R&M Engineering Contract Language for the Middle Tier of Acquisition (MTA) Pathway

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Office of the Under Secretary of Defense for
Research and Engineering

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R&M Engineering Contract Language for the Major Capability Acquisition Pathway

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Preface

This guide provides sample language for Department of Defense (DoD) program offices to use to incorporate reliability and maintainability (R&M) engineering activities into contracts for the Middle Tier of Acquisition (MTA) pathway. The guide provides recommendations for tailoring the MCA pathway activities and corresponding language to plan for the appropriate R&M for the type of program. MTA is one of the six Adaptive Acquisition Framework (AAF) pathways introduced in DoD Instruction 5000.02, "Operation of the Adaptive Acquisition Framework" (November 2020):

- Major Capability Acquisition (MCA)
- Urgent Capability Acquisition (UCA)
- Middle Tier of Acquisition (MTA)
- Software Acquisition
- Defense Business Systems (DBS)
- Acquisition of Services

Programs may use a combination of acquisition pathways to provide value not otherwise available through a single pathway. The latest information on implementing the AAF is located at: https://aaf.dau.edu/.

Section 1 of this guide provides an overview of the AAF and MTA pathway. Section 2 provides the R&M guidance and sample language for Requests for Information (RFIs). Section 3 provides R&M tailoring guidance and sample contract language for Requests for Proposals (RFPs).

These sections include selected hyperlinks to major sources. Additional sources and links are available in the reference list at the end of the document.

This guidance provides supplemental information to the DoD R&M Engineering Management Body of Knowledge (BoK) located at: https://www.dau.edu/cop/rm-engineering/bok. The R&M BoK was initiated before DoD instituted the AAF and is organized according to a policy in place at the time for hardware-intensive programs. The BoK approach closely aligns with the current AAF MCA pathway. The R&M BoK and this guidance will be updated as needed to incorporate advanced R&M practices and current policy.

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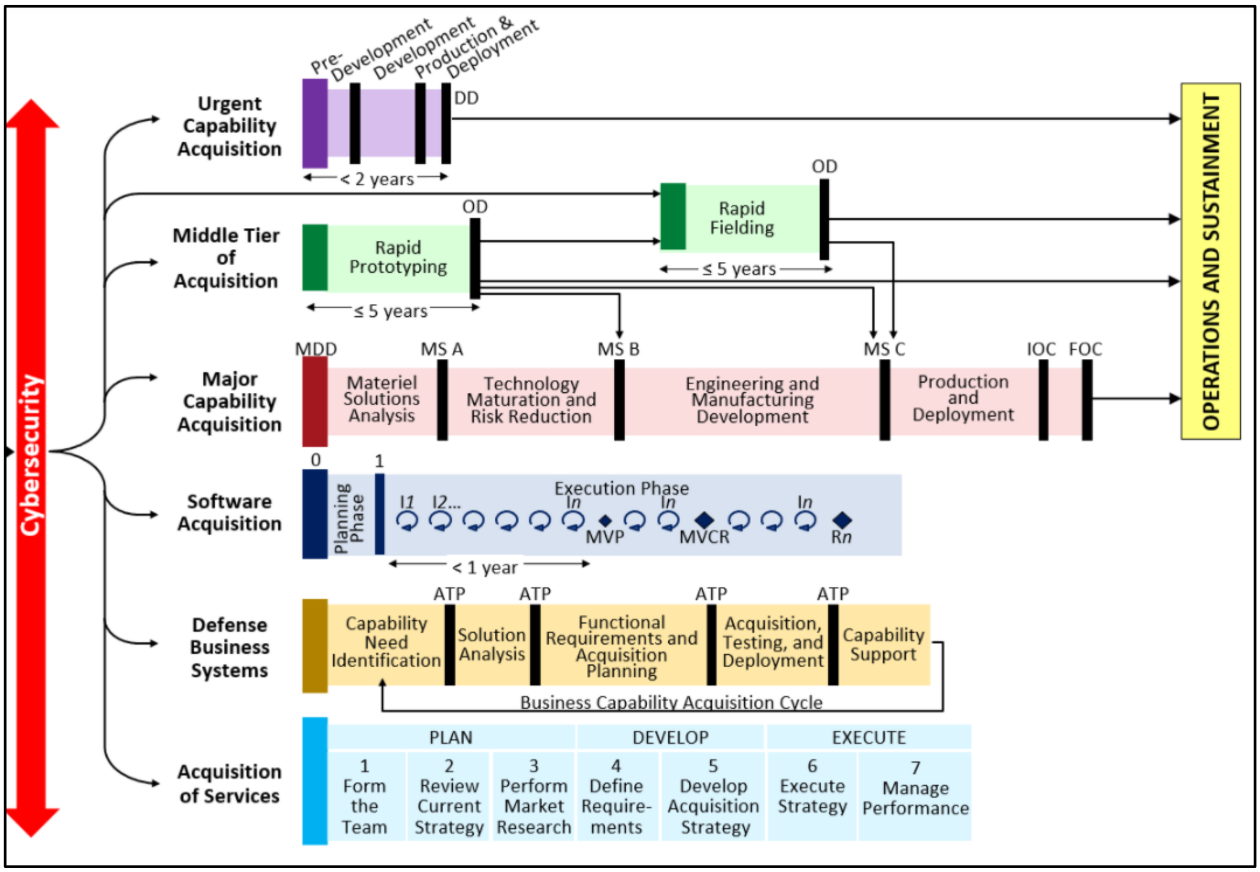
1 INTRODUCTION

1.1. Adaptive Acquisition Framework

The AAF pathways provide opportunities for Milestone Decision Authorities[1], Decision Authorities (DAs)[2], and Program Managers (PMs) to develop acquisition strategies and employ acquisition processes that match the characteristics of the capability being acquired and deliver capability at the speed of relevance. Figure 1-1 shows the six pathways of the AAF.



Source: DoDI 5000.02, "Operation of the Adaptive Acquisition Framework," January 23, 2020

Figure 1-1. DoD Adaptive Acquisition Framework

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[1] A Milestone Decision Authority (MDA) is the overall executive sponsor responsible for any Major Defense Acquisition Program (MDAP). The MDA formally initiates each increment of an evolutionary acquisition program. The PM is responsible for reporting to the MDA and adhering to their guidelines.

[2] An official responsible for oversight and key decisions of programs that use the software acquisition pathway in accordance with this issuance and related component policies. The official designates a PM and supports them in tailoring and streamlining processes, reviews, and decisions to enable speed of capability delivery. The official may be the Defense Acquisition Executive, Component Acquisition Executive (CAE), or the Program Executive Officer, or other designated official by the CAE.

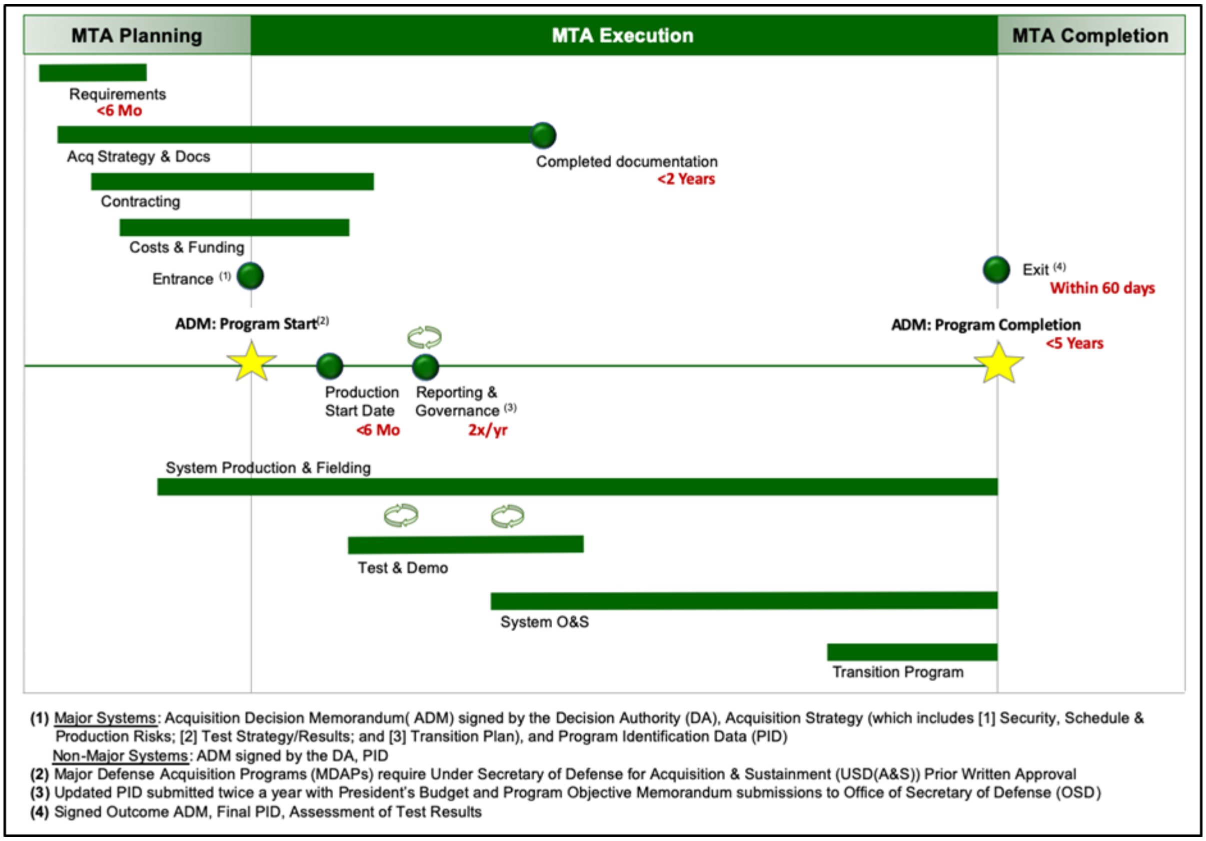
Visit https://aaf.dau.edu/ for a discussion of the AAF with guidance on selecting a pathway. The site provides detailed information on the pathways, policies, phases, and frequently asked questions.

The DoD acquisition system is designed to acquire quality products that satisfy warfighter needs with measurable improvements to mission capability. The AAF is intended to shorten cycle times and enable programs to rapidly develop, acquire, and deliver capabilities to the warfighter.

1.2. MTA Pathway

The purpose of the MTA pathway is to rapidly develop fieldable prototypes to demonstrate new capabilities or to rapidly field production quantities of systems with proven technologies that require minimal development. MTA programs may not be planned to exceed 5 years to completion. In execution, they will not exceed 5 years after MTA program start without a Defense Acquisition Executive (DAE) waiver. The MTA pathway consists of two paths: Rapid Prototyping (RP) and Rapid Fielding (RF).

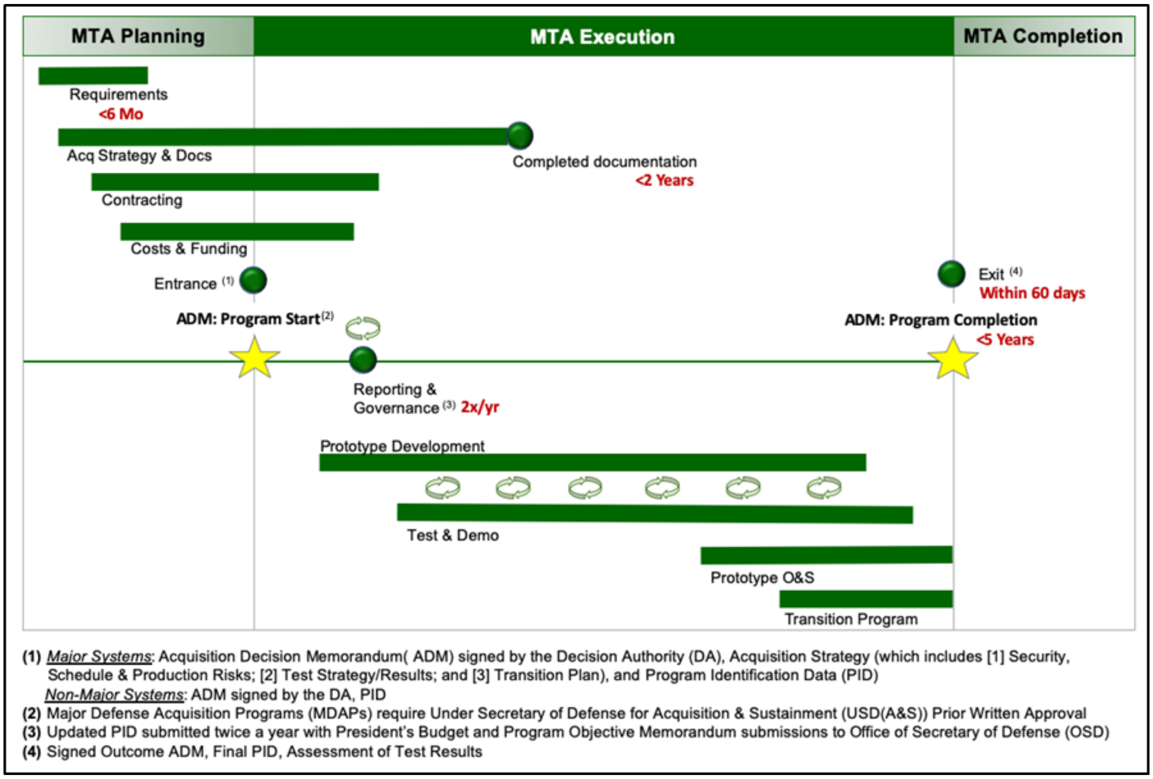
Rapid Prototyping (Figure 1-2) provides for the use of innovative technologies to rapidly develop fieldable prototypes to demonstrate new capabilities and meet emerging military needs. The objective of a program under this path is to field a prototype meeting defined requirements that can be demonstrated in an operational environment and provide for a residual operational capability within 5 years. Virtual prototyping models are acceptable if they result in a fieldable residual operational capability.



Source: https://aaf.dau.edu/aaf/mta/

Figure 1-2. MTA Rapid Prototyping

Rapid Fielding (Figure 1-3) provides for the use of proven technologies to field production quantities of new or upgraded systems with minimal development required. The objective of a program under this path is to begin production within 6 months and complete fielding, again within 5 years of the program start date. The MTA RF program production start date will not exceed 6 months after MTA program start date without a DAE waiver.



Source: https://aaf.dau.edu/aaf/mta/

Figure 1-3. MTA Rapid Fielding

DoDI 5000.80 establishes policy, assigns responsibilities, and prescribes procedures for managing the MTA. MTA programs are not subject to guidance in Chairman of the Joint Chiefs of Staff Instruction 5123.01H and DoD Directive 5000.01 [Change 2, 31 Aug 2018]. Each DoD Component will develop a streamlined process that results in a succinct requirement document no later than 6 months from the time the operational needs process is initiated. Approval authorities for each capability requirement will be delegated to a level that promotes rapid action.

The initial authority for the MTA pathway was granted by Congress in the FY16 National Defense Authorization Act (NDAA) Section 804. Table 2.1 summarizes the NDAA Section 804.

DoD Component-required procedures will be compliant with applicable statute and consistent with the requirements for acquisition programs stated in this issuance. When necessary, requests for waivers to the provisions of this issuance will be submitted to the DAE.

Not all programs are appropriate for the MTA pathway as they may be too complex. For example, major systems that are critical to a major interagency requirement, are primarily focused on technology development, or involve significant international partnership are discouraged from using the MTA pathway

Table 1-1 Summary of NDAA 2016, Section 804 Statutory Language

	Rapid Prototyping	Rapid Fielding
Purpose	• Provide for using innovative technologies to rapidly develop fieldable prototypes to demonstrate new capabilities and meet emerging military needs.	• Provide for use of proven technologies to field production quantities of new or upgraded systems with minimal development required.
Objective	• Field a prototype that can be demonstrated in an operational environment and provide for a residual operational capability within 5 years of the development of an approved requirement.	• Begin production within 6 months and complete fielding within 5 years of the development of an approved requirement.
Starts With	• A merit-based process for the consideration of innovative technologies and new capabilities to meet needs communicated by the Joint Chiefs of Staff and combatant commanders.	• A merit-based process for the consideration of existing products and proven technologies to meet needs communicated by the Joint Chiefs of Staff and combatant commanders.
Includes	• Developing and implementing acquisition and funding strategies. • Process for demonstrating and evaluating the performance of fieldable prototypes developed pursuant to the program in an operational environment. • Transitioning successful prototypes to new or existing acquisition programs for production and fielding under RP pathway or the Major Capability Acquisition pathway.	• Demonstrating performance and evaluating for current operational purposes the proposed products and technologies. • Developing and implementing acquisition and funding strategies for the program • Considering life cycle costs and addressing issues of logistics support and system interoperability • Opportunities to reduce total ownership costs
Not subject to the Joint Capabilities and Development System Manual and DoDD 5000.01, except to the extent specifically provided in guidance.		
Term “major defense acquisition program” does not include an acquisition program or project that is carried out using the RF or RP acquisition pathway (FY18 NDAA Sec 831)		

2 REQUESTS FOR INFORMATION FOR THE MTA PATHWAY

This section provides discussion, R&M guidance, and sample language for a Request for Information (RFI).

