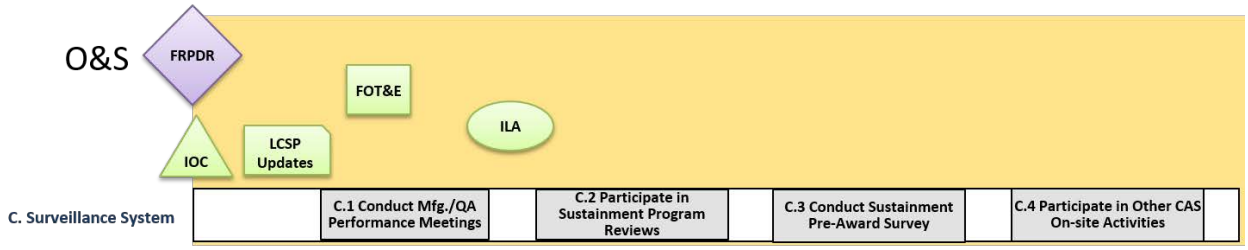
Tools

- DoD Progress-Based Payments Tool, Version 4.2
- Cash Flow Tool for Evaluating Alternative Finance Arrangement
- Learning Curve Tool

- Work Measurement Time Study Worksheet
- Resources
- Performance Based Payments Guide
- DFAR Subpart 232.10 Performance-Based Payments
- Application of Learning Curve Theory, DAU Teaching Note, Feb 2011
- Chapter 8 – Work Measurement

C. SURVEILLANCE SYSTEM

The Program Manager and Program Office should utilize to the maximum extent possible available Contract Administration Services (CAS) and functions in accordance with FAR 42.302(a) Contract Administration Functions. Typical CAS functions involving engineering, manufacturing and quality assurance can provide program offices with timely, value-added analysis, acquisition insight, and early confirmation of progress and risk reporting.



Note: Many manufacturing/QA functions may have moved from prime contractor facilities to government owned and operated facilities such as depots and MROs where CAS surveillance may not be available.

C.1 Conduct Manufacturing/QA Performance Meetings

Manufacturing and Quality Tasks

- Manufacturing should support the contractor's government/contractor status meetings. At the prime contractor facility as well as at key/critical subcontractors and suppliers. Manufacturing should provide inputs to the government accountable property system that documents all government owned property whether it is held and managed by the government, contractor, or third party. Production tooling, testing equipment, spares, and materials left from production are all important assets that must be maintained and may be held for use during the Sustainment phase.
- The government accountable property system that documents all government owned property whether it is held and managed by the government, contractor, or third party, in accordance with 40 USC 524.

After IOC, the DoD Components will continue to conduct Independent Logistics Assessments (ILAs) at a minimum interval of every 5 years. Assessments will focus on the weapon system-level product

support performance in satisfying warfighter needs, meeting sustainment metrics, and providing best-value outcomes. They must specifically assess O&S costs to identify and address factors resulting in growth in O&S costs and adapt strategies to reduce such costs. Results will inform LCSP and analyses updates.

The contractor shall conduct regular (weekly/monthly) government/contractor status meetings.

Metrics

- Meetings held with Manufacturing/QA discussions
- Independent Logistics Assessments

Tools

- Material Management and Accounting System checklist
- DAU Logistics Assessment Guidebook, Appendix A: Integrated Product Support Element Assessment Criteria (checklist), Mar 2017

Resources

- DCMA-INST-205 Major Program Support
- AS6500
- DCMA-INST-204 Manufacturing and Production
- AS9100
- DCMA-INST-309 Government QA Surveillance Planning
- Army, AT&L Memo, Independent Logistics Assessments (ILA), Aug 2013
- SECNAVINST4105.1C, Independent Logistics Assessment and Certification Requirements,
- Integrated Logistics Assessment Handbook (Navy), Sep 2012
- DoD Logistics Assessment Guidebook, 2011
- Material Management and Accounting System udit Program, Apr 2017
- FAR Part 46 Government Property
- DFARS 245 Government-Furnished Property
- DoDI 4161.02 Accountability and Management of Government Contract Property
- ISO 9000

C.2 Participate in Sustainment Program Reviews

Manufacturing and Quality Task

The In-Service Review (ISR) is a multi-disciplined product and process assessment to ensure that the fielded system is operationally employed with well-understood and managed risk. This review is intended to characterize in-service technical and operational health of the fielded system by providing an assessment of risk, readiness, technical status, and trends in a measurable form that will substantiate in-service support budget priorities.

- Provide input of quality, manufacturing, engineering and software related issues, deficiencies and/or risks during program reviews
- Current levels of System Operational Risk and System Readiness have been quantified and related to current O&M and procurement budgets.
- Future levels of System Operational Risk and System Readiness have been quantified and related to future Operations and Maintenance (O&M) and procurement budgets.
- Risk assessment checklist are use to assess risk during the review process.
- Sustainment Reviews may include time-phased transitions between commercial, organic, and partnered product support providers. Manufacturing should help ensure resources are programmed and necessary IP deliverables and associated license rights, tools, equipment, and facilities are acquired to support each of the levels of maintenance that will provide product support; and will help establish necessary organic depot maintenance capability.
- Manufacturing should help identify features that are likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs. The reviews will focus on sustainment planning and execution, to include the core logistics analyses and establishment of organic capabilities.
- Manufacturing should support Performance-Based Logistics (PBL) planning, development, implementation, and management during Sustainment. PBL is performance-based product support, where outcomes are acquired through performance-based arrangements that deliver warfighter requirements and incentivize product support providers to reduce costs through innovation.
- Production Planning and Systems Engineering must account for product obsolescence and the likelihood of future redesign in order to upgrade system capability. It is unlikely that the impacts of Diminishing Manufacturing Sources (DMS) and obsolescence can be eliminated entirely. Manufacturing should support by addressing likely risk areas, particularly in avionics and electronics, during design and production before the part supply evaporates. This can make the system more affordable and supportable.
- Production surveillance performed by manufacturing is a function of contract administration used to determine contractor progress and to identify any factors that may delay performance. DCMA provides production surveillance of the contractor's performance based on the Surveillance Criticality Designator (SCD).
    - Manufacturing should be working with the depots to determine what tooling and data must be kept after production ends.
    - Capture and list what the tooling name is, serial number, what part it makes or operation it performs, and for which configuration.
    - Manufacturing should support program office shutdown activities as needed.
    - Manufacturing should be a member of the shutdown Integrated Product Team (IPT).

The LCSP may include time-phased transitions between commercial, organic, and partnered product support providers. The Program Manager will ensure resources are programmed and necessary IP deliverables and associated license rights, tools, equipment, and facilities are acquired to support

each of the levels of maintenance that will provide product support; and will establish necessary organic depot maintenance capability in compliance with statute and the LCSP.

The DoD Components will conduct independent logistics assessments to assess the adequacy of the product support strategy, and to identify features that are likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs. The reviews will focus on sustainment planning and execution, to include the core logistics analyses and establishment of organic capabilities.

DCMA supports program office shutdown activities as needed and should be a member of the shutdown IPT.

Metrics

- Manufacturing and quality support the performance of the In-Service Review

Tools

- Independent Logistics Assessment

Resources

- Independent Logistics Assessment Handbook, Sep 2013
- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- ISO 9000, Quality Management System

C.3 Conduct Sustainment Pre-Award Survey

Manufacturing and Quality Tasks

- Evaluate Technical Capability; Production Capability; Quality Assurance; Packaging; Flight Operations/Safety; Technical documentation; Configuration Management; and Software Capability.
- Manufacturing must be aware that over the system life cycle, operational needs, technology advances, evolving threats, process improvements, fiscal constraints, plans for follow-on systems, or a combination of these influences and others may warrant revisions and system modifications.
- Manufacturing should help ensure that appropriate measures are taken to reduce operating and support costs by influencing system design early in development, developing sound product support strategies, and addressing key drivers of cost.

- Manufacturing should support independent logistics assessments prior to Milestones B and C and the Full-Rate Production Decision to assess the adequacy of the product support strategy, and to identify features that are likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs. The reviews will focus on sustainment planning and execution, to include the core logistics analyses and establishment of organic capabilities.

Over the system life cycle, operational needs, technology advances, evolving threats, process improvements, fiscal constraints, plans for follow-on systems, or a combination of these influences and others may warrant revisions to the LCSP.

Each DoD Component will establish its criteria for independence, and will provide (1) guidance to ensure consistency within the respective Component and (2) the scope of the assessment for key acquisition decision points. At a minimum, these reviews will be chartered by the Component Acquisition Executive (CAE) and conducted by logistics, program management, and business experts from outside the program office. Each DoD Component will establish its criteria for independence, and will provide guidance to ensure consistency within the respective Component and the scope of the assessment for key acquisition decision points. At a minimum, these reviews will be chartered by the CAE and conducted by logistics, program management, and business experts from outside the program office (manufacturing/quality experts should participate in this activity.

Ensure that sustainment factors are fully considered at all key life-cycle management decision points, and that appropriate measures are taken to reduce operating and support costs by influencing system design early in development, developing sound product support strategies, and addressing key drivers of cost.

The DoD Components will conduct independent logistics assessments (ILAs) for all weapon system Major Defense Acquisition Programs (MDAPs) prior to Milestones B and C and the Full-Rate Production Decision to assess the adequacy of the product support strategy, and to identify features that are likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs. The reviews will focus on sustainment planning and execution, to include the core logistics analyses and establishment of organic capabilities.

Metrics

- Pre-Award Survey

Tools

- SF 1404 Pre-award Survey – Technical
- SF 1405 Pre-award Survey – Production
- SF 1406 Pre-award Survey – Quality Assurance
- SF 1407 Pre-award Survey – Financial Capability

Resources

- DCMA Pre-award Survey Guide
- AS9100
- ISO 9000

C.4 Participate in Other CAS On-Site Activities

Manufacturing and Quality Tasks

- DCMA-INST-205, Major Program Support and FAR 42.302(a) Contract Administration Functions outlines how DCMA personnel can be used to support Program Office functions.
- Manufacturing and Quality Task
- Manufacturing and Quality Assurance personnel may be called out to perform some or all of the following functions:
- Input into the development of a Memorandum Of Agreement (MOA) between with program office and the government contract administration activity.
- Attend/participate in Post Award Orientation Conference (PAOC).
- Provide independent program status of cost, schedule and technical performance.
- FLIGHT OPERATIONS, if applicable. Request unrestricted government ability to select and access to test and inspect Safety of Flight (SOF) characteristics.
- Accept/reject minor Requests for Variation (RFVs) Material Review Board (MRB) proposals for Use-As-Is (UAI) and repair non-conformances.
- Verify supplier complies with contractual Special Packaging Instructions (SPIs) for end item systems and spares, as defined in the contract.
- Perform Government Contract Quality Assurance (GCQA), to include Inspection and Acceptance, of production quantities.
- Verify Surveillance Critical Designator (SCD) (FAR 42.11) applied to the contract is the correct designator.
- Perform government surveillance of the supplier's compliance to DFARS 252.242-7004, Material Management and Accounting System (MMAS), when invoked in the contract.
- Verify Beyond Economical Repair (BER) requests.
- Perform evaluation of Over and Above (O&A) requests.
- Perform Physical Progress Reviews (PPRs) to support Progress Payments.
- Perform Estimates to Completion (EAC) when requested.
- Provide delivery delay notices to the customer.
- Validate/verify Performance Base Payment requests.
- Provide support to customer priority delivery requests.
- Support Material Review Board activities
- Support of Failure Reporting, Analysis and Corrective Action (FRACAS)
- Support assessment of field failures

Metrics

- Various activities supported or not

Tools

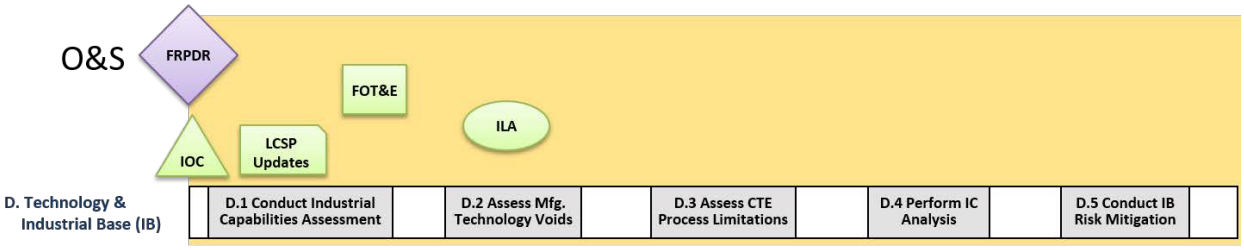
- DMCA Program Support Plan
- DCMA Manufacturing and Production Surveillance Plan
- DMCA Engineering Surveillance Plan
- DMCA QA Surveillance Plan

Resources

- DMCA-INST-205 Program Support
- DCMA-INST-204 Manufacturing and Production
- DMCA-INST-207 Engineering Surveillance
- DMCA-INST-309 Government Contract QA Surveillance Planning
- AS9100
- ISO 9001

D. TECHNOLOGY AND INDUSTRIAL BASE

The O&S phase is characterized by on-going production and sustainment operations. The Program Manager should evaluate the industrial base to ensure that there will be a source of material for future development, production and sustainment.



During the O&S phase the industrial base will include depots, MROs and other organic activities. There are several concerns for the PM during this phase to include:

- Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Obsolescence
- Counterfeit Parts
- Insertion of New Technology
- Smart Shutdown
- Demil and Disposal

D.1 Conduct Industrial Capabilities (IC) Assessment

Industrial Base Assessments are required by law:

- 10 USC 2440: Technology and Industrial Base
- 10 USC 2503: Analysis of the Technology and Industrial Base
- 10 USC 2504: Annual Report to Congress
- 10 USC 2505: Periodic Defense Capability Assessments

Manufacturing and Quality Tasks

Industrial base assessments are about understanding the "capability of the industrial base of the United States to support the development, production and sustainment of weapon systems used by our defense forces." There are several concerns during the sustainment phase.

Prior to completing or terminating production, manufacturing should ensure an adequate industrial capability and capacity to meet post-production operational needs. The risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule is the major program risk during the O&S phase.

The analysis should also address product technology obsolescence, diminishing manufacturing sources and material shortages, counterfeit parts, replacement of limited-life items, regeneration options for unique manufacturing processes, and conversion to performance specifications at the subsystems, component, and spares levels as these will drive a program's cost and risk.

