



Reliability and Maintainability (R&M) Engineering Update

Mr. Andrew Monje

**Office of the Deputy Assistant Secretary of Defense
for Systems Engineering**

**16th Annual NDIA Systems Engineering Conference
Arlington, VA | October 31, 2013**



Purpose/Outline



PURPOSE

- **Provide an update of DoD R&M Engineering Activities**

OUTLINE

- **Policy**
- **Guidance and Standardization**
- **Workforce Development**



Reliability Analysis, Planning, Tracking and Reporting



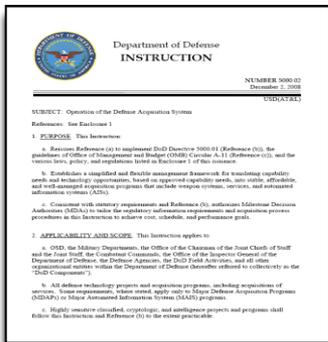
USD AT&L MEMO



Impetus for Reliability Policy

- Directed by Dr. Carter in response to memo from DOT&E
- DASD(SE) to assess existing reliability policy and propose actions to improve effectiveness

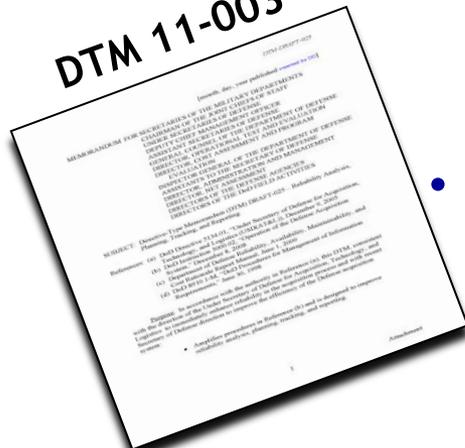
DoDI 5000.02



DoD Acquisition Policy (DoDI 5000.02)

- Does not adequately or uniformly consider R&M engineering activities throughout the acquisition process
- Fails to capture R&M planning in new or existing acquisition artifacts to inform acquisition decision making

DTM 11-003



DTM 11-003 (Approved 21 Mar 2011)

- Amplifies current DoDI 5000.02 by requiring PMs to perform reliability activities
- Institutionalizes planning and reporting timed to key acquisition activities

<http://www.dtic.mil/whs/directives/corres/pdf/DTM-11-003.pdf>



DTM 11-003 Overview



- **Engineering activities (The Acquisition Strategy (AS) to describe tasks and processes to be stated in the RFP)**
 - R&M Allocations, block diagrams and predictions
 - Failure definitions and scoring criteria
 - Failure Mode, Effects and Criticality Analysis (FMECA)
 - Built-in Test (BIT) and maintainability demonstrations
 - Reliability Growth testing at system/subsystem level
 - Failure Reporting, Analysis and Corrective Action System (FRACAS)
- **Preliminary RAM-C Report in support of Milestone (MS) A and updated for MS B & C**
 - Provides early (Pre-MS A) reliability, availability, maintainability and ownership cost feasibility assessments of alternative concepts
 - Includes early formulation of maintenance & support concepts
 - Provides an audit trail that documents and supports JCIDS thresholds
 - Ensures correct balance between the sustainment metrics (Availability-KPP, Materiel Reliability-KSA, and Ownership Cost-KSA)
 - Provides early risk reduction by ensuring requirements are realistic and correct
- **AS and SEP to specify how the JCIDS sustainment thresholds have been translated into R&M design requirements for use in contract specifications**



DTM 11-003 Overview



- **Reliability Growth Strategy**

- Documents system-level reliability growth curves in the SEP beginning at MS A and updated in the Test & Evaluation Master Plan (TEMP) beginning at MS B
- Establishes intermediate goals for reliability growth curves that will be tracked through fully integrated system-level test and evaluation events until the threshold is achieved
- Requires MS C PMs and Operational Test Agencies to assess reliability growth required to achieve the reliability threshold during Initial Operational Test and Evaluation

- **Tracking and Monitoring**

- Requires PMs to report status of reliability objectives and/or thresholds as part of the formal system engineering review process
- Incorporates Reliability Growth Curves into the Defense Acquisition Executive Summary (DAES) review process