In accordance with DoDI 5000.88, in all defense acquisition programs, the Lead Systems Engineer[3] (LSE), working for the PM, will integrate R&M engineering into the overall engineering process and the digital representation of the system being developed. The LSE will plan and execute a comprehensive R&M program using an appropriate strategy consisting of engineering activities, products, and digital artifacts, including:

- R&M allocations, block diagrams, and predictions
- Failure definitions and scoring criteria
- Failure modes, effects, and criticality analysis
- Maintainability and built-in test (BIT) demonstrations
- Reliability testing at the system and subsystem level
- A failure reporting, analysis, and corrective action system (FRACAS) maintained through the life cycle

The RFI is the initial opportunity to ensure that R&M engineering activities are integrated into the overall engineering process.

2.1. Purpose

Before developing a Request for Proposal (RFP), the Government acquisition team may issue one or more RFIs. An RFI is a solicitation document used for market research, to obtain general information from suppliers about their products, services, and capabilities. An RFI is seldom the final stage but is commonly used in combination with an RFP or similar solicitation.

2.2. RFI Sample Language

The information gained from an RFI will help the program office determine the potential of each alternative system to fulfill the operational mission. The intent is to have potential contractors describe their designs and, where they make R&M projections, to state how they determined the

[3] The R&M engineer is responsible to the LSE for developing the R&M engineering program, overseeing the implementation of the R&M engineering activities, and coordinating with the LSE in evaluating risk areas and progress in meeting the R&M specifications.

projections. The RFI also provides an opportunity for each contractor to submit supplemental data to substantiate their R&M projections. The R&M projections should be for the anticipated Engineering and Manufacturing Development (EMD) configuration. Contractor format is acceptable, and modeling results in lieu of formal presentations or reports are acceptable.
Table 2-1 shows sample language that is appropriate for RFIs sent to potential contractors during the Materiel Solution Analysis (MSA) phase or for study or prototyping contracts performed as part of the MSA or early Technology Maturation and Risk Reduction (TMRR) phase.

Table 2-1 Sample RFI Language

(1) Provide a reliability growth planning curve, including assumptions, depicting the growth achieved on recently developed systems or recently fielded systems. Describe growth potential inherent in the weapon system, and the systems/subsystems where reliability improvement is considered achievable.
(2) Describe the environmental and usage conditions and mission profile(s) for the system-level R&M predictions and compare/contrast with usage conditions and mission profile(s) for this program. Provide system-level R&M predictions, using fielded performance for applicable R&M measures: (a) Reliability measures (mission and logistics) (b) Maintainability measures (to repair mission failures and logistics failures) (c) Direct maintenance corrective and preventive maintenance measures (d) Built-in test (percentage of faults detected, percentage of faults isolated, false alarm rate) (e) Operational availability

3 REQUEST FOR PROPOSAL FOR THE MTA PATHWAY

This section provides discussion, R&M guidance, and sample language for Requests for Proposals (RFPs) and helps the R&M engineer identify the engineering activities that should be placed on contract.

3.1. Purpose and Structure of the RFP

The RFP is a solicitation used in negotiated acquisition to communicate Government requirements to the prospective contractors and to solicit proposals.[4] At a minimum, the Federal Acquisition Regulation (FAR) requires that solicitations describe the Government's requirement, anticipated terms and conditions that will apply to the contract, information required in the Offeror's proposal, and (for competitive acquisitions) the criteria that will be used to evaluate the proposal and their relative importance. The official "Solicitation and Receipt of Proposals and Information" is located at: https://www.acquisition.gov/far/subpart-15.2, https://www.acquisition.gov/dfars/part-215.2, and the DoD Source Selection Procedures at: http://www.acq.osd.mil/dpap/policy/policyvault/USA004370-14-DPAP.pdf

The process for developing an RFP consists of six steps:

Step 1: Conduct market research (see FAR Part 10)

Step 2: Determine the functional and non-functional requirements for the system (See FAR Part 1, Market Research)

Step 3: [Optional] Write a draft RFP

Step 4: [Optional] Share the draft RFP with industry to obtain feedback

Step 5: Finalize the RFP

Step 6: Release to potential Offerors

FAR 15.204, Contract Format, specifies a Uniform Contract Format (UCF) for a government RFP, with the following sections:

Section A – Solicitation/Contract Form (SF-33)

Section B – Supplies and Services and Prices/Costs

Section C – Description/Specifications/Statement of Work

[4] Note that a draft RFP may be used to solicit comments and ideas from interested parties. These inputs would then be used to revise the final RFP.

Section D – Packaging and Marking

Section E – Inspection and Acceptance

Section F – Deliveries or Performance

Section G – Contract Administration Data

Section H – Special Contract Requirements

Section I – Contract Clauses

Section J – List of Attachments

Section K – Representations, Certifications, and Other Statements of Offerors

Section L – Instructions, Conditions, and Notices to Offerors

Section M – Evaluation Factors for Award (unnecessary for sole-source acquisitions)

Note that Section C includes the system specification and the Statement of Work (SOW). The specification includes quantitative technical requirements. The contract SOW lists tasks and deliverable data. The deliverable data is required via the DoD Contract Data Requirements List (CDRL) and appropriate Data Item Descriptions (DIDs). One of the primary purposes of the specification and SOW is to ensure the contractor and the Government agree on all the terms for the acquisition program, so the specification and SOW must clearly define all requirements to allow a reasonable and accurate response by the contractor.

Although the UCF indicates that the specifications and SOW belong in Section C of the RFP and contract, the usual and accepted practice is to attach them to the RFP or contract (the list of attachments is in Section J of the UCF) and reference the attachments in Section C. The following paragraphs 3.2 through 3.7 suggest language for a requiring organization to use to incorporate R&M engineering activity requirements into the specification and the SOW, to result in a clear RFP and therefore a strong and effective contract. This guidance document focuses on Sections C, J, L, and M. The other sections are of less or no concern to the R&M engineer and are properly the focus of contracting specialists.

3.2. Contract Section C – Guidance for the Specification

The system specification includes quantitative system R&M requirements, which should be written in clear, conventional language. The specification should identify the associated system and should identify specific subsystems, equipment, and software to be included in the design and performance definitions. R&M requirements should always be quantitative and verifiable. Qualitative requirements, such as "minimize the number of new tools," cannot be verified and should not be included in a specification.

Table 3-1 provides a list of the specification requirements and verification provisions. These requirements contain technical content for the design and quantitative R&M performance requirements placed in Section 3 of the specification and the verification criteria included in Section 4 of the specification. The specification should list all system components or subsystems to be supplied as Government-furnished equipment (GFE)[5] and should describe GFE R&M characteristics. The specification should provide this information for any special item, whether existing or in development, that is an integral part of the system concept.

Table 2-1: Specification Outline

Specification Section	Content
Section 2 – Applicable Documents	List documents referenced in sections 3 and 4 of the specification
Section 3 - Requirements	Quantitative R&M performance requirements
	Mission profile
	Definitions for Reliability (e.g., failures), Maintainability (e.g., corrective maintenance, direct maintenance support, and built-in test)
	Qualitative design requirements
Section 4 - Verification Provisions	Responsibility for test
	Classification of tests
	Rules for conduct of tests/demonstrations
	Description of R&M tests/demonstrations
	Other methods (inspection and analysis)

The requiring organization should be careful to avoid creating unrealistic or ambiguous requirements or requirements that conflict with information in referenced documents (i.e., handbooks, standards) or in the specification itself.[6]

[5] In the past 5 years definitions of equipment have been refined by financial audit requirements. DoD 7000.14-R defines material items (some of which used to be considered equipment) and DoDI 5000.64 defines equipment. Regulations in the DFARS has shifted to use of the term Government Furnished Property (GFP) that includes both material and equipment.

[6] The contract is the only legal document committing a contractor to deliver items, data, and services in accordance with specified requirements under agreed-upon terms and conditions. With its other requirements, the contract should include the R&M requirements, terms, and conditions initially outlined by the requiring organization in the Request for Proposal. 10 U.S.C. 4328, Weapon System Design: Sustainment Factors, addresses Program Manager responsibilities for emphasizing R&M requirements, activities, and source selection criteria early during weapon systems design.

The specification generally is not used to task contractors to perform work tasks, or for specifying requirements for deliverable data that are addressed in the SOW and contract deliverables. See MIL-STD-961E for additional information on the format and content of a specification.

3.2.1. Quantitative R&M Performance Requirements

The specification should define the level of performance, operating conditions, design reference mission profile, use environment, failure definitions, and design constraints in quantitative terms. The R&M thresholds defined in the Capability Development Document (CDD) should be validated through the Reliability, Availability, Maintainability, and Cost (RAM-C) analysis and documented in the RAM-C Rationale Report, and these R&M thresholds then must be translated to design-controllable R&M requirements for inclusion in the specification.

DoDI 5000.80 discusses in detail how performance requirements should be developed for MTA programs. Briefly stated, DoD Components develop a process for demonstrating performance and evaluating for current operational purposes the proposed products and technologies. This process will result in a test strategy or an assessment of test results, included in the acquisition strategy, documenting the evaluation of the demonstrated operational performance, to include validation of required cybersecurity and interoperability as applicable. Programs on the Director, Operational Test and Evaluation (DOT&E) oversight list will follow applicable procedures.

Design-controllable R&M requirements address only those failures that the contractor can influence through design, manufacturing, processing, and integration of the system. Depending on contract structure, these requirements could then exclude failures of GFE (though if a failure of GFE is caused by the contractor's system design it would be relevant), maintenance-induced failures, failures due to operation of system out of "spec," and failures due to test equipment. The time to repair these failures could exclude items such as tool and part procurement times, maintenance expended on special or scheduled inspections not due to design-controllable factors, maintenance performed on GFE, and maintenance-induced problems resulting from maintenance error or negligence.

The operational R&M requirements, stated in Service-unique terms, are included in the CDD.[7] The R&M engineer must convert (translate) these requirements into quantitative contractual

[7] The Manual for the Operation of the Joint Capabilities Integration and Development System (JCIDS) lays out the operational requirements (Key Performance Parameters, Key System Attributes, and Additional Performance Attributes) related to R&M. Although JCIDS provides useful guidance for all programs, DoDI 5000.80 states that MTA programs will not be subject to the guidance in Chairman of the Joint Chiefs of Staff Instruction 5123.01H and DoD Directive 5000.01.

specifications. At a minimum, the specification should include the following contractual R&M requirements:

- *Mission Reliability* – The measure of the ability of an item to perform its required function for the duration of a specified mission profile, defined as the probability that the system will not fail to complete the mission, considering all possible redundant modes of operation. Includes all design-controllable failures that would prevent the system from performing its mission(s).
- *Logistics Reliability* – The measure of the ability of an item to operate without placing a demand on the logistics support structure for repair or adjustment, including all failures to the system and maintenance demand as a result of system operations. Includes all design-controllable failures that place a demand on the logistics system.
- *Maintainability* – The probability that a failed component or system will be restored or repaired to a specified condition within a specified period or time when maintenance is performed in accordance with prescribed procedure. Includes maintenance burden (labor and material overheads that contribute to overall maintenance cost), corrective and preventive maintenance support, and direct maintenance support.
- *Built-In Test* – The means by which a system can test itself. Includes fault detection, fault isolation, and false alarms rates.

Maintainability requirements derived from the operational thresholds must be compatible with the derived reliability requirements. The reliability, maintainability, maintenance concept, and logistic support analysis for the system should be adjusted during the system requirements analysis process to be compatible with the existing design constraints and program limitations. The relationship among reliability, maintainability, product support, and operations and support (O&S) cost must be acknowledged early in the formative stages of system design. The data from analyses conducted for these areas must be coordinated throughout the product life cycle.

The requiring activity should include the following details in the specification:

- *Design Requirements* – The translation of the R&M thresholds from the draft CDD or CDD to the quantitative specification measures that the contractor can influence through the design or manufacture of the system.
- *Operational Mode Summary/Mission Profile (OMS/MP)* – A document describing how a system or training device will be used in wartime or peacetime at the time it is fielded, with focus on the future. The OMS/MP is also typically used for setting the Reliability, Availability, and Maintainability (RAM) goals in an early phase of weapon system development. An OMS/MP projects the anticipated variety of ways a system will be used for each moment of time to include both peacetime and wartime. It also includes the percentage of time the system will be exposed to each type of environmental condition

and terrain. The Combat Developer produces the OMS/MP following development of the system Concept of Operations (CONOPS)[8] and uses the OMS/MP to determine the maintenance activities that will be conducted at each level.

- *Use Conditions* – All known natural and induced conditions under which the system must function or survive. Use conditions include the environmental conditions the system is expected to encounter, and which could cause system failure if the design is not capable of withstanding the stresses the conditions impose. System reliability is, by definition, a function of specified conditions. Therefore, the conditions that prevail on the total system or subsystem should be defined by the development of an environmental profile and use conditions. It is important to understand that a failure may not occur at the time of stress application but could occur at another point in time because of a weakening process that may be dependent upon other factors.

  All use conditions associated with the total life cycle must be considered in designing for reliability. The total life cycle of a system is the period from acceptance of the item until final disposal. Use conditions should include a description of the anticipated installation interfaces, interference characteristics of adjacent or associated systems, interactions with support systems, and the environments with which the system is to be compatible during its life cycle. The description should include packaging, handling, storage, transportation, maintenance, test, and checkout as well as operational conditions. Use conditions may be presented as a brief narrative description of the anticipated operational conditions under which the system will be used, or presented as an itemized list of known or anticipated ranges of environments and conditions. In either case, the environmental profile should be included in the specification. Each phase of the system's life cycle involves natural or induced environments.

- *Mission Profile* – A description of environmental and use duty cycles throughout the mission period for which reliability must be specified. The mission profile describes the time sequence of operational events required to accomplish mission objectives and is related to the time the system is operating and duty cycle (percentage of mission time system is used), with sub-conditions such as standby, alert time, and secure or deactivation time. The mission profile must define all the significant objectives and constraints that affect each special mission. A mission constraint is a limit or rule that a variable must not exceed under any condition. Types of constraints may include natural

[8] A CONOPS is a verbal or graphic statement of a commander's assumptions or intent regarding an operation or series of operations. The CONOPS is frequently embodied in campaign plans and operation plans, particularly when these plans cover simultaneous and successive operations. The CONOPS presents an overall picture of the operation with the intent of providing additional clarity of purpose.

phenomena and weather conditions, design ground rules for various flight conditions, and limiting factors such as configuration and reliability.

- *Definitions* – The definition of failure for the system in relation to its important performance parameters. In general, failure can be defined as the inability to complete the stated mission because one or more performance parameters are outside of specification limits. System failure must be oriented to the specific mission of interest, which should have been identified during the development of mission profiles. The definition of failure for a system that performs multiple functions with different equipment or groups of equipment consists of a family of failure definitions, which relate through the configuration, functional mode, phase, and alternative mode similarities but may vary from mission to mission. Definitions for each metric and for failure should start with definitions developed as part of the Failure Definition and Scoring Criteria (FDSC) but should be updated to reflect design-controllable metrics and failures. This modification includes changes in operational "test" environment and use conditions and inclusion or exclusion of GFE (depending on the contract structure), as well as tailoring based on when and how contract compliance will be verified. (For example, if contract compliance will be measured at the end of developmental test, an interim reliability requirement, not a "mature" requirement, should be specified.)
- *Test Requirements* – The R&M demonstration and test requirements and the acceptance criteria by which the system will be evaluated for conformance to the requirements.
- *Clarifying Notes* – Notes and R&M evaluation criteria (i.e., failure definitions and scoring criteria) intended to eliminate ambiguity or misunderstanding in specified requirements.

