Reliability and Maintainability Engineering Contract Language for the Urgent Capability Acquisition (UCA) Pathway

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Office of Systems Engineering and Architecture

Office of the Under Secretary of Defense for Research and Engineering

Washington, D.C.

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R&M Engineering Contract Language for the Urgent Capability Acquisition Pathway
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Preface

This guide provides sample language for Department of Defense (DoD) program offices to use to incorporate reliability and maintainability (R&M) engineering activities into contracts for the Urgent Capability Acquisition (UCA) pathway. The guide provides recommendations for tailoring the UCA pathway activities and corresponding language to plan for the appropriate R&M for the type of program.

UCA is one of the six Adaptive Acquisition Framework (AAF) pathways introduced in DoD Instruction (DoDI) 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 on the Defense Acquisition University (DAU) website: https://aaf.dau.edu/.

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

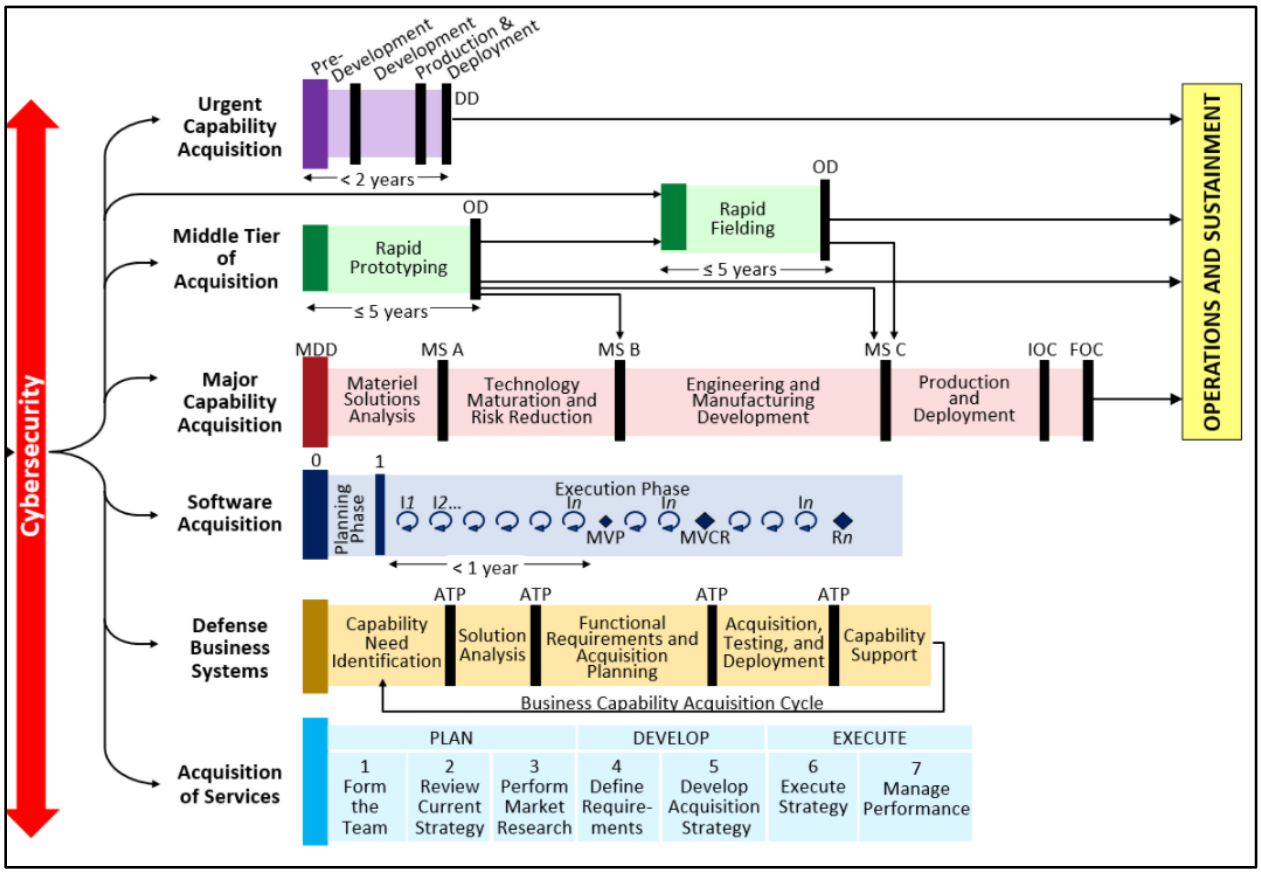
These sections include selected hyperlinks to major sources. Additional sources and links are available in the reference list at the end of the document.

