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

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Office of the Under Secretary of Defense for
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R&M Engineering Contract Language for the Major Capability Acquisition Pathway

Office of the Under Secretary of Defense for Research and Engineering
3030 Defense Pentagon
Washington, DC 20301
https://ac.cto.mil/engineering
https://www.cto.mil
osd.r-e.comm@mail.mil | Attn: Specialty Engineering

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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 Major Capability Acquisition (MCA) 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.

MCA 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 MCA 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).

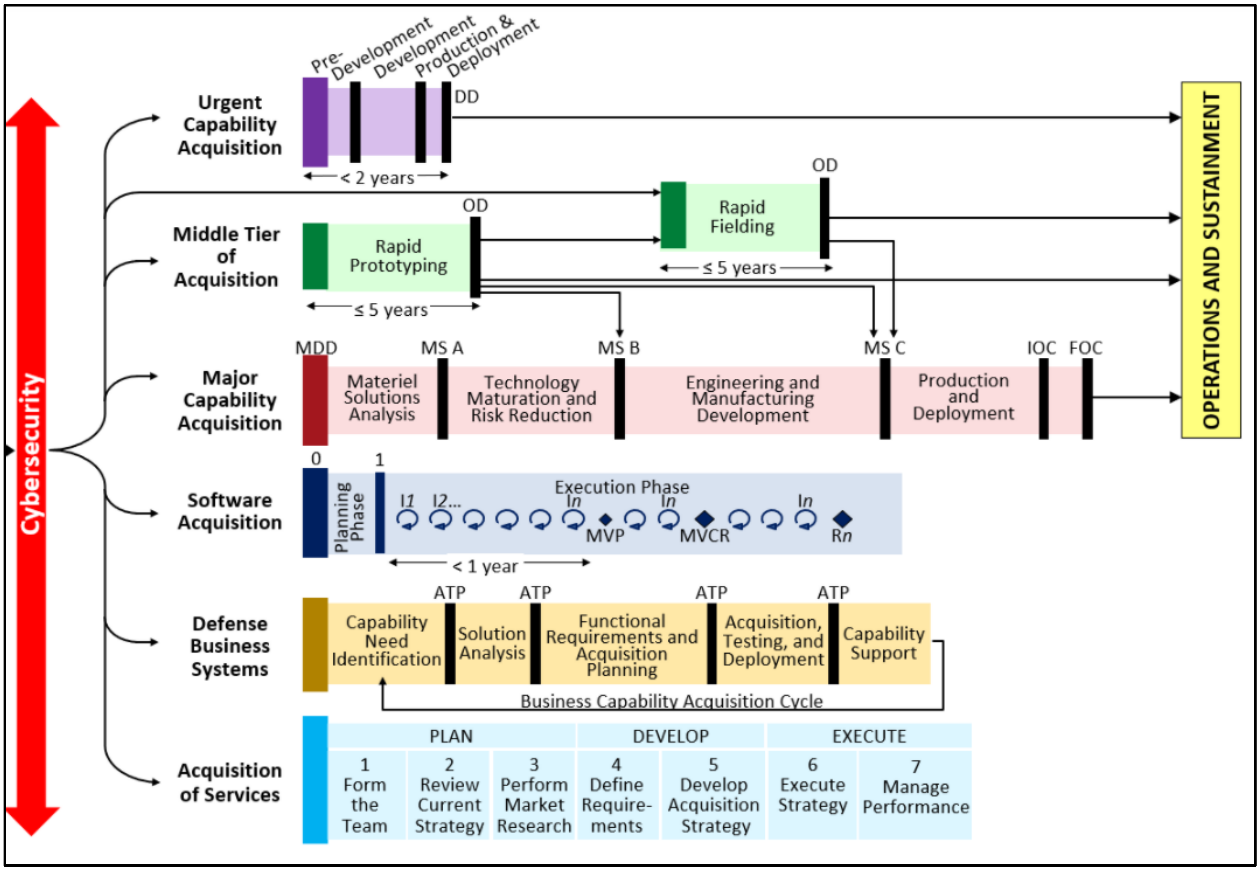
These sections include selected hyperlinks to major sources. Additional sources and links are available in the reference list at the end of the document.

This guidance provides information supplemental 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.

1 INTRODUCTION

1.1. Adaptive Acquisition Framework

The AAF pathways provide opportunities for Milestone Decision Authorities, Decision Authorities, 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. 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. 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

