Overview of SAE's AS6500 "*Manufacturing Management Program*"

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Agenda

- Background
- Objectives/Conformance/Definitions
- Requirements
  - Manufacturing Management
  - Manufacturing Design Analysis
  - Manufacturing Risk Identification
  - Manufacturing Planning
  - Manufacturing Operations Management
- Implementation & Tailoring
- Benefits
- Summary

Background

- **DoD Issues: Weapon systems performance shortfalls, cost overruns, supplier quality escapes, production transition problems, negative GAO reports, etc.**

- **Air Force conducted a 360 Degree study of manufacturing and quality problems**
  - **Included: customers, peers, industry (commercial and aerospace)**
  - **Industry's message: The Air Force does not:**
    - **Specify the right deliverables in their contracts**
    - **Use the right metrics to measure performance**
    - **Specify proper MFG/QA contractual requirements in contracts**
    - **Focus on the right parameters for PRRs**

Acquisition reform eliminated the military standard for manufacturing management

Background

- OSD formed Gap Analysis Working Groups (2011) to evaluate standardization gaps and potential solutions in several functional areas, including Manufacturing
- Recommendation for a manufacturing standard was briefed to Defense Standardization Council (DSC)
  - Need based on Mfg/QA root causes of problems in weapon system acquisition
  - Quality area was deemed to have sufficient coverage by commercial standards
- DSC agreed with recommendations
  - OSD clarified direction in summer 2012: All teams are to develop commercial standards
- OSD issued direction to establish a Manufacturing Standard Working Group (Dec 2012)
- In Sep 2013, Working Group selected SAE International to develop the manufacturing management standard

Background

SAE created new G-23 Manufacturing Management Committee

Chair: David Karr
Vice-Chair: Mark Gordon
SAE Technical Project Specialist: Becky Lemon

DoD Members

- Army
- Navy
- Air Force
- OSD
- DCMA
- DAU
- AFIT

Industry Members

- Boeing
- Lockheed Martin
- BAE
- Raytheon
- Northrop Grumman
- GE Aviation
- L-3

AS6500 Published 13 November 2014

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Objectives of the Standard

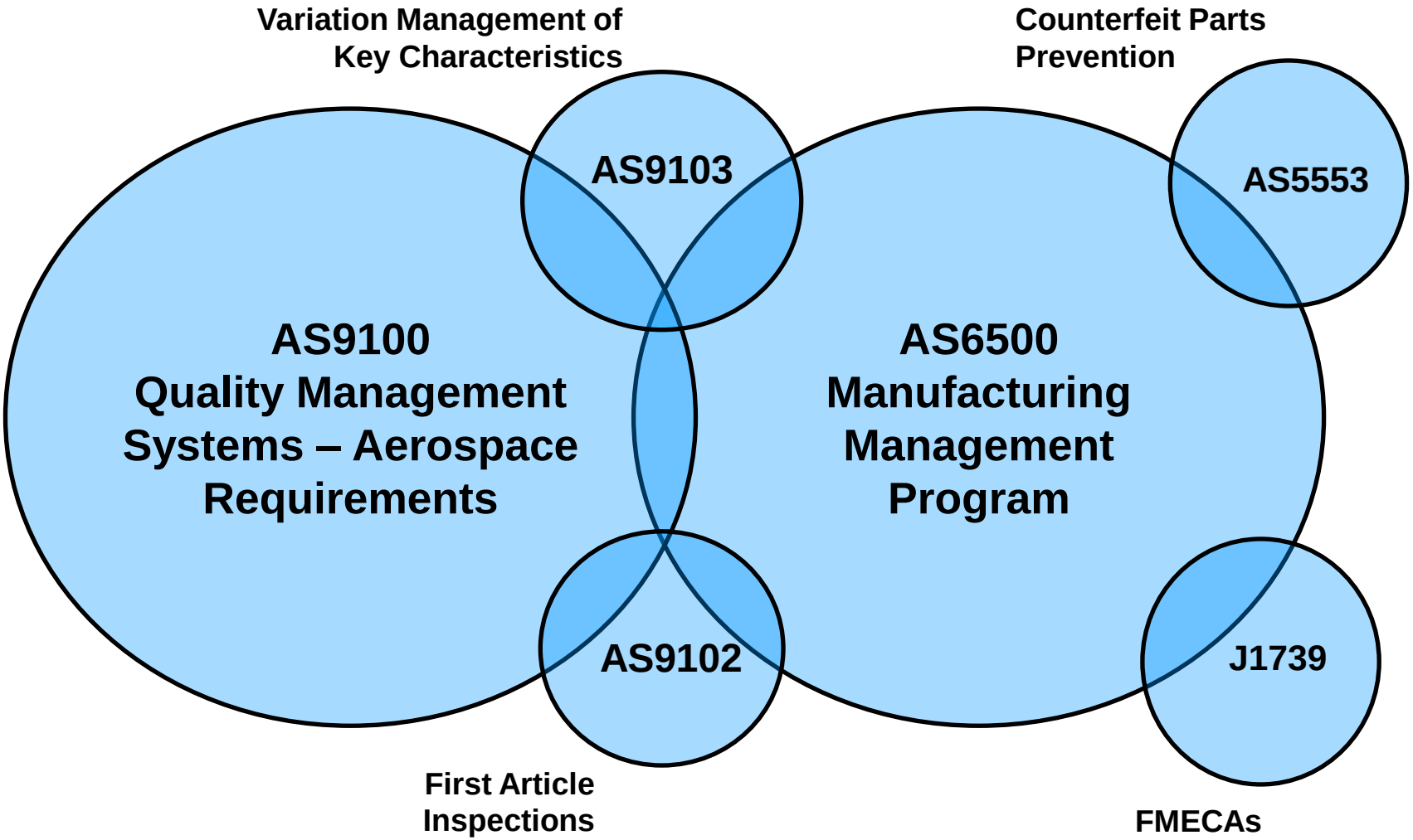
- **Documented best manufacturing management practices aimed at promoting the *timely* development, production, modification, fielding, and sustainment of *affordable* and *capable* products**