3.2.2. Verification Provisions

Every specification requirement must have associated with it methods for verifying that the requirement has been met. Verification is the activity of checking that the design or production of an item (e.g., component, equipment, or system) meets the mandatory functions for attributes of the item. Following are the four fundamental methods of verification and hypothetical examples of each.

1. *Demonstration* – The performance of operations at the system or system element level where visual observations are the primary means of verification. Demonstration is used when quantitative assurance is not required for the verification of the requirements.
    - Aircraft: Start the aircraft and ensure the environmental control system is operating normally.
    - Software: Enter the required fields on a screen and select the button to return a specific report. Ensure that the report is returned with the type of data needed.

2. *Inspection (Examination)* – Visual inspection of equipment and evaluation of drawings and other pertinent design data and processes. The inspection should be used to verify conformance with characteristics such as physical, material, part, and product marking and workmanship.
    - Aircraft: Visually inspect to ensure there are no obvious problems with flight controls.
    - Software: Visually examine that requested screens appear correctly.
3. *Analysis* – The use of recognized analytic techniques (including computer models) to interpret or explain the behavior or performance of the system element. Analysis of test data or review and analysis of design data should be used as appropriate to verify requirements.
    - Aircraft jet engine: Complete a series of tests running the engine at specific throttle settings for a set length of time, while monitoring thrust. Use this information to model the engine's thrust versus rpm curve.
    - Software: Sample and correlate measured data and observed test results with calculated expected values to establish conformance with requirements.
4. *Test* – An activity designed to provide data on functional features and equipment operation under fully controlled and traceable conditions. The data are subsequently used to evaluate quantitative characteristics.
    - Aircraft: Advance the throttle and monitor engine gas temperature and fuel flow.
    - Software: Enter the values of an equation and exercise the software to produce the result. Check to ensure the result is correct.

Of these methods, testing is the most precise and controlled form of verification. An item is tested to confirm that it behaves precisely as specified under a set of carefully specified test conditions and using different sets of test conditions. Testing often is used to verify performance requirements, beginning with components and progressing to higher levels of design, eventually reaching the system level. System-level testing is possible only near the end of a development program, however, and testing an entire system, such as an aircraft or ship, is extremely expensive. Using the other methods of verification throughout the development process is essential and reduces the risk of failing to meet system performance requirements.

3.3. Contract Section C – Guidance for the Statement of Work

The SOW is the contract vehicle for defining the work to be performed by contractors in support of an acquisition program. Preparing the SOW is an important step in planning and defining the acquisition process and work responsibilities. R&M activity descriptions are included in section 3 of the proposed SOW and serve to implement the R&M program outlined in the RFP. The description of all R&M activities involving design verification and data collection must be explicit. The general format for the SOW is shown in Table 3-2. This format is generally applicable to all acquisition phases. Refer to MIL-HDBK-245E for additional information on SOW format and content.

Table 3-3 Statement of Work Outline

SOW Section	Content
1. Scope	This section includes a brief description of SOW coverage. This section must not include direction to the contractor to perform work activities, discuss data requirements, or identify deliverable products.
2. Applicable Documents	Section 2 should list only those documents referenced in the Requirements Section (section 3) of the SOW. Contractual citing of standards, specifications, and other documents needed to clarify the work activity must be limited to currently available documents in effect at the time the contract is executed. Referenced documents must be cited specifically and directly by number and title. Listing documents in this section without referencing them in the SOW Requirements section can adversely affect program costs by adding unnecessary data requirements.
3. Requirements	This section includes the specific work tasks (activities) the contractor must perform to satisfy program needs, technical objectives and goals, and specific design requirements. Activities generally are dictated by program requirements but should be presented in chronological order. The R&M engineer should tailor the required R&M engineering activities by selecting those that are applicable, beneficial, and cost-effective for the program. The description of activities must be complete and stated in clear, plain language. Any references to standards or other sources should be accurate, current, and applicable to the requirements the contractor must fulfill. If the requirements or references are ambiguous, the contractor may assume total compliance is required and encumber the program with unnecessary costs. This section of the SOW should never be used to specify design requirements.

R&M engineering activities should be fully integrated within the program's systems engineering process. When appropriately tailored, the activities can be used for contracts in the TMRR, EMD, P&D, and O&S phases. The R&M program plan should address the entire life cycle. However, the SOW for each contract will contain only the contractor's execution of the required activities appropriate to the program phase and that can be accomplished during the contract period of performance. If a contract covers more than one phase of the program (e.g., production options on an EMD contract), each phase will be covered by separate contract line items and will require a separate SOW.

The following tailoring guidance assumes that the quantitative R&M requirements, FDSC, and other requirements have been used in the development of the performance requirements and defined verification methodology in the system specification. If there will be a down-selection at the end of the contract based, in part, on demonstrated or projected R&M performance, language explaining how the R&M data will be used in the down-selection process should be included in the contract as appropriate.

3.3.1. R&M Engineering Activities

R&M activities involve R&M analyses and tests; program plans, subcontract management, and controls; problem and risk identification and control; failure and material review processes and forums; and other program-related tasks that are essential for an effective R&M engineering program. An acquisition program imposes these activities to clearly define the R&M program and to help establish activities for lower tier equipment suppliers and software developers. Imposing R&M engineering activities aids in the early identification of potential or actual R&M problem areas.

Collectively, these activities will provide statistical evidence of whether the specified quantitative design requirements have been achieved. Activities associated with reliability design such as math models, allocations, Failure Modes, Effects, and Criticality Analyses (FMECAs), parts selection, derating criteria, and thermal analysis are imposed to ensure that reliability-enhancing features are incorporated in the system design from its inception. Budget, schedule, and other limitations vary from one acquisition program to another and sometimes vary significantly even within a single program over its development life. It is important to recognize that not every program needs to impose all activities. However, general reference to guidance documents or standards is insufficient for contractor planning, execution, or cost analyses.

Furthermore, a general reference to guidance documents or standards does not reflect a carefully considered need for assurance measures tailored for a particular acquisition program. The program contract must identify each R&M activity essential to the successful achievement of program objectives as an individual and necessary activity with a specific purpose and with distinct data requirements. A tailored R&M program entails selecting, modifying, and imposing only those activities that are applicable to a given acquisition program, are cost-effective for that program, and are considered necessary to achieve the specified quantitative R&M requirements for that program.

3.3.2. Tailoring R&M Engineering Activities for the MTA Pathway

For RP, DoDI 5000.80 states, regarding operational needs, that “DoD Components will develop a merit-based process for considering innovative technologies and new capabilities to meet needs communicated by the Joint Chiefs of Staff and the Combatant Commanders. This process will result in an approved requirement and a DA signed acquisition decision memorandum (ADM) that validates the rationale for using the MTA pathway and identifies the full funding required."

For RF, DoDI 5000.80 states, regarding operational needs, that "DoD Components will develop a merit-based process for the consideration of existing products and proven technologies to meet needs communicated by the Joint Chiefs of Staff and the Combatant Commanders. This process will result in an approved requirement and a DA signed ADM, with minimum fielding plan criteria, identifying the full funding required."

From the DoDI 5000.80 statements regarding operational needs, RP and RF R&M activities may be differ. Although both RP and RF may transition to the MCA pathway, RP may transition earlier. In addition, RP may involve innovative technologies that carry more risk. In accordance with FY16 NDAA Section 80, the guidance for an RP acquisition must include a process for transitioning successful prototypes to new or existing acquisition programs for production and fielding under the RF pathway or the traditional acquisition system. The result is that many R&M activities either will be waived or will be limited in scope, with additional activities applied after the prototype transitions to either a new or existing acquisition program. Finally, the pathway may be a feeder to another pathway and not field a residual capability.

3.3.3. Tailoring R&M Activities for the MTA Pathway by Pathway

Rapid Prototyping

This path provides for the use of innovative technologies to rapidly develop fieldable prototypes to demonstrate new capabilities and meet emerging military needs. The path may be a feeder to an RF or MCA pathway. The objective of an acquisition program under this path will be to field a prototype that meets defined requirements, can be demonstrated in an operational environment, and provide for a residual operational capability all within 5 years of the MTA program start date. Virtual prototyping models are acceptable if they result in a fieldable residual operational capability. MTA programs may not be planned to exceed 5 years to completion and, in execution, will not exceed 5 years after MTA program start without Defense Acquisition Executive (DAE) waiver.

Each RP program requires a process for demonstrating performance and evaluating for current operational purposes the proposed products and technologies. This process will result in a test strategy or an assessment of test results, included in the acquisition strategy, documenting the evaluation of the demonstrated operational performance.

For each RP program, there must be a process for transitioning successful prototypes to other development programs (new or existing acquisition programs) for integration, production, fielding, and operations and sustainment under either the rapid fielding or the MCA pathway. This process will result in a transition plan, included in the acquisition strategy, which provides a timeline for completion within 2 years of all necessary documentation required for transition, as determined by the DA, after MTA program. Figure 3-1 lists some of the objectives that prototyping addresses.

- Ensure the requirements are technically feasible.
- Identify the necessary or potential trade-offs required among requirements.
- Determine if the technology is ready to move into the next stage of development.
- Determine if the end item can be manufactured affordably.
- Determine if the Concept of Operations is valid.
- Evaluate if the technology/capability is ready to become a Program of Record (PoR) or be integrated with a PoR.

Figure 3-1. Some Questions Addressed by Prototyping

Prototyping is meant to generate a data set to inform a future decision. A prototyping project “succeeds” if it provides that data set, even if the prototype itself does not work. Likewise, a prototyping project that does not generate a data set to inform a future decision “fails.” Perspectives of “success” and “failure” in prototyping should have less to do with the prototype itself and more to do with the data that the prototyping project generates. The reality is that, by their nature, prototypes should be expected to “fail” frequently. It is part of the prototyping and learning process. The concept of “Fail Fast, Fail Cheap” justifies exploring technology development that may fail to perform but also may contribute to future success.

In tailoring the R&M program for the RP path, the R&M engineer should consider the following factors:

- Whether the prototype transitions to an RF or MCA program, or goes directly to fielding
- The degree of innovation associated with the proposed technologies.
- An assessment of the mission and safety criticality of the prototype.

In addition to the foregoing guidance regarding tailoring of R&M for the RP path, the R&M engineer should consider how the prototype is to transition. A successful RP project may transition to:

- An RF program.
- An existing acquisition program.

- A new acquisition program.
- The field. The residual capability can be sustained in the field.

If the Acquisition Decision Authority and the capability requirement community want to continue to operate the initial rapid prototype in the field, the PM is not required to enter RP under this guidance. The PM will develop the appropriate sustainment package to support the items in the field until they are dispositioned. If the rapid prototype is transitioning to an MCA pathway, the system must follow the guidance under DoDI 5000.02 and JCIDS.

When the prototype is to transition to an existing or new acquisition program, or to a rapid fielding program, additional time will be available to implement R&M activities and to address deficiencies found during prototyping. In these cases, the R&M engineer may tailor R&M quite severely. If the prototype is to transition directly to the field, however, the R&M engineer should focus on risk reduction. Specifically, the reliability engineer should develop a program addressing safety critical failures, and ideally mission critical failures, with the objective of resolving them prior to fielding.

Rapid Fielding

The RF path provides for the use of proven technologies to field production quantities of new or upgraded systems with minimal development required. The objective of an acquisition program under this path will be to begin production within 6 months and complete fielding within 5 years of the MTA program start date. MTA program production start date will not exceed 6 months after MTA program start date without DAE waiver. MTA programs may not be planned to exceed 5 years to completion and, in execution, will not exceed 5 years after MTA program start without DAE waiver.

For each RF program, there must be a process for demonstrating performance and evaluating for current operational purposes the proposed products and technologies. This process will result in a test strategy or an assessment of test results, included in the acquisition strategy, documenting the evaluation of the demonstrated operational performance, to include validation of required cybersecurity and interoperability as applicable. The operational demonstration assessment will support the initial production decision by the DA. Programs on the DOT&E oversight list will follow applicable procedures. In addition, there must be a process for transitioning successful RF programs to operations and sustainment. This process will result in a transition plan, included in the acquisition strategy, which provides a timeline for completion within 2 years of all necessary documentation required for transition, as determined by the DA, after MTA program start.

In tailoring the R&M program, the R&M engineer should then consider the following factors:

- The degree of proposed proven technologies.

- The availability of R&M data for the proven technologies.
- Planned process for demonstrating R&M performance.
- Whether the RF will transition to an MCA program at MS C or go directly to the field.

When proven technologies are being used for which sufficient R&M data are readily available, the R&M engineer may reduce or even eliminate R&M activities such as testing. Of course, the R&M engineer must account for any differences in the application of the technology or the environment in which it will be used for the RF program.

Whenever the technology is not proven or is less mature, or when R&M data are not readily available, the R&M program must be more robust, with special attention to safety critical failures, especially when the RF capability is to transition directly to the field. It again should be noted that not all deficiencies might be resolved prior to production or deployment of RF programs. At the very least, the R&M program must identify those deficiencies, the level of associated risk, and a proposed plan for addressing these deficiencies after fielding.

When an RF capability is to transition to an MCA program at Milestone (MS) C, there is additional time to address unresolved deficiencies.

3.3.4. Tailoring R&M Activities for the MTA Pathway by Type of Equipment.

Equipment type is another consideration the R&M engineer needs to address for a successful R&M program. A variety of equipment types is used in the material acquisition process. There are newly designed equipment and major changes, modified equipment and minor changes, GFE, Commercial Items (CIs), Commercial Off-the-Shelf (COTS), and Non-Developmental item (NDI). Note that a COTS item must be a commercial item sold in the exact same form in substantial quantities. A single change or a new design will result in the item being simply a CI. A CI is not sold in substantial quantities and compared with COTS, would require additional analyses (e.g., parts count or stress analysis) to confirm its reliability characteristics. See FAR, Part 2.101 Definitions, for more information on commercial products in general and COTS specifically. Depending on the type of equipment the program plans to use, the R&M engineer should understand that the R&M engineering design and test activities required would be different.

1. Newly designed equipment and Major changes: The usual reason for this type of procurement is the capability does not exist until it is designed as part of the program. For newly designed equipment and major changes, all R&M design, manufacturing, and test engineering activities will generally apply. MIL-STD-3046, paragraph 5.5.3.1.1 can be used as a guide for identifying a Major change. In general, a Major change is one that affects safety, significantly alters end use form, fit, function, or interface, or significantly impacts any following requirements:

a. Performance.

b. Reliability, maintainability, durability, or survivability.

c. Weight, balance, moment of inertia.

d. Electromagnetic characteristics.

e. Other technical requirements in the specifications.

f. Impact to logistical support requirements, such as training, technical or operational manuals, spares, maintenance procedures or equipment, etc.

g. Cost.

h. Re-qualification of the item.

i. Need to retrofit existing items.

Major changes are generally those that are significant to the degree that the end user of the product will likely perceive changes in performance, operational characteristics, or operational documentation or the maintainer of the product will perceive changes to maintenance procedures or maintenance documentation.

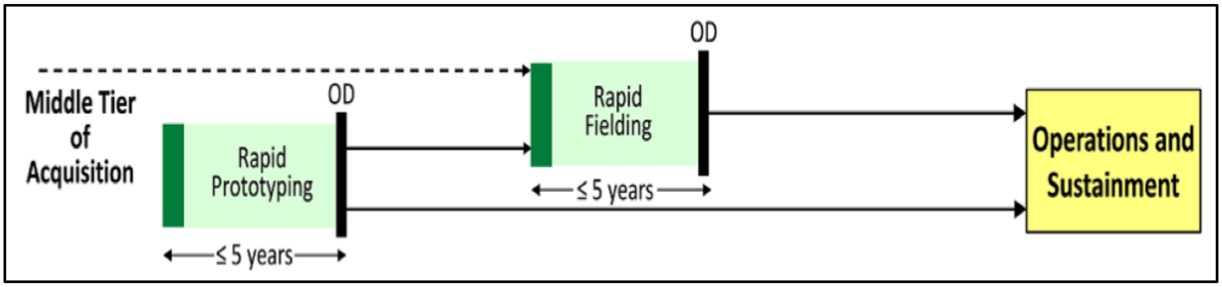
1. Modified equipment and Minor changes: MIL-STD-3046, paragraph 5.5.3.1.1 can be used as a guide for identifying a Minor change. In general, a Minor change is one that does not meet the definition of a Major change; and which affects or potentially affects form, fit or function, interface, producibility, material, visual characteristics, marking, packaging, etc. Minor changes are generally minor additions, deletions, or changes to physical features; minor changes to requirements that do not affect end use functionality; and changes to dimensions, tolerances, materials, quality assurance requirements, packaging, marking, etc. The R&M engineer must ensure that the appropriate R&M design, manufacturing, and test activities are properly applied. Even if only a part is changed, it should be designed to be reliable and maintainable.