This guidance provides supplemental information to the DoD R&M Engineering Management Body of Knowledge (BoK) located at: https://www.dau.edu/cop/rm-engineering/resources/welcome. 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 (MDAs), 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. UCA Pathway

The purpose of the Urgent Capability Acquisition (UCA) pathway is to field capabilities to fulfill urgent existing or emerging operational needs or quick reactions in less than 2 years. Because of the operational urgency, the normal acquisition processes are aggressively streamlined. The goal is to plan for the capability in a few weeks with development and production measured in months. The imperative is to deliver a useful capability to the warfighter in a timely manner. DoDI 5000.81, "Urgent Capability Acquisition," establishes policy, assigns responsibilities, and provides procedures for acquisition programs that provide capabilities to fulfill operational needs and other quick reaction capabilities that can be fielded in less than 2 years.

Figure 1-2 shows the UCA pathway.

Figure 1-2. The UCA Pathway

UCA has four phases:

- **Pre-Development:** The purpose of this phase is to assess and select a course or courses of action to field a quick reaction capability and develop an acquisition approach.
- **Development:** This phase includes an assessment of the capability in the following areas: performance, safety, suitability, survivability, supportability (including software), and lethality, if appropriate. Not all identified deficiencies, including those related to safety, need be resolved before production or deployment. In consultation with the user and the requirements validation authority, the MDA will determine which deficiencies must be resolved and what risks can be accepted.
- **Production and Deployment (P&D):** During the P&D phase, the acquiring organization provides the warfighter with the needed capability, to include training, spares, technical data, known hazards and accepted mishap risks, computer software, temporary or permanent facilities or infrastructure, support equipment, maintenance, or other necessary logistics support.
- **Operations and Support (O&S):** In the O&S phase, the PM executes a supportability strategy that meets materiel readiness and operational support performance requirements, is safe, and sustains the capability in the most cost-effective manner over its anticipated total life cycle. Planning for O&S, including support funding, will begin during pre-development and will be documented in the acquisition strategy.

The PM and the product support manager (PSM) or life cycle logistician (LCL) will use operational data, including an assessment of the fielded urgent need capability's operational utility, as well as user feedback concerning its performance, to help inform the disposition official's recommendation and highlight key risk areas. The PSM or LCL will identify risks to inform any follow-on procurement and product support performance metrics to create incentives for future improvements in the capability's design to achieve authority to operate and control costs should it transition to a program of record.

DoDI 5000.91, "Product Support Management for the Adaptive Acquisition Framework," establishes policy, describes procedures, and assigns responsibilities for product support management to establish product support factors early in the requirements development and acquisition process to achieve effective and efficient weapon system capability and life cycle management.

A streamlined, highly tailored strategy consistent with the urgency of the need will be employed. Regulatory requirements will be tailored or waived, as appropriate. The tailored acquisition strategy should be brief and contain only essential information, such as resourcing needs and sources; key deliverables; performance parameters; key risks and mitigation approaches; a production schedule; a fielding schedule; contracting methodology and key terms; and preliminary plans for performance assessment of the capability and its supportability, to include software. The UCA pathway includes three types of urgent program efforts:

- **Urgent Operational Need (UON):** Capability requirements identified as having an impact on an ongoing or anticipated contingency operation. If left unfulfilled, UONs are capability gaps that could result in loss of life or critical mission failure. When validated by a single DoD Component, these are known as DoD Component UONs. In their terminology, DoD Components may use a different name for a UON.
- **Joint Emergent Operational Need (JEON):** UONs that are identified by a Combatant Command (CCMD), Chairman of the Joint Chiefs of Staff (CJCS), or the Vice CJCS (VCJCS) as inherently joint and affecting an anticipated contingency operation.
- **Joint Urgent Operational Need (JUON):** UONs that are identified by a CCMD, CJCS, or VCJCS as inherently joint and affecting an ongoing contingency operation.