- **Provide maximum flexibility and tailorability in application by a diverse contractor community**

- **Non-prescriptive (top level requirements only) – allow flexibility to use existing company processes**

- **To provide clear contractual requirements for use by both government and industry**

AS6500 Integration with Other SAE Standards



AS6500 and AS9100: Companion documents

Conformance

- **Two ways to conform to the provisions of AS6500:**
  - **Full conformance: Achieved by demonstrating that all of the requirements of the declared set of processes have been satisfied using the outcomes as evidence.**
  - **Tailored conformance: For tailored conformance, the clauses are selected or modified using the tailoring process agreed to between the customer and the organization. Tailored conformance is achieved by demonstrating that requirements for the processes, as tailored, have been satisfied using the outcomes as evidence.**

No intent to have certification or registration process

Definitions

- **The standard provides common definitions for 36 manufacturing-related terms with sources identified**
  - **DoD**
  - **Commercial**
  - **Mixture**
- **Definitions represent consensus agreements between government and industry**
  - **Consistency across programs, services, and companies**

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Requirements Overview of Content

Manufacturing Management System:
Program, Policies, Objectives

Manufacturing planning

- Manufacturing Plan
- Supply chain, materiel management
- Manufacturing technology
- Cost
- M&S
- System Verification
- Workforce
- Tooling/Test Equipment/Facilities

Design analysis for manufacturing

- Producibility analysis
- Key Characteristics
- Process FMEAs

Manufacturing operations management

- Scheduling & control
- Surveillance
- Continuous Improvement
- Process control plans
- Process capabilities
- Production Process Verification
- FAIs / FATs
- Supplier Management
- Supplier Quality

Manufacturing Risk Identification

- Feasibility assessments, MRLs, PRRs

Manufacturing Management System

- **Each program shall establish, document and maintain Manufacturing Management System**
- **Applicable to all life cycle phases**
- **Document how, when, who for accomplishment**
- **Define Authority/Responsibility for each element**
- **Tailoring is acceptable**
  - **Different programs/different needs**