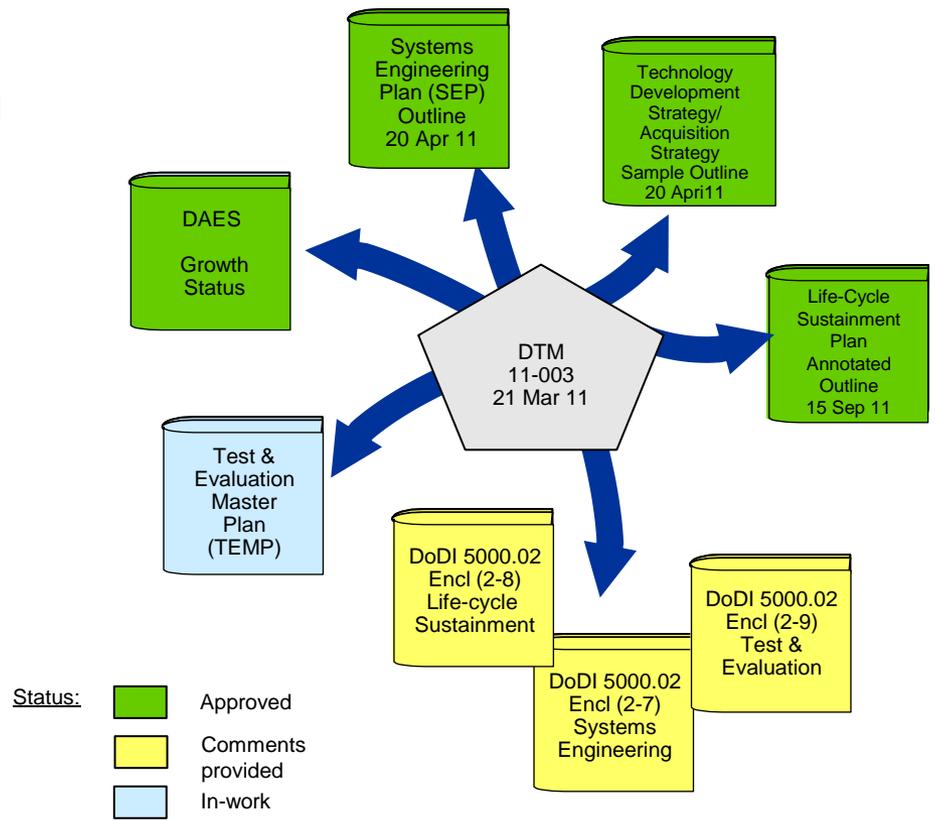
Relationship to DoD Documents



Integrating DTM-required engineering activities into DoD Policy

- Approved Outlines
 - Systems Engineering Plan
 - Technology Development Strategy and Acquisition Strategy
 - Life Cycle Sustainment Plan
- DAES Growth Status
- Comments provided
 - DoDI 5000.02, Encl 2-2 (SE)
 - DoDI 5000.02, Encl 2-3 and 2-4 (T&E)
 - DoDI 5000.02, Encl 2-5 (LCSP)
- In-Work
 - TEMP – DDT&E evaluating format

DTM Relationship to DoD Policy Documents





DAES RGC Reporting



OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

15 JUL 2013

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Implementation of Reliability Growth Status Data Collection and Reporting for Major Defense Acquisition Programs (MDAPs)

This memorandum provides direction and procedures for collecting and reporting the reliability growth status of MDAPs for Office of the Under Secretary of Defense for Acquisition, Technology & Logistics (OUSD(AT&L)) management and oversight. This information will satisfy Directive Type Memorandum (DTM) 11-003, "Reliability Analysis, Planning, Tracking, and Reporting" requirement that "Reliability Growth Curves (RGC) shall be employed to report reliability growth status at Defense Acquisition Executive System reviews." The objective of this reporting is to achieve visibility into the MDAPs' reliability growth status during system level developmental testing. This information will be used to track reliability growth status on individual programs as a measure of progress to plan, recommend programs for Defense Acquisition Executive Summary (DAES) reviews, and support reliability growth planning for future programs.

MDAPs that are currently in system level developmental testing shall report reliability against their reliability growth curve(s) documented in the Systems Engineering Plan (SEP) and Test & Evaluation Master Plan (TEMP). As MDAPs enter system level developmental testing in accordance with their RGC in the SEP and TEMP, reliability growth reporting will begin for that program. Reliability reporting will continue until the end of IOT&E, at which time if the MDAP reliability threshold is met, DTM-directed reliability reporting will cease. Otherwise, reporting will continue until the reliability threshold is met.

The reliability data will be collected in two phases. Phase I shall consist of non-automated reporting of reliability data via Microsoft Excel spreadsheets. This phase will leverage off the existing DAES supplemental data submission process. The reliability data will be submitted as a Microsoft Excel file along with the mandated Risk and Issue charts currently submitted as part of DAES reporting. Phase II will instantiate data collection directly into the Defense Acquisition Management Information Retrieval (DAMIR)/Acquisition Visibility.

MDAPs shall report the data elements via the spreadsheet located in the DAMIR portal, under Acquisition Documents/DAES Meeting/Guidance. The initial reporting will include the planning elements of the MDAP reliability growth program (Planning tab in spreadsheet). Thereafter, MDAPs will only report their reliability growth status using the Reporting tab. For MDAPs that are in system level testing at the release of this memorandum, all planning elements (i.e. Planning tab) must be reported but demonstrated reliability data for previous quarters does not need to be retroactively submitted.

