Manufacturing Readiness Levels (MRLs) and Manufacturing Readiness Assessments (MRAs)

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# Manufacturing Readiness Levels (MRLs) and Manufacturing Readiness Assessments (MRAs)

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**Abstract:**

Manufacturing Readiness Levels (MRLs) and Manufacturing Readiness Assessments (MRAs) are critical components of technology development and acquisition. MRLs are used to measure the readiness of a technology or system to be acquired and deployed. MRAs are used to assess the readiness of a technology or system to be acquired and deployed. MRLs and MRAs are used to ensure that technology and systems are acquired and deployed in a timely and cost-effective manner. MRLs and MRAs are used to ensure that technology and systems are acquired and deployed in a timely and cost-effective manner.
Outline

• Why Manufacturing Readiness?
• Manufacturing Readiness Levels & Assessments
• Implementation of MRLs
• MRA Tools
• Example results
• Policy Status
• Closing Thoughts
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
Today’s Air Force Reality

• Diminishing manufacturing infrastructure
  – People, policy, programs gutted
  – Lost recipe on how to manage manufacturing risk
  – Won’t get infrastructure back, but still need to manage and mitigate manufacturing risk

• Utilize MRL/MRA as a tool
  – Supports knowledge-based acquisition
  – Integral to Systems Engineering Plan
  – Essential for effective and efficient transition of capability to the warfighter
Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs)

- TRLs provide a common language & 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?

**MRLs assist in answering these questions**

- MRLs provide a 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 the technology into a weapon system application
## MRL Relationships

### Relationship to System Acquisition Milestones

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<th>Concept Refinement</th>
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<th>System Development &amp; Demonstration</th>
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<td>Prototype in Ops Environment</td>
<td>System Qual</td>
<td>Mission Proven</td>
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### Relationship to Technology Readiness Levels
Nine MRL Evaluation Criteria ("Threads")

1. Technology and Industrial Base
   – Technology maturity, technology transition to production, ManTech development

2. Design
   – Producibility program, design maturity

3. Cost and Funding
   – Production cost knowledge (cost modeling), cost analysis, mfg investment budget

4. Materials (raw matls, components, subassys, subsystems)
   – Maturity, availability, supply chain management, special handling

5. Process Capability and Control
   – Modeling & Simulation (product & process), mfg process maturity, process yields/rates

6. Quality Management, to include supplier quality

7. Manufacturing Personnel, to include specialization, training, & certification

8. Facilities, to include capacity and plant layout & design

9. Manufacturing Management
   – Manufacturing planning and scheduling
   – Materials planning
   – Tooling and special test equipment
What is a Manufacturing Readiness Assessment?

• An Assessment of a Program’s Readiness to Manufacture and Produce its Intended Design

• A Tool to Develop and Implement -
  • Manufacturing Risk Mitigation Plans
  • Business Strategies
    – Effects of Design Changes (Planned Upgrades, Spiral)
    – Pricing Agreements (Long Term vs. Single Lot)
    – Capital Investment Plans (Contractor and/or Government)

• Results in an Assignment of MRLs to Key System Components and Development of a Manufacturing Maturation Plan as Required
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 Manufacturing Maturity Plan
Implementing MRLs: Who is Using Them?

- Mandated by AFRL for all Category 1 hardware ATDs and certain high-visibility programs
- Selected Air Force acquisition programs, including all at AAC
- Army using on Future Combat Systems development efforts
- Missile Defense Agency
- Industry has adopted and is using MRLs within their gated processes

And the list is growing......
MRL Implementation Approach

• Conduct pilot MRAs on various programs
  – Hardware-intensive Category 1 ATDs
  – Weapon system acquisition programs

• Conduct tailored training for key program personnel
  – Category 1 ATD IPTs, ACAT pilot program, and Air Force Product Centers
  – Transition training
    • DAU for awareness and policy
    • AFIT for in-depth MRA and manufacturing instruction

• Put MRLs into policy documents
  – AFRL, AFMC, AF, OSD

• Socialize MRLs whenever possible

• Develop and deploy Manufacturing Readiness products
  – Continuously refine products based on feedback, need
MRL/MRA Products/Tools

- Most of our MRL products/tools have been developed with other Services and industry
  - MRL definitions, entry/exit criteria
  - MRL training blocks (2-hr, 4-hr, multi-day)
  - MRA Deskbook (modeled after TRA Deskbook)
  - Pre-MRA self-assessment questionnaire
  - Excel-based MRA tool
  - Draft DoD and AF policy
  - Defense Acquisition Guidebook language
  - MRA “frequently asked questions” repository
MRA Results Examples

- Focused Lethality Munition - ready for LRIP
  - Eglin High Explosive Research Development facility originally assessed at MRL 5 (May 07); now at MRL 8
  - Aerojet composite warhead case originally assessed at MRL 5 (March 07); now at MRL 8
- AMRAAM C-7 - production rate increased from <10 to 28+ per month
- F135 Propulsion Persistent Strike - accelerated F135 thrust improvement by ~4 yrs w/plan to mature advanced casting producibility from MRL 3 to 5
- MQ-9 Reaper
Goal: Establish manufacturing risk management as a tenet of acquisition management

- Recommended levels
  - MS A – MRL 4
  - MS B – MRL 6
  - MS C – MRL 8
  - FRP – MRL 9

- Not designed to be a ‘go/no-go’ criteria

OSD (AT&L) recently sent a draft policy memo to the Services

- Services and OSD Systems Engineering nonconcurred; suggested MRL use at MS C only
- Expect AT&L to press forward with revised language in coming weeks
Some MRA Lessons Learned

• Process is more effective if company and program office are actively engaged in the assessment
• System integration and test operations are often ripe for maturation efforts
• With few exceptions, requires ‘feet on the (shop) floor’
• Resources required to conduct an MRA will vary significantly
  – Not all programs are equal
• Subject matter expertise is needed to ‘do it right’
• Templates and guidelines developed
  – Not a ‘one size fits all’ solution
  – Engineering skills/judgment still needed
  – Must avoid a checklist mentality
Closing Thoughts

• Feedback from those who have applied MRLs thus far has been positive
• Expectations management is important; MRLs will not solve world hunger
• Congress, National Defense Industry Association and other industry consortia have been vocally supportive
• Policy implementation pending, but many are using as a best practice and DAU is including MRLs in courses
• Fits well within Defense Systems Engineering construct, but should not be diluted to the point of becoming ineffective (e.g. PRRs)