Manufacturing Design Analysis

Elements

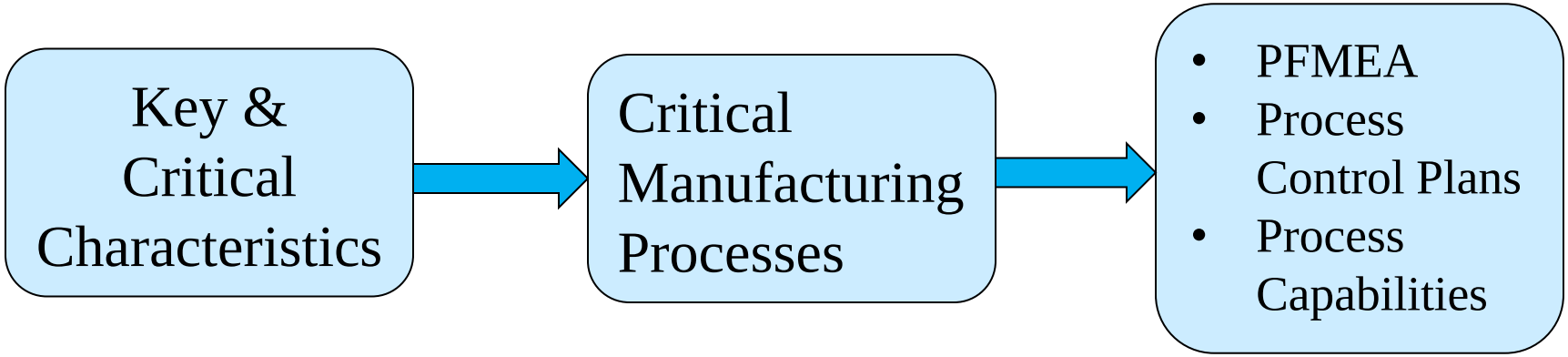
- Producibility Analysis
- Key Characteristics
- Process Failure Modes Effects Analysis

Manufacturing Design Analysis

- **Producibility Analysis**
  - **Selection: Procedures and criteria for candidate selection during cost and trade studies**
  - **Analysis: identify drivers and potential initiatives**
  - **Trade studies shall include: production process capabilities, manufacturing costs, special tooling, special test equipment, long lead material, capacity, special training, and schedule impacts**
  - **Decision criteria: Implementation of process for prioritizing, approval, and monitoring implemented projects**
  - **Reporting: assessment of status, analysis, and issues**

Manufacturing Design Analysis

- **Key Characteristics (KC)**
  - **Identify KCs in technical data package**
  - **Add or delete KC due to engineering changes**
  - **Identify critical manufacturing processes for each KC**
  - **Develop process control plans for critical manufacturing processes**
  - **Flow down to suppliers**



Manufacturing Design Analysis

- **Process Failure Modes Effects Analysis (PFMEA)**
  - **Identify failure modes in critical manufacturing processes**
  - **Identify actions to prevent or mitigate the failures**
  - **Perform prior to PDR and updated by CDR**
  - **Updated with engineering or significant process changes**
  - **Reference: SAE J1739**

Process	Failure Mode	Failure Effects	Causes	Preventive Action

Manufacturing Risk Identification

Manufacturing risk management activities shall be integrated into program risk management process

Elements

- **Manufacturing Feasibility Assessments**
- **Manufacturing Readiness Level Assessments**
- **Production Readiness Reviews**

Manufacturing Risk Identification

- **Manufacturing Feasibility Assessments**
  - Conduct assessment for each design alternative
  - Use MRL matrix as a guide
  - Identify immature production processes and manufacturing technologies
- **Manufacturing Readiness Level Assessments**
  - Identify MRL Targets
  - Identify risk by assessments
  - Conduct MRL assessments prior to PDR,CDR,PRR,Milestones
  - Implement maturation plans for threads not a target MRL
  - Reference: DoD MRL Deskbook and MIL-HDBK-896
- **Production Readiness Reviews**
  - Prior to production decision
  - MRL assessments support manufacturing elements
  - More details on PRR in IEEE 15288.2

Manufacturing Planning

Elements

- Manufacturing Plan
- Supply Chain and Material Management
- Manufacturing Technology Development
- Cost
- Manufacturing Modeling & Simulation (M&S)
- Manufacturing System Verification
- Manufacturing Workforce
- Tooling/Test Equipment/Facilities

Manufacturing Planning

Manufacturing Plan shall include:

- Manufacturing methods and processes
- Manufacturing technology investments
- Production control
- Producibility
- Material management
- Manufacturing system verification
- Minimization of scrap, rework and repair
- Facilities
- Tooling
- Test equipment
- Capital commitments
- Personnel with appropriate technical skills and training
- Customer furnished hardware, software, and other items
- Customer inspections
- Capacity analysis reflecting effects of other business on resources
- Manufacturing capability for critical manufacturing processes

