Manufacturing Readiness Assessment Overview

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Overview

• What is a Manufacturing Readiness Assessment (MRA)?
• Why Manufacturing Readiness?
• What are Manufacturing Readiness Levels (MRLs) and how do they pertain to the Acquisition Life Cycle?
• How to do an MRA
• Sample Outputs and Deliverables
• Finding and Conclusions
• Additional Information
What Is A Manufacturing Readiness Assessment?

• An MRA is
  – An assessment of a program’s readiness to manufacture and produce its intended design
  – A tool to develop and implement:
    • Manufacturing Maturating Plans (MMPs)
    • Business Strategies
      – Effects of Design Changes (Planned Upgrades, Spiral)
      – Pricing Agreements (Long Term vs. Single Lot)
      – Capital Investment Plans (Contractor and/or Government)

• An MRA
  – Assigns Manufacturing Readiness Levels (MRLs) to key system components
  – Analogous to Technology Readiness Levels (TRLs)
Why Manufacturing Readiness?
Manufacturing & Industrial Base Challenge

• Consensus among Congress, OSD, CSAF, GAO:
  “Advanced weapon systems cost too much, take too long to field, and are too expensive to sustain”

• GAO study of 54 weapons programs:
  – Core set of 26 programs: RDT&E costs up by 42% ($42.7B total) and schedule slipped by 20% (2.5 years on average)
  – Characteristics of successful programs (GAO):
    • Mature technologies, stable designs, production processes in control
    • S&T organization responsible for maturing technologies, rather than program or product development manager

• Products made by immature manufacturing processes generally:
  – Cost more
  – Are prone to quality problems
  – Experience schedule delays
  – May not perform the same
  – Are less reliable in service
Technology Readiness Levels (TRLs)

Provide a common language and widely-understood standard for:

• Assessing the *performance maturity* of a technology and plans for its future maturation
• Understanding the level of *performance risk* in trying to transition the technology into a weapon system application

**TRLs leave major transition questions unanswered:**

• Is the technology producible?
• What will these cost in production?
• Can these be made in a production environment?
• Are key materials and components available?
What are MRLs?

• Common language and standard for
  – Assessing the *manufacturing maturity* of a technology or product and plans for its future maturation
  – Understanding the level of *manufacturing risk* in trying to produce a weapon system or transition technology into a weapon system application

• Designed to complement TRLs
• Designed to help set the agenda for manufacturing risk mitigation
• Establish an expectation of achieving manufacturing maturity at critical decision points

**NOTE:** FY04 - Joint Defense Manufacturing Technology Panel (JDMTP) formed MRL Working Group to develop basic MRL definitions and criteria
MRL Relationships

Relationship to System Acquisition Milestones

Pre-Material Solution Analysis (MSA)  MSA  Technology Development  Engineering & Manufacturing Development  Production & Deployment

TRL 1  Basic Mfg Implications Identified  MRL 1
TRL 2  Mfg Concepts Identified  MRL 2
TRL 3  Mfg Proof of Concept Developed  MRL 3
TRL 4  Manufacturing Processes in Lab Environment  MRL 4
TRL 5  Components in Production Relevant Environment  MRL 5
TRL 6  System or Subsystem in Production Relevant Environment  MRL 6
TRL 7  System or Subsystem in Production Representative Environment  MRL 7
TRL 8  Pilot Line Demonstrated Ready for LRIP  MRL 8
TRL 9  LRIP Demonstrated Ready for FRP  MRL 9
TRL 10  FRP Demonstrated Lean Production Practices in place  MRL 10

TRL 1  Basic Principles Observed  MRL 1
TRL 2  Concept Formulation  MRL 2
TRL 3  Proof of Concept  MRL 3
TRL 4  Breadboard in Lab  MRL 4
TRL 5  Breadboard in Rep Environment  MRL 5
TRL 6  Prototype in Rep Environment  MRL 6
TRL 7  Prototype in Ops Environment  MRL 7
TRL 8  System Qual  MRL 8
TRL 9  Mission Proven  MRL 9

Relationship to Technology Readiness Levels

Distribution Statement A: Approved for Public Release (PA); Distribution Unlimited.
PA Case No: 88ABW-2015-1568 Date Cleared: 4/1/2015
MRL Evaluation Criteria
(Threads)

• Nine “Threads” were developed to help assess the current MRL
  – A - Technology and Industrial Base
  – B - Design
  – C - Cost and Funding
  – D - Materials
  – E - Process Capability and Control
  – F - Quality Management
  – G - Manufacturing Workforce
  – H - Facilities
  – I - Manufacturing Management
MRL Assessment Process (MRA)