- **DAES RGC Reporting to begin Oct 1 per Director, ARA memorandum**
 - **Requires reliability data from MDAPs in system-level Developmental Testing (~20 MDAPs required to report)**
 - **Captures planned and demonstrated data**
 - **Phase 1 – Manual submission of data via spreadsheets**
 - **Phase 2 – Automated submission directly into Defense Acquisition Management Information Retrieval (DAMIR) (implementation TBD)**



Guidance and Standardization



- Defense Acquisition Guidance (DAG)**

- (Phase 1) DAG Chapter 4, paragraph 4.4.15 updated for “fact of life” changes
- (Phase 2) Participated in DAG Ch 4 Rewrite as primary R&M Section Author

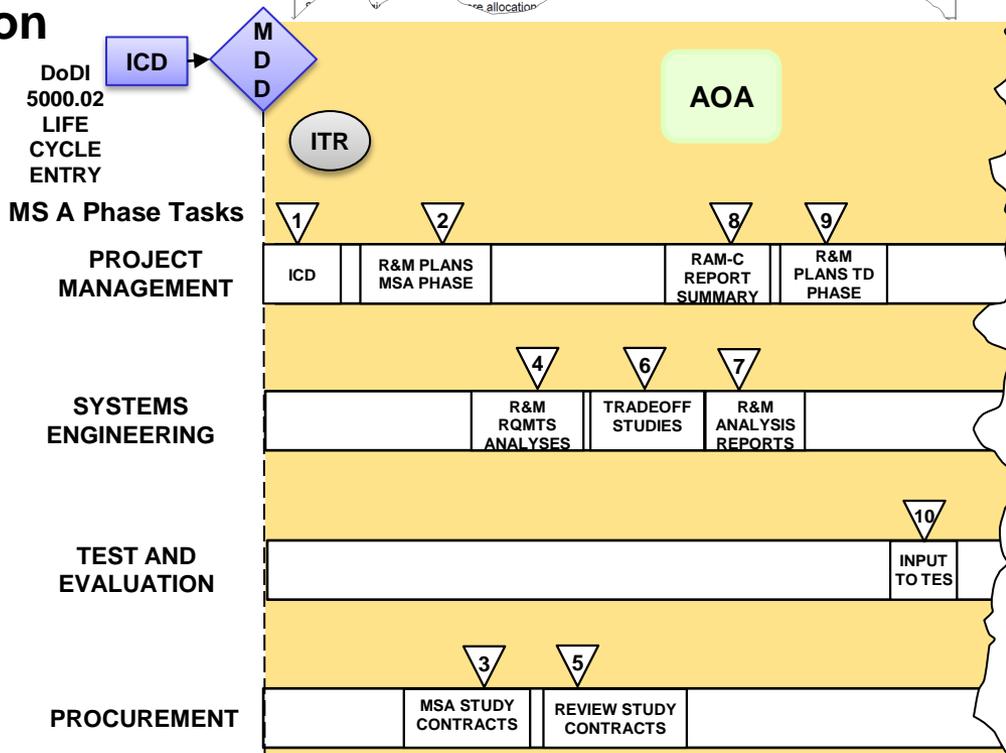
- <https://acc.dau.mil/CommunityBrowser.aspx?id=638295>

- Lower Level Guidance**

- Developing R&M engineering guidance by phase and by program functional areas
 - All phases complete
 - Pending contract language updates and peer review

Table 1. DTM 11-003 Required R&M Engineering Activities by Functional Area

Functional Area	DTM 11-003-Required R&M Engineering Activities	MSA	TD	E&MD	P&D	O&S
Project Management	Formulate a comprehensive R&M program using appropriate reliability growth strategy	•	•	•	•	•
Project Management	Integrate R&M Engineering Program in Systems Engineering Plan (SEP) including a system reliability growth curve	•	•	•		
Project Management	Prepare/Update RAM-C Report and attach to the SEP	•	•	•		
Project Management	Report reliability status during formal design review process and technical reviews (SRR, PDR, CDR, etc.)	•	•	•		
Project Management	Prepare reliability growth assessment of the likelihood of meeting the CDD threshold by IOT&E			•		
Project Management	Evaluate reliability growth and report status in DAES reviews until the threshold is achieved			•		





R&M Engineering Guide Framework



- **Introduction**
- **Chapter 1 - R&M Engineering in the MSA Phase**
- **Chapter 2 - R&M Engineering in the TD Phase**
- **Chapter 3 - R&M Engineering in the EMD Phase**
- **Chapter 4 - R&M Engineering in the P&D Phase**
- **Chapter 5 - R&M Engineering in the O&S Phase**
- **Appendix A – R&M Contract Language**
- **Appendix B – R&M Task Checklists by Phase and Milestone**
- **Appendix C – Reliability Growth Strategy**

284 total pages, including TOC and blank pages



R&M Engineering Guide Organization



- The guide is organized in the following three areas:
 - First, by the defense acquisition life cycle phases
 - Second, by functional area (Project Management, Systems Engineering, Test and Evaluation, Procurement)
 - Third, each functional area lists R&M engineering tasks that trace back to the required R&M engineering activities established in DTM 11-003

Table 1. DTM 11-003 Required R&M Engineering Activities by Functional Area

Functional Area	DTM 11-003-Required R&M Engineering Activities	MSA	TD	E&MD	P&D	O&S
Project Management	Formulate a comprehensive R&M program using appropriate reliability growth strategy	•	•	•	•	•
Project Management	Integrate R&M Engineering Program in Systems Engineering Plan (SEP) including a system reliability growth curve	•	•	•		
Project Management	Prepare/Update RAM-C Report and attach to the SEP	•	•	•		
Project Management	Report reliability status during formal design review process and technical reviews (SRR, PDR, CDR, etc.)	•	•	•		
Project Management	Prepare reliability growth assessment of the likelihood of meeting the CDD threshold by IOT&E			•		
Project Management	Evaluate reliability growth and report status in DAES reviews until the threshold is achieved			•		
	Resource allocation					