JUONs and JEONs are defined in CJCS Instruction (CJCSI) 5123.01H and the validation approval will be by the Joint Staff in accordance with that instruction. Program execution for JUONs and JEONs will be assigned in accordance with DoDD 5000.71. DoD Component-specific UONs are defined in CJCS Instruction 5123.01H and further discussed in DoDD 5000.71, "Rapid Fulfillment of Combatant Commander Urgent Operational Needs." Approval authorities for DoD Component-specific UONs, including their validation, program execution, and the designation of the MDA, will be at the DoD Component level.

2 REQUESTS FOR INFORMATION FOR THE UCA PATHWAY

This section provides discussion, R&M guidance, and sample language for a UCA pathway RFI.

In accordance with DoDI 5000.88, 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 for all defense acquisition programs. 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 contracting for a UCA program, 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 other 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.

development configuration. Contractor format is acceptable, and modeling results in lieu of formal presentations or reports are acceptable. Table 2-1 shows sample language appropriate for RFIs to send to potential contractors during study or prototyping contracts (Pre-Development phase).

Table 2-1. Sample RFI Language

(1) Explain how useful R&M measures will be captured from recently developed or fielded similar systems and used in analyzing the potential for the new system to meet operational R&M and sustainment requirements.
(2) Describe the environmental and usage conditions and mission profile(s) for the similar systems from which R&M measures are captured and compare/contrast with usage conditions and mission profile(s) for this program.
(3) Provide system-level estimates based on the similar system analysis for: (a) Reliability measures (mission and logistics) (b) Maintainability measures (to repair mission 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 CONTRACTING FOR THE UCA PATHWAY

Several contracting tools can be used to expedite resolution of urgent needs.

1. Urgent and compelling requirements are exempted from the Competition in Contracting Act. This allows the contracting officer to expedite the procurement, when appropriate, with a sole source award rather than go through the considerably longer competition process of the deliberate acquisition system.

2. Agencies can use an RFP to secure competitive proposals.

3. Agencies can place task orders or delivery orders under GSA Federal Supply Schedule for required products or services. In addition, agencies can establish blanket purchase agreements (BPAs) under all schedule contracts.

4. Agencies can place delivery orders or task orders directly with the schedule contractors.

5. Agencies can use letter contracts. A letter contract, also known as undefinitized contract action,[2] is a means to authorize a contractor to begin delivering supplies or performing services immediately before the terms and conditions of the contract can be agreed upon. This strategy is used only when negotiating a definitive contract is not possible in sufficient time to meet the urgent requirement, and the Government's interest demands that the contractor start immediately.

6. Agencies can establish a Schedule BPA to simplify the acquisition of recurring needs for services or products that are on federal supply schedules.

7. The Department can use Rapid Acquisition Authority (RAA). The RAA is authority, not funding, granted by the Congress to the Secretary or Deputy Secretary of Defense to expedite urgent requirements. RAA should be considered when, within certain limitations, a waiver of a law, policy, directive, or regulation will greatly accelerate the delivery of effective capability to the warfighter. DoD Manual 5000.78, Rapid Acquisition Authority (RAA) provides instructions on submitting RAA requests.

The remainder of this section provides discussion, R&M guidance, and sample language for a letter contract and a contract requiring an RFP. This section is intended to help the R&M engineer identify the engineering activities that should be placed on contract.

[2] The contract term "undefinitized contract action" may be abbreviated UCA but is not necessarily related to the UCA pathway.

3.1. Letter Contract

Letter contracts are used when supplies, products, or services urgently are needed to support a contingency operation or humanitarian/peacekeeping operation. Table 3-1 lists the advantages and disadvantages of a letter contract compared with a contract based on an RFP. Letter contracts are governed by Federal Acquisition Regulation Part 16.603 – Letter Contracts and Defense Federal Acquisition Regulations Supplement Part 216.603 – Letter Contracts.