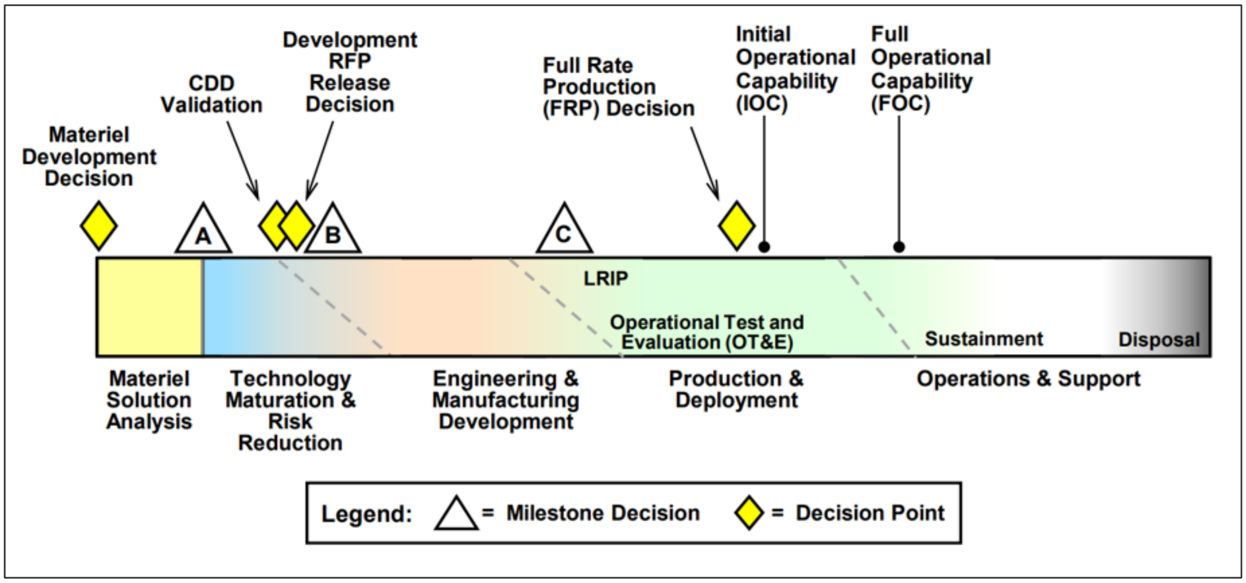
The DoD acquisition system is designed to acquire quality products that satisfy warfighter needs with measurable improvements to mission capability. The AAF is intended to shorten cycle times and enable programs to rapidly develop, acquire, and deliver capabilities to the warfighter.

1.2. MCA Pathway

The purpose of the MCA pathway is to acquire and modernize military-unique systems that provide an enduring capability. When PMs use this pathway, they may need to acquire software-intensive components. To satisfy this need, they can integrate the Software Acquisition pathway into the MCA pathway. This combination is just one example in which the PM can customize the pathway to a desired end-state. MCA programs include Major Defense Acquisition Programs (MDAPs); other programs categorized as acquisition category (ACAT) I; major systems, usually categorized as ACAT II; automated information systems (not managed by other acquisition pathways); and other capabilities developed via the MCA pathway. See DoD Instruction (DoDI) 5000.85, “Major Capability Acquisition,” for more information.

MCA programs typically follow a structured approach to analyze, design, develop, integrate, test, evaluate, produce, and support a major system. MCA includes five phases alternating with transitional milestones, milestone decisions, and decision points (Figure 1-1).

- Materiel Development Decision (decision point)
  - Develop Requirements
  - Analysis of Alternatives
  - Study Contracts
- Materiel Solution Analysis (MSA) phase
  - Milestone A (milestone decision)
- Technology Maturation and Risk Reduction (TMRR) phase
  - Capability Development Document (CDD) Validation (decision point)
  - Development RFP Release Decision (decision point)
  - Milestone B (milestone decision)
- Engineering and Manufacturing Development (EMD) phase
  - Milestone C (milestone decision)
- Production and Deployment (P&D) phase
  - Full-Rate Production (FRP) Decision (decision point)
- Operations and Support (O&S) phase



Source: DoDI 5000.85, "Major Capability Acquisition," August 6, 2020

Figure 1-2. Hardware-Intensive Program

The MCA pathway requires the PM to hold a series of reviews to support MCA program decisions. Three of the reviews assess a program's readiness to proceed to the next acquisition phase, and one determines whether the program is ready to go to FRP. Through these reviews, defense experts examine the technical status of a program to ensure the Department makes sound decisions before committing financial resources. Reviews provide data and insight to allow the Milestone Decision Authority to judge whether the program is ready to proceed.

This multi-phase process supports MDAPs, major systems, and other complex acquisitions. Programs tailor the acquisition and product support processes (DoDI 5000.91, "Product Support Management for the Adaptive Acquisition Framework"), reviews, and documentation to accommodate the program size, complexity, risk, urgency, and other factors. The program may choose to acquire software-intensive components using the Software Acquisition pathway, integrating the outputs and dependencies with the overall MCA pathway.

2 REQUESTS FOR INFORMATION FOR THE MCA PATHWAY

This section provides discussion, R&M guidance, and sample language for an RFI.

In accordance with DoDI 5000.88, "Engineering of Defense Systems," in all defense acquisition programs, the Lead Systems Engineer[1] (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 an 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 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

[1] 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.

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 MSA phase or for study or prototyping contracts performed as part of the MSA or early 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 MCA PATHWAY

This section provides discussion, R&M guidance, and sample language for 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.[2] 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)

[2] 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 B – Supplies and Services and Prices/Costs

Section C – Description/Specifications/Statement of Work

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) 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 3-1. 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

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.[3]

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. MIL-STD-961E can be referenced 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.

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.[4] The R&M engineer must convert (translate) these requirements into quantitative contractual specifications. At a minimum, the specification should include the following contractual R&M requirements:

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[3] 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 USC 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.
[4] 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.

- *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 alarm 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)[5] 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

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[5] 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 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 3-2. 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 MCA Pathway

R&M engineering activities to be placed on contract (i.e., in a SOW) should be tailored depending on the program phase and equipment type.