Some activities occur in more than one phase



R&M Engineering Guide Functional Areas



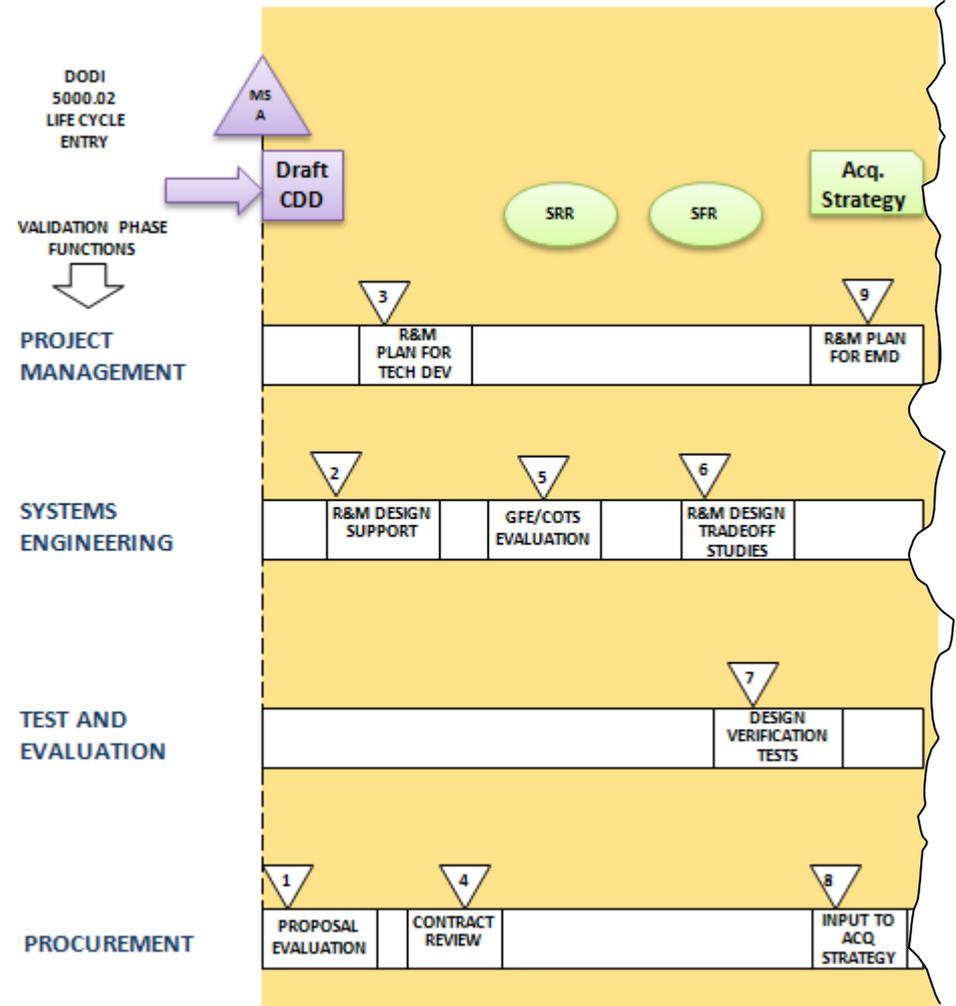
- **The guide defines and allocates R&M tasks to the functional areas into which a materiel acquisition program can normally be divided:**
 - Project Management
 - Planning, definition, and implementation of R&M control criteria, assurance procedures, in-process review for compliance, and R&M decision-making criteria
 - Systems Engineering
 - R&M design analyses, trade-off study, failure mode effects and criticality analysis, R&M problem and correction, and R&M design support
 - Test and Evaluation
 - Planning and conducting tests for evaluation and demonstration of R&M
 - Procurement
 - Definition, documentation, and review of R&M requirements and provisions in procurement requests, requests for proposals, contracts and exhibits
- **R&M engineering tasks should be properly integrated across all functional areas of the program in order to implement an effective R&M engineering program**



R&M Engineering Guide Task Overview



- The guide identifies specific tasks needed to support each DTM-required R&M engineering activity
 - MSA phase – 13 tasks
 - TD phase – 14 tasks
 - EMD phase – 14 tasks
 - P&D phase – 13 tasks
 - O&S phase – 5 tasks
- Each acquisition phase has a figure showing timelines for the tasks in the functional areas across the phase





Application Example

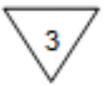
- Program has progressed to TD phase
- Determine that a required engineering activity is to “Formulate a comprehensive R&M program using appropriate reliability growth strategy”

Table 1. DTM 11-003 Required R&M Engineering Activities by Functional Area

Functional Area	DTM 11-003-Required R&M Engineering Activities	MSA	TD	EMD	P&D	O&S
Project Management	Formulate a comprehensive R&M program using appropriate reliability growth strategy	•	•	•	•	•

- Task associated with that activity during the TD phase is part of the Project Management functional area

Table 2-3. Project Management R&M Tasks – TD Phase

R&M Task	Description
 Develop/review R&M planning for TD phase	Review the R&M plans to ensure conformance to requirements defined in the RFP and contract and to verify consistency with requirements and provisions.