2. GFE/COTS/NDI: The basic guideline is that GFE/COTS/NDI should meet or exceed the overall R&M performance requirements when being considered for use by the program and must generally meet its R&M allocation of the system requirements. GFE/COTS/NDI items should not be excluded from system assessments. GFE/COTS/NDI generally must be unmodified being produced from an existing manufacturing line. GFE should also be equipment that has completed the EMD phase of an MCA program, has been fully qualified, and has successfully achieved all

performance requirements to an approved Service or government specification. The DAU Glossary describes the definitions of GFE/COTS/NDI.

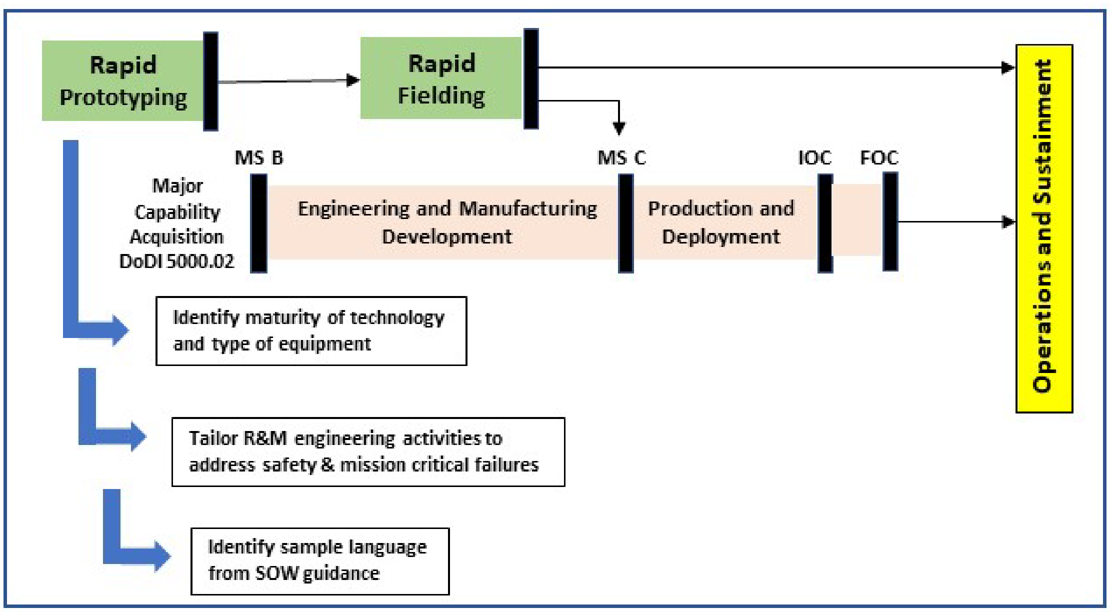
3.3.4 Tailoring Guide.

Figure 3-2 shows the flow for the MTA paths. Figures 3-3, 3-4, 3-5, 3-6, and 3-7 depict how the entire set of potential R&M engineering activities is tailored to what is required based on the MTA paths to achieve a cost-effective R&M program.



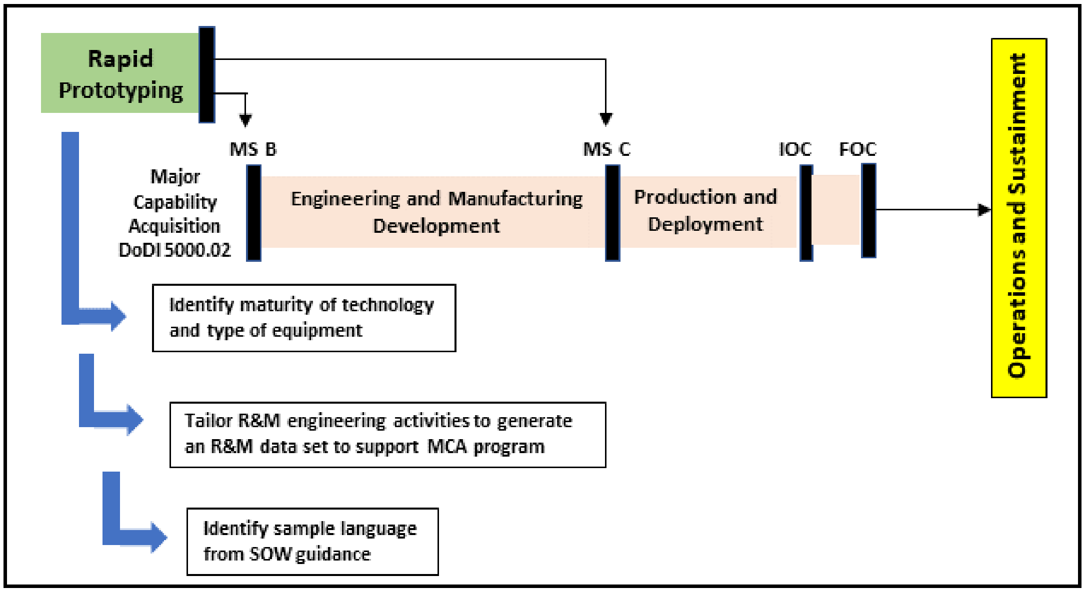
Source: DoDI 5000.80

Figure 3-2. Flow of the MTA Paths



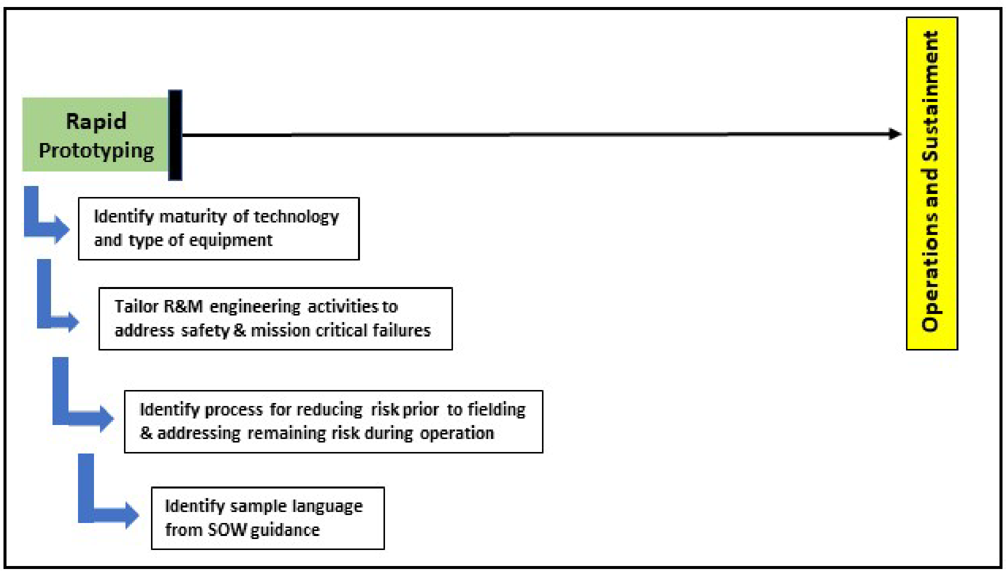
Source: DoDI 5000.80 as modified

Figure 3-3. Tailoring Flow Diagram for the RP Path: Transition to RF



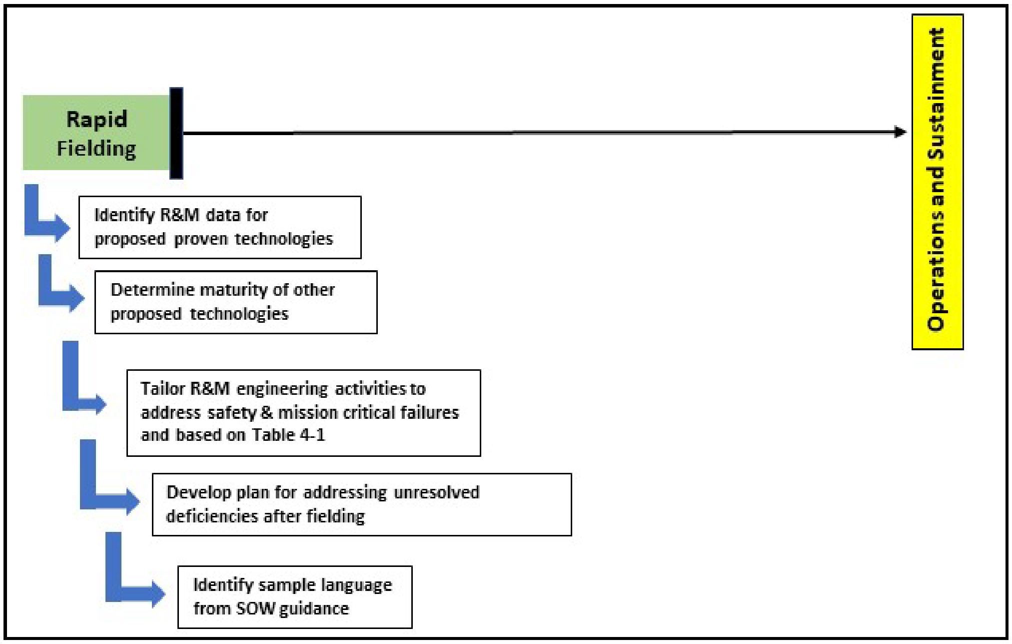
Source: DoDI 5000.80 as modified

Figure 3-4. Tailoring Flow Diagram for the RP Path: Transition to MCA



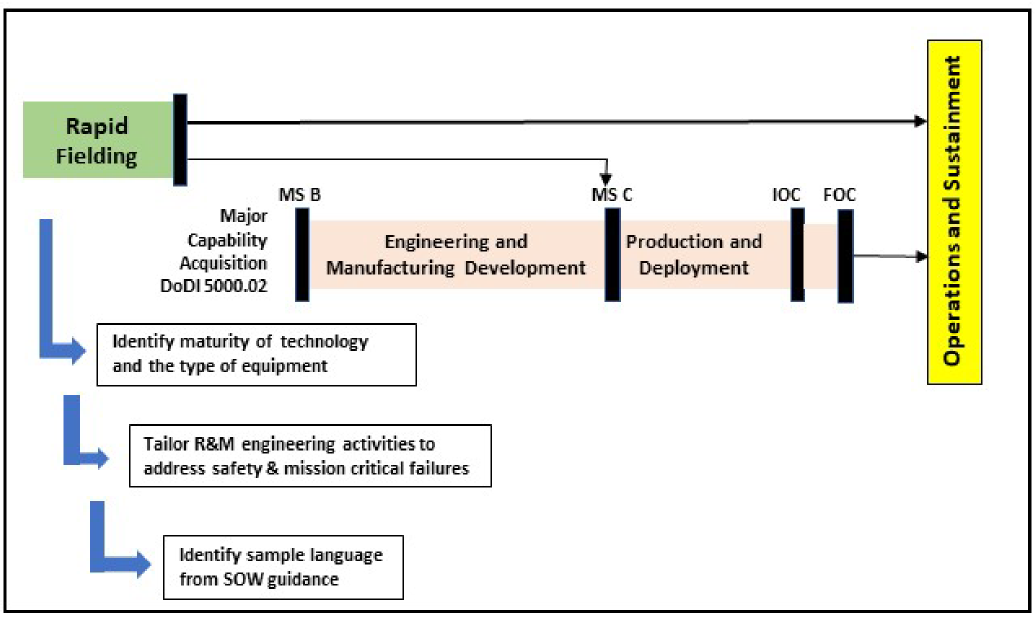
Source: DoDI 5000.80 as modified

Figure 3-5. Tailoring Flow Diagram for the RP Path: Transition Directly to field



Source: DoDI 5000.80 as modified

Figure 3-6. Tailoring Flow Diagram for the RF Path: Transition Directly to Field



Source: DoDI 5000.80 as modified

Figure 3-7. Tailoring Flow Diagram for the RF Path: Transition to MCA

Table 3-3 provides a guide for tailoring R&M tasks by the type of MTA (i.e., rapid fielding or rapid prototyping) and type of equipment. The latter includes all or some of the following: new development items, modified GFE, CI, NDI, and COTS.

Table 3-3: Tailoring Guide for MTA (MTA Type and Equipment Type)

SOW Paragraph	R&M Discipline	5000.88	MTA Type: RP	MTA Type: RF	Equipment Type: New Design, Major Change to CI/GFE:	Equipment Type: Modified, Minor Change to GF/CI	Equipment Type: NDI/COTS
Program Requirements							
3.19	R&M and BIT Program	•	●	⌘●	✓	✓	✓
3.19.1.1	R&M and BIT Organization		●	⌘●	✓	✓	
3.19.1.2	Subcontractor R&M and BIT Requirements		●	⌘●	✓	✓	✓
3.19.1.3	Trade Studies		●5		✓	✓	✓
3.19.1.4	Market Survey		●5				✓
3.19.1.5	Spares Reliability Provisions		●	⌘●	✓	✓	
Design Analyses							
3.19.2.1	Mission Profile Definition		●	⌘●	✓	✓	✓
3.19.2.2	Environmental Effects Analysis		●	⌘●	✓	✓	✓
3.19.2.3	Reliability Math Models, Allocations, and Predictions (part level stress and Physics of Failure analyses in EMD only for MTA)	•	●	⌘●	✓	✓	✓ 1
3.19.2.3	Maintainability and BIT Allocations, Predictions and Analysis	•	●	⌘●	✓	✓	✓ 2
3.19.2.4	FMECA and Reliability Critical Items	•	●	⌘●	✓	✓ 4	✓ 3
3.19.2.5	Worst Case/Sneak Circuit Analysis		●	⌘●	✓		
3.19.2.6	Thermal Analysis and Survey		●	⌘●	✓	✓	✓
3.19.2.7	Parts, Material and Processes Program		●	⌘●	✓	✓	
3.19.2.8	Documentation/Data Items		●	⌘●	✓	✓	✓
Tests							
3.19.3.1	Subsystem/Equipment Level Reliability Growth Test	•	● 5	⌘● 5	✓		
3.19.3.2	Subsystem/Equipment Level BIT Assessment Tests	•	●	⌘● 5	✓		
3.19.3.3	System-Level Reliability, Maintainability and BIT Demonstration	•		⌘●	✓	✓	✓
3.19.3.4	Manufacturing Screening				✓	✓	
3.19.3.5	System Test Monitoring	•			✓	✓	✓
3.19.3.6	FRACAS	•			✓	✓	✓

Legend

- • Identifies activity listed as an R&M engineering activity in DoDI 5000.88.
- • Indicates activity that must be tailored for the path
- • Identifies activity that should be performed for a specific equipment type
- ● Indicates activity that must be tailored for the path
- ⌘ If transitioned to an MCA program, tailor accordingly

Notes

1. Excludes parts count or stress analysis prediction, analysis generally limited to equipment end-item.
2. Maintainability analysis generally limited to equipment end-item.
3. Applicable to the interfaces of COTS/NDI equipment.
4. Applicable to modified portions/interfaces.
5. Limited due to schedule constraints.

Abbreviations

MTA – Middle Tier of Acquisition
RP – Rapid Prototyping
RF – Rapid Fielding
BIT – Built-in Test
FMECA – Failure Modes, effects, and Criticality Analysis
FRACAS – Failure Reporting and Corrective Action System
SOW – Statement of Work

3.3.5. Examples of Tailoring for the MCA Pathway

It is impossible to generalize the tailoring that should be made to all programs following the MTA (either RP or RF) acquisition pathway. In tailoring the R&M program, the R&M engineer must consider the type of system being developed, the specific acquisition path, the technologies being considered, the specific schedule, the system requirements, and many other factors. It is, however, possible to give some examples of the tailoring required for these acquisition pathways.