- *By Program Phase* – The program phase is the first discriminator that establishes the type of R&M engineering activities that need to be conducted. For example, in the MSA phase a FRACAS would generally not be required as testing has usually not started. Likewise, when developing prototypes to demonstrate the feasibility of an approach or investigate risk reduction technologies during the TMRR phase, production-oriented disciplines such as manufacturing screening are inappropriate; however, during the EMD phase, most R&M engineering activities are applicable with the engineering staff focused on achieving the specified requirements through the various levels of integration, demonstration and test, and analysis. When the program reaches the P&D phase, there is usually no need to address derating, predictions, allocations, modeling, or subsystem reliability growth testing as these activities should have been completed during earlier phases; however, these analyses should be kept up to date with configuration, test, and field data. Updating the analyses supports the use of some of these R&M engineering activities if upgrades or modifications are anticipated or required during the P&D phase.

- *By Type of Equipment* – Equipment type is another consideration that the R&M engineer needs to address for a successful R&M program. A variety of equipment types are 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) items, and Non-Developmental Items (NDIs). A COTS item must be a commercial item sold in the exact 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 which type of equipment the program plans to use, the R&M engineer should understand that the required R&M engineering design and test activities would be different.

    - *Newly Designed Equipment and Major Changes* – The usual reason for this type of procurement is the capability does not exist and must be 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-HDBK-61B is 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:

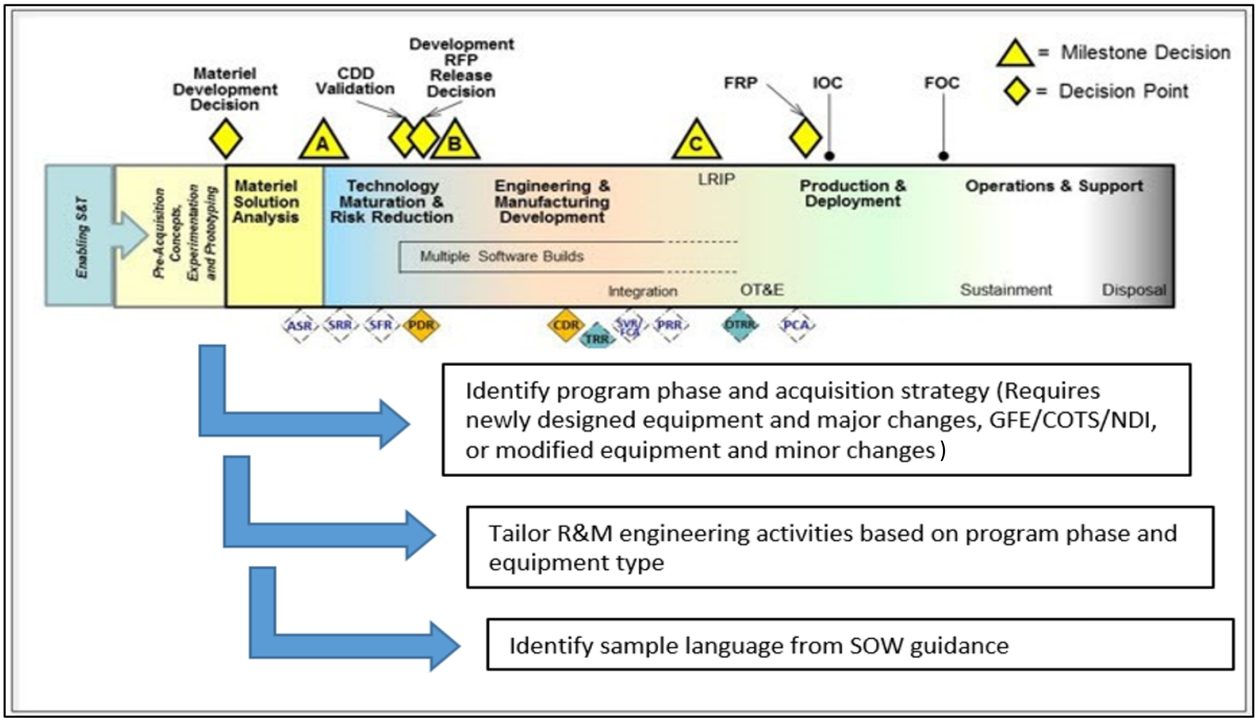
- Performance
- Reliability, maintainability, durability, or survivability
- Weight, balance, or moment of inertia
- Electromagnetic characteristics
- Other technical requirements in the specifications
- Logistical support requirements, such as training, technical or operational manuals, spares, maintenance procedures or equipment, etc.
- Cost
- Re-qualification of the item
- 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.

- *Modified Equipment and Minor Changes* – MIL-HDBK-61B (paragraph 5.5.3.1.1.b) 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 variation to physical features; minor variations to requirements that do not affect end use functionality; and variations in dimensions, tolerances, materials, quality assurance requirements, packaging, marking, etc. The R&M engineer must ensure that the appropriate R&M activities assess the effect of the minor change on R&M. Even if only a part is changed, it should be designed to be reliable and maintainable.
- *GFE/COTS/NDI* – The basic guideline is that the program ensures that the GFE/COTS/NDI it is considering to use meets or exceeds the overall R&M performance requirements and generally meets its R&M allocation of the system requirements. GFE/COTS/NDI items should be included in system assessments. GFE/COTS/NDI generally should be unmodified and produced from an existing manufacturing line. GFE should also be equipment that (1) has completed the EMD phase, (2) the Government has fully qualified, and (3) has successfully achieved all performance requirements in an approved Service or Government specification. The DAU Glossary describes the definitions of GFE/COTS/NDI.