R&M Engineering Guide Task Example



- Each task in each phase has a task overview, control procedure, data requirements, and review criteria

- Overview of task
 - Brief description of task and its importance
- Control Procedure
 - Procedure that should be followed in accomplishing the task
- Data Requirements
 - Data required to complete the task
- Review Criteria
 - Criteria to be used in determining if the task has been completed successfully

2.1.1 Develop/Review R&M Planning for TD Phase

TD Phase Task 3

TASK



The R&M engineer and project management team review the R&M program planning for the TD phase that the Government developed before initiating the TD phase and contract. The team updates the planning as appropriate to reflect specification changes approved during negotiations.

R&M PLANNING FOR TD: CONTROL PROCEDURE

The Government R&M planning for the TD phase should be updated from the MSA phase and as a minimum should address the following in the appropriate program planning documents:

- *Management* – Identify the organizational elements and personnel and clearly define their responsibilities and functions.
- *Management Tasks* – Prepare a detailed listing and description of each R&M task and the procedures to evaluate the status of and to control each task.
- *Resources* – Estimate the Government R&M funding and man-hours for each R&M task (or task that the R&M team is involved in) required in the TD phase.
- *Objectives* – Determine provisions for updating the quantitative and qualitative R&M objectives to reflect the current approved configuration and the related analyses and trade-off studies.
- *Problem and Risk Areas* – Establish procedures for identifying critical R&M problems and risks and the plans for resolving and mitigating these problems in the TD phase.
- *Acquisition Program Documents* – Provide steps for updating the R&M inputs to the Systems Engineering Plan (SEP), Acquisition Strategy (AS), the RAM-C Report, the Test and Evaluation Master Plan (TEMP), and other program documents as required.
-

R&M PLANNING FOR TD: DATA REQUIREMENTS

The contractor's R&M program plans should include the data requirements outlined above and as required by the RFP. The Government should review these plans in preparation for the System Requirements Review (SRR). The plans should allow for updating as plans or procedures change by mutual agreement to conform to the needs of the program. Essential features of the contractor's approved R&M plans should be integrated into appropriate sections of the SEP and internal program documents including technical review entrance criteria.

R&M PLANNING FOR TD: REVIEW CRITERIA

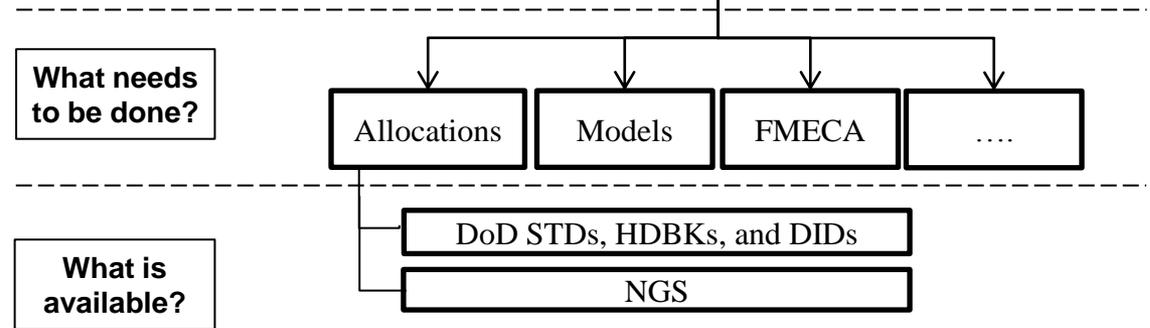
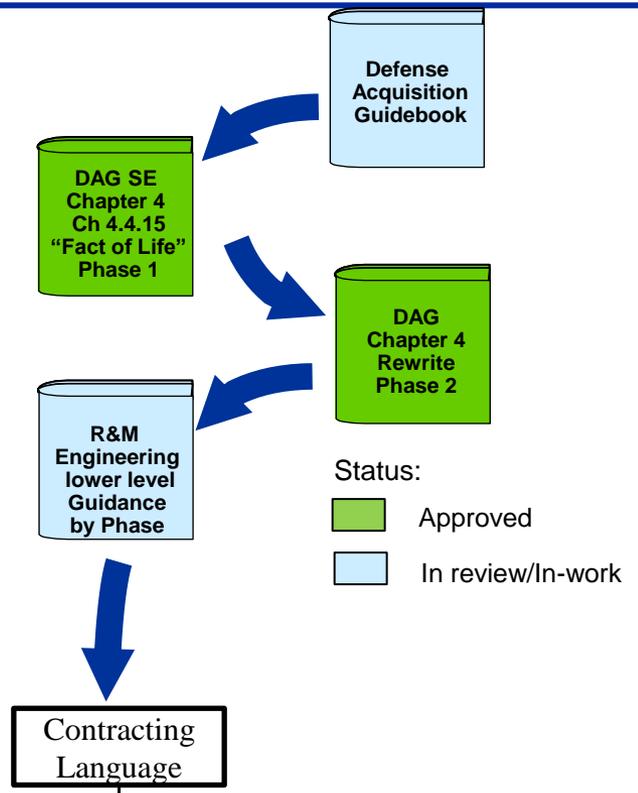
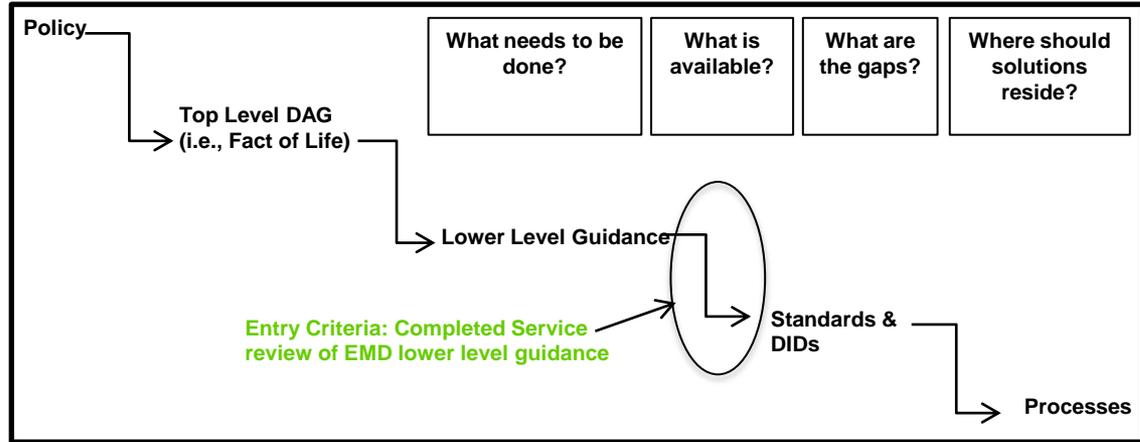
- The contractor's R&M program plans satisfy the requirements outlined in the control procedure and data requirements above.