Manufacturing Planning

- **Supply Chain and Material Management**
  - Assess supply chain capability to support program
  - Identify sole and foreign sources (stability and risks)
  - Identify all critical parts and materials
  - Develop plans for adequate supply
  - Develop and implement DMSMS (Ref: ANSI STD 0016/SD-22)
  - Implement counterfeit parts program (Ref: AS5553/AS6174)
- **Manufacturing Technology Development**
  - Determine if new manufacturing technologies are required
  - Identify resources to develop, mature, and implement
- **Cost**
  - Estimate and maintain production costs
  - Cost models to be used in design trades
  - Presentation of costs at major design and program review

Manufacturing Planning

- **Manufacturing M&S**
  - **Analyze manufacturing processes using M&S**
  - **Evaluate design concepts using M&S**
  - **Match the M&S techniques to program complexity**
    - **Spreadsheet analysis → virtual simulation**

- **Manufacturing System Verification**
  - **Verify that proposed production processes, tooling, and test equipment meet program requirements**
  - **Verification via Line Proofing and/or virtual simulations**

Manufacturing Planning

- **Manufacturing Workforce**
  - **Identify workforce requirements**
  - **Identify special skills, certification, and training**
  - **Develop plans to acquire and maintain skills and certification to meet program requirements**

- **Tooling/Test Equipment/Facilities**
  - **Identify requirements including capability and capacity constraints**
  - **Identify Capital investments and schedule**
  - **Incorporate principles of Lean Manufacturing**

Manufacturing Operations Management

Elements

- Production Scheduling and Control
- Manufacturing Surveillance
- Continuous Improvement
- Process Control Plans
- Process Capabilities
- Production Process Verification (PPV)
- First Article Inspection (FAI) & First Article Test (FAT)
- Supplier Management
- Supplier Quality

Manufacturing Operations Management

- **Production Scheduling and Control**
  - Determine production lead times
  - Schedule planned activities to meet production lead times
  - Identify milestones to meet production goals
  - Tracks components/assemblies to assure schedules are met
  - Incorporate engineering changes
- **Manufacturing Surveillance**
  - Identify factors which may adversely impact product quality, delivery, performance, or cost
  - Establish metrics for production effectiveness and product quality

Manufacturing Operations Management

- **Continuous Improvement**
  - Target factors that may adversely impact product quality, performance, or cost
  - Identify improvement opportunities both on the factory floor and for the processes that support production
- **Process Control Plans**
  - Implement variability reduction techniques
  - Focus on achieving stable and capable critical manufacturing processes
  - Develop, document, and implement Process Control Plans for all critical production processes

Manufacturing Operations Management

- **Process Capabilities**
  - **Establish Cpk goals for each critical process**
  - **Use process capability data in design of product**
  - **Track Cpk of all critical manufacturing processes**
    - **Improvements instituted where needed**

- **Production Process Verification (PPV)**
  - **Verify that manufacturing processes, documentation, and tooling are statistically capable of producing parts and assemblies that meet requirements**

- **First Article Inspection (FAI) & First Article Test (FAT)**
  - **Performed only on production part and with production processes, documentation, and tooling that have undergone a PPV**
  - **Performed on parts that have not previously been manufactured, or that have: a change in the design; a change in manufacturing source, process, etc.; a change in NC program or to another media; have experienced a natural or man-made event which may adversely affect the manufacturing process; had a lapse in production for two years or as specified by the customer**
  - **Complete inspection of specifications, work instructions, test procedures**
  - **Ref: AS9102**

Manufacturing Operations Management

- **Supplier Management**
  - Establish, implement, and maintain Supplier Management System
  - Perform Make/Buy Analysis
  - Develop robust requirements flow-down
  - Understand risk associated with “Work Transfer”
  - Continuously assess overall health of supplier management organization
  - Identify and manage supplier risks
  - Identify qualified suppliers
  - Develop a corrective action system to resolve customer complaints
  - Prevent the acquisition of counterfeit parts
  - Identify major and critical suppliers
  - Identify suppliers with critical manufacturing processes

Manufacturing Operations Management

- **Supplier Quality**
  - **Establish and maintain a supplier quality assessment process**
  - **Flow down quality requirements to suppliers to include: Key Characteristics, critical manufacturing processes, FAI, and FAT**
  - **Delegation of MRB authority to qualified suppliers**
  - **Assessment of supplier quality risks**
  - **Definition of qualification requirements for critical manufacturing processes**
  - **Documented acceptance criteria**
  - **Assessment and monitoring of supplier performance**