3.3.3. Tailoring Guide

Figure 3-1 depicts how the set of potential R&M engineering activities to be placed on contract is tailored based on the MCA pathway to achieve a cost-effective R&M program.



Source: "Major Capability Acquisition" as modified; https://aaf.dau.edu/aaf/mca/srr/

Figure 3-1. Tailoring Flow Diagram for MCA Pathway

Table 3-3 outlines tailoring guidelines[6] based on the program phase and type of equipment. This table identifies the engineering activities called out in DoDI 5000.88, as well as additional lower-level activities that support the overall R&M engineering program. Checkmarks indicate where tailoring is required to address the equipment type and unique requirements of the system.

[6] Many R&M activities taper off in the later phases of acquisition (P&D, O&S); however, the tailoring guidance is less likely to be true for software because much of the testing and reliability growth may be determined by telemetry in the field in a process of continual improvement throughout the lifetime of the software. Reliability in software is mainly a function of the software environment, with new input streams and loads seen over the software's lifetime as the environment changes (i.e., the source of randomness that stresses the software is external, not internal).

Table 3-3. Tailoring Guide (Program Phase and Equipment Type)

SOW Paragraph	R&M Discipline	5000.88	MCA Program Phase					Equipment Type		
			MSA	TMRR	EMD	P&D	O&S	New Design or "Major" Change	Modified or "Minor" Change	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		✓	✓	✓			✓	✓	✓
3.19.1.4	Market Survey			✓	✓					✓
3.19.1.5	Spares Reliability Provisions				✓	✓	✓	✓	✓	
3.19.3.1	Subsystem/Equipment-Level Reliability Growth Test	•		✓	✓	✓		✓		
3.19.3.2	Subsystem/Equipment-Level BIT Assessment Tests	•			✓			✓		
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.
- ✓ Identifies activity that should be performed during a specific program phase or for a specific equipment type

Abbreviations:
BIT – Built-In Test
COTS – Commercial Off-the-Shelf
FRACAS - Failure Reporting, Analysis, and Corrective Action System
MCA – Major Capability Acquisition
NDI - Non-Developmental Item
SOW – Statement of Work

Table 3-3 Tailoring Guide (Program Phase and Equipment Type) (continued)

SOW Paragraph	R&M Discipline	5000.88	MCA Program Phase					Equipment Type		
			MSA	TMRR	EMD	P&D	O&S	New Design or "Major" Change	Modified or "Minor" Change	NDI/COTS
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	•	✓	✓	✓			✓	✓	✓(1)
3.19.2.3	Maintainability and BIT Allocations, Predictions, and Analysis	•	✓	✓	✓			✓	✓	✓(1)
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	•		✓	✓	✓		✓		
3.19.3.2	Subsystem/Equipment-Level BIT Assessment Tests	•			✓			✓		
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.
- ✓ Identifies activity that should be performed during a specific program phase or for a specific equipment type.

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 the modified portions and interfaces.

Abbreviations:
BIT – Built-In Test
COTS – Commercial Off-the-Shelf
FMECA – Failure Modes, Effects, and Criticality Analysis
FRACAS - Failure Reporting, Analysis, and Corrective Action System
MCA – Major Capability Acquisition
NDI - Non-Developmental Item
SOW – Statement of Work

For major capability acquisitions, MSA activities are usually performed by the acquisition component and therefore generally do not need a SOW. These activities are described in Chapter 1, MSA Phase, of the R&M Engineering Body of Knowledge. Government program management may add contractor R&M engineering activities to the SOW as applicable for the specific program. In recommending to the Systems Engineer and PM the activities the contractor should perform, the R&M engineer conducts an assessment to determine:

- All R&M program influences on and impacts of system and program requirements as well as Service and DoD requirements that pertain to the acquisition.
- Whether the resources allotted to R&M are sufficient to identify design and manufacturing problems, determine the underlying cause of those problems, and develop and implement corrective actions. Sufficient resources are critical to achieving a reliability growth program's objectives.
- The appropriate set of best practices that apply to the technical and engineering challenges particular to the acquisition that will drive the shape of the R&M program required of the contractor(s).
- What the contractor(s) will need to provide or share with the community of stakeholders.
- The R&M technical and acquisition risks to be mitigated in part through contractual requirements.

3.3.4. Examples of Tailoring for the MCA Pathway

It is impossible to generalize the tailoring of contract SOW tasks and deliverable data needed for each MCA program. The deliverable data is obtained via the DoD CDRL and appropriate DIDs. Tailoring the SOW and CDRLs requires the PM to consider the type of system to be developed, 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.

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.

The FMECA should be updated throughout the life cycle, first with test and subsequently with field failure data. Continuing FMECA updates will support reliability-centered maintenance (RCM) analysis for optimizing preventive maintenance schedules. MIL-HDBK-2155 requires the FRACAS program to establish a failure review board (FRB), which will review and approve proper failure analysis and corrective actions on all program failures.