Guidance and Standardization

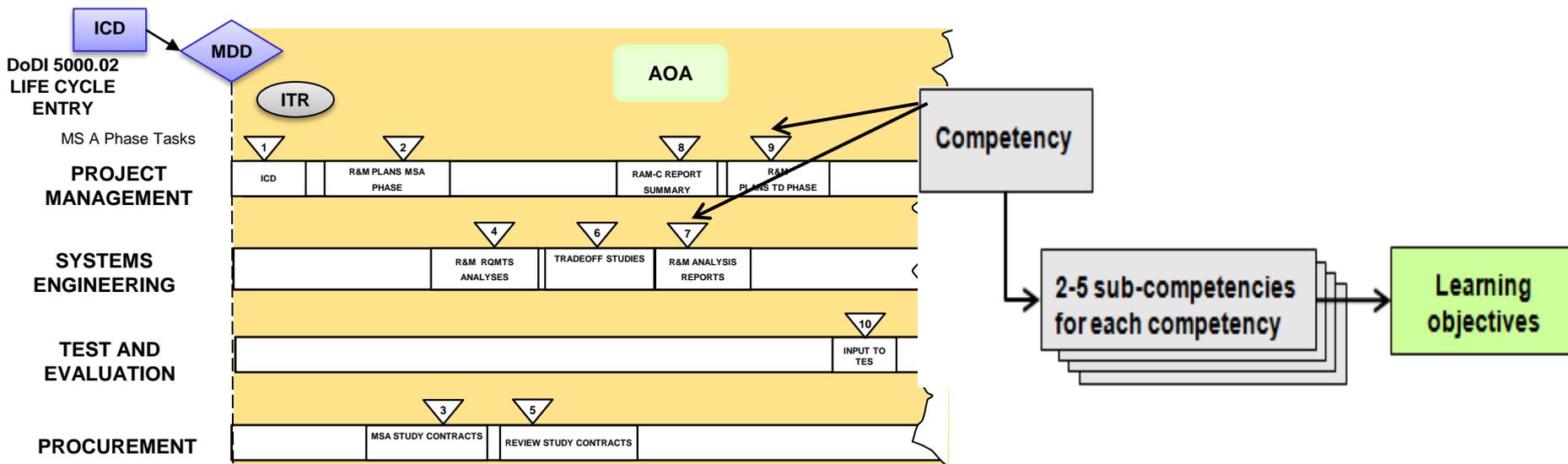
R&M Standards working group

- Priority will be given to standards that directly relate to R&M engineering activities required by the DTM
- Contracting language will define the standardization activity to contract for R&M





Workforce Development



- **Competencies are focused by program functional areas**
- **Developing competencies, sub-competencies, and supporting standard skills for basic, intermediate, and advanced career levels to support learning architecture development**
- **Mapping sub-competencies to DAU courseware learning objectives**
- **Opportunities exist to partner with Services and academia to identify core R&M engineering training requirements.**

The R&M competency structure spans the acquisition life cycle, and addresses all levels of proficiency.