Metrics

- Program Industrial Base Assessment Conducted
- DCMA inputs to the following documents, go/no-go (either is or is not included)
- Manufacturing Readiness Assessment
- Technology Readiness Assessment
- Industrial Base Assessment
- Systems Engineering Plan
- Test and Evaluation Master Plan
- Integrated Master Plan/Schedule

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Technology Readiness Assessment (TRA)
- Manufacturing Readiness Level (MRL) Assessment Checklist, Technology and Industrial Base thread
- Integrated Master Plan/Schedule (IMP/IMS)
- Test and Evaluation Master Plan (TEMP)

- Systems Engineering Plan (SEP)

Resources

- DoDI 5000.02, Jan 2017
- DODI 5000.60H Defense Industrial Capabilities Assessments
- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base
- TRA Deskbook, Apr 2012
- MRL Deskbook Version 2016
- Systems Engineering Plan (SEP) Outline, Jun 2015
- Test and Evaluation Management Guide, Dec 2012
- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide, Oct 2005

D.2 Assess Manufacturing Technology Voids

Typically, the program is very mature, but may still require research and development of new technologies to keep weapon systems current with new threats.

- Update assessments and analysis of emerging technologies needed to upgrade existing weapon systems.
- Perform manufacturing trade studies on potential technologies to solve the requirements gap
- Identify costs and risks associated with these new technologies
- Update current ManTech and other technology development plans and roadmaps.
- Manufacturing Technology programs should specifically target the risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule following production.
- Manufacturing analysis should address product technology obsolescence, replacement of limited-life items, regeneration options for unique manufacturing processes, and conversion to performance specifications at the subsystems, component, and spares levels.
- Lab resources: We may be able to provide expert assistance or financial resources from the labs to help contractors solve some of the most difficult technical problems.

Manufacturing and Quality Tasks

- ManTech analysis conducted

Metrics

- ManTech Assessment

Tools

- Producibility Assessment Worksheet
- Pugh Matrix
- Technology Readiness Assessment
- ManTech Roadmap
- Manufacturing Readiness Level (MRL) Assessment Checklist, Technology and Industrial Base thread

Resources

- NAVSO P-3687Producibility Systems Guidelines, Dec 1999
- Technology Transition Managers Guide, June 2005
- TRA Deskbook, Apr 2012
- MRL Deskbook Version 2016

D.3 Assess CTE Product and Process Limitations

The risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule is the major program risk during the O&S phase.

Manufacturing and Quality Tasks

- Manufacturing should watch for critical processes that may be difficult to provide on a limited production basis. Some processes operate much more efficiently at a high production rate than would be possible during spare part manufacturing.
- Assess Critical Technology Element (CTE) Process Limitations
- Assess CTE for impacts to feasibility, affordability, producibility, and supportability.
- Assess maturity of the technology.
- Manufacturing and QA feed into product and process assessments.

Metrics

- CTEs identified
- Product limitations identified

Tools

- Producibility Assessment Worksheet
- Technology Readiness Assessment
- TRL Calculator
- Manufacturing Readiness Level (MRL) Assessment Checklist, Technology and Industrial Base thread

Resources

- DoDI 5000.02, 5d(4)(b)3. And 5d(4)(c)
- Defense Acquisition Program Support Methodology, Ver. 3.0
- NAVSO P-3687Producibility Systems Guidelines, Dec 1999Technology Readiness Assessment Deskbook, Jul 2009
- MRL Deskbook Version 2016

D.4 Perform Industrial Capability Analysis

Identify DoD investments needed to create and maintain access to competitive suppliers for critical areas at the system, subsystem and component level. When the analysis indicates that industrial capabilities needed by DoD are in danger of being lost, the components should determine whether government action is required to preserve the industrial capability. Address product technology obsolescence, replacement of limited-life items, regeneration options for unique manufacturing processes and conversion to performance specifications at the subsystem, component and spares levels.

Manufacturing and Quality Tasks

- Identify where industrial capabilities are endangered, an additional analysis is required as the basis for determining what if any DOD action is required to preserve an industrial capability.
- Perform Industrial Capabilities Analysis (ICA) per DoD Handbook 5000.60H
- Identify potential Industrial Base Investments
- Identify ManTech projects
- Initiate ManTech projects

Metrics

- Industrial Base Capability assessment conducted
- Industrial Base investments identified
- ManTech projects identified and initiated

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- TRL Assessment Checklist
- Manufacturing Readiness Level Assessment Checklist, Technology and Industrial Base thread

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Apr 1996

- MRL Deskbook Version 2016

D.5 Conduct IB Risk Mitigation

When there is an indication that industrial capabilities needed by DOD are endangered, an additional analysis is required as the basis for determining what if any DOD action is required to preserve an industrial capability (see DODD 5000.60 and DOD 5000.60H).

The risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule is a major risk during this phase.

- Manufacturing should consider industrial surge requirements and capability for operationally-expendable items such as munitions, spares, and troop support items. These are likely surge candidates and should receive close attention and specific planning, to include use of contract options.
- Manufacturing should identify production bottlenecks at both the prime and sub-tier supplier levels for high use/high volume programs in an asymmetric warfare construct. Consider surge capability in evaluation criteria for contract award.
- If manufacturing analysis indicates that industrial capabilities are in danger of being lost to include DMSMS and Obsolescence, the DOD Components should determine whether government action is required to preserve the industrial capability.
- Conduct Industrial Base (IB) Risk Handling

Where feasible, Acquisition Strategies should consider industrial surge requirements and capability for operationally-expendable items such as munitions, spares, and troop support items. These are likely surge candidates and should receive close attention and specific planning, to include use of contract options. The program office should identify production bottlenecks at both the prime and sub-tier supplier levels for high use/high volume programs in an asymmetric warfare construct. Surge capability can be included in evaluation criteria for contract award.

Manufacturing and Quality Tasks

- Initiate mitigation plans that address current and future manufacturing and quality Industrial Base risks. Plans should:
- Address all manufacturing and quality capabilities required that should be maintained throughout the life of the program
- Mitigate product or technology obsolescence, lifetime replacement, or regeneration of items projected to go out of production
- Address the approach to making production rate and quantity changes that support a response to contingency and support requirements including surges
- Mitigate the vulnerability of the supply chain (to include sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources)

- Address the availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment (required to include the availability of alternatives for obtaining such items from within the National Technology Industrial Base (NTIB)
- Address the risks introduced by new and unique capabilities and processes

Metrics

- Mitigation plans developed

Tools

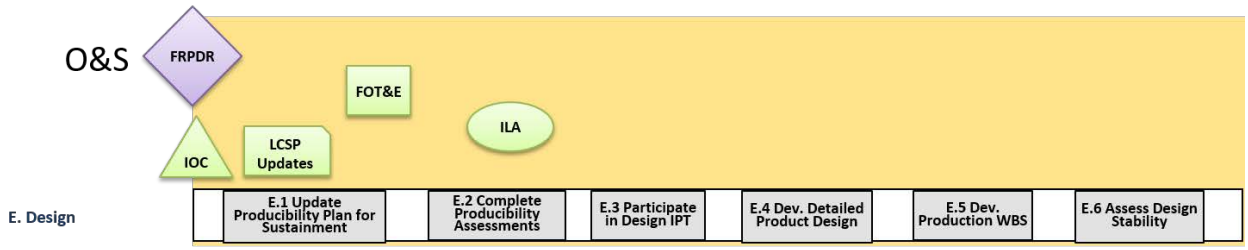
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Manufacturing/QA Risk Mitigation Plan (no Template available)
- Manufacturing Readiness Level Assessment Checklist, Technology and Industrial Base thread

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions, Apr 1996
- MRL Deskbook Version 2016, Chapter 5.2 Development of a Manufacturing Maturation Plan

E. DESIGN

Manufacturing and quality personnel participation in and support to Program Systems Engineering IPTs is critical to success in producing a manufacturable and affordable systems with acceptable risks. Manufacturing and quality industry best practices are integral to design and development efforts in both Manufacturing Management System (MMS) and Quality Management System (QMS) requirements (e.g., AS6500, ISO 9001, AS9100, etc.). The Program should integrate manufacturing and quality into the product design and development process and engage manufacturing and quality expertise as early as possible and throughout the entire life cycle of a system to include the O&S phase. Analyses of design alternatives through trade studies, producibility analyses, and manufacturing feasibility based on Program requirements need to be conducted with results incorporated into the design. To accomplish Program objectives, producibility planning and analysis along with manufacturing/QA planning and analysis need to be performed throughout the supply chain (e.g., failure mode analyses, Key Characteristics, quality capabilities, test processes, etc.), enabling appropriate visibility and accountability through collection, recording, and communication of technical and programmatic data to all levels.



During the O&S phase, manufacturing and quality should be assessed to support all sustainment activities and concerns. This includes continued production and design activities associated with value engineering activities, pre-planned product improvements and capability enhancements. It should be noted that during the O&S phase design, manufacturing and QA activities can be taking place at contractor facilities or at government depots, maintenance, repair and overhaul facilities, or other forms of government facilities.

E.1 Update Producibility Plan for Sustainment

The purpose of Producibility Engineering and Planning (PEP) is to ensure that product designs reflect good producibility considerations prior to release for manufacturing. Although there is no commonly accepted starting point for PEP, it is prudent to anticipate production system requirements as early in the program as in the material solution analysis phase, when only a small percentage of the total expected program life cycle costs has been incurred.

PEP involves the engineering tasks necessary to ensure timely, efficient and economic production of essential material. It includes efforts related to development of the Technical Data Package (TDP), Quality Assurance (QA) procedures, and evaluation of special production processes through trade studies. Also included are development of unique processes essential to the design and manufacture of the material and details of performance ratings; dimension and tolerance data; manufacturing methods; sequences; assembly; schematics; physical characteristics including form, fit and function; inspection test and evaluation requirements; calibration information and quality control procedures.

PEP is, in effect, a qualification process that will confirm the adequacy of the production planning, tool design, manufacturing process, and procedures before rate production begins.

It is DoD policy that factors affecting producibility and supportability shall be fully integrated during EMD. The design and test cycle shall be structured to provide a continuum in development for production, as opposed to discrete phases that cause iterative and redundant activities. The PEP program should be defined contractually and contain specific tasks and measurable performance that will support an orderly transition. PEP progress should be tracked by means of production readiness reviews required before initial or full production decisions. The objective of a transition plan is to provide visibility of how well each activity is being executed. Progress should be regularly compared against the transition plan.

Employ a "Should-Cost" management and analysis approach to identify and implement system and enterprise sustainment cost reduction initiatives. Should-cost targets will be established and reviewed periodically based on analysis of acquisition sustainment costs and operations and support (O&S) cost element drivers. Program managers will capture product support metrics and cost data in DoD Component- and DoD-level information systems, and track performance against should-cost targets.

Continually monitor product support performance and correct trends that could negatively impact availability and cost.

Manufacturing and Quality Tasks

- Manufacturing and QA should provide input into the LCSP.
- Manufacturing should provide input into producibility/design reviews, systems engineering, and trade studies for Sustainment planning.
- Review contractor/governments plans for producibility planning
- Ensure the plan describes how the design engineers will apply producibility principles
- Identify specific producibility engineering techniques (Design For Manufacturing and Assembly (DFMA), Design for Reliability and Maintainability, Design for Six Sigma DFSS), DfX, etc.)
- Identify producibility risks and issues

Metrics

- Producibility Plan Updated

Tools

- Producibility Engineering and Planning Data Item Description
- Manufacturing Readiness Level Assessment Checklist, Design thread

Resources

- IEEE15288.2, System and Software Engineering, Standard for Technical Reviews and Audits on Defense Programs, 2015
- NAVSO P-3687 Producibility System Guidelines, Dec 1999
- Producibility System Guidelines, Missile Defense Agency, Apr 2009
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning
- MRL Deskbook Version 2016

E.2 Complete Producibility Assessments

Manufacturing/quality personnel should provide input into producibility/design reviews, systems engineering, and trade studies.

Manufacturing/quality assurance managers should look at producibility assessments as a vehicle for encouraging the contractors to continually improve their processes and products. Also note this is not confined to contractors - encourage internal improvements at depots and within the support facilities.

According to DODD 5000.01, Knowledge-Based Acquisition, program managers (PMs) "shall reduce manufacturing risk and demonstrate producibility prior to full-rate production."

DOD policy on major system acquisitions makes producibility considerations a requirement prior to the start of Technology Development. The Alternative Systems Review should have included producibility assessments of the design concepts. Producibility assessments and engineering should be a part of the on-going systems engineering process. DoDI 5000.02 states that "design for producibility" shall be a part of the Engineering and Manufacturing Development phase. DoDD 5000.01 states that the PM shall "reduce manufacturing risk and demonstrate producibility" prior to full-rate production.

History has demonstrated that as the complexity of systems increases, so does the acquisition cost (including life-cycle cost). Therefore, producibility programs are necessary as a management means for assuring that practicality is addressed and that the cost increases associated with the growing complexity of systems are minimized. It should be recognized that the producibility analysis accomplished by the program management office (must be performed by a team of specialists assembled from the program office: and supporting organizations. One functional organization cannot possibly accomplish the total producibility effort without assistance from other functional organizations. Consequently, the PMO approach to organizing for producibility is of prime importance to a successful defense system.

Congress passed the following laws that impact the U.S. industrial base. U.S. Code; Title 10, Chapter 148, Section 2501 sets the national security objectives that the U.S. industrial base must be capable of:

- Supplying, equipping, and supporting the force structure of the armed forces;
- Sustaining production, maintenance, repair, logistics, and other activities in support of military operations of various durations and intensity;
- Maintaining advanced research and development activities to provide the armed forces with systems capable of ensuring technological superiority over potential adversaries;
- Reconstituting within a reasonable period the capability to develop, produce, and support supplies and equipment, including technologically advanced systems, in sufficient quantities to prepare fully for a war, national emergency, or mobilization of the armed forces before the commencement of that war, national emergency, or mobilization;

- Providing for the development, manufacture, and supply of items and technologies critical to the production and sustainment of advanced military weapon systems within the NTIB;
- Providing for the generation of services capabilities that are not core functions of the armed forces and that are critical to military operations within the NTIB;
- Providing for the development, production, and integration of information technology within the NTIB; and
- Maintaining critical design skills to ensure that the armed forces are provided with systems capable of ensuring technological superiority over potential adversaries.