Example 1: Failure Modes, Effects, and Criticality Analysis (FMECA) and Design

The DID DI-SESS-81495B, for the FMECA, requires that the analysis be performed for the piece part (or lowest indenture level specified) through all indenture levels through the subsystem and system levels. The objective is to identify all failure modes, the underlying causes of the failure modes, the effects of the failure modes on system operation, and the criticality of the failure modes. The contractor will use the results of the FMECA to improve the design in the following ways:

- Eliminating failure modes by eliminating the underlying causes.
- Decreasing the effect of the failure mode on operation.
- Reducing the probability that a failure mode will occur.

Due to the limited development time for MTA programs, the R&M engineer must tailor the FMECA to focus on safety and mission critical functions. In general, contractors should be required to identify potential critical hardware and software failure modes and causes (failure mechanisms) within the product design and estimate the risk and effect of failure modes on mission success and safety. All mission-essential functions of the system should be identified and documented, as should failure modes by system function from system level effect down to the part level for mission and safety critical functions. The contractor should identify failure detection methodology and capability of the product design and potential mitigations and compensating provisions for all failure modes affecting mission success and safety. The analysis should be periodically updated to reflect changes to design configuration as it matures. A Failure Modes, Effects, and Criticality Analysis (FMECA) Report (DI-SESS-81495A) should be appropriately tailored.

In addition to the preceding guidance, the approach to the FMECA for an MTA program will vary depending on the specific paths (RP or RF) and how the paths transition. Considering the objective to use proven technologies as much as possible, the FMECA should also focus on innovative and high-risk technologies being considered.

RP Path: When the RP prototype transitions directly to the field, little time is available to conduct a full FMECA analysis. As stated previously, it should focus first on safety-critical and then mission-critical failures. However, even then, either not all failures will be identified or not all failures will be resolved by design changes. To compensate, the R&M engineer should include the following activities in the R&M program plan.

1. Robust design techniques to reduce the sensitivity of a component to potential failure modes.
2. Accelerated testing to find failure modes more quickly.
3. Capitalizing on FMECAs performed for GFE, COTS, and NDI, only modifying the analysis as necessary to account for differences in environment, application, etc.

When the prototype transitions to a fielding program, additional time will be available to continue the FMECA analysis. Nevertheless, additional activities, such as robust design, should be considered to reduce risk.

Finally, a very different situation exists when the prototype is to transition to either MS B or MS C of an MCA program, especially MS B. In the case of MS C, the start of Production and Deployment, some time is available for residual engineering to address unresolved failures. In the case of MS B, the start of EMD, a standard FMECA can be performed as part of the overall EMD systems engineering effort.

RF Path: An RF program can transition directly to fielding or to MS C of an MCA program. In both cases, the same guidance for RP transitioning to a fielding program or MS C applies.

Example 2: Reliability Growth Testing (RGT)

As components, assemblies, and even subsystems have become more complex, the time to implement conventional reliability growth testing can run into thousands of hours. Even for MCA programs, the time can be incompatible with the program schedule. (Program schedules should be developed to provide the needed capability in a timely manner while providing time to reduce risks to an acceptable level.) In addition, based on growth potential, dedicated funding is needed to incorporate corrective actions (design changes) that enable reliability growth.

For an MTA program, whether RP or RF, there may not be sufficient time to implement a conventional reliability growth program at the system level. If a system level RGT is not possible, the RGT should focus on the component and equipment level combined with engineering analysis to determine reliability (and impacts) at the system level. To supplement any RGT or test-fix-test process that is feasible, the R&M engineer may implement one or more of the following.

1. Accelerated Life Testing (ALT) can be used, especially at the component level. ALT is the process of testing a product by subjecting it to conditions (stress, strain, temperatures, voltage, vibration rate, pressure etc.) in excess of its normal service parameters in an effort to uncover faults and potential modes of failure and to measure reliability in a short amount of time. ALT can be very complex in that the objective is to measure the reliability at the accelerated conditions and then to extrapolate the result back to normal conditions. For this purpose, and to ensure that the accelerated conditions do not introduce failures that would not occur at normal conditions, statistical and life-stress models must be used.

2. Highly Accelerated Life Testing (HALT) can be used. Under the HALT approach, environmental stresses (temperature, vibration, humidity, voltage, etc.) are applied, eventually reaching a level significantly beyond that expected during use. Ideally, the process of increasing the stresses is continued until the limit of the technology is reached (a simple example is that despite adding cooling, the device eventually melts). Although the name is similar to ALT, HALT is different for two reasons.

    a. The objective is not (nor is possible) to measure reliability.

    b. No attempt is made to avoid introducing failures that would not occur at normal conditions.

3. Robust Design Techniques can be implemented. Sometimes referred to as Taguchi Methods, robust design is intended to make the item in question insensitive to variations in environmental stress. Robust design makes it possible to:

    a. Improve processes and products used in a broad variety of environments in their life cycle and make processes and products reliable and durable.

    b. Decrease the sensitivity to factors of noise that reduce reliability and other measures of performance.

    c. Adjust or develop formulas and design processes for a product to achieve the desired at a reduced cost in the shortest turnaround time.

    d. Make designs easier and processes at a reduced cost.

4. Physics-of-Failure (PoF) can be used at subsystem and lower levels if the cause-and-effect physical processes and mechanisms that cause degradation and failure of materials and components are understood. PoF is a science-based approach to designing reliability into weapon systems. It is based on the analysis of loads and stresses in an application and evaluating the ability of materials to endure them from a strength and mechanics of material point of view. These techniques known as load-to-strength interference analysis are a basic part of mechanical, structural, construction

and civil engineering processes. The approach uses structural and material fundamental engineering principles to evaluate the ability of materials, assemblies and structures to endure the accumulated effect of expected life-cycle usage and environmental stress load profiles. The stress loading profile will involve both usage related (e.g., power dissipation, frictional wear, mechanical loads, self-generated vibration & shock) and environmental related (e.g., daily and seasonal climatic temperature and humidity, contaminates, environmental vibration and shock).

The PoF approach requires the development and validation of life cycle equations that model the relationships and dominant failure mechanism between the materials, assemblies and structures to the stress load profiles. These models are used to create probability of failure versus life (cycles, miles, hours) plots that indicate the expected failure free operating period of a properly fabricated or assembled (i.e. defect free) device and identifies when wear out and the end of useful service life can be expected to occur. Before the models (equations) are used to predict reliability, the models have to be verified, calibrated, and validated. For more information on PoF, see the NASA Methodology for Physics of Failure-Based Reliability Assessment Handbook (https://ntrs.nasa.gov/citations/20230004376). For more on model verification, calibration, and validation, see Integrated Reliability— Roadmap, Framework, and Implementation (DOT/FAA/TC-16/32) https://www.tc.faa.gov/its/worldpac/techrpt/tc16-32.pdf

Limitations of PoF Modeling:

- Models for every component and every failure mechanism do not yet exist
- Difficult to estimate field reliability for a weapon system
- Models require calibration to reduce uncertainty in probability of failure vs life plots

In addition to the preceding guidance, and considering the objective to use proven technologies as much as possible, the RGT should also focus on the innovative and high-risk technologies being considered.

Example 3: Reliability and Maintainability Predictions

The prediction process for MTA programs presents a challenge, given the limited time available in development. It may be difficult for the R&M engineer to use complex methods, such as Physics of Failure (PoF), and testing may be so limited that the R&M engineer cannot make meaningful statistical measures. Consequently, the R&M engineer must tailor the process of making predictions to be consistent with the time available. When methods that use data such as comparable system and historical (surrogate) or depend on engineering estimates are the only methods that can be feasibly used, the risks associated with the predictions from such methods must be clearly indicated, even if using subjective measures (i.e., high, low, and medium risk; see next paragraph).

Programs should require contractors to assign each element of the system an assessed and consistent R&M metric (e.g., mean time between failures (MTBF)). This process is known as allocation. The contractor should base the values on one of the following methods: (1) R&M analysis from comparable systems/elements; (2) historical R&M from predecessor systems/elements; or (3) documented subject matter expert engineering estimation. The R&M predictions should identify the source(s) of the data and the evaluated validity of data used in the reliability predictions, along with the risk associated with the data from each source. Each system element should include its associated R&M metric and risk criteria (low, medium, high) based upon the following guidance:

- Low Risk Test data or R&M analysis of comparable systems (under the new system's OMS/MP conditions)
- Medium Risk Historical R&M of systems of similar complexity, test data, or R&M analysis of comparable systems (not following OMS/MP conditions), and
- High Risk SME engineering estimates using handbook data

Programs should require contractors to develop a plan to mitigate all critical elements rated as high or medium risk. Mitigation plans may include additional testing, redesign, part selection, etc. If contractually required, the contractor must provide the Government all mitigation plans upon development.

Reliability predictions must include all elements in the design and follow industry standard guidance including:

- Comparison to field data of similar systems where all environmental and use factors have been adjusted for differences. The source of the field data should be verifiable including those parameters.
- Empirical prediction using handbook data. Data supported justification is required for any deviation from the governing document.
- A mixture of the previous two prediction methods with other methods (e.g., PoF or life data analysis.) Regardless of the method used, the contractor should justify using the source of data and use the method(s) correctly.

R&M engineers should tailor the prediction process to account for the equipment type in question. Predictions for NDI and COTS, for example, may be able to draw on field experience with the equipment in prior use. However, R&M engineers should evaluate these data for their applicability to what may be a very different environment and different stress levels. The R&M

engineer would have to use some judgment in how to adjust any predictions made with field data to account for these differences. For GFE, field data should be available. Again, the R&M engineer would have to adjust predictions made with the data to account for differences in environment and stress levels.

Maintainability predictions should address all levels of maintenance and follow guidance of MIL-HDBK-470A or equivalent as closely as possible given the time constraints associated with MTA programs. The same risk criteria for the validity of data used for reliability predictions also applies to maintainability predictions

Once R&M test results or field data from the current program are available they should be used to update the R&M predictions. Test results may not apply to the component level, but engineers can use the prediction to allocate the high-level results to the low-level components. In summary, for newly designed equipment, the process of prediction progresses from early estimates using surrogate data, to using test data, PoF, and statistical models, to applying the results of any formal statistical demonstration testing. The program should include an R&M Prediction Report in the CDRL A068 to receive a report of the details of the prediction activity.

Example 4: Mission Profile and Environmental Characterization

A program cannot achieve adequate levels of reliability without the R&M and design engineers having complete knowledge of the operating and non-operating environments and stress levels to which a system and its lower-level indentured items (subsystems, major components, assemblies, and parts) will be exposed. The process of environmental characterization should be tailored to the specific system. Consider for example a ground-based radar housed in a protective dome and a main battle tank (MBT).

- The ground-based radar is transported to a site, installed, and then operated, usually on a 24/7 basis. The R&M engineer must understand the total environment to determine which “phases” of the fielding and operation of the radar pose the highest levels of stress. In the case of the radar, the highest stresses may occur during transport and installation, not during actual operation.
- In the case of an MBT used by the Army and Marine Corps, the process becomes much more involved. The MBT is transported by rail, ship, or aircraft. The Service may operate it in climates ranging from hot desert with driving sandstorms to cold regions with snow and ice; in open terrain filled with streams, muddy areas, and hardscaped roads; and in urban areas on dirt or paved roads. Each environment to which the MBT is exposed may cause the system to react or perform quite differently. In addition, the electronics, fuel system, and engine may see environmental stress in each environment that differ from that seen by the system.

Likewise, when a system has different mission phases, such as for an aircraft, the R&M engineer must evaluate the reliability performance of a system in each phase of the mission and must ensure that the reliability is adequate for all phases.

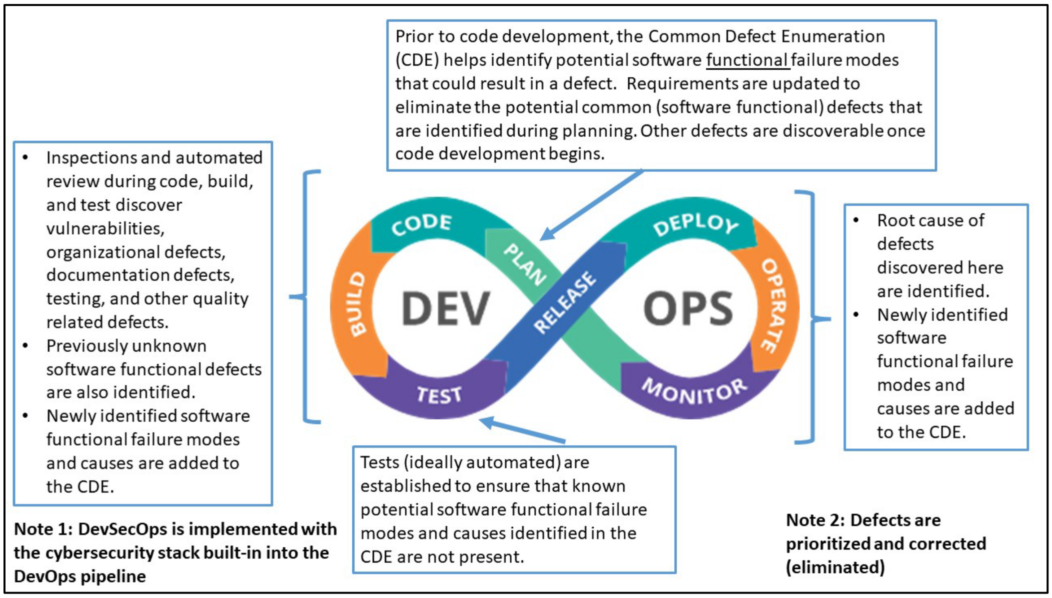
In view of the short schedule associated with RP and RF programs transitioning directly to the field, characterizing the environment should focus on what the R&M engineer determines is the most critical mission. When the capability involves only one mission, the R&M engineer should focus on identifying the environment for the most critical phase of the mission. When the RP program transitions to MS B of an MCA program, characterization can be more robust. When either an RP or RF program transitions to MS C of an MCA program, there may be an opportunity, as part of residual engineering, to characterize the environment more fully.

Finally, software reliability requires a different approach than that for hardware reliability. One important difference in approach is that the FMECA is used for hardware, whereas a Failure Modes and Effects Analysis (FMEA) is used for software; a criticality analysis cannot be meaningfully performed because estimating (predicting) reliability is not well suited for software acquisitions. An important result of conducting the software FMEA is the identification of Common Defect Enumeration (CDE). The CDE provides a listing of software defects applicable for virtually all software intensive systems. Figure 3-1 shows the goals of the CDE within a continuous development environment. The goal for the CDE is to include defects that:

- Can be tested
- Aren’t detected by automated code analysis tools
- Represent the span of things that can and have gone wrong with software systems
- Can be identified in the specifications and design as opposed to code reviews.
- Are cheaper to fix earlier rather than later

Figure 3-8 shows the goals of the CDE within a continuous development environment.

While the R&M engineer can attempt to characterize reliability ahead of time, the main evidence of software reliability is measuring its behavior in situ. One should plan to capture telemetry in the field to capture this behavior.



Source: Report No. FCDD-AMR-MR-22-08, September 2022

Figure 3-8. Goal of the CDE within DevOps

3.4. Contract Section C – Sample Statement of Work Language

Table 3-4 has sample Statement of Work (SOW) language regarding R&M activities. However, note that for MTA acquisitions, some activities may be limited or eliminated to ensure production of a capability can begin within 6 months and the capability fielded within 5 years of an approved requirement. Consequently, the R&M engineer should tailor the sample SOW language in Table 3-4 for type of MTA and equipment based on the Tailoring Guide shown earlier in Table 3-3. Most if not all activities will have to be conducted in parallel, again to achieve fielding within the required time. The items in bold at the end of the paragraphs in Table 3-4 are CDRL (DD Form 1423) deliverables. The associated sample CDRLs are shown in "EXHIBIT A," which follows this sample SOW language. The CDRL and included DIDs for an MTA program must align with the R&M activities planned for the program and must be tailored to be consistent with the activities as planned. The paragraph numbering is shown for illustration only.