Identification of Training Needs for Competency Coverage



- A Gap Analysis was conducted to determine if and where R&M competencies and sub-competencies are being taught
- DAU courseware, Services and non-governmental training courses, and university education programs were reviewed
- The analysis identified topical areas for which DAU courseware can address:

- Level III R&M Course
- RAM-C Document Guidance Course
- Additional Modules or Case Studies

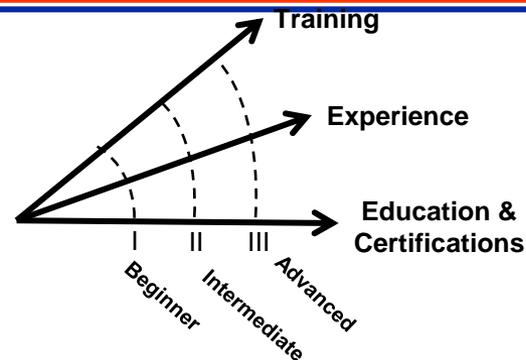
	MSA	TD	EMD	PRD		
Review ICD	1					
R&M Planning for CURRENT phase	2	3	3	3	1	
Issue contract for MSA phase	3					Procurement
R&M Requirement Analysis	4					SE
Issue contract for CURRENT phase	5	4	2	1		Procurement
Design Tradeoffs	6	6				SE
R&M Analysis Report	7					SE
R&M Planning for NEXT phase	9	9	11			PM
TEMP	10	11	13	12		T&E
TDS/AS	11	8	9	9		Procurement
Input to RFP for NEXT phase	13	12	14			Procurement
SEP/RAM-C	8, 12	10	12			PM
Milestone Review	MS A	MS B	MS C	FRP	ISR	N/A
Evaluate Proposal		1	1			Procurement
R&M Design Support		2	5	4		SE
GFE/COTS		5				SE
Design Verification Test		7				T&E
Preliminary Design Analysis		13				SE
Program Review		14	6	6		PM
Integrated Test Plan			4	2		T&E
Subsystem Test			7			T&E
System Test			8	7		T&E
Government System Test			10	11	3	T&E
Reliability Acceptance Test				5		TR
Evaluate FRACAS				10		
Production R&M				13		
R&M Engineering				8		
Management						



R&M Engineering Learning Architecture



- R&M Learning Architecture Implementation
 - Specialty Engineering Annex to Engineering Certification Guidelines
- Focus on R&M Engineering Capability Progression through DAWIA I, II, III
- Allows for both Manager and Individual to Plan Capability Growth
- 3 Components
 - Training
 - Experience
 - Education and Certifications
- Training Sources
 - DAU
 - Services
 - Academia
 - Non-Government, i.e. RIAC



CERTIFICATION STANDARDS & CORE PLUS DEVELOPMENT GUIDE	
ENGINEERING LEVEL II	
ANNEX A: SPECIALTY ENGINEERING CORE PLUS DEVELOPMENT: RELIABILITY & MAINTAINABILITY	
Functional Training	CLE 301, Reliability & Maintainability
	SYS 20X, Intermediate Systems Engineering
	LOG 103, Reliability, Availability and Maintainability
	SE2T, U.S. Army RDECOM
	RAM Modeling Part I and II, Reliability Information Analysis Center (RIAC)
Experiences	Process
	R&M Project Technical Management
	R&M Requirements Analysis
	Failure Data Analysis
	Review Proposals for R&M Sufficiency
Product	R&M Production Processes
	R&M Activities During Operations & Sustainment
	System Engineering Plan and RAM-C Rationale Report
	DAES Reporting for Reliability
	FRACAS, FMECA and Failure Modes
Education and Professional Certifications	Reliability Test Results Reports at Subsystem Levels
	Engineering Change Proposals for Reliability and Maintainability
	Pursuit of Graduate Degree or Certificate in Engineering or Physical Sciences
	DAWIA Level II Certification in Engineering
	Reliability Engineer Certification - CRE

Learning architecture will support capability and career growth for the DoD R&M Engineering Workforce



Summary



- **Awaiting release of DoDI 5000.02**
- **Lower level guidance**
 - Complete final reviews prior to staffing for security and public release
- **Finish development of R&M Learning Architecture**



