

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



U.S. AIR FORCE



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Report Documentation Page

Form Approved
OMB No. 0704-0188

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1. REPORT DATE SEP 2008	2. REPORT TYPE	3. DATES COVERED 00-00-2008 to 00-00-2008			
4. TITLE AND SUBTITLE Manufacturing Readiness Levels (MRLs) and Manufacturing Readiness Assessments (MRAs)		5a. CONTRACT NUMBER			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S)		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AFRL/RXMT,2977 Hobson Way,Wright Patterson AFB,OH,45433		8. PERFORMING ORGANIZATION REPORT NUMBER			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)			
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM002183. Presented at the Technology Maturity Conference held in Virginia Beach, Virginia on 9-12 September 2008.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 16	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



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

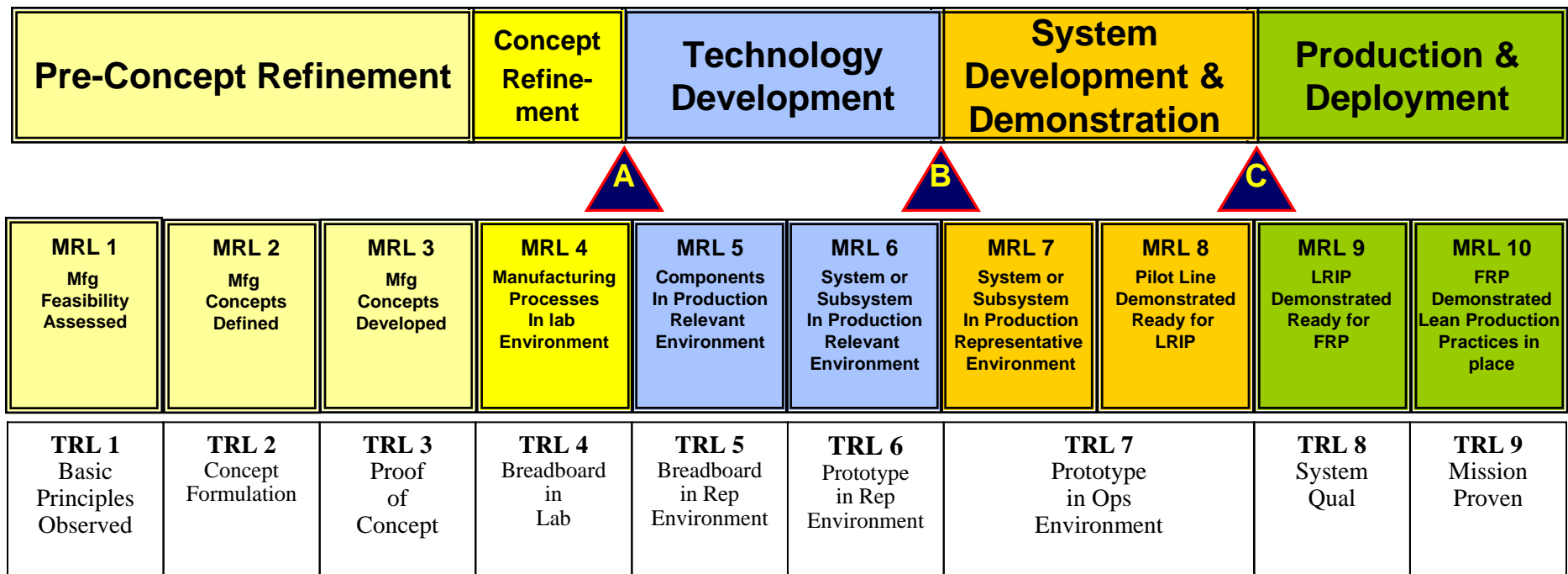
- MRLs provide a common language and standard for
 - Assessing the **manufacturing maturity** of a technology or product and plans for its future maturation
 - Understanding the level of **manufacturing risk** in trying to produce a weapon system or transition the technology into a weapon system application



MRL Relationships



Relationship to System Acquisition Milestones



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 mats, 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



MRL Policy Status



- 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 nonconcurrent; 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)