Manufacturing and Quality Tasks

Producibility assessments are required in order to develop and manufacture products that will satisfy the warfighter. NAVSO P-3687, Producibility Systems Guidelines, outlines a five-step process for ensuring that producibility planning and execution is integrated into the systems engineering process and into the Life Cycle Sustainment Plan. One of the major steps in that process is to "determine the process capability" and that means to assess the producibility of the item.

Metrics

- Producibility Assessment Rating

Tools

- Producibility Assessment Worksheet
- Manufacturing Readiness Level Assessment Checklist, Design thread

Resources

- NAVSO P-3687 Producibility System Guidelines, Dec 1999
- MRL Deskbook Version 2016

E.3 Participate in Design IPT

The producibility engineering review is conducted in addition to normal and necessary design reviews. These reviews during the O&S phase are conducted by the engineering IPT and should be used to assess progress against specific goals and metrics for the product. Producibility Engineering should naturally support any requirements for "design for supportability."

Metrics should be derived from the mission requirements and first expressed as Measures of Effectiveness (MOEs), and then as Key Performance Parameters (KPPs). The KPPs then get expresses as Measures of Performance and the as Technical Performance Measures. Manufacturing and quality personnel need to understand their role in achieving the MOEs/KPPs and develop systems and processes that will help the program to achieve these measures. A good example to illustrate this concept is you have a requirement to fly two sorties a day and in order to do that you

need an operational availability rate Operational Availability (Ao) of .98. In order to achieve that availability rate, the entire system, to include subsystems and components, must be highly reliable and have a long Mean Time Between Failure (MTBF). That means that the design must be producible and that there is very little variation on Key Characteristics.

Since it is imperative that the IPT maintain a focus on producibility, the regular design reviews address many producibility issues. However, they are typically focused on individual processes and components and normally include tool, production, and facilities planning for those processes.

In contrast, the focus of the producibility engineering review expands to an evaluation of whether the entire product can be manufactured in the intended facility within the given schedule and budget. Internal experts who are not part of the product IPT nor involved in the product development are normally brought in to conduct this review.

Manufacturing and Quality Tasks

- Manufacturing and QA personnel participate in the Systems Engineering process.
- Manufacturing and QA personnel ensure adherence to appropriate manufacturing and QA requirements and best practices
- Manufacturing and QA personnel provide inputs to any trade studies
- Manufacturing and QA personnel provide inputs to any engineering trouble analysis on factory floor problems or on field failures (FRACAS, etc.)

Metrics

- Manufacturing and QA personnel participate in the Systems Engineering process

Tools

- Systems Engineering Plan (SEP) Outline
- Life Cycle Sustainment Plan outline
- Manufacturing Readiness Level Assessment Checklist, Design thread

Resources

- Defense Acquisition Guide, Chapter 3 – Systems Engineering
- Systems Engineering Plan (SEP) Outline, Jun 2015
- LCSP memo, Sep, 2011 and DAG Chapter 4-3.1
- Defense Acquisition Guide, Chapter 4 – Life Cycle Sustainment
- MRL Deskbook Version 2016

E.4 Develop Detailed Product Design

One of the roles of Manufacturing/QA personnel is to “influence the design.” It must be noted that Manufacturing/QA personnel are not design engineers and thus their role is a supporting role. They

need to assess the design to ensure that the design is manufacturable and inspectable/testable. The existing factory floor is a "capability," and a design that cannot be produced on the existing factory floor either requires a design change to match the existing condition or the development of manufacturing and QA processes that will ensure that the design can be build that results in uniform, defect-free products that are affordable. A good example was when the Air Force first started putting composite materials on the skin of aircraft to make them less visible. Manufacturing processes had to be developed that would ensure wing skins were put down uniformly and that the process was affordable. Quality assurance personnel had to think about new inspection methods and the development of acceptance criteria for these new materials.

- Manufacturing must assess the detailed production designs, processes, WBS, and schedules must be transitioned from full rate production to a schedule and rate that can be used to produce spares during sustainment.
- Manufacturing must assess new analytical methods, tools, and processes for analyzing production schedules against spare parts manufacturing.

Manufacturing and Quality Tasks

- Assess proposed design changes for manufacturability.
- Assess proposed design changes for inspectability and high levels of quality (yields).

Metrics

- Manufacturing/QA personnel influencing the design process

Tools

- Design for Performance
- Design for Manufacturing and Assembly (DFMA)
- Design for Six Sigma
- Design for Producibility
- Design for Affordability
- Manufacturing Readiness Level Assessment Checklist, Design thread

Resources

- Defense Acquisition Guide, Chapter 3 – Systems Engineering
- IEEE15288.2, System and Software Engineering, Standard for Technical Reviews and Audits on Defense Programs, 2015
- AS6500, Manufacturing Management Program
- MRL Deskbook Version 2016

E.5 Develop Production Work Breakdown Structure (WBS)

Manufacturing should support developing an overarching WBS framework to identify "smart shutdown" tasks. This would stop full rate production efforts and change over to a limited spares production capability.

The planning, execution and control of the production phase activities require that the work be divided into manageable tasks that are compatible with the existing manufacturing and performance measurement systems. Often, the WBS used during the development phases will not be appropriate for the production phase or for sustainment. Consequently, the contractor should, as a basis for production planning, identify and develop the WBS which is to be used. While this was may differ from the EMD structure, the two should be such that production phase costs can be related to the development WBS and the sustainment costs can be related to the production costs. This is critical for those programs which have utilized a design-to-unit production cost management approach during development.

The objective of the O&S phase is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. When the system reaches the end of its useful life, the department should dispose of it.

During the sustainment effort of the operations and support phase, systems engineering processes support in-service reviews including identifying root causes and resolutions for safety and critical readiness degrading issues. This effort includes participating in trade studies and decision making relative to the best resolution (e.g., changes to the product support package, manufacturing process improvements, modifications, upgrades, and future increments of the system), considering the operational needs and the remaining expected service life. Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, joint or service commonality, etc. may all indicate the need for a system upgrade(s) or process improvements.

The last activity associated with the operations and support acquisition phase is disposal. Early systems engineering processes should include and inject disposal requirements and considerations into the design processes that ultimately facilitate disposal.

Manufacturing and Quality Tasks

- Develop a production WBS

Metrics

- Development of a Production WBS

Tools

- WBS Template
- Manufacturing Readiness Level Assessment Checklist, Design thread

Resources

- MIL-STD-881 – Work Breakdown Structure for Defense Materiel Items, Oct 2011
- MRL Deskbook Version 2016

E.6 Design Stability

Designs should be stable and mature prior to going into production, with design changes limited to those required for continuous improvement. All Key Characteristics should be stable and under control per appropriate quality standards. Any significant design changes should be assessed for maturity prior to release to production.

Contractors and production organizations during the O&S phase may be experiencing the following:

- On-going production (no design impact)
- Ramp up or ramp down in production (no design impact)
- Production of Spares (no design impact)
- Design changes to meet changing requirements or for continuous improvement
- Changing requirement could indicate a significant design change
- Continuous improvement may involve “tweaking” of the design or manufacturing processes

Manufacturing/QA personnel should advocate Continuous Improvement. This activity involves the use of the “bully pulpit” of the SPO and the role we have in encouraging the contractors to continually improve their processes and products. The manufacturing/quality assurance managers have numerous opportunities to do this, such as during teleconferences, Program Management Reviews, Fact Findings, etc. Also note this is not confined to contractors - we can encourage internal improvements at depots and within the SPOs.

Manufacturing and Quality Tasks

- Manufacturing/QA personnel should be encouraging the contractors to continually improve their processes and products and change from rate production to limited production of spares.
- Manufacturing/QA personnel monitor field failures and the potential for design changes due to a variety of problems (Field Failure Reports, etc.).

Metrics

- Manufacturing/QA personnel participation in design reviews

Tools

- Design for Performance
- Design for Six Sigma
- Design for Producibility
- Design for Affordability
- Manufacturing Readiness Level Assessment Checklist, Design thread

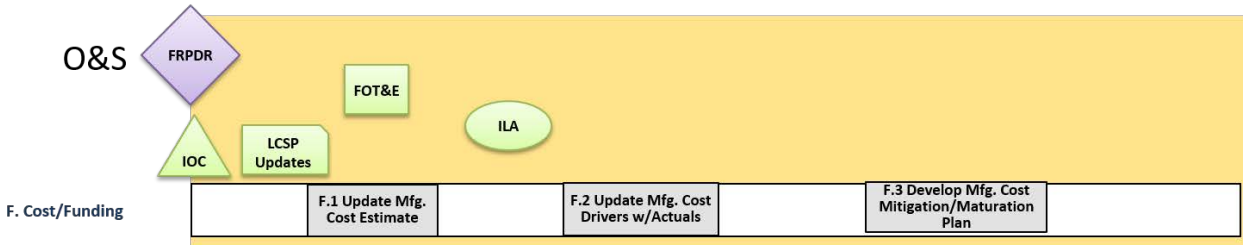
Resources

- Defense Acquisition Guide, Chapter 3 – Systems Engineering
- MRL Deskbook Version 2016

F. COST AND FUNDING

Cost and Funding is mainly concerned about having cost models to initially estimate costs, then validating the cost models by collecting and analyzing actual cost against cost targets or budget goals, and finally, establishing a budget to support future Manufacturing/QA efforts. Mainly, improvement efforts.

Manufacturing/QA cost estimates for the O&S phase are normally often based on actual costs that were experienced during the Production and Operations phase, the costs associated with Full Rate Production. Cost associated with FRP should be well known, however, during the O&S phase you may not be producing product or spares at the same rate and the contractor may not be in full rate production, so the cost may be higher. Or the O&S cost are now associated to depot level work, and because the throughput is lower and thus the cost per unit to remanufacture may be higher.



Additionally, DoD's Sustainability Analysis Guidance: Integrating Sustainability into Acquisition Using Life Cycle Assessment, Dec 2016, provides weapon system and product support managers with guidance for conducting sustainability cost estimates. Sustainability Analysis combines Life Cycle Cost (LCC) estimating and Life Cycle Assessments (LCA). The LCA quantifies resource requirements, environmental releases, and waste through each life cycle stage of a system, and estimates the associated impacts on the following:

- **Resource Availability:** Includes natural resource use (e.g., land, water, mineral, and fossil resources), potential impacts on resource quality and availability, and the associated marginal cost increases.

- **Climate Change:** Includes greenhouse gas emissions, their contribution to global warming, and the associated impacts, including changes in net agricultural productivity, human health, property damages from increased flood risk, and ecosystem services.
- **Human Health**: Includes environmental releases, water use, and noise emissions, and the associated impacts on human health and productivity.
- **Ecosystem Quality**: Includes environmental releases, land use, and water use, and the associated impacts on biodiversity and ecosystem services.

Together LCC estimating and LCA are employed to reveal and estimate three types of sustainability related costs:

- Internal Cost
- External Cost
- Contingent Cost

F.1 Update Manufacturing Cost Estimate

Manufacturing and Quality Tasks

Detailed cost estimates need to be established and/or updated. Costs could be related to contractor or depot/MRO activities and products. Historical costs estimates based on Full Rate Production quantities may not be appropriate for the O&S phase.

- Manufacturing/QA may want to establish cost models for the O&S phase based on the planned rates and quantities.
- Manufacturing/QA estimates need to take into consideration that the work may be done by a contractor or the government, and at a production facility or at a depot or MRO.
- Manufacturing/QA should assess if DOD investments are going to be needed to create or enhance certain critical industrial capabilities.
- Manufacturing/QA should be able to track expenditures and the estimate to complete using approved techniques such as Earned Value Management System (EVMS) analysis, or its predecessor Cost/Schedule Control System (C/SCS) during sustainment operations.

Manufacturing cost estimates for the production phase are normally based on the assumption that the design is complete, that the manufacturing processes are known, stable and in control, and manufacturing operations will be accomplished as planned. The same hold true for the O&S phase. However, the O&S phase may see several changes to the P&D model.

- Full Rate Production may not continue, and if it stops and the contractor is only producing spares, then the unit cost may go up.
- Work may be done at a public or private

Any deviation from these assumptions could cause a growth in cost. As such, time and conformance measures can give some indication of potential or real cost aberrations since there is normally a direct correlation between late delivery or conformance problems and cost.

Support Earned Value Management System (EVMS) analysis, or its predecessor Cost/Schedule Control System (C/SCS). This will help in updating manufacturing costs using production phase actuals when developing cost estimates for the O&S phase to ensure that the government receives the full benefit of the contractor's production learning curve.

Metrics

- Should Cost or Could Cost Models
- Design to Cost Goals
- Manufacturing/QA Cost Estimates
- Estimate to Complete

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- Cost, Schedule Control Systems Criteria (CSCSC)
- Manufacturing Readiness Level (MRL) Assessment Checklist, Cost and Funding thread
- See CAPE website for tools

Resources

- Sustainability Analysis Guidance: Integrating Sustainability into Acquisition Life Cycle Assessment, Dec 2016
- Earned Value Management Guide, Oct 2006
- CSCSC Reference Guide, Sep 1992
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766 Design to Cost
- Should-cost and Affordability Memo, Aug 2011
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- Defense Acquisition Guidebook, Section 3.4.4 Cost Assessment Reporting Requirements
- MRL Deskbook Version 2016
- CARD Website and process

F.2 Update Manufacturing Cost Drivers with Actuals

Manufacturing and Quality Tasks

Typically, in any industry, materials and labor are the two biggest manufacturing cost drives. Another major factor is rate and quantity. During the O&S phase there are several changes that often take place that impact costs. Changes to rate and quantity as the contractor's original rate from full rate production goes down, and the majority of their production is in support of spares. There may also be changes to the supply chain as contractors either move in and out of a business or contractors look for lower prices and higher quality. Then there is the problem of Diminishing Manufacturing Sources and Material Shortages (DMSMS), obsolescence and counterfeit parts.