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Implementation
Policy Requirements

- **Air Force Instruction 63-145 "Manufacturing and Quality Management" – *published Sept 2016*:**

  A3.1 ". . .the program office addresses the following manufacturing and quality management requirements in contracts." (Alternatively, the PM can document in the SEP why they do not apply)

  A3.1.1. "Manufacturing Management System. For programs with a manufacturing component, require contractors to have a manufacturing management system that promotes the timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risk throughout the program life cycle. To meet this requirement, ACAT I programs include SAE AS6500, *Manufacturing Management Program,* in contracts, with tailoring appropriate to the program's needs. SAE AS6500 is the preferred approach for programs in other ACATs. NOTE: Existing contracts at the time of publication of this AFI do not have to be changed to include AS6500."

Implementation
Example RFP Language

Statement Of Work (SOW):

"The contractor's Manufacturing Management Program shall meet the requirements of AS6500."

Section L: Instructions to Offeror's

"The offeror shall describe how their manufacturing management system meets the requirements of AS6500."

Section M: Evaluation Criteria

"This subfactor is met when the offeror's proposal…Describes how their manufacturing management system meets the requirements of AS6500."

Implementation Tailoring

- **AS6500 is intended for all phases and all programs with manufacturing content; however, tailoring for your specific program is encouraged**

- **A table of typical situations is available in MIL-HDBK-896A, "*Manufacturing Management Program Guide*," to be used as a guide (not an absolute solution)**

Excerpt of tailoring guide

REQUIREMENT	MSA	TMRR	EMD	Production	Sustainment	Commercial Derivative	Built to Print
5.2 Design Analysis for Manufacturing	Y	Y	Y	Y	As needed	Y	Y
5.2.1 Producibility Analysis	Y	Y	Y	Y	As needed	Y	N
5.2.2 Design Trade Studies	Y	Y	Y	N	As needed	Y	N
5.2.3 Key Characteristics	N	Y	Y	Y	As needed	Y	As needed

Tailoring

- **Considerations: Scale of the program, costs/benefits, program phase, unique program risks/issues/opportunities**

- **Tailoring options: Delete, clarify, tailor "down" (can't add requirements) – *Everything is tailorable as long as both parties agree***

- **Execution/Mechanics: Attach Word or Excel document as appendix to SOW that lists *exceptions* to AS6500**

NOTIONAL EXAMPLES

SOW: The contractor's manufacturing management system shall meet the requirements of AS6500/T.

SOW Appendix:

- 6.2.2 Key Characteristics: "For the XXX program, KCs are features that only affect product fit."

- 6.3.1 Manufacturing Feasibility Assessments: Replace with "Not required for the XXX Program."

Tailoring

- **Two key questions for each requirement:**
  - ***How*** **will you meet the requirement?**
    - **AS6500 requires the "what"; Contractor identifies the "how"**
    - **Typically described in a company-level process**
    - **Compliance matrix is a helpful tool**
  - ***When (or to what extent)*** **will you accomplish the tasks?**
    - **Typically a program-level decision**
    - ***It's not sufficient to have a process in place, you actually have to do it!***
    - **Variations from AS6500 requirements/timing/scope should be documented in the tailoring agreement**
      - **Example of tailoring: "KCs shall only be identified on landing gear."**

AS6500 Implementation

- **On contract:**
  - F-16 Modular Mission Computer (Raytheon)
  - Adaptive Engine Technology Program (GE & P&W)
  - Presidential Aircraft Replacement (Boeing)
  - Multiple Space and Missile Center programs
  - Long Range Stand-Off missile (LRSO) (Lockheed Martin, Raytheon)

- **Released RFPs:**
  - T-X
  - C-130H AMP Increment 2
  - UH-1N (Huey replacement)

Many companies are taking this as an opportunity to improve existing processes and incorporate current best practices