• Assessment Team Lead briefs PM on manufacturing assessment efforts/expectations
  – Determine appropriate level for MRA(s)
    • System may contain several critical technologies/components/manufacturing cells
  – Schedule on-site MRA with contractor(s)
  – Send questionnaire to contractor(s)
  – Define assessment team membership
  – Define deliverables of assessment results
  – Conduct on-site assessment with contractor(s)
  – Develop Manufacturing Maturation Plan (MMP)
  – Determine risk of reaching target MRL
  – Deliver final report/briefing
Identifying Technologies That Need to be Assessed (Critical Technologies)

• A “yes” to any of the below is an indication that the technology should be assessed for manufacturing readiness

  – Are there materials which have not been demonstrated in similar products or manufacturing processes?
  – Is the technology new with high cost uncertainty?
  – Is the item design novel or does it contain nonstandard dimensions or tolerances or arrangements?
  – Will the item require the use of manufacturing technology, processes, inspection, or capabilities that are unproven in the current environment?
  – Does the item have historical/anticipated yield or quality issues?
  – Does this item require a new manufacturing facility or scale up of existing facilities?
  – Is this a critical item manufactured by a sole or foreign source?
Example Process Flow
Generic Aircraft

• Large programs can require multiple MRAs

Colors represent supplier/facility location
MRA Deliverables

Provide briefing and/or written report
• Identify current MRL/target MRL
• Identify key factors where manufacturing readiness falls short of target MRL
  – Define driving issues
• Identify programs and plans to reach target MRL
• Assess type and significance of risk to cost, schedule or performance
• Next step: Stay engaged to assist in implementing and executing the MMP
• Assessing Risk is Independent of the MRL Value Assigned
  – Higher MRL Value may be Highest Risk
    • Eg. Requires New Equipment, High Cost Process

• Risk Assessment should consider
  – Time Needed to Reach Target MRL
  – Require New Personnel, Training, or Capital
  – Leverage Other Programs
  – Supplier Dependency??
  – Part of a Company’s Core Business
    • Leads to an Industrial Base Assessment

• Effective of Use of Design for Manufacturing Tools and Other Simulation Techniques.
Some MRL Thoughts

• MRLs are not a report card
  – MRL 7 might not be good
  – MRL 3 might not be bad

• MRLs are a tool to manage and mitigate manufacturing risk
  – A common language used to assess manufacturing maturity
  – Provide insight not oversight
Findings and Conclusions

• Looking at transitioning technology to production
  – Must incentivize good decision-making processes;
  – Unlike TRLs, going backwards on MRLs might be a good thing

• A low MRL number may be OK
  – Is there time to raise the level?
  – Is there a new manufacturing process being pursued?
  – Replacing a manual process with an automated process
    • Encouraging repeatability, faster cycle time, etc.

• Identify opportunities to validate manufacturing processes
  – Avoid accepting analogous process claims during the design phase and claiming fabrication is maturing

• May never build enough units to reach MRL 10
  – Achieve a Six Sigma or equivalent process
  – Stable line, may require a multi-product factory
Some MRA Lessons Learned

• Process is more effective if company is actively engaged in the assessment
• System integration and test operations are often ripe for maturation efforts
• Resources required to conduct an MRA will vary significantly
• Subject matter expertise is needed to “do it right”
“I work S&T, why should I be worried about manufacturing”?

"You can pay me now, or pay me later"

• Address manufacturing concerns early to reduce risk later
  – Technical – remove manufacturing barriers that slow technology transition
  – Affordability – cost avoidance
  – Transition speed and acquisition schedule slip – rapid response technology solutions are necessary
MRLs in S&T

Minimal effort with possible huge payoff!

• S&T
  – 6.1 Projects – MRLs 1&2
    • Limited applicability
    • Can be used to characterized a top level assessment of the manufacturing risk of the project
      – Provide insight into new manufacturing processes that need to be developed to achieve
        innovative new products.
  – 6.2 Projects – MRLs 1-4
    • Provides an assessment of the manufacturing feasibility of the S&T project
    • Should be useful in deciding the next steps
  – 6.3 Projects – MRLs 3-6
    • A valuable tool in assessing and maturing manufacturing capability for new technology
    • Should be major concern to whomever receives the technology
    • Could be funded by either S&T or Acq – or ignored and transition technology w/o risk
      understood
    – ManTech – critical tool to assess and demonstrate manufacturing maturity – essential
      to effectively implement into acquisition programs
  • MRLs have value in S&T – some work remains in refining the process
    for the S&T Community
MRL/MRA Resources

• Found at www.dodmrl.com or www.dodmrl.org
  – MRL Deskbook – the “how to” of MRAs
  – MRL Criteria
  – MRL definitions
  – MRL users guide
  – Under AF ManTech's MRA Tool
    • Air Force ManTech MRA Questions

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"Without materials and manufacturing, you'll never make it..."
Summary

- MRL processes are well defined
- MRLs are being used by DOD and Industry
- Utilizing MRLs in S&T - minimal investment, huge return
- ManTech and MRL Working Group addressing MRL use in S&T – stay tuned!