- During the Production phase manufacturing used Should Cost management and other techniques to identify manufacturing cost and cost drivers, and then continuously control and reduce cost. The actuals generated should be used to update Sustainment costs to determine new cost drivers and to validate funding estimates.
- Assess manufacturing/QA risks and the costs associated with those risks.
- Manufacturing should employ a "Should-Cost" management and analysis approach to identify and implement system and enterprise sustainment cost reduction initiatives.
- Manufacturing should periodically establish and review should-cost targets based on analysis of acquisition sustainment costs and operations and support (O&S) cost element drivers. Support the program manager to capture product support metrics and cost data and track performance against should-cost targets.
- Manufacturing should conduct cost analysis on the vendors as nearly 80% of the life cycle cost of any system is locked in during prior to sustainment. Typically, the supplier network represents an enormous opportunity of distributed technological knowledge and an excellent source of cost savings.

During this phase Should Cost management and other techniques will be used continuously to control and reduce cost.

Employ a "Should-Cost" management and analysis approach to identify and implement system and enterprise sustainment cost reduction initiatives. Should-cost targets will be established and reviewed periodically based on analysis of acquisition sustainment costs and operations and support (O&S) cost element drivers. Program managers will capture product support metrics and cost data in DoD Component- and DoD-level information systems, and track performance against should-cost targets.

Metrics

- Should Cost Estimate
- Design to Cost Estimate
- Manufacturing/QA Actuals

Tools

- Cost Analysis Requirements Description template
- Cost and Lead Time Estimating Worksheet
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- Cost, Schedule Control Systems Criteria (CSCSC)
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding thread
- See CAPE website for tools

Resources

- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766 Design to Cost
- Should-cost and Affordability Memo, Aug 2011
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- MRL Deskbook Version 2016

F.3 Develop Manufacturing Cost Mitigation/Maturation Plan

Manufacturing and Quality Tasks

Once manufacturing/QA cost drivers and risks have been identified, then manufacturing/QA personnel should be engaged in the development of a Cost Mitigation/Maturation Plan.

- Manufacturing/QA personnel should take inputs from the Integrated Logistics Assessment to help them in developing the Cost Mitigation/Maturation Plan.
- Utilize Earned Value Management or Cost, Schedule Control Systems Criteria or other means to track cost and cost trends.
- Manufacturing should assess if DOD investments are going to be needed to create or enhance certain critical industrial capabilities.
- Manufacturing should continually monitor product support performance and correct trends that could negatively impact availability and cost.
- Develop Manufacturing Cost Risk Handling/Maturation Plans for key and critical subcontractors and vendors.
- Utilize field data and failure reports to update cost models and help ensure that Sustainability targets are being met.
- Identify and account for Demil and Disposal cost.
- Use factors and assumptions consistent with those used in the analysis of alternatives and affordability analysis, or justify any deviation from those factors and assumptions.

- Manufacturing should ensure reliability and maintainability data from operational and developmental testing and evaluation and fielding informs estimates of O&S costs for major weapon systems.

Metrics

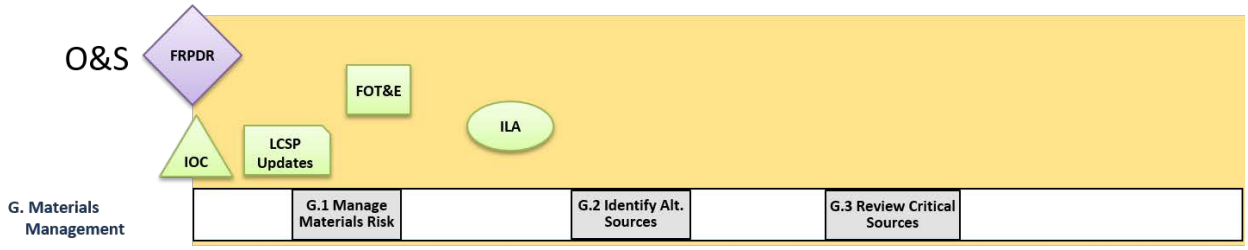
- Manufacturing/QA cost estimates
- Manufacturing/QA risk assessment

Tools

- Manufacturing Readiness Assessment Cost and Funding thread
- EVM and CSCSC software tools or in excel
- Cost and Lead Time Estimating worksheet
- Manufacturing Readiness Level Assessment Checklist, Cost and Funding thread
- Resources
- MRL Deskbook Version 2016
- 10 USC Sec. 2334 Independent Cost Estimation and Cost Analysis
- DoDI 5000.73 Cost Analysis Guidance and Procedures, Jun 2015
- Public Law 114-328, §807, Cost, Schedule and performance of major defense acquisition programs
- CARD - Cost Analysis Requirements Description Template (See CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide, Sep 1992
- DODI 5000.73 Cost Analysis Guidance and Procedures
- MRL Deskbook Version 2016
- Risk, Opportunities and Issues Guide, Jun 2015

G. MATERIALS MANAGEMENT

During the sustainment phase, programs face unique challenges as they attempt to manage their military supply chains, especially during wartime. Thus, they should have a general understanding of the Supply Chain Operations Reference (SCOR) Model. DOD 4140.1R, DoD Supply Chain Material Management Regulation, directs DoD Components to use the supply chain operational reference processes of Plan, Source, Maintain/Make, Deliver, and Return as a framework for developing, improving, and conducting material management activities. Most of the DoD supply chain focus is on operations and logistics. However, there is growing concern within the acquisition communities for improving the way supply chains are managed on large weapon system programs.



At the strategic level, military and private organizations are driven by many material management opportunities and constraints. They must address the logistics issues of acquisition, distribution, sustainment, and disposition and disposal. In addition, as the program matures and moves from production to spares production, and on-going maintenance and sustainment activities, the nature of the business arrangement often changes as DoD contractors get out of the business and DoD MRO activities take on increasingly more responsibilities. No doubt, adopting blanket business solutions and practices and applying them with little thought to the DoD supply chain would be problematic. However, many of the problems faced in today's DoD supply chain are the same ones that the commercial sector has dealt with or is currently facing.

As the program matures and transitions from the Production and Deployment phase to the Operations and Support phase, Sustainment managers should be concerned about:

- Material availability and in particularly DMSMS, Obsolescence and Counterfeit parts
- Material maturity
- Supply Chain Management
- Special Handling

Many of these material considerations should have been matured by this time, but because of changes in where (facilities) the production or remanufacturing is taking place, these considerations may have changed or regressed.

G.1 Manage Materials Risk

The objective of this phase is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. When the system reaches the end of its useful life, the department should dispose of it.

During the sustainment effort of the operations and support phase, systems engineering processes support in-service reviews including identifying root causes and resolutions for safety and critical readiness degrading issues. This effort includes participating in trade studies and decision making relative to the best resolution (e.g., changes to the product support package, manufacturing process improvements, modifications, upgrades, and future increments of the system), considering the operational needs and the remaining expected service life. Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature

failures, changes in fuel or lubricants, joint or service commonality, etc. may all indicate the need for a system upgrade(s) or process improvements.

Many DOD systems require maintenance long beyond the useful life initially anticipated. Extending the service life of military systems increases the costs of ownership. For the purposes of Commercial Operations and Support Savings Initiative (COSSI), O&S costs are the costs of owning and operating a military system, including the costs of personnel, consumables, goods and services, and sustaining the support and investment associated with the peacetime operation of a weapon system. One way to reduce O&S costs is to take advantage of the commercial sector's technological innovations by inserting commercial technology into fielded weapon systems. The COSSI was initiated under 10 U.S. Code 2511 to develop and test methods for reducing DOD operations and support cost by inserting commercial items into fielded military systems.

One of the major challenges facing DOD is modernizing legacy systems using state-of-the-art technology. Therefore, from the start of an acquisition program, DOD must consider not only how to get a useful military capability to the field quickly, but also how it can upgrade a system later. Considerations include the latest technology, increasing mission performance, reducing O&S costs, and enhancing supportability.

Although basic and applied research are the foundations for meeting future technology needs, other programs - such as Advanced Technology Demonstration , Advanced Concept Technology Demonstrations , warfighter experiments, and other approaches - are key to accelerating the transition from Science and Technology (S&T) to military weapons systems. Managers of S&T, Research and Development (R&D), and acquisitions must collaborate on their efforts if a technology is to be transitioned into weapons systems.

Identifying and selecting technologies are important early steps in developing or upgrading weapon systems. Numerous technology "clearinghouses" exist for identifying technologies.

Often PMs rely on prime contractors to identify and select technologies to insert into systems, believing the contractor will always use the best source for technology, and use it to develop the system. However, this is not always the case and may not be the best way to find leading technologies that are applicable to weapons systems. Working together, the communities for capability needs, S&T, R&D, T&E, acquisition, and sustainment, must work hard to communicate program requirements and identify the technologies, regardless of their source, that most benefit the warfighters.

S&T leaders (government and industry) must maintain close and continuous ties with the warfighters or other users of systems, as well as with acquisition and sustainment PMs. Maintaining these ties can help ensure that S&T leaders understand the needs, develop technologies that will be useful for satisfying those needs, have a sense for the timing needed for integration, and anticipate future warfighting needs. The ties can be maintained through formal forums or, even more effectively,

through frequent interactions between technologists and acquisition or sustainment PMs. The interaction will help keep S&T projects focused on increasing the effectiveness of a mission capability while decreasing cost, increasing operational life, and incrementally improving products through planned product upgrades.

Manufacturing and Quality Tasks

- Manufacturing should identify obsolete parts in specifications and develop plans for suitable replacements.
- Periodically assess product support performance and assist program managers, users, resource sponsors, and materiel enterprise stake holders to take corrective action to prevent degraded materiel readiness or O&S cost growth.
- Materiel Reliability is the design metric that has the most significant impact on the program's operational availability and O&S cost. Higher materiel reliability will result in higher Operational Availability and Materiel Availability since both A_o and A_m are a function of R_m. The inherent reliability of a system is, by far, the biggest contributor to high Operational Availability.

Metrics

- Material Reliability

Tools

- Manufacturing Readiness Level Assessment Checklist, Materials Management thread
- DMSMS Product Life Cycle Assessment
- Market Research
- Supply Chain Management Risk Assessment Checklist

Resources

- MRL Deskbook Version 2016
- DOD 4140.1R, DoD Supply Chain Material Management Regulation, May 2003
- DMSMS Acquisition Guidelines, 2001
- DoD Market Research Guide, May 2012

G.2 Identify Alternate Sources

Diminishing Manufacturing Sources and Material Shortages (DMSMS), the loss of sources of items or material, surfaces when a source announces the actual or impending discontinuation of a product, or when procurements fail because of product unavailability. DMSMS may endanger the life-cycle support and viability of the weapon system or equipment.

Although electronics are the most likely parts to be discontinued, obsolescence of non-electronic and COTS items also poses a significant problem to weapon systems. In short, DMSMS is a threat to system supportability.

Solving DMSMS is complex, data intensive, and expensive. There are two approaches to solving DMSMS in a system: reactive (you address DMSMS problems after they surface) and proactive (you identify and take steps to mitigate impending DMSMS problems). DoD policy prescribes the proactive approach.

Materiel Reliability. As required by the Manual for the Operation of the Joint Capabilities Integration and Development System (JCIDS), materiel reliability is the design metric that has the most significant impact on the program's operational availability and O&S cost.

Counterfeiting of parts and materials, especially in the electronic business segment, is growing at an alarming rate. According to the General Accountability Office (GAO), the increase in counterfeit parts is one of several potential barriers the DoD faces in addressing part quality problems. As we draw from a large network of suppliers in an increasingly global supply chain, there can be limited visibility into these sources and greater risk of procuring counterfeit parts. Additionally, there are unique conditions that make aerospace and defense products susceptible to counterfeiting, including a long life-cycle and Diminishing Manufacturing Sources and Material Shortages issues. Therefore, supporting aerospace and defense products throughout their lifecycle sometimes requires the use of parts that may no longer be available from the Original Equipment Manufacturer , authorized aftermarket manufacturer or through franchised or authorized distributors or resellers.

Manufacturing and Quality Tasks

- Manufacturing should work with product support integrators and product support providers to investigate alternate source options. These may be organic, commercial, or a combination.
- Verify prime supplier has validated alternate sources are capability of meeting quality, manufacturing, engineering and software requirements.
- Periodically assess product support performance and assist program managers, users, resource sponsors, and materiel enterprise stake holders to take corrective action to prevent degraded materiel readiness or O&S cost growth.

Metrics

- SCM Functional Performance Measures
- Customer Satisfaction, Cost, Readiness and Sustainability
- MOE's - KPPs - TPMs

Tools

- Manufacturing Readiness Level Assessment Checklist, Materials Management thread
- DMSMS Product Life Cycle Assessment

- Market Research
- Supply Chain Management Risk Assessment Checklist

Resources

- MRL Deskbook Version 2016
- DOD 4140.1R, DoD Supply Chain Material Management Regulation, May 2003
- SCM: A Recommended Performance Measurement Scorecard, Jun 1999
- DMSMS Acquisition Guidelines, 2001
- DoD Market Research Guide, May 2012
- Developing Alternative Sources Thesis, Mar 1987

G.3 Review Critical Sources

DMSMS and obsolescence are often used interchangeably within the DoD, however there is one minor difference between the two terms. Obsolescence is a DMSMS problem that was created by a regulatory or statutory requirement. For example, the banning of lead in electronics by the European Union has led to a drop in the number of suppliers for these products. But whether it's called DMSMS or obsolescence, the outcome is the same; the customer has a product or weapon system that may no longer be supportable.

In simple terms DMSMS occurs because the market for an item, and therefore availability, shrinks to the point where it becomes unprofitable for a company to continue to manufacture the item. When this occurs, any customer (*e.g.* , DoD) that still has a requirement for that item will find it increasingly difficult to obtain the item and the cost will be markedly higher due to scarcity. Obsolescence occurs within DoD when:

- Weapon system capability becomes degraded due to reduced availability of parts and sources.
- New technology displaces old.
- Costs become unaffordable for production, support, and sustainment.

Where and how you get sources of material can be a vital concern for PMs. Having just one sole source, single source or foreign source in supply chain could be a show stopper, especially if that item is a critical item that significantly impacts the capability of the system to perform its mission.

A sole source is one in which there is only one source for that item. There are no other alternatives. What happens if that sole source goes bankrupt or goes out of business for any reason? What happens if this situation happens overnight, like the plant burns down? What are you going to do to keep your program from being stopped in its tracks?