Table 3-4. Sample Statement of Work Language

3.19 Reliability, Maintainability (R&M) and Built-In Test (BIT) Program requirements.
3.19.1 General. The contractor shall have an active R&M engineering program during the **(indicate the program phase)**. This program shall be directed toward ensuring R&M is factored into the hardware and software design solution decisions to ensure the system R&M characteristics meet the specification requirements. The contractor shall prepare and follow an R&M program plan that identifies and describes the planned contractor activities for implementation of the R&M program. **(CDRL, R&M program plan).**

3.19.1.1 R&M and BIT Organization. The contractor shall designate an individual responsible for the planning, implementation, and evaluation of R&M program activities. This individual shall be delegated sufficient authority to effectively implement the R&M program and shall serve as the principal contact for the Government.
3.19.1.2 Subcontractor R&M and BIT Requirements. The contractor shall be responsible for ensuring that the R&M levels achieved by the subcontractors and suppliers are consistent with the performance requirements of the **(Program Name)** performance specification(s). The contractor shall be responsible for flowing R&M quantitative requirements, analyses, and test activities down to subcontractors and suppliers.
3.19.1.3 Trade Studies. The contractor shall ensure that R&M aspects are addressed in trade studies and must consider total life cycle costs including user operations and maintenance. The contractor shall present the results of trade studies in R&M to the Government and discuss them at appropriate program and design reviews.
3.19.1.4 Market Survey. The contractor shall explore COTS/NDI alternatives to determine what R&M attributes exist and what resources would be required to meet the **(Program Name)** performance specification requirements before a decision is made to proceed with the use of COTS/NDI. The contractor shall conduct a market survey and a Logistics Support Analysis (performed by the product support team) to ensure that the COTS/NDI equipment or software is reliable, maintainable, and supportable before its procurement and fielding. The contractor shall also consider the adequacy of technical data that would have to be used for maintenance by user personnel during operational use. [In some cases, this data may also include details of the R&M engineering activities associated with the design of the equipment (e.g., FMECA, FRACAS to assess where adequate usage data are not available to support a contractor's claim of inherent reliability, maintainability, or BIT.]
3.19.1.5 Spares Reliability Provisions. The contractor shall include provisions in the R&M program for reliability of spares and spare parts for equipment at all levels of repairable assembly.
3.19.2 R&M and BIT Design Analyses
3.19.2.1 Mission Profile Definition. The contractor shall analyze the mission profile (OMS/MP) provided by the Government to ensure it: (1) represents a description of system environmental and use duty cycles throughout the mission period for which reliability is to be specified and (2) identifies a time sequence description of operational events required, in the mission period, to accomplish the objective(s), and (3) is documented in the Mission Profile Definition Report. This profile shall include identification of the total envelope of environments that will exist in the mission sequence and the functions to be performed in the mission sequence. **(CDRL, Mission Profile Definition Report)**
3.19.2.2 Environmental Effects Analysis. The contractor shall analyze the specified environments (e.g., thermal, shock, vibration, sand, dust, humidity, as applicable) that affect reliability and shall describe the anticipated levels for each zone/location for the **(Program**

Name). The Environmental Effects Analysis Report shall include a complete definition of the environments to which the end item and each regime of operation and for the logistics phases of transportation, storage, and maintenance. The report shall include revisions to account for updated test results and actual experience. The definition of environment shall be in terms of the acceleration, vibration, temperature, humidity, and any other conditions bearing on reliability or design of the system. **(CDRL, Environmental Effects Analysis Report)**

3.19.2.3 Reliability, Maintainability & BIT Block Diagrams, Math Models, Allocations and Predictions. The contractor shall develop and maintain R&M block diagrams and math models for the **(Program Name)**. The block diagrams and math models shall consist of the lowest identifiable functions/elements and their relationship to each other and shall encompass all hardware and non-hardware elements. At minimum, the system R&M models shall be used to:

1) Form the analytical basis for trade studies,
2) Allocate R&M requirements down to lower indenture levels and flow them down to subcontractors and suppliers,
3) Aggregate system-level R&M based on estimates from lower indenture levels, and
4) Identify single points of failure and critical elements in the system design and form the basis of trade study efforts. Critical elements are defined as those elements whose failure impacts mission completion, essential functions, or safety; or elements whose failure rates contribute significantly to the overall system. The Government will provide the contractor with a Failure Definition/Scoring Criteria.

The R&M Allocation Report shall provide the results and describe the process of allocating the Reliability, Maintainability and Fault Detection, Fault Isolation, and False Alarm requirements to each component end-item.

R&M (including BIT) predictions shall be performed to assess whether the design, including GFE/COTS/NDI, can meet the specification requirements in the operational environment. To support the prediction process, existing predictions and BIT analyses for GFE/COTS/NDI may be used if assumptions employed are consistent with this program. The contractor shall also develop data to support system age-reliability relationships (particularly for the identification of life limits) for reliability-centered maintenance (RCM) analysis to develop appropriate life limits or maintenance activities. The R&M Prediction Report shall contain the documented results for both logistics (i.e., serial) and mission R&M predictions.

The reliability section of the report shall include:

1) Applicable failure rates, failure distributions, failure rate adjustment factors, and reliability variables used in the calculation of each configuration item.
2) The source(s) of the data and the evaluated validity of data used in the reliability predictions, along with the risk associated with the data from each source. Each system element shall include its associated R&M metric and risk criteria (low, medium, high) based upon the following guidance:

- Low-Risk Test data or R&M analysis of comparable systems (under OMS/MP conditions),

- Medium-Risk Historical R&M of systems of similar complexity, test data, or R&M analysis of comparable systems (not following OMS/MP conditions), and
- High-Risk SME engineering estimates (using handbook data).

3) Contractors shall develop a plan to mitigate all critical elements rated as high or medium risk. Mitigation plans may include additional testing, redesign, part selection, etc. The contractor shall provide the Government with all mitigation plans upon development.
4) The operating and environmental stress factors and ratios, along with other factors used in determining part failure rates, shall be specified in in the report and shall be individually identified as estimated (i.e., documented SME engineering opinion), calculated (i.e., reliability analysis from comparable systems), and measured (i.e., historical reliability from predecessor systems and shall include test and field data).
5) The contractor shall identify how the accumulated operating hours were determined when using field experience data for similar items in a like environment.

The maintainability section of the report shall include:

1) Predictions that account for each associated level of maintenance.
2) Both unscheduled and scheduled maintenance, where appropriate.
3) Repair time source data for the prescribed level of maintenance.
4) Conclusion and recommendations based on the prediction report effort.

The BIT predictions shall include:

1) Prediction of the overall system-level BIT fault detection, weighted by failure rate, for the individual items, including GFE.
2) Prediction of the system-level of fault isolation and false alarm rate.
3) Identification of system/subsystem/equipment parameters that are monitored and not monitored by BIT or other diagnostic/test systems.
4) Diagnostic trade-offs, including the impact on life cycle cost, labor, and training.

Part failure rates shall be consistent with the individual procurement specification requirements. The predictions shall be done for continuous operation under the appropriate environment for steady state worst-case conditions (for all missions). To evaluate the prediction against the individual equipment specification reliability, the specified steady state continuous operating worst-case temperature shall be used. Pertinent information from other analyses shall be used as applicable (i.e., thermal analyses, worst-case analysis, applicable testing).

The contractor shall redesign as necessary to meet the requirements specified in the **(Program Name)** specifications. The contractor shall combine assessments using actual data on GFE/COTS/NDI with predictions from newly designed and modified equipment to develop an overall system R&M prediction. (CDRLs, Reliability & Maintainability Block Diagrams and Mathematical Models Report, Reliability & Maintainability Allocation Report, Reliability & Maintainability Prediction Report)

3.19.2.4 Failure Modes, Effects, and Criticality Analysis (FMECA). The contractor shall perform a FMECA on the **(Program Name)**. To support the equipment FMECA, existing FMECAs may be used if assumptions employed are consistent with this program. The analysis shall be performed for the mission profiles under worst-case conditions. A preliminary FMECA that addresses system functions shall be completed, with a final FMECA to support failure mode analyses that accurately represent the complete physical system configuration as that configuration is defined. The FMECA shall document failure modes down to the appropriate component, piece part, or configuration item level (for newly designed, significantly modified, and portion of modified equipment); effects (up to higher indenture levels, including the subsystem and weapon system level); and severity levels. Single-point failure modes having the most serious effects, particularly the single-point failures that directly result in mission failure or create unsafe conditions shall be identified, evaluated, and minimized via the design process. The FMECA shall clearly identify those failure modes that are detectable by BIT to support troubleshooting procedure development.

The FMECA Report shall include the analysis performed for the system's mission profile conditions and shall document and relate associated failure modes from the piece part through subsystem and system levels, and severity levels (categories I through IV) for each indenture level. Single point failure modes shall be identified, evaluated, and design mitigation documented. This report shall also identify those failure modes that are detectable by BIT.

The contractor shall use the results of the FMECA to identify a list of reliability critical items, which require special attention due to complexity, life limit, application of advanced state-of-the-art techniques, impact of potential failure on safety, readiness, mission success, or the demand for maintenance or logistics support. The status and results of these analyses shall be discussed in detail at design reviews. **(CDRL, Failure Modes, Effects, and Criticality Analysis)**

3.19.2.4.1 Software Failure Modes Effects Analysis (FMEA). The contractor shall identify, confirm, and mitigate the software failure modes affecting mission-critical functions. The contractor should demonstrate understanding of software controls that do not depend on human interaction that link to mitigating mission-critical functions. The contractor shall analyze the software specifications and features from the software functional FMEA viewpoint employing the software centric failure modes in accordance with IEEE 1633 Clauses 5.2.2 and Annex A. The contractor shall consider the sources of software faults discussed in the Joint Software Systems Safety Engineering Handbook Appendix E.3.16, E.4, E.6, and E.9. All mission modes shall be considered in the analysis. The contractor shall employ fault trees and defect root cause analysis in preparation for the software FMEA in accordance with IEEE 1633 clauses 5.2.1 and 5.2.3.

The Software FMEA (SFMEA) shall be conducted by personnel who have experience with software development or shall be a cross-functional effort between software engineering, systems engineering, and reliability engineering before completion of the development of software code. If the models employed are incremental or agile, then the SFMEA is conducted incrementally before the development of the code for each increment. The

software FMEA shall be delivered as part of the Failure Modes, Effects, and Criticality Analysis Report. The contractor shall derive software requirements for identification and recovery for each specific fault identified in the software FMEA. The software fault and failure management requirements shall be incorporated into the software requirements, software design, and software test and verification plans in accordance with DI-IPSC-81433A, DI-IPSC-81435A, DI-IPSC-81438A, and DI-IPSC-81439A. All the above applies to software, firmware, FPGAs, COTS, GOTS, GFS, FOSS, and any other software. **(CDRL, Tailor the Failure Modes, Effects and Criticality Analysis to only include the FMEA)**
3.19.2.5 Worst Case/Sneak Circuit Analysis. The contractor shall perform a worst-case analysis on **(type or category of equipment)** where functional criticality has been identified. The worst-case analysis shall be performed on those critical functions to determine the response of the design with inputs, components, and environments at their high, ambient, and low levels. This analysis should be performed early in the design phase after basic functional requirements have been met. The contractor shall conduct an integrated software and hardware Sneak Circuit Analysis of mission-critical and safety-critical components/circuits. This analysis shall ensure that no latent paths or conditions are present that may cause unwanted functions or that inhibit desired functions. The path may consist of hardware, software, operator actions, or combinations of these elements. Sneak circuits are not the result of hardware failure but are latent conditions, inadvertently designed into the system or coded into the software program, which can cause it to malfunction under certain conditions. The sneak analysis results shall be provided to the Government at design reviews, and as required to make program decisions. **(CDRL, Electronic Parts/Circuit Tolerance Analysis Report)**
3.19.2.6 Thermal Analysis and Survey. For critical items identified in paragraph 3.19.2.3 and for safety-critical components, the contractor shall conduct a thermal analysis on **[type or category of equipment]** to ensure adequate application of parts and derating policies. The contractor shall conduct a thermal survey to verify the accuracy of the thermal and derating analyses. The results of these thermal surveys shall be coordinated with the stress analyses required in 3.19.2.3.1 to eliminate hot spots and derating non-conformances. **(CDRL, Technical Report for Studies and Services)**
3.19.2.7 Parts, Materials, and Processes (PM&P) Management Program The contractor shall establish and maintain an effective PM&P management program as an integral part of the overall design, quality, reliability, and production efforts to ensure uniform PM&P reliability throughout the program life cycle. It shall include provisions for optimizing part reliability and standardization through the system, subsystem, or equipment life cycle. The PM&P program shall consist of: 1) Management of specific PM&P contractual requirements. 2) Applying "lessons learned" for items that can introduce unacceptable reliability risk to fielded hardware that have been identified from best practice and specific items identified by the Government **[list or reference specific items].**

3) Performing requirement analysis, allocation, and design assessments of system element PM&P requirements. Traceability of requirements shall be provided to the end item circuit level. Design assessments shall determine the degree to which system element requirements have been achieved within the element/sub-elements. Results of the analyses and assessments shall be documented and made available at design and program reviews.
4) Ensuring that NDI/COTS items meet contractual and system requirements.
5) Providing a Pb-free electronics risk management plan in accordance with best industry practice for high-reliability fielded military hardware. The Pb-free management requirements should ensure that the electronic systems containing approved Pb-Free components or solder will continue to be reliable.
6) Ensuring that processes to be utilized for the manufacture of electronic hardware will produce assemblies and equipment that meet system performance requirements. The PM&P program shall describe the materials, methods, and verification criteria for producing quality electrical interconnections and assemblies. Requirements shall be detailed to utilize process control methodologies for the planning, implementation, and evaluation of the manufacturing processes for assemblies.
7) Requirements for parts and materials qualification, acceptance testing, and validation.
8) The contractor and subcontractor in-house and vendor surveillance activities planned during equipment fabrication and assembly to ensure sources of degradation and variability are isolated and controlled.
9) Thermal and electrical reliability derating levels to be met for hardware design.
10) The integrated team approach for Government and contractor evaluation of PM&P selection and application during the design activities.

(CDRL, Parts Management Plan)

3.19.2.8 Documentation/Data Items. The contractor shall prepare, submit, and maintain R&M documentation/data items (e.g., plans, procedures, reports, and data) in accordance with the related CDRL and the R&M program plan. The absence from the CDRL of documentation required by this SOW does not relieve the contractor of the responsibility to prepare and maintain the documents on file and to make them available for Government review.[9] An electronic file is the preferred submission method, which is compatible with **[R&M software program name]** software for required analyses.