When conducted properly and in a timely manner, the FRACAS is an engineering activity during development, production, and sustainment to provide management visibility and control to improve R&M of HW and associated SW. The FRACAS requires timely and disciplined use of failure data to generate and implement effective corrective actions to prevent a recurring failure.[7] Contractors should submit periodic failure reports starting when the first failure is observed. Such reports should include root cause analysis, results and status, failure trends, and failure identification by part description, part number, serial number, geographical location, etc.

When GFE/COTS/NDI are used, it may not be necessary to conduct a new or complete FMECA as the analysis may have been conducted on the items or equipment when they were developed. If the former FMECA results are available, the R&M engineer should evaluate whether the application of the NDI/COTS/GFE or the environment in which it will be used differs substantially from that for which the original FMECA was conducted. If so, the R&M engineer may need to repeat portions of the FMECA to account for the differences.

In addition, the main purpose of the FMECA for GFE/COTS/NDI is to determine the effect on system R&M without changing the design. GFE/COTS/NDI, being produced from an existing manufacturing line, generally should be unmodified. Some modification may be needed because of the differences in application or environment. If the item/equipment can be used "as is," then logistics costs can be minimized (although additional GFE might need to be acquired to provide sufficient spares) because:

- COTS/NDI items can be sent back to the Original Equipment Manufacturer (OEM) for repair or replacement.
- Existing repair procedures and facilities for the GFE can be used and replacements can be obtained from the Government supply system.

[7] Standardizing failure and defect data facilitates the export and exchange of data between systems and permits the efficient rollup of data to the enterprise level.

The R&M engineer also should tailor the FMECA based on the acquisition phase. When in the TMRR phase, the R&M engineer need conduct only a functional FMECA to address 100 percent of the functions, and to develop a preliminary Critical Items List. The R&M engineer conducts a physical FMECA during the EMD phase.

Example 2: Reliability Growth Testing (RGT)

As components, assemblies, and even subsystems have become more reliable, the time to implement conventional reliability growth testing can be thousands of hours. Program schedules should accommodate the testing and allow time to reduce risks to an acceptable level. In addition, there must be time and resources to develop and incorporate corrective actions (design changes) that are the cause of reliability growth.

The R&M engineer should tailor the RGT program based on the levels of indenture for the capability being acquired.

- If a program is acquiring a major system, such as an aircraft or ship, it is impractical to conduct RGT at the system level. RGT would be appropriate at the "box" level (e.g., an amplifier, a radio, a pump, or an actuator). It might be practical to conduct on much larger removable items such as an engine, depending on the availability of test items and the level of reliability to be achieved.

- If a program is acquiring a system or capability that is a subsystem or lower level of design, such as a radar or an engine, then it might be possible and practical to conduct RGT at the system level.

When conventional RGT is impractical (insufficient time in the schedule, very high reliability requirements, insufficient test articles), then Accelerated Life Testing (ALT) or Highly Accelerated Life Testing (HALT) should be considered.

- ALT. The term ALT is commonly understood as equivalent to *quantitative* ALT.[8] ALT refers to testing an item while accelerating either the usage rate or the stress. An underlying life distribution and life-stress relationship model (statistical or empirical) must be selected or developed to fit the accelerated test data. The distribution and model ensure that:

[8] An alternative to quantitative ALT, qualitative ALT is used primarily to reveal probable failure modes for an item so engineers can improve its design. Qualitative ALT does not use models, and in general, qualitative ALT does not provide information that can be used to quantify the life characteristics of the product under normal use conditions.

- Failure modes that cannot occur at actual levels of use or stress are not introduced at the accelerated levels.
- The reliability observed at the accelerated levels can be correlated to the reliability at actual levels.

ALT is usually practical at low levels of design, parts, small assemblies, etc., because of the difficulty in accelerating all stresses, for example, at the same rate. ALT has many uncertainties, especially at higher levels of design (i.e., indenture), and must be used judiciously.

- HALT. A form of accelerated testing, HALT is used to determine whether an item (e.g., components) can withstand environmental stresses. Early in the development phase of an MCA program, a contractor can use HALT to expose items to a full range of operating conditions. During HALT, environmental stresses are controlled and incrementally applied until they eventually reach a level beyond that which is expected during operational use. Ideally, the process of increasing the stresses continues until reaching the limit of the technology (an extreme example is that despite adding cooling, the device eventually melts). Stresses applied during HALT are typically temperature or vibration; however, other stresses, such as electrical or mechanical, also can be considered. HALT is not a compliance test and does not provide a measure of reliability. Although the name is like ALT, HALT is different for two reasons:
    - The objective is not (nor is it possible) to measure reliability.
    - No attempt is made to avoid introducing failures that would not occur at normal conditions.
- Robust Design Techniques. Engineers can implement robust product design based on the Taguchi method (see MIL-HDBK-338B Section 7.4.2). Robust design is an approach to reduce variation in a product without eliminating the causes of the variation, that is, to make the product or process insensitive to variation. The variation (sometimes called noise) can come from a variety of factors and can be classified into three main types: internal variation, external variation, and unit-to-unit variation. Internal variation is due to deterioration such as the wear of a machine and aging of materials. External variation is from factors relating to environmental conditions such as temperature, humidity, and dust. Unit-to-unit variation is variation between parts resulting from variations in material, processes, and equipment. Robust design makes it possible to:
    - Improve products exposed to a broad variety of manufacturing and operating environments during their life cycle, thereby increasing product performance.
    - Decrease the sensitivity to factors of noise within the design and manufacturing process that reduce reliability or other measures of performance.