A single source is one in which there is only one "qualified" source. This condition is slightly better than the sole source situation as there are other companies capable of making your item, they just

have not been "qualified" as a source. Qualification can be an expensive and time-consuming process. If you find yourself in a sole or single source situation you may want to consider an investment strategy to get a second source qualified, now do you not only have a backup source, you have competition.

A foreign source is one that is outside of the U.S. industrial base. Remember that Canada is by law a part of the U.S. industrial base. Foreign sources carry with them many problems. The transfer of some intellectual information to companies outside of the U.S. can be restricted by International Traffic in Arms Regulations (ITAR) making it difficult to do business outside of the U.S. In addition, some countries restrict the types of items that their companies can sell to the U.S., for example items that go into nuclear programs are often restricted by countries with strong nuclear concerns. Sometimes politics can play a role and an item that is available this week may not be available next week due to political pressures. If you have a foreign sources item that is critical to your program, you might want to consider funding a second source, a U.S. source.

Manufacturing and Quality Tasks

Identifying and assessing materials risks, especially critical materials and sources, should include the assessment of:

- Material Availability: Concerned primarily about sole source and foreign source, but could also include limited sourcing and long lead sourcing. In the O&S phase there will be growing concerns about DMSMS and Obsolescence. Along with that will be concerns about counterfeit parts.
- Material Maturity: Concerned about the introduction on new parts, especially electronic parts that are replacing parts that are old and no longer being produced. This is usually concerned with having complete material knowledge at the time of production.
- Material Supply Chain Management (SCM): Concerned about SCM since 60-80% of the fabricated and assembled items come from subcontractors and vendors and this is often where we have problems. Often the design occurs at the supplier level. The supply chain for the)&S phase often shifts from the prime and subcontractors to Maintenance Activities, Inventory Control Points, Depots, Maintenance, Repair and Overhaul facilities, and Installation Support Activities.
- Material Special Handling: Concerned about the movement of material to and within the plant and any ESOH concerns.

The review of critical sources should include a review of the contractor’s technical capabilities to include engineering, configuration management, and quality assurance.

- Manufacturing should analyze and encourage sources to continually improve their processes and products. Also encourage internal improvements at depots and within the support facilities.

- Manufacturing should be looking at counterfeiting of parts and materials in the electronic business segment are a growing problem especially during the Sustainment phase when many of the OEMs have moved on to other programs.
- As we draw from a large network of suppliers in an increasingly global supply chain, there can be limited visibility into these sources and greater risk of procuring counterfeit parts.
- Additionally, there are unique conditions that make aerospace and defense products susceptible to counterfeiting, including a long life cycle and DMSMS issues.
- Therefore, supporting aerospace and defense products throughout their lifecycle sometimes requires the use of parts that may no longer be available from the OEM, authorized aftermarket manufacturer or through franchised or authorized distributors or resellers.
- Prime contractors need to ensure a flow-down of technical requirements to include quality requirements. The DCMA organization at the prime contractor level needs to ensure the flow-down of oversight to their counterparts at subcontractor and vendor organizations.

Metrics

- 1st Pass Yields
- Quality Deficiency Reports

Tools

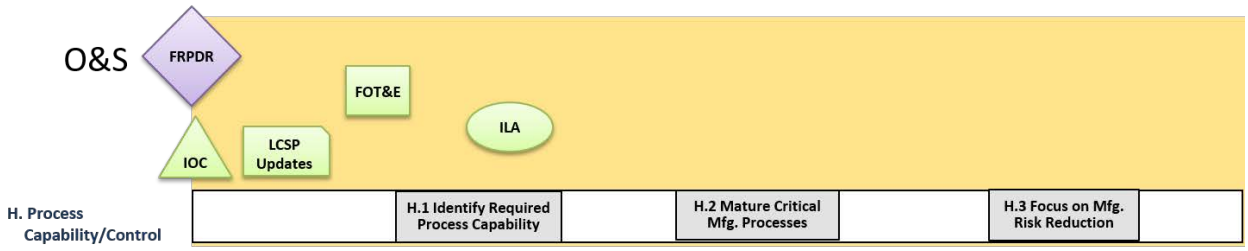
- ISO 9001 Quality Audit Checklist
- AS9134 Supply Chain Risk Management Guidelines
- AS9100 Quality Audit Checklist

Resources

- AS9100, Quality Management System – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016

H. PROCESS CAPABILITY AND CONTROL

During the sustainment phase, Process Capability and Control should be well understood, based on knowledge and experience during the Production and Deployment phase. However, production operations may shift from the prime contractor to government owned and operated facilities such as Depots, MROs and other industrial operations. Moving from one facility to another, with a different workforce, machines and other factory floor considerations may cause the process capability and control to slip, and slip below levels that are required to satisfy the warfighter.



H.1. Identify Required Process Capability

Product quality, and effective operations and sustainment results, are a product of the feedback of quality and other data during production and after the item has been fielded and is in use. The results of the design and manufacturing efforts receive their real test when the item or system is actually placed in use under rigorous field conditions. If all of the prior efforts have been adequately performed, the resulting product should meet the user's needs. The goal is to strive for no failures and full user satisfaction. If this is not achieved, then corrective action must be taken, and taken quickly to remove the cause of failure and of the user discontent. Of course, this is more difficult at this late stage of the acquisition cycle then if action were taken to identify and correct the root cause of the problem early in design or production. If the root cause of the problem requires a design change then engineering changes after this point cost more to implement than those discovered during initial design; therefore, it is important that all quality actions take place during design, development, and manufacture of the product. It is essential that manufacturing/QA personnel are involved in all aspects of any program, and are involved early in the process. If the problem is in the production or MRO/Depot facility then root cause corrective action must be taken on the industrial facilities that caused the defect or problem.

Manufacturing and Quality Tasks

- Review supplier’s key/critical characteristics/features list to identify possible government surveillance.
- Review supplier's process control plan to identify possible government surveillance.
- Review supplier process capability information of key/critical product characteristics/ features in the form of CP and CPK to identify possible government surveillance and flow-down requirements, and to determine process stability.
- Review supplier process yields and Process Failure Modes and Effects Analysis (PFMEA) conducted on key/critical manufacturing processes to identify possible government surveillance.
- Manufacturing should use Sustainment metrics mapped to the sustainment key performance parameter and key system attributes to manage sustainment performance.
- Manufacturing should conduct a series of either PRRs or MRAs to monitor progress in standing up a new spare parts or repair facility.

Metrics

- Key/Critical Characteristics identified
- Process Capability Gap analysis
- Quality Defects

Tools

- MRL Assessment Checklist for the Process Capability and Control Thread
- Process Capability Studies (Cp and Cpk assessment)
- Producibility Assessment Worksheet (PAWs)
- Six Sigma Worksheet
- FMEA Template

Resources

- MRL Deskbook Version 2016
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma) Program, May 2008
- DoD Continuous Process Improvement Transformation Guide, May 2006
- Capability-Based Assessment (CBA) Handbook, Mar 2014

H.2. Mature Critical Manufacturing Processes

If AS6500, Manufacturing Management Program is invoked on contract, verify supplier has conducted a PFMEA of critical manufacturing processes. This may also be required to be accomplished by the supplier when required by contract requirements language.

- Review supplier process yields and PFMEA conducted on critical manufacturing processes to identify possible government surveillance.

Studies have shown that by the time a Preliminary Design Review (PDR) is held around 80% of a program's life cycle cost are locked in even though only a small percentage of the programs cumulative costs have been expended. It is also the time when a program or contractor has the most opportunity to impact life cycle cost savings. By the time the Critical Design Review (CDR) is held the LCC commitment is around 90%. Manufacturing, logistics and other considerations must be taken seriously early or the program is doomed to becoming unaffordable. All manufacturing processes should have been demonstrated and those processes, especially the key processes should be stable and in-control. However, there may have been changes to manufacturing due to engineering changes (Value Engineering Change Proposals, etc.), or to changes in manufacturing facilities as production of items and spares moves from the prime contractor to subcontractors, vendors or at government facilities.

Manufacturing and Quality Tasks

Sustainment Process uses an integrated product support capability implementing the program's mix of government and industry providers supported by appropriate analyses.

- Manufacturing should support performance-based logistics planning, development, implementation, and management in developing a system's product support arrangements. PBL is performance-based product support, where outcomes are acquired through performance-based arrangements that deliver warfighter requirements and incentivize product support providers to reduce costs through innovation.
- Manufacturing should continually assess and refine the product support strategy based on projected and actual performance.
- Assess key/critical manufacturing processes to ensure that they are stable and in control.

The Program Manager has the responsibility for and authority to accomplish program objectives for development, production, and sustainment to meet the user's operational needs. These activities rely heavily on the capabilities and capacity of the defense industrial base. PMs need to specifically assess the capabilities of that industrial base in order to understand if the base can support their program.

Metrics

- Statistical Process Control (Cp and Cpk)
- Yield Rates

Tools

- MRL Assessment Checklist for the Process Capability and Control Thread
- AS6500, Manufacturing Management Program, Nov 2014
- Process Capability Study (Cp and Cpk assessments)

Resources

- MRL Deskbook Version 2016
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program, May 2008
- DoDI 5000.02, Jan 2017

H.3. Focus on Manufacturing Risk Reduction

Employ effective performance-based logistics (PBL) planning, development, implementation, and management in developing a system's product support arrangements. PBL is performance-based product support, where outcomes are acquired through performance-based arrangements that deliver warfighter requirements and incentivize product support providers to reduce costs through innovation

During the P&D phase the contractor will produce and deliver requirements compliant products to receiving military organizations. During the O&S phase they will have to supply compliant sustainment products, parts, limited-life supplies to maintain the systems they have produced.

Continually assess and refine the product support strategy based on projected and actual performance.

The sustainment KPP (Availability) is as critical to a program's success as cost, schedule, and performance. Acquisition Category (ACAT) I and II program managers will use availability and sustainment cost metrics as triggers to conduct further investigation and analysis into drivers of those metrics, to develop Should Cost targets, and to develop strategies for improving reliability, availability, and maintainability of such systems at a reduced cost. The materiel availability portion of the KPP will be based on the entire system inventory and supported by the following sustainment metrics.

The EMD Acquisition Strategy should have highlighted the strategy for assessing the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a pilot line environment, prior to Milestone C.

To the maximum extent practical, the environment should utilize rate production processes using production processes forecasted to be used in LRIP. The Acquisition Strategy should strategically describe the planning to assess and demonstrate that the manufacturing processes/capabilities, required for production will have been matured to a level of high confidence for building production configuration products in the P&D phase and spares during sustainment.

Manufacturing and Quality Tasks

During the Sustainment phase the contractor will support and maintain requirements compliant products for receiving military organizations.

- Assess manufacturing risks and develop a manufacturing maturity program.
- Manufacturing should use the sustainment KPP (Availability) is as critical to a program's success as cost, schedule, and performance.
- Use availability and sustainment cost metrics as triggers to conduct further investigation and analysis into drivers of those metrics, to develop Should Cost targets, and to develop strategies for improving reliability, availability, and maintainability of such systems at a reduced cost.
- The materiel availability portion of the KPP will be based on the entire system inventory.

Metrics

- KPPs – TPMs
- Availability (Reliability and Maintainability)

Tools

- MRL Assessment Checklist for the Process Capability and Control Thread
- Manufacturing Maturation Plan

Resources

- MRL Deskbook Version 2016

I. QUALITY MANAGEMENT

An effective quality management strategy (QMS) and quality controls are required if the Program is to deliver, operate and sustain operationally safe, suitable and effective weapon systems. The initial quality strategy should have been developed during the MSA phase and updated in every phase in support of the Systems Engineering Plan (SEP). The QMS assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The strategy requires monitoring and measuring of processes and products (including embedded software and firmware) to ensure they conform to requirements. Quality strategy development must begin during the earliest stages of system development and must continue throughout the program life-cycle.

During the sustainment phase, a contractor or a government owned or operated remanufacturing facility (Depot/MRO, etc.) should have implemented an effective QMS in accordance with FAR 46.202-4 Higher-level Contract Quality Requirements.

I.1 Update Quality Strategy

The Quality Strategy should be updated based on performance results, sustainment metrics mapped to the sustainment key performance parameter and key system attributes, to manage sustainment performance.

- Continually monitor product support performance and correct trends that could negatively impact availability and cost.
- Outcome metrics to support sustainment elements included in capability requirements documentation or required by the DoD Component to manage the system development, product support package, and supply chain to develop and maintain the system.
- Department by department status (schedule, work measurement, Scrap, Rework, and Repair, yields, etc.)

- Provide focus on improving manufacturing/quality assurance processes to reinforce the need for process improvement efforts.
- Update the Quality Strategy

Address problem/failure reports through the use of a comprehensive data collection approach such as a Failure Reporting, Analysis and Corrective Action System. Determine root cause of problems, identify corrective actions, and manage to completion.

- Process and analyze mission data
- Manage Preplanned Product Improvements (P3I)
- Develop and implement technology refresh schedules
- Conduct technology insertion efforts as needed to maintain or improve system performance
- Update system safety assessments
- Perform engineering analysis to investigate the impact of DMSMS issues
- Work with vendors and the general technical community to determine opportunities for technology incursion to increase reliability and affordability
- The disposal activities in which the Systems Engineer should participate include:
- Support demilitarizing and disposing of the system; in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment
- Document lessons learned
- Archive data

Metrics

- Quality Strategy updated

Tools

- Acquisition Strategy Template
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment (MRL) Questionnaire for the Quality thread
- Requirements Analysis Roadmap

Resources

- DSMC Acquisition Strategy Guide, Dec 1999
- AFMC Instruction 63-145 Manufacturing and Quality
- AS9100, Quality Management System – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- FAR 46.202 Types of Contract Quality Requirements
- FAR 52.246-11, Quality
- MRL Deskbook Version 2016

I.2 Verify Subcontractor Quality Management Plan

Subcontractors make up 60-80% of the material content on many programs, thus prime control of sub-contractors Quality Management System and Plan are essential to the success of any program. This includes during the O&S phase when the government may be acting as the prime contractor or during government management of Depot/MRO activities.