3.19.3 R&M and BIT Tests

3.19.3.1 Subsystem/Equipment Level Reliability Growth Test. Reliability Growth Tests [specify which test: Accelerated Life Test, Highly Accelerated Life Test, Highly Accelerated Stress Test, conventional reliability growth tests] shall be conducted on [type or category of equipment]. The test articles shall be representative of production equipment to the

[9] R&M engineers are cautioned to not requests data or documentation not addressed by a CDRL in a specific format Such requests can result in contract claims if contractors did not plan on presenting data in a specific format to the Government.

maximum extent possible in materials, configuration, manufacturing processes, and workmanship. This test shall be designed to identify failure modes and BIT anomalies, which if uncorrected could cause the equipment to exhibit unacceptable levels of performance during operational usage. Prior to testing, a test readiness review is to be conducted. The contractor is expected to submit a test procedure for approval. The test procedure shall include the levels and tolerances for time, temperature, and other details of combined stress environmental cycle, including duty cycle, vibration stress, and duration and input voltage. Data sheets used in the test shall include an equipment failure report form for recording data associated with equipment failure, failure analysis, and corrective action. The Government reserves the right to witness the growth testing. The test shall be judged to have been satisfactorily completed when the total test time/cycles has been completed and the Government has approved the corrective actions for failures that occurred during the test. **(CDRLs, Reliability and Maintainability Test Plan, Reliability Test Procedure, Reliability Test Report)**
3.19.3.2 Subsystem/Equipment Level BIT Assessment Tests. BIT assessment tests shall be conducted on **[type of category of equipment]**. The BIT assessment tests are structured to identify problems, both hardware and software, and shall verify compliance with the individual equipment specification(s) BIT requirements. The contractor is expected to provide procedures including fault determination, fault selection, test conduct, data recording and analysis. The Government reserves the right to witness the BIT assessment tests. **(CDRLs, Reliability and Maintainability Test Plan, Maintainability and BIT Demonstration Test Procedure, and Maintainability, and BIT Demonstration Test Report)**
3.19.3.3 Test Data**.** The contractor shall provide all test related information associated with any test data used to show hardware/software/firmware state with respect to Reliability and Maintainability metrics or measures. Test related information includes, but is not limited to, purpose of test, test strategy, test description, test time duration, test cycles, failures, test time of failure, quantities tested, anomalies, test environmental conditions, and chargeability (i.e., Unit Under Test [hardware, software, and firmware), test set, operator, procedure, etc.), maintenance performed during testing and any diagnostic data generated. **(CDRL: Test/Inspection Report)**
3.19.3.4 System-Level Reliability, Maintainability and BIT Demonstration. The contractor shall incorporate into system test articles corrective actions identified from the subsystem/equipment level growth tests, subsystem/equipment BIT assessment tests, environmental qualification tests, and relevant system-level integration tests. This configuration shall be tested in accordance with a procedure approved by the Government to verify the overall R&M of the system meets the **(Program Name)** specification requirements. The contractor shall perform reliability evaluations on data from analysis, modeling & simulation, test, and the field. The contractor shall track the evaluations as a function of time and compare them against reliability allocations, reliability requirements, and values to be achieved at various points during development to verify the implementation of corrective actions. When applicable, the contractor shall use formal reliability growth methodology to plan, track, and project reliability improvement. The ground rules for this evaluation shall be

in accordance with **[Add reference to Service/Agency scoring criteria]** for this SOW and the Government-approved contractor-prepared test procedures. **(CDRL, Maintainability and BIT Demonstration Test Procedure, Maintainability and BIT Demonstration Test Report, Test Procedure, and Reliability Test Report)**
3.19.3.5 <u>Manufacturing Screening</u>. The contractor shall address in the reliability program plan the use of manufacturing screening for development and production systems to eliminate or reduce latent defects, parts problems, workmanship, and manufacturing problems. The contractor shall recommend, with adequate justification, the approach to be used from incoming inspection to DD250 to ensure the manufacturing processes do not degrade the inherent reliability of the design. For COTS/NDI, the subcontractor/supplier' established in-house manufacturing screening for these equipments shall be used. For GFE, the manufacturing screening required by the appropriate approved Service or Government procurement specification shall be used. **(CDRL, Environmental Stress Screening and Implementation Plan)**
3.19.3.6 <u>System Test Monitoring</u>. The contractor shall monitor R&M parameters on systems and equipment required to meet the requirements of the **[Add Program Name here]** performance specification. A joint contractor and Government R&M review board shall determine the relevancy of the maintenance actions, failures, maintenance labor-hours expended, and BIT indications. The contractor shall be responsible for correcting deficiencies identified in the equipment during the test program and incorporating the necessary modifications into the development item before formal Government technical evaluation. The contractor shall monitor the maintenance activity for the entire system test program.
3.19.3.7 <u>Failure Reporting, Analysis, and Corrective Action System (FRACAS)</u>. The contractor shall establish and maintain a closed loop FRACAS for hardware, software, and firmware failures during system development, fabrication, testing, and operations using MIL-HDBK-2155 as a guide. All failures shall be tracked until root-cause failure mechanisms have been identified and corrective action initiated and verified. The contractor will provide to the Government failure and subsequent details of failure analysis results and corrective action recommendations. The contractor shall establish a Government-chaired Failure Review Board (FRB) to disposition all failures entered into the FRACAS. The FRB will meet quarterly at a minimum and more often as required. The contractor shall provide historical failure data and the context of the test regarding any hardware, software, and firmware that is intended for delivery to the Government and any corrective actions implemented to prevent further occurrences. <u>**(CDRL, Failure Summary and Analysis Report)**</u>
3.19.3.7.1 <u>Failure Reporting</u>. Failures, BIT anomalies or non-conformances experienced on components and configuration item articles during laboratory, qualification, R&M tests and demonstrations, incoming inspection, manufacturing, acceptance tests, and system tests shall be recorded by the contractor. A database shall be maintained with failure and BIT anomaly analyses and corrective actions to reduce or prevent repetition of failures and BIT anomalies.

3.19.3.7.2 Failure Analyses. The contractor shall perform failure analyses, on recorded failures and BIT anomalies, to the level required to determine the root cause of failure, define the failure mode and mechanism, and to develop materiel or non-materiel corrective actions to eliminate or limit their recurrence. The analyses of parts shall, as necessary, include electrical failure verification, dissection, microphotography, and adequate chemical and metallurgical analysis to define the failure mechanism (e.g., most fundamental cause). Records of failure analyses, including causes and effects, shall be maintained by the contractor with data feedback to R&M and related design analyses functions.
3.19.3.7.3 Corrective Actions. The contractor, in conjunction with the failure analysis effort, shall develop and implement effective corrective actions to eliminate or minimize recurrence of failure modes, mechanisms, and BIT anomalies. Corrective actions for failures and BIT anomalies must meet the following criteria: 1) Be analytically and/or by test established as an effective corrective action to the satisfaction of the Government, and 2) Scheduled for incorporation into production equipment via official change controls as approved by the Government.
3.19.3.8 Transition Planning. To support the transition into another pathway or to continue to rapid fielding under the MTA pathway, the contractor's R&M engineer will assist, as requested, the Product Support Manager (PSM) in developing the transition plan to be submitted to the PM. The plan shall include the use of operational data to track and measure trends related to system performance, reliability, and maintainability. The transition plan also will include all risk reduction activities and contract requirements used to support the program's transition. The plan should address predictive analysis and modeling tools to be used to improve materiel availability (A_M) and reliability, increase operational availability (A_O), and reduce O&S costs. **(CDRL: Transition Plan, tailored)**

3.5. Contract Section J – List of Attachments

Section J of the RFP lists all attachments, including all data requirements. The contractor will develop valuable data sets in conducting work and completing required activities. R&M engineering data are defined as data resulting from the performance of R&M activities in direct support of an equipment or system acquisition program. Each imposed R&M activity will have some associated technical data, and each contract normally requires contractors to retain all such data in their files and make them available for Government review upon request. The Government identifies in a Contract Data Requirements List (CDRL), listed in Section J of the RFP as an attachment (usually called an Exhibit), only those items of data to be delivered to the Government as required by the SOW.

The combination of the CDRLs and appropriate DIDs defines and schedules the ordering and delivery of data as required by the SOW. Since these documents describe only the data to be submitted by the contractor, neither the CDRL nor the DID may impose a requirement for the performance of work tasks. Specifically, the following phrases are prohibited (see MIL-STD-963C) because they task the contractor to perform work:

- “The contractor shall…”
- “… records shall be maintained...”
- “… data shall be prepared…”
- “… data shall be submitted…”
- “… data shall be reviewed…”
- “… data shall be approved by…”

Each CDRL entry, however, must reference the paragraph number, document title, and associated task of the SOW. When completed by the contractor, these references aid in generating the data ordered by the CDRL.

Programs may tailor out DID requirements, but in accordance with MIL-STD-963C, they may not add requirements by tailoring. More information on tailoring DIDs is located here: https://ac.cto.mil/rme/tailoring-data.pdf. The following phrases shall not be used in a DID because they imply requirements can be added by tailoring the DID in the CDRL:

- “… shall include but not be limited to…”.
- “… shall include as a minimum…”
- the term “and/or”

Referencing a task in the CDRL does not obviate the need for a DID. The DID is used to describe the format and content of the deliverable data.

The remainder of this section provides guidance and examples of R&M data typically required in the conduct of a materiel acquisition program that should be listed in a CDRL.

Attachments, such as the CDRL, are often called Exhibits. This sample Exhibit A would be just one of those attachments. The due dates shown in the CDRLs that follow are examples only. R&M engineering should establish due dates based on the program schedule and technical and technology challenges, in coordination with the LSE. When establishing dates, programs should allow sufficient read-ahead time for the R&M engineer, systems engineers, and others to adequately review the material in advance of the stated event. Due dates could vary between 30 to 60 days (or longer) and would not be applicable in a model-based continuous integration environment. In a digital environment, the contract should define an initial access date for accessing and viewing the data and at a specified frequency.

3.5.1. EXHIBIT A: Sample Contract Data Requirements Lists (DD Form 1423)

All information related to due dates, frequency, and government approval shown in the following CDRLs are for illustration purposes only. The R&M engineer should complete all blocks based on program-specific information. This list of CDRLs is not inclusive; a program may need other data, such as from a testability analysis, maintenance task analysis, and other activities stated in a SOW.

For an MTA program, it may be a challenge for the R&M engineer to place all these DIDs on contract. However, if they are not on contract, the R&M engineering activities described in this addendum should still be accomplished. If not on contract with the prime contractor, then the program office should determine how to perform the activities from within, especially key activities such as the FMECA. Programs should always tailor DIDs or use a one-time DID to deliver the needed information. For example, in the case of the FMECA, the DID could be tailored to provide a list of the potential failure modes only for all newly designed items.

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<tr><td colspan="5" rowspan="3">16. REMARKS

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1. DATA ITEM NO 002	2. TITLE OF DATA ITEM Scientific and Technical Reports					3. SUBTITLE Mission Profile Definition Report			
4. AUTHORITY (Data Acquisition Document No.) DI-MISC-80711A				5. CONTRACT REFERENCE SOW Para: 3.19.2.1		6. REQUIRING OFFICE			
7. DD 250 REQ LT	9. DIST STATEMENT REQUIRED D	10. FREQUENCY ONE/R		12. DATE OF FIRST SUBMISSION (See block 16)		14. DISTRIBUTION			
8. APP CODE A		11. AS OF DATE N/A		13. DATE OF SUBSEQUENT SUBMISSION ASREQ (See block 16)		a. ADDRESSEE	b. COPIES: Draft	Final: Reg	Final: Repro
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DI-SESS-81497B</td><td colspan="2">5. CONTRACT REFERENCE
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BLOCK 12: Submission is due 60D prior to SRR

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A. CONTRACT LINE ITEM NO. 1	B. EXHIBIT A	C. CATEGORY: TDP _______ TM ________ OTHER ___PS______________

D. SYSTEM/ITEM PROGRAM NAME	E. CONTRACT/PR NO. N00019-01-XXXX	F. CONTRACTOR TBD

1. DATA ITEM NO 008	2. TITLE OF DATA ITEM Failure Modes, Effects, and Criticality Analysis (FMECA)	3. SUBTITLE

4. AUTHORITY (Data Acquisition Document No.) DI-SESS-81495B	5. CONTRACT REFERENCE SOW Para: 3.19.2.4	6. REQUIRING OFFICE

7. DD 250 REQ LT	9. DIST STATEMENT REQUIRED D	10. FREQUENCY ONE/R	12. DATE OF FIRST SUBMISSION (See block 16)	14. DISTRIBUTION
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16. REMARKS	a. ADDRESSEE	b. COPIES: Draft	Final: Reg	Final: Repro
BLOCK 8: Government comments or approval will be provided within 30 days after receipt of initial submission. The revised of the report shall be submitted within 30 days after receipt of Government comments. BLOCK 12: A preliminary FMECA that covers 100% of the system functions shall be submitted 60D prior to PDR. A final FMECA that covers 100% of the physical system design shall be submitted 60D prior to CDR.				
	Other offices: logistics and safety			

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<tr><td colspan="3">D. SYSTEM/ITEM PROGRAM NAME</td><td colspan="2">E. CONTRACT/PR NO.
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N00019-01-XXXX</td><td colspan="4">F. CONTRACTOR
TBD</td></tr>
<tr><td>1. DATA ITEM NO
009</td><td colspan="3">2. TITLE OF DATA ITEM
Parts Management Plan</td><td colspan="4">3. SUBTITLE</td></tr>
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DI-SDMP-81748</td><td colspan="2">5. CONTRACT REFERENCE
SOW Para: 3.19.2.7</td><td colspan="4">6. REQUIRING OFFICE</td></tr>
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D. SYSTEM/ITEM PROGRAM NAME	E. CONTRACT/PR NO. N00019-01-XXXX	F. CONTRACTOR TBD

1. DATA ITEM NO 010	2. TITLE OF DATA ITEM Reliability and Maintainability Test Plan	3. SUBTITLE

4. AUTHORITY (Data Acquisition Document No.) DI-SESS-81585C	5. CONTRACT REFERENCE SOW Para: 3.19.3.1 and 3.19.3.2	6. REQUIRING OFFICE

7. DD 250 REQ LT	9. DIST STATEMENT REQUIRED D	10. FREQUENCY ONE/R	12. DATE OF FIRST SUBMISSION (See block 16)	14. DISTRIBUTION
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	Other offices: logistics and safety			

CONTRACT DATA REQUIREMENTS LIST (1 Data Item)	Form Approved OMB No. 0704-0188

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A. CONTRACT LINE ITEM NO. 1	B. EXHIBIT A	C. CATEGORY: TDP _______ TM ________ OTHER ___PS_______________

D. SYSTEM/ITEM PROGRAM NAME	E. CONTRACT/PR NO. N00019-01-XXXX	F. CONTRACTOR TBD

1. DATA ITEM NO 011	2. TITLE OF DATA ITEM Reliability Test Procedure	3. SUBTITLE

4. AUTHORITY (Data Acquisition Document No.) DI-SESS-81629B	5. CONTRACT REFERENCE SOW Para: 3.19.3.1 and 3.19.3.3	6. REQUIRING OFFICE

7. DD 250 REQ LT	9. DIST STATEMENT REQUIRED D	10. FREQUENCY ONE/R	12. DATE OF FIRST SUBMISSION (See block 16)	14. DISTRIBUTION
8. APP CODE A (See block 16)		11. AS OF DATE N/A	13. DATE OF SUBSEQUENT SUBMISSION ASREQ (See block 16)	

16. REMARKS	a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
BLOCK 8: Government comments or approval will be provided within 30 days after receipt of initial submission. The revised of the report shall be submitted within 30 days after receipt of Government comments. BLOCK 12 and 13: Submit 90 days prior to each reliability test. Revisions submitted 30 days after receipt of Government comments.	Other offices: logistics and safety			

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BLOCK 4: Applicable for each reliability test performed.

BLOCK 8: Government has 30 days to review and approve.

BLOCK 12 and 13: Submit 30 days after each reliability test</td><td></td><td></td><td></td><td></td></tr>
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<tr><td colspan="5" rowspan="3">16. REMARKS

BLOCK 8: Government comments or approval will be provided within 30 days after receipt of initial submission. The revised of the report shall be submitted within 30 days after receipt of Government comments.

BLOCK 12: Submit preliminary 60D prior to PDR for Government review and comment. Submit final 60D prior to CDR. Updates as required to address changes in test program.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other offices: logistics and safety</td><td></td><td></td><td></td></tr>
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D. SYSTEM/ITEM PROGRAM NAME	E. CONTRACT/PR NO. N00019-01-XXXX	F. CONTRACTOR TBD

1. DATA ITEM NO 011	2. TITLE OF DATA ITEM Maintainability and Built-in-Test Demonstration Report	3. SUBTITLE

4. AUTHORITY (Data Acquisition Document No.) DI-SESS-81603B	5. CONTRACT REFERENCE SOW Para: 3.19.3.2 and 3.19.3.3	6. REQUIRING OFFICE

7. DD 250 REQ LT	9. DIST STATEMENT REQUIRED D	10. FREQUENCY ONE/R	12. DATE OF FIRST SUBMISSION (See block 16)
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14. DISTRIBUTION			
a. ADDRESSEE	b. COPIES		
	Draft	Final	
		Reg	Repro
Other offices: logistics and safety			

16. REMARKS

Block 4: Applicable for each maintainability and BIT test performed.

BLOCK 8: Government has 30 days to review and approve.

BLOCK 12 and 13: Submit 60 days after completion of each test

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Repro</td></tr>
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BLOCK 8: Government has 30 days to review and approve.