- Adjust or develop design and manufacturing processes for a product to achieve the desired performance at a reduced cost in the shortest turnaround time.
- Make designs easier to produce and less susceptible to variation in manufacturing processes.

Example 3: Reliability and Maintainability Predictions

Reliability predictions involve the use of block diagrams, mathematical models, and simulations. Predictions start with very preliminary information, such as field data from “similar” systems or data from handbook sources.[9] As testing begins, additional data regarding failure modes and mechanisms become available. When sufficient information is available, engineers should use Physics of Failure (PoF)[10] models to make more robust predictions, replacing earlier estimates. In addition, various statistical tests can be conducted, beginning with parts, to develop predictions with confidence intervals (as opposed to point estimates) on the prediction.

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.

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

[9] Such as MIL-HDBK-217, *Military Handbook: Reliability Prediction of Electronic Equipment*; Telcordia SR-332/Bellcore Standard, *Reliability Prediction Procedure for Electronic Equipment, Special Report SR-332*; NPRD Non-electronic Parts Reliability Data; and EPRD, Electronic Parts Reliability Data.

[10] The SAE J2816 standard defines Physics-of-Failure (PoF) as a science-based approach to reliability that uses modeling and simulation to design-in reliability. This approach models the root causes of failures such as fatigue, fracture, wear, and corrosion.

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 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)
- High-Risk – Subject matter expert (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 with 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 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 the guidance of MIL-HDBK-470A or equivalent. 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 differs 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.

Finally, software reliability requires a different approach than hardware reliability. 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.

3.4. Contract Section C – Sample Statement of Work Language

The R&M engineer should tailor the SOW language in Table 3-4 for program phase and equipment type based on the Tailoring Guide shown earlier in Table 3-3. The items in bold at the end of the paragraphs in Table 3-4 are CDRL (DD Form 1423) deliverables. The paragraph numbering is shown for illustration only. The associated sample CDRLs are shown in the same "EXHIBIT A" (see 3.5.1) of this document.

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 **(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)**

3.19.2.3.1 Physics of Failure and Part Level Stress Analyses. For critical items identified in paragraph 3.19.2.3 and for safety-critical components, the contractor shall conduct a part-level stress analysis for **(type or category of equipment)** to verify fatigue service life and that derating is being applied in accordance with best practices. In addition, the junction temperature of microcircuits and semiconductor devices under steady state worst-case circuit operating and environmental conditions shall be detailed. This analysis shall verify that parameter deratings are compliant under the following conditions:

1) Steady state nominal ambient operating temperature and piece part stress.
2) Steady state worst case piece part stress
3) Steady state worst case system-level thermal environments at the operational extremes.

The contractor shall conduct a thermal survey to verify the accuracy of the thermal and derating analyses and to help eliminate hot spots and derating non-conformances.
The contractor shall apply, to the maximum extent possible, Physics of Failure (PoF) reliability optimization modeling to determine the fatigue service life and reliability distribution under the stated (worse case) environmental conditions life profiles. The modeling shall consist of performing a dynamic structural analysis to determine the stress distribution. The stress distribution is then incorporated into PoF failure mechanism and fatigue life models that calculate durability life and generate reliability versus time plots to support the reliability prediction. As a minimum, the PoF analysis shall account for the individual and combined effects experienced by the item for the following stress factors:

1) Thermo-mechanical (expansion/contraction) cycling at worst case power dissipation
2) Vibration fatigue
3) Shock events

The results of the stress analysis shall be integrated with the reliability prediction.

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 may identify common failure modes using the Common Defect Enumeration (CDE). The CDE provides a listing of software defects applicable for virtually all weapon or combat systems with software. 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 <u>Worst Case/Sneak Circuit Analysis</u>. 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 <u>Thermal Analysis and Survey</u>. 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 <u>Parts, Materials, and Processes (PM&P) Management Program</u> 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. 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 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 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)**
3.19.3.4 Manufacturing Screening. 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)**
3.19.3.5 <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.
3.19.3.6 <u>Failure Reporting, Analysis, and Corrective Action System (FRACAS)</u>. The contractor shall, as part of the R&M program, define and implement a closed-loop FRACAS program. The contractor shall provide for visibility and traceability of reported failures and BIT anomalies, in all levels of testing, from discovery to closeout. **(CDRL, Failure Summary and Analysis Report)**
3.19.3.6.1 <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.
3.19.3.6.2 <u>Failure Analyses</u>. 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.
3.19.3.6.3 <u>Corrective Actions</u>. 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.

3.5. Contract Section J – List of Attachments

3.5.1. Purpose

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 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.

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

Attachments, such as the CDRL, are often called Exhibits. This sample Exhibit A would be just one of those attachments. This section provides examples of R&M data typically required in the conduct of a materiel acquisition program that should be listed in a CDRL.

The due dates shown in the following sample CDRLs 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.

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.