- Assess how efficiently the subcontractor o vendor is producing products, primarily through on-site quality assessments and the evaluation of work measurement data. It also includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.
- Verify the supplier is conducting a Corrective Action Board (CAB) and/or Material Review Board (MRB), or similar meetings, to discuss quality, manufacturing/production, supply chain, engineering and software deficiencies/issues and proposed/status corrective actions, at a minimum.
- Draw attention to troubled suppliers or critical processes needing corrective action by on-site visits/reviews.
- Perform government surveillance of supplier's compliance to Software Quality Assurance, Configuration Management, and Testing contract requirements
- Review how primes and suppliers conduct training in Counterfeit Parts Avoidance for Inspectors, Operators, Auditors and lower tier suppliers. Training should discuss how to inspect parts and identify possible counterfeits (e.g., non-conforming part markings).

The intent of verifying supplier quality programs is to draw attention to troubled suppliers or critical processes needing corrective action by on-site visits/reviews. The contractor will usually respond by sending his own representative to the site when you explain your reasoning. Consider inviting the program chief engineer or even the program director if the situation warrants their attention. The contractor will usually respond with equal high-level attention.

Primes and suppliers conduct training in Counterfeit Parts Avoidance for Inspectors, Operators, Auditors and lower tier suppliers to include awareness of AS5553. Training should discuss how to inspect parts and identify possible counterfeits (e.g., non-conforming part markings).

As our major defense acquisition programs become more complex and supply chains become longer, more obscure, and prone to unforeseen quality breakdowns, program risk associated with supplier processes has increased exponentially. Since the issues surrounding the supply chain typically impact program quality, cost, and schedule, the manufacturing and quality assurance personnel at DCMC can be key contributors in addressing this type of risk and providing visibility into potential future suppliers’ problems/ issues.

Metrics

- Supplier Quality Audit Rating

Tools

- Supplier QA Questionnaire
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- AS9134 Supply Chain Risk Management Guidelines
- Manufacturing Readiness Level Assessment Questionnaire for the Quality thread

Resources

- AS9100, Quality Management System – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- MRL Deskbook Version 2016
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, Jan 2017
- DAG Chapter 14.3.1.3.6 Quality Plans

I.3. Evaluate Contractor Quality Management System

A Quality Management System (QMS) is a formal system that documents policies, processes and procedures that may be required in order to achieve specific quality goals and objectives. The intent is to use the QMS to meet or exceed customer expectations and improve overall efficiency and effectiveness. The two dominant QMS programs that are currently available are ISO 9001 and AS9100. A QMS should be in place at all contractor facilities with a higher level quality requirement per FAR/DFAR or at any government owned and operated facility doing production type work.

- Primes and suppliers should institute strong incoming quality assurance on all parts, and visually inspect for defects.
- Prime contractors require certificates of conformance, testing certification, and procedures for handling any counterfeit parts that might slip through the system.
- Perform/delegate government surveillance of First Article (FA)/Qualification unit(s) (QUAL), if conducted.
    - Determine the need for delegated government surveillance on critical products, configuration items, critical product characteristics and critical manufacturing processes that are produced at a sub-tier supplier, especially those that have been designated high or moderate risk and those that impact KSA/KPP compliance.
    - Review implementation of a reliability improvement program based on Failure Modes and Effects Criticality Analysis (FMECA) (or defect tracking for software), other engineering data developed during the systems engineering process, system health information generated by applicable on-board and off-board technologies, and data sources.
    - Continually assess and refine the product support strategy based on projected and actual performance.

- Conduct Benchmarking to survey outside organizations that perform similar processes. Ideally, benchmarking should be performed in conjunction with the contractor, who should be investigating better ways to do business.
- At the end of the Production phase the Prime has a large responsibility in effecting line shutdowns. In addition to assessing and controlling in-house shutdown activities, the Prime is responsible for working with the suppliers to ensure their involvement as early as possible as well as ensuring ongoing support is available.

Metrics

- Quality Audit results/ratings

Tools

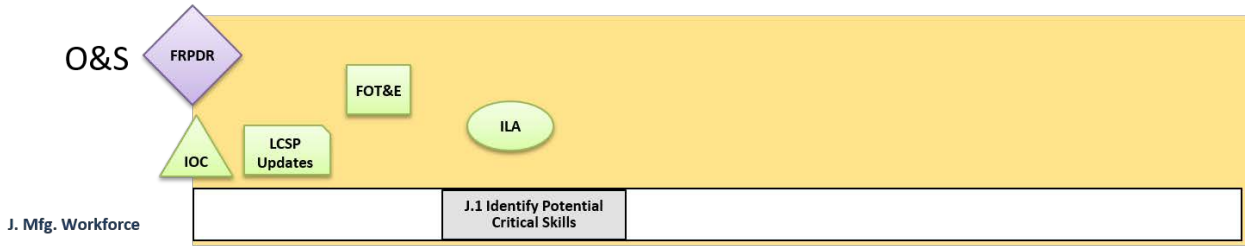
- ISO 9001 QMS Audit Checklist
- AS9100 Audit Checklist
- Manufacturing Readiness Level Assessment Questionnaire for the Quality thread

Resources

- AS9100, Quality Management System – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- MRL Deskbook Version2016

J. MANUFACTURING WORKFORCE

During the sustainment phase, workforce management is concerned about the availability of workers and skill levels required to perform the production and quality operations. Problems may occur when the prime contractor cuts back from Full Rate Production to supporting production for spares and sustainment operations. This lower level of production may cause the contractor to lose sight of important functions while they put their resources into higher rate production programs. Or, the work may now be delegated to government owned and operated facilities such as Depots, MROs and other organic activities.



J.1. Identify Potential Critical Skills

During the sustainment phase,

- Review and assess the contractors Manufacturing Plans to identify workforce requirements for skills, capabilities, training and certification requirements:
  - Contractor's make/buy processes for factors that determine the outsourcing of workforce skills
  - Scale-up or scale down of materials, subsystems, items, and components for TMRR
  - Contractor's labor market (availability, stability, capabilities, training, etc.)
  - Potential ManTech changes, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
  - Potential facilities changes (e.g., location, improvements and expansion, lay-out changes, etc.)
  - Materials handling (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
  - Environmental, safety, and health
  - Manufacturing machinery and equipment (e.g., programming and operation, maintenance, calibration, and repair, etc.)
  - Facilities and tooling (e.g., operation and maintenance, safety, security, cleanliness, acoustics, Heating, Ventilation, Air Conditioning (HVAC) and environmental controls, etc.)
  - Quality (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- Manufacturing and factory floor environment (union contract status, earthquakes, power outages, etc.) to determine potential impacts to program performance and sustainability goals.
- Assess Factory Efficiency. This activity involves the assessment of how efficiently the contractor is producing products, primarily through the evaluation of work measurement data. It also includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.

Metrics

- Manufacturing Plans (Throughput, Cycle Time, Takt time, etc.)

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Resource Planning (MRPII)
- MRL assessment using Manufacturing Management thread
- Route Sheet Analysis

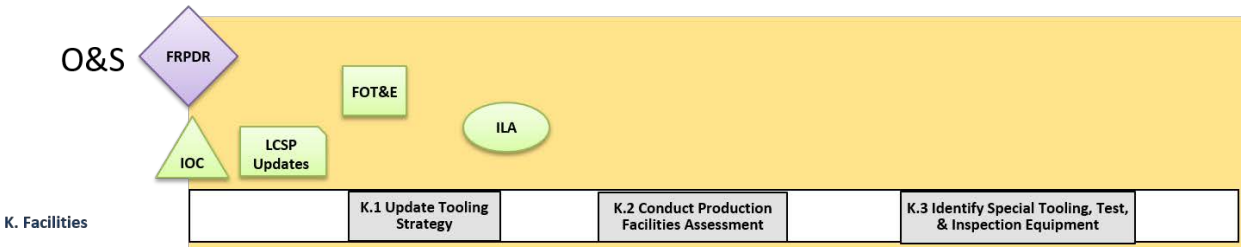
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management System, Sep 2016
  - MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
  - MRL Deskbook Version 2016
  - Manufacturing Resource Planning (MRP II) software

K. FACILITIES

During the sustainment phase, manufacturing and quality personnel should update the facility and tooling strategies and plans developed and used during production and operations. Additionally, they should conduct assessments of proposed production facilities, and update and finalize the tooling plan for the O&S phases and then plan for smart shutdown.



During the sustainment phase, a contractor or a government owned or operated remanufacturing facility (Depot/MRO, etc.) should have implemented an effective facilities management plan along with a tooling plan.

K.1. Update Tooling Strategy

Manufacturing tooling, to include Special Tooling (ST), Special Test Equipment (STE) and Special Inspection Equipment (SIE), should be assessed for its ability to support sustainment production and operations. Current special tooling strategies favor Condition-Based Maintenance or Total Productive Maintenance. Often special tools, test and inspection equipment has been in use in the production environment for a long time and may face the need for refurbishment or purchasing of new tools and test equipment. But as production rates and quantities go down, the budget for special tools and test equipment may also go down. In addition, the manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as Depots, MROs, etc.

Manufacturing/QA personnel should ensure:

- Identification of the condition of current special tooling, test and inspection equipment.
- Identify special tooling, test and inspection replacement or refurbishment costs and schedule and update the manufacturing plan (tooling section).
- Identify smart shutdown conditions and operations with respect to special tooling, test and inspection equipment. Preservation and Storage of Unique Tooling Plan once shutdown has been accomplished.
- Identify ST, STE and SIE risk areas.
- Identify ST, STE and SIE requirements to maintain equipment for the life of the program.
- Manufacturing review the use of existing government owned inventory prior to use of product support arrangements.
    - The government accountable property system that documents all government owned property whether it is held and managed by the government, contractor, or third party.
    - The government accountable property system that documents all government owned property whether it is held and managed by the government, contractor, or third party, in accordance with 40 U.S.C. 524.

Metrics

- ST, STE and SIE plans and risks assessments

Tools

- Acquisition Strategy Template
- Manufacturing Strategy (no template available)
- Manufacturing Readiness Level Assessment Questionnaire, Facilities thread

Resources

- P.L. 110-417, Section 815, program documentation must include the review cycle for assessing tool retention across the life of the system.
- FAR / DFAR 52.245.17 Special Tooling
- FAR / DFAR 52.245.18 Special Test Equipment
- DoDI 4151.22, Condition Based Maintenance Plus for Material Management, Oct 2012
- Condition Based Maintenance Plus DoD Guidebook, May 2008
- MRL Deskbook Version 2016
- Acquisition Plan Preparation Guide, Jan 2009
- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5, Elements of a Manufacturing Strategy

K.2. Conduct Production Facilities Assessment

Manufacturing facilities should be assessed for its ability to support sustainment production and operations. Often the prime and subcontractor facilities have been in use in for production for a long

time and may face the need for refurbishment or capital investment. But as production rates and quantities go down, the budget for facility improvement may also go down. In addition, the manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as Depots, MROs, etc.

Manufacturing/QA managers should ensure that:

- Facilities assessments should consider the impact of a program winding down production and producing only to support spares.
- Facilities should plan for a smart shut down at the end of the program.
- The contractor's manufacturing plan has been updated to include facilities management.
- That the current usage and utilization rates are cost effective and affordable.
- Product support integrators and product support providers identify future production or remanufacturing as organic, commercial, or a combination.

Manufacturing should prepare information on the facility capacity. Information such as:

- General knowledge of factory and environment (union contract status, earthquakes, power outages, etc.)
- Identify schedule, key milestones, decision points, risks, and long lead items.
- Delineate between shutdown tasks to be charged directly to the shutdown effort, tasks covered by existing contracts including post production planning, and tasks to be otherwise allocated to overhead/indirect expenses.
- Assess any impact to the last production contract due to Ramp-Down. There may be a loss of efficiency due in part to employee morale, unless the workforce moves to another program immediately.
- Process to include government personnel in the preliminary planning phases to identify items to be retained, disposed and/or stored for sustainment or production restart.
- Union termination agreements.
- Shutdown of subcontractor activities and contract close-out.
- Cessation of production, disposal, and other related activities unless initially negotiated for the government to pay certain costs.

Sustainment Planning must be an integral element of the capability requirements and acquisition process from inception. This includes:

- Product support integrators and product support providers may be organic, commercial, or a combination.

During the O&S phase the Program Manager will:

1. Develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and lead to a product support package to achieve and sustain warfighter requirements.
   a. The product support strategy will address, at a minimum:

i. An integrated product support capability implementing the program's mix of government and industry providers supported by appropriate analyses included in 10 U.S.C. 2337.
ii. Sustainment metrics mapped to the sustainment key performance parameter and key system attributes to manage sustainment performance.
iii. Implementation of a reliability improvement program based on FMECA (or defect tracking for software), other engineering data developed during the systems engineering process, system health information generated by applicable on-board and off-board technologies, and data sources in accordance with DoD Instruction 4151.22.
iv. Competition, or the option of competition, at the prime and subcontract levels for large and small businesses, and system and sub-system levels.
v. The necessary intellectual property deliverables and associated license rights, consistent with and integrated with the program IP Strategy.
vi. How and when computer software and computer software documentation (as defined in Defense Federal Acquisition Regulation Supplement section 252.227-7014) and other material and activities required to maintain and sustain the software after Initial Operational Capability will be provided to the government for systems that require core logistics support or when depot level software maintenance is required.
vii. The use of existing government owned inventory prior to use of product support arrangements as required in 10 U.S.C. 2337.
viii. The government accountable property system that documents all government owned property whether it is held and managed by the government, contractor, or third party, in accordance with 40 U.S.C. 524.

b. Product support integrators and product support providers may be organic, commercial, or a combination.

2. Ensure identification of obsolete parts in specifications and develop plans for suitable replacements in accordance with P.L. 113-66, section 803.
3. Employ effective performance-based logistics planning, development, implementation, and management in developing a system's product support arrangements. PBL is performance-based product support, where outcomes are acquired through performance-based arrangements that deliver warfighter requirements and incentivize product support providers to reduce costs through innovation.
4. Continually assess and refine the product support strategy based on projected and actual performance.
5. Employ a "Should-Cost" management and analysis approach to identify and implement system and enterprise sustainment cost reduction initiatives. Should-cost targets will be established and reviewed periodically based on analysis of acquisition sustainment costs and O&S cost element drivers. Program managers will capture product support metrics and cost data in DoD Component- and DoD-level information systems, and track performance against should-cost targets.
6. Continually monitor product support performance and correct trends that could negatively impact availability and cost.
7. Minimize unique Automatic Test Equipment (ATE) by utilizing designated DoD automatic test system families for all ATE hardware and software in DoD field and depot operations.
8. Begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components, as required by DoD

Manual 4160.28-M with sufficient lead time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.