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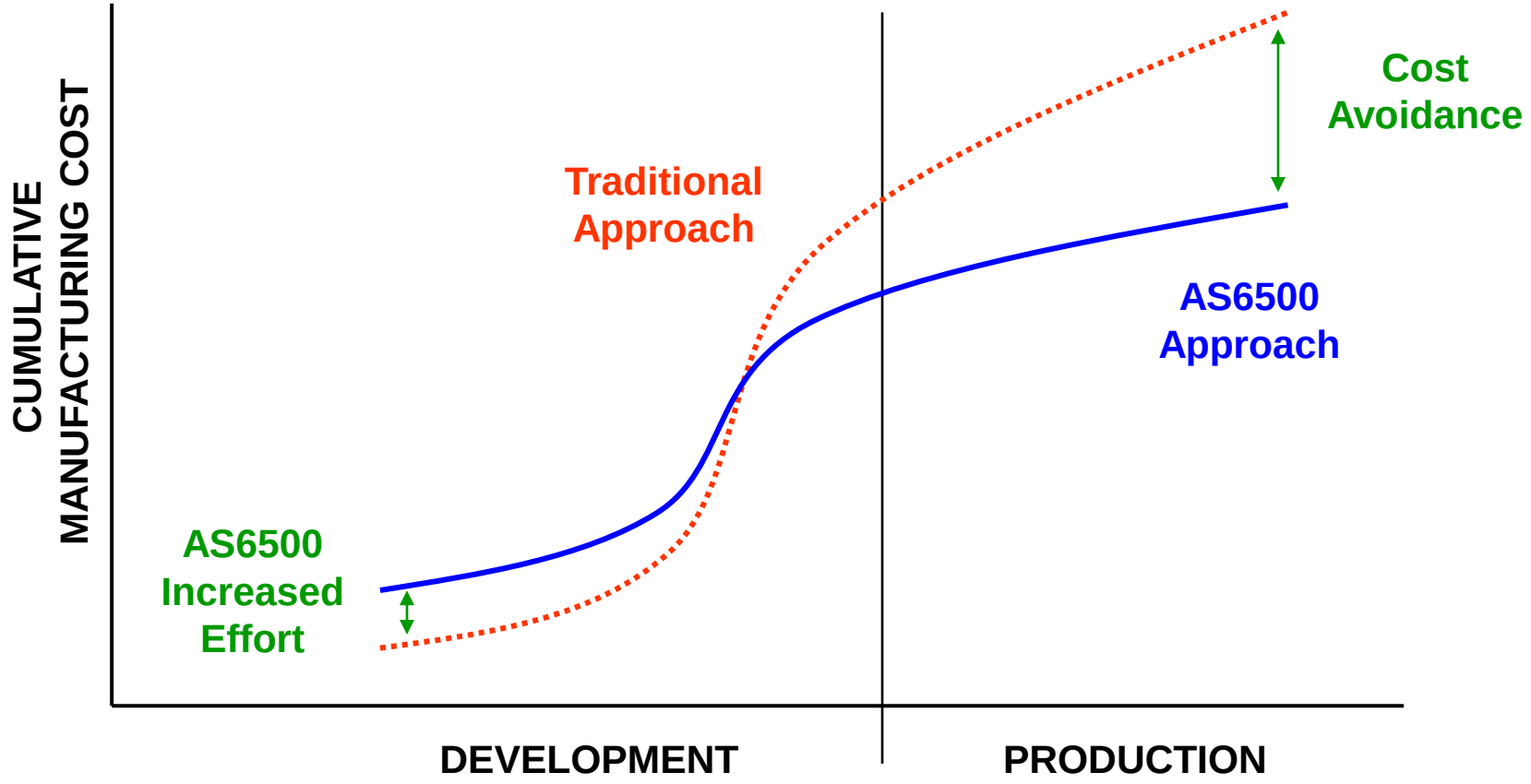
Benefits

- **A Manufacturing Management standard benefits both DoD and Industry:**
  - **Provides a vehicle to contractually communicate manufacturing requirements**
  - **Promotes more consistent customer requirements**
  - **Puts all offerors on the same playing field during competitive purchases**
  - **Better enables contractors to implement best manufacturing practices by providing a customer requirement against which to budget**
- **Supports DoD's Better Buying Power (BBP) initiative**
  - **BBP Tenets: Affordability & Productivity**
  - **AS6500: Producibility, Production Cost Estimates, Continuous Improvement, etc.**
- **More consistent application of best practices will result in reduced costs, higher schedule confidence, and more robust products**

Benefits (Notional)

AS6500 Savings



AS6500 implementation will reduce program life cycle costs

Summary

- **DoD directed the creation of AS6500 because a lack of focus on Manufacturing and Quality Management led to numerous weapon system issues**
- **We can legitimately tailor AS6500 down to what we would have done anyway**
- **However, if we continue to do what we have always done, we will not see any improvement**

"If you stay in this world, you will never learn another."
-- W. Edwards Deming