The following best practices offset the disadvantages of a letter contract:

- The requiring organization issues a statement of urgency.
- The letter contract is used only after the head of the contracting activity or a designee determines in writing that no other contract is suitable.
- The Government is not committed to a definitive contract providing more than the funds available at the time the letter contract is executed.
- A letter contract is not used without competition when competition is required by FAR Part 6.
- A letter contract is not amended to satisfy a new requirement unless that requirement is inseparable from the existing letter contract.
- A letter contract is confirmed within 180 days or before completion of 40 percent of work.

Table 3-1. Advantages and Disadvantages of a Letter Contract

Advantages	Disadvantages
Provides opportunity to rapidly meet urgent mission requirements	Undefined terms and conditions and limited ability to control cost increases risk to the Government
	Reporting requirements increase burden on program office and contracting activity
Reduces time to execute for an immediate authority to proceed	Initial proposals may not meet Government standards, resulting in prolonged negotiations and increasing risk to the definitization[3] schedule
	Elevated level of approvals and government oversight and increases burden on program office and contracting activity

[3] Definitization is the process of determining or agreeing on the terms, specifications, and price of a contract, turning an undefinitized contract into a definitive contract.

An R&M engineer[4] should be involved in the selection of the sole-source contractor for a UCA program. Early involvement by an R&M engineer helps ensure the program emphasizes best R&M practices and a sound systems engineering approach during the program development, P&D, and O&S.

When the Government issues a letter contract, the Government indicates the specific type of definitive contract intended. The contractor will agree to begin promptly negotiating with the contracting officer the terms of the definitive contract that will include the following.

- All clauses required by the Federal Acquisition Regulation (FAR) on the date of execution of the letter contract.
- All clauses required by law on the date of execution of the definitive contract.
- Any other mutually agreeable clauses, terms, and conditions.

Finally, the contractor agrees to submit a specific type of proposal (e.g., fixed-price or cost-and-fee) proposal and cost or pricing data supporting its proposal.

3.2. Purpose and Structure of the RFP

An agency can use an RFP for a UCA acquisition. The RFP is a solicitation used in negotiated acquisition to communicate Government requirements to the prospective contractors and to solicit proposals.[5] At a minimum, the 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

[4] Depending on the size and complexity of the program, one or more R&M engineers may be assigned, or for some smaller programs, the R&M engineer may be part-time, shared with other programs.
[5] 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.

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

Step 5: Finalize the RFP

Step 6: Release to potential Offerors

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

Section A – Solicitation/Contract Form (SF-33)
Section B – Supplies and Services and Prices/Costs
Section C – Description/Specifications/Statement of Work
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.

3.3. Contract Section C – Guidance for the Specification

Table 3-2 provides a general outline of the specification content and lists the requirements that should be integrated into the specification. UCA pathway systems are often procured quickly and without competition. Consequently, it is questionable whether R&M performance requirements are enforceable or how they might be measured, tested, and verified. Therefore, the focus should be on specification guidance for any available R&M performance requirements (e.g., qualitative or quantitative) and acquiring reliability performance data from completion of other tests (e.g., assuming there is little to no R&M specific testing).

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 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.

Table 3-2. Specification Outline

Specification Section	Content
Section 1 - Scope	The Scope statement shall repeat the item name and its modifiers and consist of a clear, concise abstract of the coverage of the specification.
Section 2 – Applicable Documents	List of 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 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. 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. The requiring organization should be careful to avoid creating unrealistic or ambiguous requirements or

requirements that conflict with referenced documents (i.e., handbooks, standards) or with the specification itself.[6]

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

3.3.1. Quantitative R&M Performance Requirements

The specification should define the level of performance, operating conditions, mission profile, use environment, failure definitions, and design constraints in quantitative terms. Other documents, including the Initial Capabilities Document (ICD)/Capability Development Document (CDD)/Capability Production Document (CPD), and Test and Evaluation Master Plan (TEMP), may be used to identify R&M goals and objectives; however, each of the Services may implement UCAs using different documents or may call the documents by different names. In any case, R&M threshold should be validated via the Reliability, Availability, Maintainability, and Cost (RAM-C) analysis and RAM-C Rationale Report, and then translated to design-controllable R&M requirements for inclusion in the specification.