Metrics

- Facilities Plans
- Facilities Risk Assessment

Tools

- Manufacturing Readiness Level Assessment Questionnaire, Facilities thread
- DCMA Production Planning and Control Risk Assessment Checklist
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist

Resources

- DoDI 5000.02, Jan 2017
- AS6500, Manufacturing Management Systems
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016DCMA-INST-204 Manufacturing and Production
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, Jan 2017

K.3. Identify Special Tooling, Test, and Inspection Equipment

Manufacturing tooling, to include special tooling (ST), special test equipment (STE) and special inspection equipment (SIE), should be assessed for its ability to support sustainment production and operations. Often ST/STE/SIE has been in use in the production environment for a long time and may face the need for refurbishment or purchasing of new tools and test equipment. But as production rates and quantities go down, the budget for special tools and test equipment may also go down. In addition, the manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as Depots, MROs, etc.

Manufacturing/QA managers may want to:

- Review the contractors or governments tooling plan and inventory.
- Review the use of existing government owned inventory prior to use of product support arrangements.
- Minimize unique automatic test equipment (ATE) by utilizing designated DoD automatic test system families for all ATE hardware in DoD field and depot operations.
- Review the Preservation and Storage of Unique Tooling Plan. It must include the review cycle for assessing tool retention across the life of the system.
- Review STE whether single or multipurpose integrated test units engineered, designed, fabricated, or modified to accomplish special purpose testing in performing a contract.

The manufacturing/quality assurance role is to:

- Identify unique tooling associated with the production of hardware in order to facilitate its protection and storage through the end of the program's service life.
- Review movement of special tooling and special test equipment

Government Activities: As part of a shutdown numerous activities will be the responsibility of the government. Along with these activities come additional costs the government will endure. Some shutdown activities the government will be responsible for include: Movement of special tooling and special test equipment.

Metrics

- ST, STE and SIE plans and risks assessments

Tools

- Life Cycle Sustainment Plan Outline, Tooling Plan

Tooling Inventory

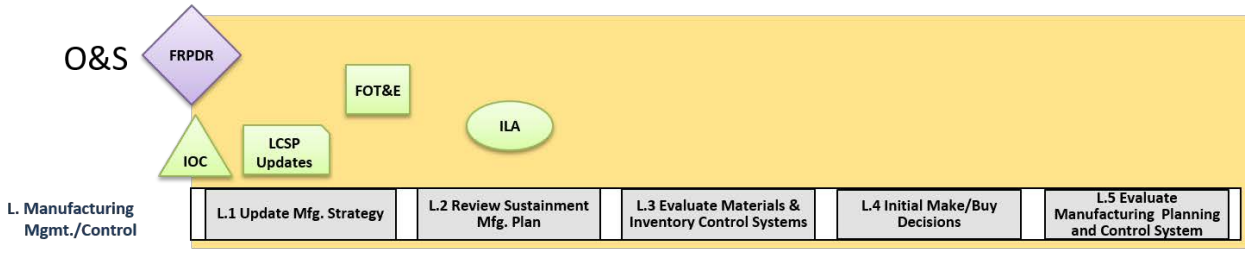
- Manufacturing Readiness Level Assessment Questionnaire, Facilities thread

Resources

- FAR 45 Government Property
- FAR 52.245-1(J)
- DUSD Memo, Preservation and Storage of Tooling for MDAPs, Aug 2009
- Guidebook for Contract Property Administration, Apr 2012
- DCMA Instruction 124, Contract Property Administration
- MRL Deskbook Version 2016
- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5, Elements of a Manufacturing Strategy

L. MANUFACTURING MANAGEMENT AND CONTROL

During the sustainment phase, Manufacturing Management/Control includes Materials Planning (MRP) and Manufacturing Planning (MRP II).



Materials Requirements Planning (MRP) is a production control system that integrates production requirements (rates and quantities) with the Bill of Material and inventories in order to calculate purchasing and shipping schedules for parts and components. The primary functions of an MRP system is to ensure that the right materials are at the right place and at the right time in order to support production operations. A secondary function is to reduce waste by maintaining only the lowest possible levels of materials and stock (inventory) while still meeting customer demand.

Manufacturing Resource Planning (MRPII) is a planning control system that addresses factory floor planning from rough cut capacity planning, to capacity requirements planning, and down to the daily execution of shop floor activities to meet daily demand.

Manufacturing Plans should have been developed in support of the O&S phase and sustainment operations. The manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as Depots, MROs, etc.

Manufacturing resources consist of facilities, materials, machines, manpower, methods, measurement systems, and capital that are used to convert or transform raw materials and component parts into end products. Contractors must have an effective combination of people and systems in order to plan for, monitor, and control these manufacturing resources. Effective implementation of a manufacturing management system is required to manage these resources. A well-structured manufacturing management system generally employs the use of industry best practices. Assessment of the contractor's manufacturing management and quality systems should be performed against the recognized industry best practices such as AS6500, ISO 9000, AS9100, etc.

L.1. Update Manufacturing Strategy

A Manufacturing Strategy should have been developed in support of the O&S phase and sustainment operations as a part of a SEP and/or the LCSP. Included in the plan would be Make/Buy decisions and the decision to have either organic or contractor sustainment support. Thus, the manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as Depots, MROs, etc.

Manufacturing should support the program managers in developing and maintaining an LCSP consistent with the product support strategy. The plan describes sustainment influences on system design and the technical, business, and management activities to develop, implement, and deliver a product support package that maintains affordable system operational effectiveness over the system life cycle and seeks to reduce cost without sacrificing necessary levels of program support.

- Specify Manufacturing Management System requirements (e.g., AS6500), if applicable to be met by the prime contractor and flowed down to suppliers, as appropriate.

Manufacturing should review sources of industrial and manufacturing readiness data to include:

- Program Status Reviews,
- pre-award surveys,
- Production Readiness Reviews,
- Industrial Capabilities Assessments,
- trade-off studies, tooling plans,
- make-or-buy plans,
- manufacturing plans,
- and bills of material.

An important output includes the identification of risks and actions to reduce or address any remaining risks.

- Manufacturing should review foreign sources and international cooperative development should be used where advantageous.
- Manufacturing should provide inputs to support production surge capability and what-if exercises.
- Manufacturing should provide inputs to program cuts and smart shutdown once a program has concluded.
- Manufacturing should review priorities of competing programs (commercial and military).
- Manufacturing should review production shutdown planning efforts.

Manufacturing should start this planning process early and benefit from their advanced planning and preparation in dealing with all potential risks embedded in this process.

- There will be some drivers which will indicate that the line should be idled with the potential to “flip the switch” and restart production in the future and other indicators which indicate the line should be shut down, dismantled and never be restarted.
- Even if the decision is made to dismantle the production line, arrangement for storage and protection of unique program tooling until the end of service life may still be required.
- Identify any current work contained in the production contract, which will need to be transitioned to other contract vehicles post production, e.g., drawing release.
- Manufacturing should conduct a series of either PRRs or MRAs to monitor progress in standing up new facility.

Modifications of production parts should be treated the same as any new start. Use the MRL guide to determine the manufacturing maturity of the item before proceeding.

During the system Sustainment, the Program Manager will deploy the product support package and monitor its performance according to the LCSP.

Program managers for all programs are responsible for developing and maintaining an LCSP consistent with the product support strategy, beginning at Milestone A. The plan describes sustainment influences on system design and the technical, business, and management activities to

develop, implement, and deliver a product support package that maintains affordable system operational effectiveness over the system life cycle and seeks to reduce cost without sacrificing necessary levels of program support. The Acquisition Strategy will also include an overview of the product support strategy and sustainment-related contracts.

Counterfeiting of parts and materials in the electronic business segment is growing at an alarming rate. As we draw from a large network of suppliers in an increasingly global supply chain, there can be limited visibility into these sources and greater risk of procuring counterfeit parts. Additionally, there are unique conditions that make aerospace and defense products susceptible to counterfeiting, including a long-life cycle and DMSMS issues. Therefore, supporting aerospace and defense products throughout their lifecycle sometimes requires the use of parts that may no longer be available from the OEM, authorized aftermarket manufacturer or through franchised or authorized distributors or resellers.

Conduct Environmental, Safety and Occupational Health risk assessments and maintain oversight of critical safety item supply chain management.

Conduct analysis to identify and mitigate potential obsolescence impacts (i.e., Diminishing Manufacturing Sources and Material Shortages).

Support implementation of follow-on development efforts in response to formal decisions to extend the weapon system's service life extension program (SLEP), or to initiate a major modification (may be treated as a stand-alone acquisition program).

Metrics

- Manufacturing Strategy updated
- Systems Engineering Plan updated
- Life Cycle Sustainment Plan updated

Tools

- Acquisition Strategy Template
- Manufacturing Readiness Level assessment questionnaire using Manufacturing Management/Control thread

Resources

- Acquisition Plan Preparation Guide, Jan 2009
- DSMC Acquisition Strategy Guide, Dec 1999
- Systems Engineering Plan (SEP) Outline, Jun 2015
- Life memo, Sep, 2011 and DAG Chapter 4-3.1
- MRL Deskbook Version 2016
- DoDI 5000.02, Jan 2017

- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes, 2015
- AS6500, Manufacturing Management System, Sep 2016
- MIL-HDBK-896A, Manufacturing Management Program Guide, Aug 2016

L.2. Review Sustainment Manufacturing Plan

Manufacturing Plans should have been developed in support of the O&S phase and sustainment operations. The manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as Depots, MROs, etc.

- Review the Manufacturing Plan to ensure it will provide the resources needed for sustainment operations as outlined in the LCSP.
- Assess the Manufacturing Plan for impact to the 'five Ms' (Manpower, Material, Methods, Measurement and Machinery).
- Assess the Manufacturing Plan for Risks, Issues and Opportunities.
- Defense acquisition programs should minimize the need for new defense-unique industrial capabilities.
- Manufacturing should identify any assumptions made in developing the shutdown plan.
- Defense acquisition programs should attempt to minimize the need for new defense-unique industrial capabilities.
- Identify any assumptions made in developing the shutdown plan. This may include potential DoD, commercial and/or foreign military sale production requirements that may impact shutdown planning.
- Ensure the contractor is conducting First Article Inspections on the hardware being produced from the new facility.

Metrics

- Manufacturing Plan updated
- Systems Engineering Plan updated
- Life Cycle Sustainment Plan updated

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Manufacturing Resource Planning (MRPII)
- Material Management and Accounting System (MMAS) audit
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis

- Manufacturing Readiness Level (MRL) assessment questionnaire using Manufacturing Management/Control thread
- Risk, Issues and Opportunities assessment

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- MRL Deskbook Version 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- Systems Engineering Preparation Guide, Apr 2008
- DAG, Chapter 3-4 3.18, Producibility, Quality and Manufacturing Readiness, 2017
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes, 2015
- DoDI 5000.02, Enclosure 14
- DFARS 252.72 Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, Jan 2017

L.3. Evaluate Materials and Inventory Control Systems

Manufacturing should periodically assess product support performance and assist program managers, users, resource sponsors, and materiel enterprise stake holders to take corrective action to prevent degraded materiel readiness or O&S cost growth.

Periodically assess product support performance and assist program managers, users, resource sponsors, and materiel enterprise stake holders to take corrective action to prevent degraded materiel readiness or O&S cost growth.

Inventory control is aimed at minimizing the total cost of inventory. It is often concerned with minimizing the amount of inventory on-hand and with the loss of inventory. Manufacturing management is concerned with the integration of manpower, materials, measurement, machines, and manufacturing methods in the production of the end item. This requires determination of material requirements and components to support the manufacturing rate and determination of manufacturing lot quantities.

Manufacturing management is generally concerned with three types of material inventories:

- Raw Materials: Raw materials are the basic building blocks for the company. Often this is in the form of raw materials and components.
- Work-in-Progress (WIP): WIP is made up of materials, components, sub-assemblies and assemblies that are in the process of being produced. That is they have been released from material stores and have not yet been through final inspection and acceptance.
- Finished Goods: Finished goods have been inspected and accepted and are awaiting delivery to the customer.

Two other types of inventory are a sub set of WIP, these are buffer inventories and de-coupler (supermarket) inventories. These inventories insulate a manufacturing process from the inherent variability of the processing stages in the manufacturing cycle. These inventories also provide protection against potential line stoppages. Buffer inventories are inventories that are carried as a safety valve or cushion against possible quality or vendor delivery problems. A decoupling inventory is inventory that exists due to the fact that all machines do not process parts and assemblies at the same speed and thus an inventory may build up in front of a slower machine. This may be a bottleneck in the production process.

Many companies use inventories to decouple successive stages of production. They view it as uneconomical to schedule parts through some systems due to the unbalanced nature of operation times in processes performed at the various machine stations and the tool changes required for each operation. The use of inventories to disengage successive stages allows each stage to operate more efficiently; the operation of a particular stage is not compromised by the demands of preceding and succeeding stages.

Although inventories provide production benefits, they represent an investment that involves capital costs that needs to be balanced against the benefits obtained. Batch processing is a term often used to describe this type of manufacturing system. Batch size should reflect the most economical order quantity for the process, thus minimizing total cost of setup and processing.

The DCMA MSRA Production Planning and Control (PPC), Material Requirement Planning Checklist can be used to assess Material Requirements Planning.

Metrics

- MMAS Audit results

Tools

- Manufacturing Readiness Level Assessment Questionnaire for the Manufacturing Management and Control thread
- AS6500 Assessment
- ISO 9001 Assessment
- AS9100 Assessment
- Material Management and Accounting System Audit
- MSRA Production Planning and Control (PPC), Material Requirement Planning Checklist

Resources

- AS6500, Manufacturing Management System, Sep 2016
- AS9100, Quality Management System – Aerospace, Sep 2016
- ISO 9001, Quality Management System, Sep 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016

- MRL Deskbook Version 2016
- Material Management and Accounting System – Audit Program, Apr 2017
- DFAR Subpart 242.72 – Contractor Material Management and Accounting System
- DCMA, Audit Policies, Procedures and Internal Controls Relative to Accounting and Management Systems, Jan 2016
- AS5553, Counterfeit Electronic Parts, 2013
- AS6174, Counterfeit Material, 2012

L.4. Initial Make/Buy Decisions

Organizations making product may be required to submit a “Make/Buy” plan identifying those major items to be produced or work efforts to be performed at the prime contractor’s facility and those items that will be subcontracted.