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

1. DATA ITEM NO 004	2. TITLE OF DATA ITEM Reliability and Maintainability Block Diagrams and Mathematical Models Report	3. SUBTITLE

4. AUTHORITY (Data Acquisition Document No.) DI-SESS-81496B	5. CONTRACT REFERENCE SOW Para: 3.19.2.3	6. REQUIRING OFFICE

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						Reg	Repro

16. REMARKS	a. ADDRESSEE	Draft	Reg	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: Submission is due 60D prior to SRR BLOCK 13: Final Submission is due 60D prior to PDR				
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SOW Para: 3.19.2.3</td><td colspan="4">6. REQUIRING OFFICE</td></tr>
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ONE/R</td><td>12. DATE OF FIRST SUBMISSION
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<tr><td>8. APP CODE
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Draft | Final (Reg, Repro)</td></tr>
<tr><td colspan="4" rowspan="3">16. REMARKS

BLOCK 12: Submission is due 60D prior to SRR

BLOCK 13: Final Submission is due 60D prior to PDR</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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<tr><td colspan="2">A. CONTRACT LINE ITEM NO.
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A</td><td colspan="5">C. CATEGORY:
TDP _______ TM ________ OTHER ___PS_______________</td></tr>
<tr><td colspan="2">D. SYSTEM/ITEM PROGRAM NAME</td><td colspan="2">E. CONTRACT/PR NO.
N00019-01-XXXX</td><td colspan="4">F. CONTRACTOR
TBD</td></tr>
<tr><td>1. DATA ITEM NO
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Reliability and Maintainability Predictions Report</td><td colspan="4">3. SUBTITLE</td></tr>
<tr><td colspan="2">4. AUTHORITY (Data Acquisition Document No.)
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SOW Para: 3.19.2.3</td><td colspan="4">6. REQUIRING OFFICE</td></tr>
<tr><td>7. DD 250 REQ
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ONE/R</td><td>12. DATE OF FIRST SUBMISSION
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BLOCK 12: Submission is due 60D prior to SRR

BLOCK 13: Final Submission is due 60D prior to PDR</td><td>Other offices: logistics and safety</td><td></td><td></td><td></td></tr>
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<tr><td colspan="3">D. SYSTEM/ITEM PROGRAM NAME</td><td colspan="2">E. CONTRACT/PR NO.
N00019-01-XXXX</td><td colspan="4">F. CONTRACTOR
TBD</td></tr>
<tr><td>1. DATA ITEM NO
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Failure Modes, Effects, and Criticality Analysis (FMECA)</td><td colspan="4">3. SUBTITLE</td></tr>
<tr><td colspan="3">4. AUTHORITY (Data Acquisition Document No.)
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SOW Para: 3.19.2.4</td><td colspan="4">6. REQUIRING OFFICE</td></tr>
<tr><td>7. DD 250 REQ
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D</td><td>10. FREQUENCY
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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.</td><td colspan="5">Other offices: logistics and safety</td></tr>
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<tr><td colspan="3">D. SYSTEM/ITEM PROGRAM NAME</td><td colspan="1">E. CONTRACT/PR NO.
N00019-01-XXXX</td><td colspan="4">F. CONTRACTOR
TBD</td></tr>
<tr><td>1. DATA ITEM NO
007</td><td colspan="3">2. TITLE OF DATA ITEM
Electronics Parts/Circuits Tolerance Analysis Report</td><td colspan="4">3. SUBTITLE</td></tr>
<tr><td colspan="2">4. AUTHORITY (Data Acquisition Document No.)
DI-SESS-81734</td><td colspan="2">5. CONTRACT REFERENCE
SOW Para: 3.19.2.5</td><td colspan="4">6. REQUIRING OFFICE</td></tr>
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BLOCK 13: Final Submission is due 60D prior to PDR</td><td></td><td></td><td></td><td></td></tr>
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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 009	2. TITLE OF DATA ITEM Parts Management Plan	3. SUBTITLE

4. AUTHORITY (Data Acquisition Document No.) DI-SDMP-81748	5. CONTRACT REFERENCE SOW Para: 3.19.2.7	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)
8. APP CODE A (See block 16)		11. AS OF DATE N/A	13. DATE OF SUBSEQUENT SUBMISSION ASREQ

14. DISTRIBUTION			
a. ADDRESSEE	b. COPIES		
	Draft	Final	
		Reg	Repro
Other offices: logistics and safety			

16. REMARKS

BLOCK 12: Submission is due 60D prior to PDR

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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)
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14. DISTRIBUTION

a. ADDRESSEE	b. COPIES: Draft	Final: Reg	Final: Repro
Other offices: logistics and safety			

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 plan 60D prior to PDR for review and comment. Submit final 60D prior to CDR. Updates as required to address changes in test program.

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

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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 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)
8. APP CODE A (See block 16)		11. AS OF DATE N/A	13. DATE OF SUBSEQUENT SUBMISSION ASREQ (See block 16)

14. DISTRIBUTION			
a. ADDRESSEE	b. COPIES		
	Draft	Final	
		Reg	Repro
Other offices: logistics and safety			

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 and 13: Submit 90 days prior to each reliability test. Revisions submitted 30 days after receipt of Government comments.