MRL use in S&T can help bridge the “valley of death”
Addendum

• A deeper dive into MRA processes
Supplier MRA Plan

• Identify and prioritize critical suppliers
• Develop common SOW for distribution to suppliers
  – Scope of MRA detailed
  – Method of MRA detailed
  – Output defined
• Developed detailed MRA execution plan with each supplier (schedule, format, personnel)
• Execute MRA
• Define/plan/execute MRL MMP
• Measure mitigation effectiveness, update assessment
On-site MRA Process Review

- Contractor welcome, review of agenda and orientation to facility
- Introduction of assessment team and contractor personnel
- Government team lead briefing to contractor describing objectives and expectations for the on-site visit
- Contractor overview and discussion of the results of their self-assessment
- Shop-floor visits to key areas by individuals or small groups
- One-on-one or small group discussions between assessment team members and contractor subject matter experts focused on key areas
- Private meeting of Government assessment team to:
  - Prepare feedback and identify any action items
  - Initial assessment of current MRL (their area or overall)
  - Key strengths/risks/issues
  - Key missing data (if any)
  - Proposed action items
- Outbriefing by Government team to contractor
# SAMPLE SUMMARY ROLL-UP OF COMPONENTS

<table>
<thead>
<tr>
<th>SubSystem</th>
<th>Top Level MRL</th>
<th>Observations</th>
<th>Most Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guidance</td>
<td>3</td>
<td>- Lacking detailed process information</td>
<td>Detector from supplier A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Key suppliers identified; Need key performance parameters</td>
<td>- Design &amp; production issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Need detailed process plans</td>
<td>- No alternate source</td>
</tr>
<tr>
<td>Data Processor</td>
<td>3</td>
<td>- New processor architecture</td>
<td>Board Supplier can’t test at their site</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Immature design tools</td>
<td>Low yields on initial run</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- New attachment processes needed</td>
<td></td>
</tr>
<tr>
<td>Propulsion</td>
<td>6</td>
<td>- Same as other systems in use</td>
<td>Re-validate manufacturing process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- New component scheme</td>
<td>Supplier handle increased rate</td>
</tr>
<tr>
<td>Air Vehicle</td>
<td>7</td>
<td>- Same supplier as system X</td>
<td>No critical items</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Need to test new mating and assembly processes at the prime</td>
<td></td>
</tr>
<tr>
<td>Test Plan</td>
<td>6</td>
<td>Several instances of re-design work and new test processes</td>
<td>- New test strategy and plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- What will new design incorporate?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Manufacturing experience vital</td>
</tr>
</tbody>
</table>
## SAMPLE SUMMARY
(Drill down)

<table>
<thead>
<tr>
<th>Guidance Sub systems</th>
<th>Top Level MRL</th>
<th>Observations</th>
<th>Most Critical</th>
</tr>
</thead>
</table>
| Front End Sensor     | 3             | - Lacking details on builds  
- Process procedures need more work  
- Test and assembly procedures have not been verified in manufacturing environment | Detector from supplier A  
- Design & production issues  
- No alternate source                                                                 |
| Data Processing PWB  | 3             | - New processor architecture  
- Awaiting Design for Manufacturing and Assembly (DFMA) results                                                                 | Low yields on initial build  
Working process controls  
Looking at re-design for easier fabrication                                                              |
| Cables For: Power Data | 3             | - Using same suppliers other weapon systems  
- Have not received prototypes, awaiting supplier delivery                                                                       | Re-validate manufacturing process as seen on past programs  
Need new process plan                                                                                   |
| Housing              | 4             | - New supplier: limited experience  
- Need new assembly processes at the prime                                                                                      | Need supplier management process; need new process plans                                            |
| Cooling              | 3             | - Form, fit factors for new cooling design not in place  
Initial process plan for build in place                                                                                         | Final cooling plan will be defined after front end is stable                                           |
| Integration Process that includes assembly and test | 3             | - Several new test processes need development for new components                                                            | New test strategy and plan  
New special test equipment must be ordered                                                                |
Follow-on Activities

• Gather any key missing data
• Convene team meeting - typically within 2 weeks of on-site assessment
  – Discuss and finalize assessment
  – Examine current program and manufacturing risk reduction plans
  – Agree on likely MRL at completion of milestone if current plan is followed
• Share results with contractor
• Identify the specific risk reduction activities necessary to reach the next milestone
• Identify the funding, time-phasing and approach to carrying out each activity
• Prepare and submit final report