Contractors are often given wide-latitude in determining whether during performance of a contract it should "make" an item or "buy" any items required. For acquisitions >$12.5 million (or at lower dollar values if circumstances justify their use) as described in FAR 15.407-2(c), a "Make or Buy" plan may be required of a contractor. The decision to require or not require a "Make or Buy" plan should be detailed.

Make or Buy decisions are often made based on factors such as lowest overall cost or technical risk. In general, a prime contractor may choose to make an item if they:

- Have the capability to produce
- Have the capacity to produce
- Can do so at a lower cost than a subcontractor

Manufacturing should conduct a Product Support Business Case Analyses that includes relevant assumptions, constraints, and analyses used to develop the product support strategy for the LCSP that details criteria for their Make/Buy decisions, which could include:

- Industrial base viability,
- Design stability,
- Process maturity,
- Supply chain management,
- Quality management,
- Facilities, and
- Manufacturing skills availability.

The program’s Product Support Strategy will be included in the LCSP and updated appropriately during the O&S phase.

Program management must establish and maintain a Product Support Strategy (PSS) to identify and manage the full spectrum of IP and related issues (e.g., technical data and computer software deliverables, patented technologies, and appropriate license rights) from the inception of a program and throughout the life cycle. The IP Strategy will describe, at a minimum, how program management will assess program needs for, and acquire competitively whenever possible, the PSS deliverables and associated license rights necessary for competitive and affordable acquisition and sustainment over the entire product life cycle, including by integrating, for all systems, the PSS planning elements required by subpart 207.106 (S-70) of the Defense Federal Acquisition Regulation Supplement for major weapon systems and subsystems thereof. The PSS Strategy will be updated throughout the entire product life cycle, initially as part of the Acquisition Strategy, and during the operations and support phase as part of the Life-Cycle Sustainment Plan. Program management is also responsible for evaluating and implementing open systems architectures, where cost effective, and implementing a consistent PSS Strategy. This approach integrates technical requirements with contracting mechanisms and legal considerations to support continuous availability of multiple competitive alternatives throughout the product life cycle.

Manufacturing plans should have been developed in support of the O&S phase and sustainment operations. However, the manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as Depots, MROs, etc. In this case the Make/Buy decision will assess organic and contractor capabilities and decide which will best serve the needs of the LCSP.

Metrics

- Product Support Business Case
- Life Cycle Sustainment Plan (LCSP)

Tools

- Product Support Business Case Analysis Guidebook Appendix A BCA Checklist
- Weapon System Acquisition Reform Product Assessment report requirements tool
- Manufacturing Readiness Level (MRL) Assessment Questionnaire for the Manufacturing Management and Control thread

Resources

- Product Support Business Case Analysis Guidebook
- MRL Deskbook Version 2016

L.5 Evaluate Manufacturing Planning and Control Systems

Manufacturing Planning and Control systems are concerned with planning and controlling all aspects of manufacturing, including managing materials, scheduling machines and people, and coordinating

suppliers and key customers should ensure the program's IP Strategy is included in the LCSP and updated appropriately during the O&S phase.

Manufacturing Planning and Control systems are divided into three different time horizons:

- Long-term planning
- Medium-term planning
- Short-term planning

Long-term planning is the "front-end" of the Manufacturing Resource Planning (MRP II) system and includes:

- Demand Management (Customer requirements, how many and when)
- Sales and Operations Planning
- Resource/Production Planning (Rough Cut Capacity Planning)
- Master Production Scheduling
- Medium-term planning is the "engine" of an MRP II system and includes:
- Detailed Material Planning
- Demand Capacity Planning (Capacity Requirements Planning)
- Material and Capacity Plans

Short-term planning is the "back-end" of an MRP II system and includes:

- Supplier Systems (Purchase Order Release)
- Shop-Floor Systems (Work Order Release)
- Shop Floor Activities

Manufacturing/QA should:

- Periodically assess manufacturing plans along with the LCSP to identify risks and develop risk mitigation measures.
- Review the Manufacturing Plan to ensure it will provide the resources needed for sustainment operations as outlined in the LCSP.
- Assess the Manufacturing Plan for impact to the 'five Ms' (Manpower, Material, Methods, Measurement and Machinery).
- Assess the Manufacturing Plan for Risks, Issues and Opportunities.
- Manufacturing should identify any assumptions made in developing the shutdown plan.
- Identify any assumptions made in developing the shutdown plan. This may include potential DoD, commercial and/or foreign military sale production requirements that may impact shutdown planning.
- Ensure the contractor is conducting First Article Inspections on the hardware being produced from the new facility.

The DCMA MSRA Production Planning and Control , Material Requirement Planning Checklist can be used to assess:

- Resource Requirements Planning
- Aggregate Planning
- Master Production Schedule
- Rough Cut Capacity Planning
- Capacity Requirements Planning
- Shop Floor Controls

Metrics

- MMAS Audit results

Tools

- DCMA Production Planning and Control Checklist
- Manufacturing Readiness Level Assessment Questionnaire for the Manufacturing Management and Control thread
- AS6500 Assessment
- Material Management and Accounting System Audit

Resources

- AS6500, Manufacturing Management System, Sep 2016
- MIL-HDBK-896A, Manufacturing and Quality Program, Aug 2016
- MRL Deskbook Version 2016

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Acronyms

A_m	Materiel Availability
A_o	Operational Availability
AoA	Analysis of Alternatives
APA	Additional Performance Attributes
APB	Acquisition Program Baseline
AS	Acquisition Strategy
ASR	Alternative Systems Review
AT	Anti-Tamper
ATE	Automatic Test Equipment
AUPC	Average Unit Procurement Cost
BER	Beyond Economical Repair
BOM	Bill of Materials
C/SCSC	Cost/Schedule Control Systems Criteria
C4I	Command, Control, Communication, Computer, and Intelligence
CAB	Corrective Action Board
CAE	Component Acquisition Executive
CAI	Critical Application Item
CAIV	Cost as an Independent Variable
CAPE	Cost Analysis and Program Assessment
CARD	Cost Analysis Requirements Description
CAS	Contract Administration Services
CBA	Capabilities-Based Assessment
CCB	Change Configuration Boards
CDD	Capability Development Document
CDRL	Contract Data Requirements List
CLIN	Contract Line Item
CM	Configuration Management
CMO	Contract Management Office
CMP	Configuration Management Plan
CMP	Critical Manufacturing Processes
CPI	Continuous Process Improvement

CONOPS	Concept of Operations
COSSI	Commercial Operations and Support Savings Initiative
COTS	Commercial Off-the-Shelf
CPAR	Contractor Performance Assessment Report
CPC	Corrosion Prevention and Control
CPD	Capability Production Document
CPFF/CPIF	Cost Plus Fixed Fee/Cost Plus Incentive Fee
CPI	Continuous Process Improvement
CpK/ CP C_{pk}s	Process Capabilities
CRI	Cost Reduction Initiative
CSCSC	Cost, Schedule Control Systems Criteria
CSI	Critical Safety Item
CTE	Critical Technology Element
CUI	Controlled Unclassified Information
DAE	Defense Acquisition Executive
DAG	Defense Acquisition Guidebook
DAPS	Defense Acquisition Program Support
DAU	Defense Acquisition University
DCMA	Defense Contract Management Agency
DFA	Design for Assembly
DFARS	Defense Federal Acquisition Regulations
DFM	Design for Manufacturing
DFMA	Design for Manufacture/Assembly
DFMEA	Design Failure Modes and Effects Analysis
DFSS	Design For Six Sigma
DID	Data Item Description
DLA	Defense Logistics Agency
DMS	Diminishing Manufacturing Sources
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DOE	Design of Experiments
DPAS	Defense Priorities and Allocation System
DPAS	Defense Priority Allocation System
DSS	Design for Six Sigma

DT&E	Developmental Test & Evaluation
DTC	Design to Cost
EAC	Estimates to Completion
ECP	Engineering Change Proposal
EMC	Electromagnetic Compatibility
EMD	Engineering and Manufacturing Development
EMI	Electromagnetic Interference
EOQ	Economic Order Quantity
ERP	Enterprise Resource Plan
ESOH	Environment, Safety, and Occupational Health
ESS	Environmental Stress Screening
EVMS	Earned Value Management System
FA	First Article
FAI	First Article Inspections
FAR	Federal Acquisition Regulation
FCA	Functional Configuration Audit
FDD	Full Deployment Decision.
FFP	Firm Fixed Price
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOT&E	Follow-on Test and Evaluation
FPIF	Fixed Price Incentive Fee
FRACAS	Failure Reporting, Analysis, and Corrective Action System
GAO	Government Accountability Office
GCQA	Government Contract Quality Assurance
GFE	Government-Furnished Equipment
GFI	Government-Furnished Information
GIDEP	Government and Industry Data Exchange Program
GOTS	Government Off-the-Shelf
HALT	Highly Accelerated Life Testing
HASS	Highly Accelerated Stress Screen
HSI	Human Systems Integration
HVAC	Heating, Ventilation, Air Conditioning

IB	Industrial Base
ICA	Industrial Capabilities Analysis
ICD	Initial Capabilities Document
IIPT	Integrating Integrated Product Team
ILA	Independent Logistics Assessment
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOC	Initial Operational Capability
IP	Intellectual property
IPS	Integrated Product Support
IPT	Integrated Product Team
ISO	International Organization for Standardization
ISR	In-Service Review
ITAR	International Trafficking in Arms Regulation
ITR	Initial Technical Review
JCIDS	Joint Capabilities Integration and Development System
KC	Key Characteristics
KLP	Key Leadership Position
KPP	Key Performance Parameters
KSA	Key System Attribute
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LCSP	Life Cycle Sustainment Plan
LFT&E	Live Fire Test and Evaluation
LRIP	Low Rate Initial Production
M&S	Modeling and Simulation
ManTech	Manufacturing Technology
MATE	Multi-Attribute Tradespace Exploration
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MIL-STD	Military Standard
MMAS	Material Management and Accounting System
MMS	Manufacturing Management System

MMS	Manufacturing Management System
MOE	Measure of Effectiveness
MRO	Maintenance, Repair and Overhaul
MOSA	Modular Open Systems Approach
MP	Mission Profile
MRB	Material Review Board
MRL	Manufacturing Readiness Level
MRP	Materials Requirements Planning
MRPII	Manufacturing Resource Planning
MS A	Milestone A
MS B	Milestone B
MS C	Milestone C
MSA	Materiel Solution Analysis
MSRA	Manufacturing Systems Risk Assessment
MTBF	Mean Time Between Failure
NDI	Non-Developmental Items
NEPA	National Environmental Policy Act
NSPAR	Non-Standard Parts Approval Requests
NTIB	National Technology and Industrial Base
O&M	Operations and Maintenance
O&S	Operating and Support
OEM	Original Equipment Manufacturer
OIPT	Over-arching Integrated Product Team
OMS	Operational Mode Summary
OSD	Office of the Secretary of Defense
OTRR	Operational Test Readiness Review
P&D	Production and Deployment
P3I/P^3I	Pre-planned Product Improvement
PBL	Performance-Based Logistics
PCA	Physical Configuration Audit
PCO	Procurement Contracting Officer
PCO	Procuring Contracting Officer
PDR	Preliminary Design Review

PEP	Producibility Engineering and Planning
PESHE	Programmatic Environmental, Safety and Occupational Health Evaluation
PFMEA	Process Failure Modes and Effects Analysis
PHL	Preliminary Hazard List
PHST	Packing, Handling, Storage, and Transportation
PM	Program Manager
PM&P	Parts, Materials, and Processes
PMO	Program Management Office
PPP	Program Protection Plan
PQM	Production, Quality, and Manufacturing
Pre-MDD	Pre-Materiel Development Decision
PRR	Production Readiness Review
PSA	Program Support Assessment
PSM	Product Support Manager
PSS	Product Support Strategy
PWBS	Preliminary Work Breakdown Structure
QA	Quality Assurance
QFD	Quality Function Deployment
QMS	Quality Management System
R&D	Research and Development
RFI	Requests for Information
RFP	Request for Proposal
RFP RDP	Request for Proposal Release Decision Point
RFV	Requests for Variation
S&T	Science and Technology
SAE	Society of Automotive Engineers
SAT	Software Acceptance Test
SCD	Surveillance Criticality Designator
SCM	Supply Chain Management
SCMP	Software Configuration Management Plan
SDP	Software Development Plan
SE	Systems Engineering
SEMP	Systems Engineering Management Plan

SEP	Systems Engineering Plan
SFMEA	System Failure Modes and Effects Analysis
SFQT	Software Formal Qualification Testing
SFR	System Functional Review
SIE	Special Inspection Equipment
SOO	Statement of Objectives
SOW	Statement of Work
SPC	Statistical Process Control
SPI	Special Packaging Instructions
SQAP	Software Quality Assurance Plan
SRR	System Requirements Review
SSA	System Safety Assessment
SSP	Source Selection Plan
ST	Special Tooling
STE	Special Test Equipment
STEM	Science, Technology, Engineering and Math
SVR	System Verification Review
SWOT	Strengths, Weaknesses, Opportunities and Threats
T&E	Test & Evaluation
TBD	To Be Determined
TDP	Technical Data Package
TEMP	Test and Evaluation Master Plan
TMRR	Technology Maturation and Risk Reduction
TO	Technical Order
TPM	Technical Performance Measures
TRA	Technology Readiness Assessment
TRIZ	Theory of Innovative Problem Solving
TRL	Technology Readiness Level
TRR	Test Readiness Review
U.S.C.	United States Code
V&V	Validation and Verification
VCRM	Verification Cross-Reference Matrix
VOLT	Validated On-line Life-cycle Threat

VR	Variability Reduction
VSM	Value Stream Mapping
WBS	Work Breakdown Structure
WIP	Work-in-Progress

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Department of Defense Manufacturing and Quality Management Body of Knowledge

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Deputy Assistant Secretary of Defense
Systems Engineering
3030 Defense Pentagon
3C167
Washington, DC 20301-3030
www.acq.osd.mil/se