For Additional Information



Andrew Monje

ODASD, Systems Engineering

703-692-0841 | andrew.n.monje.civ@mail.mil



Additional References

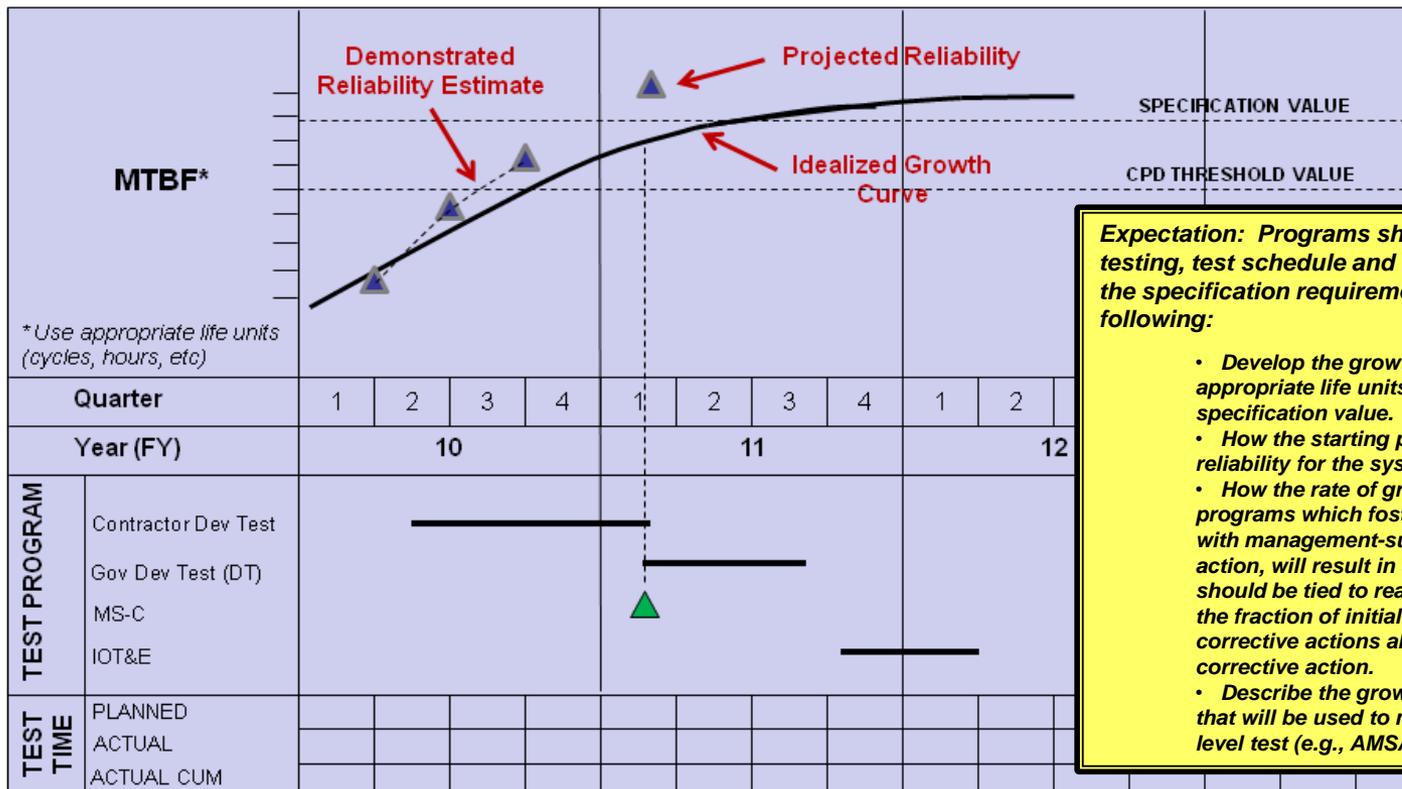




Reliability Growth Reporting in the Systems Engineering Plan



Document the Reliability Growth Curve beginning at MS A, updated at each successive milestone, ...



Expectation: Programs should understand the amount of testing, test schedule and resources available for achieving the specification requirement. Programs should consider the following:

- Develop the growth planning curve as a function of appropriate life units (hours, cycles, etc,) to grow to the specification value.
- How the starting point that represents the initial value of reliability for the system was determined.
- How the rate of growth was determined. Rigorous test programs which foster the discovery of failures, coupled with management-supported analysis and timely corrective action, will result in a faster growth rate. The rate of growth should be tied to realistic management metrics governing the fraction of initial failure rate to be addressed by corrective actions along with the effectiveness of the corrective action.
- Describe the growth tracking and projection methodology that will be used to monitor reliability growth during system-level test (e.g., AMSAA-Crowe Extended, AMPM).

System:

Date:

Remarks:

1. Demonstrated Reliability Estimate – Statistical estimate of reliability based on test data.
2. Projected Reliability – Assessment of reliability based on test data and engineering assessment of corrective action effectiveness.



Reliability Engineering Design and Test Activities



Describe planning and timing to generate R&M artifacts.

R&M Engineering Activity	Planning and Timing
R&M Allocations	
R&M Block Diagrams	
R&M Predictions	
Failure Definitions and Scoring Criteria	
Failure Mode, Effects, and Criticality Analysis (FMECA)	
Maintainability and Built-in Test Demonstrations	
Reliability Growth Testing at the System and Subsystem Level	
Failure Reporting , Analysis, and Corrective Action System (FRACAS)	

•Expectation: Programs should understand that the content of the R&M artifacts need to be consistent with the level of design knowledge that makes up each technical baseline.

- R&M Allocations – R&M requirements assigned to individual items to attain desired system level performance. Preliminary allocations are expected by SFR with final allocations completed by PDR.
- R&M Block Diagrams – The R&M block diagrams and math models prepared to reflect the equipment/system configuration. Preliminary block diagrams are expected by SFR with the final completed by PDR.
- R&M Predictions – The R&M predictions provide an evaluation of the proposed design or for comparison of alternative designs. Preliminary predictions are expected by PDR with the final by CDR.
- Failure Definition and Scoring Criteria – Failure definitions and scoring criteria to make assessments of R&M contract requirements.
- FMECA – Analyses performed to assess the severity of the effects of component/subsystem failures on system performance. Preliminary analyses are expected by PDR with the final by CDR.
- Maintainability and Built-In Test – Assessment of the quantitative and qualitative maintainability and Built-In test characteristics of the design.
- Reliability Growth Testing at the System and Subsystem Level – Reliability testing of development systems to identify failure modes, which if uncorrected could cause the equipment to exhibit unacceptable levels of reliability performance during operational usage.
- FRACAS – Engineering activity during development, production, and sustainment to provide management visibility and control for R&M improvement of hardware and associated software by timely and disciplined

Table 4.6-2 R&M Activity Planning and Timing (mandated) (sample)