BLOCK 12: Deliver 60 days prior to CDR

BLOCK 13: Revisions 30 days after receipt of Government comments. Final due 60 days before first test.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other offices: logistics and safety</td><td></td><td></td><td></td></tr>
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D. SYSTEM/ITEM PROGRAM NAME		E. CONTRACT/PR NO. N00019-01-XXXX		F. CONTRACTOR TBD			
1. DATA ITEM NO 016	2. TITLE OF DATA ITEM Failure Summary and Analysis Report			3. SUBTITLE FRACAS			
4. AUTHORITY (Data Acquisition Document No.) DI-SESS-80255B		5. CONTRACT REFERENCE SOW Para: 3.19.3.6		6. REQUIRING OFFICE			
7. DD 250 REQ LT	9. DIST STATEMENT REQUIRED D	10. FREQUENCY MNTHLY	12. DATE OF FIRST SUBMISSION (See block 16)	14. DISTRIBUTION			
				a. ADDRESSEE	b. COPIES		
8. APP CODE A (See block 16)		11. AS OF DATE N/A	13. DATE OF SUBSEQUENT SUBMISSION NA		Draft	Final	
						Reg	Repro
16. REMARKS BLOCK 8: Government has 30 days to review and comment. BLOCK 12: First report is due 30 days after start of testing.							
				Other offices: logistics and safety			

3.6. Contract Section L – Proposal Instructions (Notice to Offerors)

10 U.S.C. 4328 (formerly 10 U.S.C. 2443) requires that sustainment factors, including R&M, be given ample emphasis in the process for source selection and encourages the use of objective R&M criteria in the evaluation of competitive proposals. Programs address this requirement in section L and M of solicitations. Section 4328 is instantiated in DoDI 5000.88: "For ACAT I (MDAPs) and II (Major Systems) weapon systems designs, the PM will include in the contract and in the process for source selection, clearly defined and measurable R&M requirements and engineering activities as required by Section 4328. The PMs of MDAPs and Major Systems must provide justification in the acquisition strategy for not including R&M requirements and engineering activities in TMRR, EMD, or production solicitations or contracts."

3.6.1. Instructions for Use

Section L will ask for submission only of sufficient R&M information to support proposal evaluation in accordance with the criteria in Section M. The RFP may provide that an Offeror's proposed specification with values better than required by the RFP may be incorporated into the contract at the time of award. Note that Section M will be carefully structured to include only those criteria likely to be discriminators in the source selection, so the corresponding proposal instructions in Section L will be similarly streamlined. Table 3-5 shows sample Section L language. The R&M engineer should tailor the language based on any responses received from the RFI or draft RFP and to meet any program-specific needs. Programs can add other R&M/BIT proposal requirements as necessary to support the evaluation criteria. To reinforce the critical dependency between sections L and M, the program should include the bolded text in brackets with the sample proposal content requirements as a reference to the contract Section M evaluation criterion.

3.6.2. Sample Language

Table 3-5 Sample Section L Language

1. Describe the R&M processes, tools, procedures, practices, and schedules for integrating R&M engineering into the system engineering process and the roles and responsibilities of R&M engineers in the prototype design, fabrication, and testing. Describe the tailoring of each Section C activity and the strategy for developing an R&M program consistent with the compressed schedule for the Middle Tier Acquisition. Explain how the proposed R&M program will address mission and safety critical failures and achieve the specified R&M requirements. **[SECTION M EVALUATION FACTORS 1 and 3]**
2. Give a detailed explanation of the technical approach planned for the prototype to attain the R&M requirements listed in the System Specification at the end of the contract period of performance. **[SECTION M EVALUATION FACTORS 1,2, and 3]**
3. Provide system R&M and BIT estimates that support the specification requirements (or any higher values proposed by the Offeror) and identify the allocated R&M/BIT values of

	each configuration item. Provide details of how estimates were developed and any data (including field and historical demonstrated data) used in any R&M models to support compliance with the R&M requirements. **[SECTION M EVALUATION FACTOR 1]**
4.	Describe the proposed reliability growth strategy within the limited time available, including the process for implementing corrective actions. When a conventional program is impractical, describe other approaches that will be applied, such as Accelerated Life Testing and robust design, identifying at what levels of design these approaches will be used. Provide an estimate of the level of R&M to be achieved prior to transition. **[SECTION M EVALUATION FACTOR 2]**
5.	Provide an understanding of the R&M requirements, and the approach to perform the requisite management, design, monitoring, testing, and verification efforts. Provide the R&M program plan approach and supporting data that consider each element/interface, and functional area for the conduct of R&M activities and how they interface with other internal and external organizations over the life cycle to meet requirements. Describe the management organization, policies, procedures, and schedules to meet the specification requirements and to ensure that R&M considerations (at the prime contractor and subcontractor levels) are integrated into the systems engineering process. (i.e., R&M & BIT program reviews, status reporting, trade studies, configuration control). **[SECTION M EVALUATION FACTOR 3]**
6.	Describe proposed R&M and BIT design activities, tests (development and production), and manufacturing processes and screens to meet the specification: a) Explain the concept of operations, mission profile and operational modes of the prototype. Describe how the analysis to develop the levels of maintenance and maintenance activities at all levels of maintenance will consider the OMS/MP. Describe how R&M design will address all aspects of operation and mission-essential functions. [**SECTION M EVALUATION FACTOR 4]** b) Describe the approach and methodology used in developing R&M estimates, including any block diagrams and math models, allocations, and predictions, as well as the process for using the results to improve the equipment design. Provide the R&M methods and models that were used in design and development of the prototype and those that will be used to assess hardware and software reliability throughout the system lifecycle. Models will be developed for each system, subsystem, and lower levels with associated predictions for all items that compose the prototype (i.e., hardware, software, and firmware). Describe the process to ensure estimates are iteratively updated to reflect the current configuration of the design. **[SECTION M EVALUATION FACTOR 4]** c) Select data used in predictions from, in priority order: field data, test data, and selected from sources that reflect similar system in the intended application, and/or tabulated handbooks. The source of the failure rate and repair data will be identified for all items. **[SECTION M EVALUATION FACTOR 4]** d) Describe the methodology for decomposing (allocating) R&M requirements through successively lower levels of indenture to the lowest replaceable items. **[SECTION M EVALUATION FACTOR 4]**

e) Describe the approach for tailoring and conducting the FMECA, focusing on safety and mission critical failure modes. Include the proposed indenture level (i.e., component, configuration item, subsystem) at which the FMECA will begin, and describe how the FMECA results will be used by the logistic support analysis effort. Describe the extent to which the results of the FMECA will be used to improve the design and how the FMECA will be updated to reflect the current configuration of the design. **[SECTION M EVALUATION FACTOR 4]**

f) Describe the failure definition and scoring criteria and how they will be used during development to minimize the occurrence of failures in the field through material or non-material solutions. **[SECTION M EVALUATION FACTOR 4]**

g) Provide documentation of identified potential hardware and software failure modes and causes within the prototype design and estimate the risk and effect of failure modes on mission success and safety. **[SECTION M EVALUATION FACTOR 4]**

h) Provide documentation of failure detection methodology and capability in the prototype design. The proposal shall document potential mitigations and compensating provisions for all failure modes affecting mission success and safety. **[SECTION M EVALUATION FACTORS 4 and 5]**

i) Provide documentation of all identified mission-essential functions of the prototype system. Failures by system function shall be documented from system level effect down to the hardware and software configuration item unit level for mission and safety critical functions. Provide applicable failure use cases for each system end effect. **[SECTION M EVALUATION FACTOR 4**]

j) Describe the methods and models used to ensure reliable software. Describe software error detection, exception handling and restoration. Describe how use cases address off nominal conditions and single point failures. **[SECTION M EVALUATION FACTOR 4]**

k) Describe the use of other R&M design activities such as robust design, worst-case analysis, sneak circuit analysis, control of reliability critical items, assessment of environmental effects on reliability, and any other Offeror R&M design techniques. **[SECTION M EVALUATION FACTOR 4]**

l) Disclose any expected R&M risk and risk mitigation efforts associated with attaining the R&M requirements listed in the system specification by the end of the contract period of performance. Describe how R&M risks will be identified and ranked. Explain the how medium- and high-risk failure modes and safety-related failures will be mitigated. **[SECTION M EVALUATION FACTOR 4]**

m) Describe the FRACAS methods that will be used during all phases of the program. Include details of what data will be captured, how failures will be analyzed to determine root failure cause, how corrective actions will be verified as effective, and how results will be communicated throughout the organization for appropriate approval and action. Describe how and when failure review boards, R&M review boards, and other failure and corrective action reviews will be conducted. **[SECTION M EVALUATION FACTOR 4]**

n) Describe the PMP methodology including design rules and guidelines used to develop and produce hardware of the prototype. The proposal shall document all instances

that the prototype design does not conform to the Offeror's established PMP and present limitations to environmental and operational mission requirements. The proposal shall document each mitigation performed or planned that demonstrate performance within the operational and mission requirements. Describe how the approach will flow down to subcontractors and suppliers. **[SECTION M EVALUATION FACTOR 4]** o) Describe the derated application of parts or design methods for ensuring that the configuration items are not thermally overstressed when installed and used in the system. If use of company derating procedures or design methods is proposed, attach a copy of the company procedures to the R&M program plan submitted with the proposal. **[SECTION M EVALUATION FACTOR 4]** p) Describe Environmental Stress Screening (including the number of thermal cycles, temperature range, vibration levels and number of failure free cycles) the Offeror will perform on each development and production system at each level of the configuration items to stimulate and correct latent defects, parts problems, workmanship problems, and manufacturing problems. **[SECTION M EVALUATION FACTOR 5]**
7. Maintainability (M(t)) and Testability Design: The proposal shall describe the prototype's M(t) and testability design characteristics down to the line replaceable unit level. The proposal shall describe and provide documentation of the prototype's fault detection and isolation capabilities. Describe the ability to identify single point hardware and software faults through test built into the prototype or BIT equipment. If necessary, identify ambiguity groups as well as the role of special test equipment and/or special inspection equipment. Address corrective and preventive maintenance, fault detection, fault isolation, and false alarms rates. Describe how the design will provide the ability to repair the system and the level of demand required for labor at all levels of maintenance and storage. **[SECTION M EVALUATION FACTOR 4]**
8. M(t) and BIT Demonstration: Describe the demonstration and integrated BIT demonstration (at the subsystem and system levels) approach to mature system performance to meet specifications. **[SECTION M EVALUATION FACTOR 5]**
9. Scheduled Maintenance: The proposal shall provide the expected scheduled maintenance tasks required to fully maintain the hardware, software, and firmware. The proposal shall itemize the nature and frequency of all scheduled maintenance tasks. **[SECTION M EVALUATION FACTOR 5]**
10. Reliability Tests: Describe planned reliability subsystem/equipment level reliability tests to identify failure modes, which if uncorrected could cause the equipment to exhibit unacceptable levels of reliability performance during later stages of integration, testing, or fielding. **[SECTION M EVALUATION FACTOR 5]**
11. Test Strategy: The proposal shall describe the methods of Hardware-In-the-Loop Monte Carlo simulators and the way it is used to stimulate all inputs (nominal and off nominal) to

software under test, and methods to implement VV&A[10] using test data in a scientific manner. Describe how R&M testing is an integral part of the test program and systems engineering verification process. Describe the strategy for verifying R&M requirements under operationally realistic conditions. **[SECTION M EVALUATION FACTOR 5]**

[10] Verification, Validation, & Accreditation

3.7. Contract Section M – Evaluation Factors for Award R&M Language

10 U.S.C. 4328 requires that sustainment factors, including R&M, be given ample emphasis in the process for source selection and encourages the use of objective R&M criteria in the evaluation of competitive proposals. A program office should address this requirement in section L and M of solicitations. 10 U.S.C. 4328 is instantiated in DoDI 5000.88: "For ACAT I (MDAPs) and II (Major Systems) weapon systems designs, the PM will include in the contract and in the process for source selection, clearly defined and measurable R&M requirements and engineering activities as required by 10 U.S.C. 4328. The PMs of MDAPs and Major Systems must provide justification in the acquisition strategy for not including R&M requirements and engineering activities in TMRR, EMD, or production solicitations or contracts."

3.7.1. Instructions for Use

Section M should contain short and concise evaluation factors listed in order of priority. Section M should be streamlined to include only those criteria likely to be discriminators in the source selection. Contractor-proposed R&M activities should be supported by appropriate Basis of Estimates (BOE) to ensure R&M cost factors are accounted for in the proposal cost volume. Table 3-6 shows sample Section M language and the R&M engineer should ensure it is aligned with Section L.

3.7.2. Sample Language

Table 3-6 Sample Section M Language

Factor 1: Compliance with Specification Requirements. Compliance with specification R&M requirements for the system that are established by the results of extensive use or by the development methods proposed by the Offeror (i.e., the proposed concept will be demonstrated and documented to meet the proposed R&M requirements).
Factor 2: Reliability Growth Plan. The adequacy and practicality of the proposed reliability growth plan.
Factor 3: R&M Management and Planning. The proposed organization, policies, procedures, and schedules to meet the specification R&M requirements. Document the results of R&M activities, and track progress in meeting R&M requirements. R&M and design plans will describe: 1) How R&M is incorporated into all aspects of the system engineering design. 2) Specific features of the design that enhance ease of performing maintenance.

3) The Offeror's approach for achieving and verifying the R&M requirements contained within the proposal throughout the performance of R&M design analyses and test activities. 4) An understanding of R&M requirements and plans for the management, design, monitoring, testing, and verification efforts
Factor 4: R&M Design Activities. The adequacy of the proposed R&M activities to include design, tests (both development and production), and manufacturing processes to meet the R&M specification requirements, identify failure modes, implement a FRACAS, address PM&P, modeling, and data (i.e., how well the proposed system or subsystems have been built, tested, and documented to meet the proposed R&M requirements).
Factor 5: R&M Verification Testing: The Offeror's approach to compliance with specification verification test requirements.
Factor 6: Residual Engineering: The Offeror's recognition that to achieve fielding within the required time, not all identified deficiencies may be resolved prior to production or deployment, and the proposed manner for addressing unresolved deficiencies after fielding

Acronyms

AAF	Adaptive Acquisition Framework
ACAT	Acquisition Category
ALT	Accelerated Life Testing
BIT	Built-In Test
BoK	Body of Knowledge
CCMD	Combatant Command
CDD	Capability Development Document
CDRL	Contract Data Requirements List
CI	Commercial Item
CJCS	Chairman of the Joint Chiefs of Staff
CONOPS	Concept of Operations
COTS	Commercial Off-the-Shelf
DA	Decision Authority
DBS	Defense Business Systems
DID	Data Item Description
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
EMD	Engineering and Manufacturing Development
ESS	Environmental Stress Screening
FAR	Federal Acquisition Regulation
FDSC	Failure Definition and Scoring Criteria
FMEA	Failure Modes Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOSS	Free and Open Source Software
FPGA	Field Programmable Gate Array
FRACAS	Failure Reporting, Analysis, and Corrective Action System
FRB	Failure Review Board
FRP	Full-Rate Production
GFE	Government-Furnished Equipment
GFS	Government Furnished Software
GOTS	Government-Off-the-Shelf
HALT	Highly Accelerated Life Testing
JCIDS	Joint Capabilities Integration and Development System

LSE	Lead Systems Engineer
MBT	Main Battle Tank
MCA	Major Capability Acquisition
MDAP	Major Defense Acquisition Program
MSA	Materiel Solution Analysis
MTA	Middle Tier of Acquisition
MTBF	Mean Time Between Failures
NDI	Non-Developmental Item
O&S	Operations and Support
OEM	Original Equipment Manufacturer
OMS/MP	Operational Mode Summary/Mission Profile
P&D	Production and Deployment
PM	Program Manager
PM&P	Parts, Materials, and Processes
PoF	Physics of Failure
R&M	Reliability and Maintainability
RAM	Reliability, Availability, and Maintainability
RAM-C	Reliability, Availability, Maintainability, and Cost
RCM	Reliability-Centered Maintenance
RFI	Request for Information
RFP	Request for Proposal
RGT	Reliability Growth Testing
SFMEA	Software FMEA
SME	Subject Matter Expert
SOW	Statement of Work
TMRR	Technology Maturation and Risk Reduction
UCA	Urgent Capability Acquisition
UCF	Uniform Contract Format
UON	Urgent Operational Need
USD(A&S)	Under Secretary of Defense for Acquisition and Sustainment
USD(R&E)	Under Secretary of Defense for Research and Engineering
VCJCS	Vice Chairman of the Joint Chiefs of Staff
VV&A	Verification, Validation, & Accreditation

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