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

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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 Reliability Test Report	3. SUBTITLE

4. AUTHORITY (Data Acquisition Document No.) DI-SESS-81628B	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)	a. ADDRESSEE	b. COPIES		
					Draft	Final	
						Reg	Repro

16. REMARKS	a. ADDRESSEE	Draft	Reg	Repro
BLOCK 4: Applicable for each reliability test preformed. BLOCK 8: Government has 30 days to review and approve. BLOCK 12 and 13: Submit 30 days after each reliability test				
	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 013	2. TITLE OF DATA ITEM Maintainability and Built-in-Test Demonstration Procedure				3. SUBTITLE			
4. AUTHORITY (Data Acquisition Document No.) DI-SESS-81604B			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)		14. DISTRIBUTION			
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						Draft	Final	
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					Other offices: logistics and safety			

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A</td><td colspan="6">C. CATEGORY:
TDP _______ TM ________ OTHER ___PS_______________</td></tr>
<tr><td colspan="3">D. SYSTEM/ITEM PROGRAM NAME</td><td colspan="2">E. CONTRACT/PR NO.
N00019-01-XXXX</td><td colspan="4">F. CONTRACTOR
TBD</td></tr>
<tr><td>1. DATA ITEM NO
011</td><td colspan="4">2. TITLE OF DATA ITEM
Maintainability and Built-in-Test Demonstration Report</td><td colspan="4">3. SUBTITLE</td></tr>
<tr><td colspan="3">4. AUTHORITY (Data Acquisition Document No.)
DI-SESS-81603B</td><td colspan="2">5. CONTRACT REFERENCE
SOW Para: 3.19.3.2 and 3.19.3.3</td><td colspan="4">6. REQUIRING OFFICE</td></tr>
<tr><td>7. DD 250 REQ
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BLOCK 4: Applicable for each maintainability and BIT test preformed.
BLOCK 8: Government has 30 days to review and approve.
BLOCK 12 and 13: Submit 60 days after completion of each 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 015	2. TITLE OF DATA ITEM Environmental Stress Screening Procedures and Implementation Plan	3. SUBTITLE
4. AUTHORITY (Data Acquisition Document No.) DI-ENVR-81014A	5. CONTRACT REFERENCE SOW Para: 3.19.3.4	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			
8. APP CODE A (See block 16)		11. AS OF DATE N/A	13. DATE OF SUBSEQUENT SUBMISSION ASREQ (See block 16)	a. ADDRESSEE	b. COPIES: Draft	Final: Reg	Final: Repro
16. REMARKS 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.							
				Other offices: logistics and safety			

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

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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)
8. APP CODE A (See block 16)		11. AS OF DATE N/A	13. DATE OF SUBSEQUENT SUBMISSION NA

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
Other offices: logistics and safety			

16. REMARKS

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

BLOCK 12: First report is due 30 days after start of testing.

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

10 USC 4328 (formerly 10 USC 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 sections L and M of contracts. 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, bolded text in brackets is included 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)	Provide system R&M and BIT models and predictions that support the specification requirements (or any higher values proposed by the Offeror) and that identify the allocated R&M/BIT values of each configuration item. Provide details of data (including field and historical demonstrated data) used in the R&M models to support compliance with the R&M requirements. **[SECTION M EVALUATION FACTOR 1]**
2)	Describe the proposed reliability growth strategy, including the reliability growth planning curve and the process for implementing corrective actions, to plan, track, assess, and improve reliability. **[SECTION M EVALUATION FACTOR 2]**
3)	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]**

4) Describe proposed R&M and BIT design activities, tests (both development and production), and manufacturing processes and screens to meet the specification requirements:
   a) Describe the approach and methodology for developing the R&M block diagrams and math models, allocations, and predictions, as well as the process to ensure results are used to impact the equipment design. Describe the process to ensure analyses are iteratively updated to reflect the current configuration of the design. **[SECTION M EVALUATION FACTOR 4]**
   b) Describe the approach for conducting the FMECA. 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 process for ensuring that the results of the FMECA are used to influence the equipment design and describe the process for ensuring the FMECA is iteratively updated to reflect the current configuration of the design. **[SECTION M EVALUATION FACTOR 4]**
   c) Describe how the failure definition and scoring criteria 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]**
   d) Describe the use of other R&M design activities such as 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 **[SECTION M EVALUATION FACTOR 4]**
   e) 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 root failure cause, how corrective actions will be verified as effective, and how results will be communicated throughout the organization for appropriate approval/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]**
   f) Describe the approach for integrating the Part, Material, and Process (PM&P) management program into the reliability processes. Describe how the approach will flow down to subcontractors and suppliers. **[SECTION M EVALUATION FACTOR 4]**
   g) 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]**
   h) Describe Environmental Stress Screening (ESS) (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 4]**

5)	Describe the maintainability demonstration and integrated BIT (at the subsystem and system levels) approach to mature system performance to meet the specification requirements. **[SECTION M EVALUATION FACTOR 5]**
6)	Describe the use of 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]**
7)	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]**

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

10 USC 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 should address this requirement in sections L and M of contracts. 10 USC 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 USC 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. Ability of the system proposed by the Offeror to comply with specification R&M requirements.
Factor 2: Reliability Growth Plan. The adequacy of the proposed reliability growth plan.
Factor 3: R&M Management. The proposed organization, policies, procedures, and schedules to meet the specification R&M requirements.
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.
Factor 5: R&M Verification Testing: The Offeror’s approach to compliance with specification verification test requirements.

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
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
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

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Office of the Under Secretary of Defense for Research and Engineering
3030 Defense Pentagon
Washington, DC 20301
https://ac.cto.mil/engineering
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