DoDI 5000.81 requires the PM, in collaboration with the intended user community and the requirements validation authority, to assess the required capability and any recommended non-materiel options and, if not adequately stated, determine the performance thresholds. In exploring a possible solution to the user needs, the PM should look at the range of feasible capabilities, near, mid, and long term, to include considering an existing domestic or foreign-made capability. One possible solution to consider is the Course of Action Analysis. This analysis is required by statute and replaces and serves as the Analysis of Alternatives.

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 would then exclude failures of GFE (though if a failure of GFE is caused by the contractor's system design, then 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 parts procurement times, maintenance expended on special or scheduled inspections not due to design-

[6] A 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 (10 U.S.C. 4328 Weapon system design: sustainment factors, which addresses program manager responsibilities for emphasizing R&M requirements, activities, and source selection criteria early during weapon systems design.) initially outlined by the requiring organization in the RFP.

controllable factors, maintenance performed on GFE, and maintenance-induced problems resulting from maintenance error or negligence.

Quantitative R&M design requirements should be defined in Service terms of:

- Mission Reliability (describes the ability to perform required functions for specified mission profiles).
- Maintainability (i.e., corrective maintenance and direct maintenance support).
- Logistics Reliability (includes all failures to ensure they can describe the demand for maintenance and impact to total ownership cost).
- Built-In Test (fault detection, fault isolation, and false alarms rates) to ensure the requirements describe the ability to repair the system and the level of demand required for manpower at all levels of maintenance and storage.

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 interfaces between reliability, maintainability, and product support must be recognized and coordinated early in the formative stages of system design and continue throughout the product life cycle.

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

- *Design Requirements* – The design requirements should translate the R&M goals and objectives in the ICD, draft CDD, or CDD to quantitative specification contract measures the contractor can influence through the design or manufacture of the system, as described previously.
- *Operational Mode Summary/Mission Profile (OMS/MP)* – The OMS/MP is 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 the RAM goal setting in an early phase of weapon system development.

  An OMS/MP projects the anticipated mix 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 movement terrain.

The Combat Developer produces the OMS/MP following development of the system Concept of Operations (CONOPS).[7] The Combat Developer uses the OMS/MP to conduct an analysis to determine the maintenance and the support concepts that describe the levels of maintenance and the maintenance activities that will be conducted at each level.

- *Use Conditions* – A definition of the use conditions, which are all the known natural and induced conditions under which the system must function or survive, should be included. 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. A failure may not occur at the time of stress application but 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 should be considered. The total life cycle of a system is that 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 the system is to be compatible with during its life cycle. Packaging, handling, storage, transportation, maintenance, test, and checkout as well as operational conditions should be included in this description. Use conditions can be presented as a brief narrative description of the anticipated operational conditions under which the system will be used or in an itemized list of known or anticipated ranges of environments and conditions. In either case, an environmental profile should be included. 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 should 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 to 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 cannot be permitted to exceed under any condition. There are many types of

[7] 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.

constraints such as natural 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 relative to its important performance parameters must be clearly stated and understood by all parties. Clearly state 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. Because of this definition, system failure must be oriented to the specific mission of interest. The specific missions should have been identified with the development of the 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.

  The family of failure definitions is related through the configuration, functional mode, phase, and alternative mode similarities. The differences are reflected in those requirements that change from mission to mission. The definitions for each metric and for failure should start with definitions developed as part of the FDSC but should be modified to reflect design-controllable metrics and failures. This modification includes changes in operational to "test" environment and use conditions and inclusion/exclusion of GFE (depending on the contract structure), as well as tailoring based on when and how contract compliance will be measured. Since the UCA Pathway is to develop urgently needed capabilities, the PM should decide if the FDSC applies only to the test environment or should be included in the developmental test period. (For example, if contract compliance will be measured at the end of developmental test, a "mature" reliability requirement should not be specified.)

- *Test Requirements* – The test requirements should define the R&M demonstration and test requirements and acceptance criteria by which the system will be evaluated for conformance to the specified requirements for GO/NO GO decision.

- *Clarifying Notes* – The clarifying notes and R&M evaluation criteria (i.e., FDSC) should eliminate any ambiguity or misunderstanding in specified requirements.

DoDI 5000.81 discusses in detail how performance requirements should be developed. The PM, in collaboration with the intended user com/munity and the requirements validation authority, assesses the required capability and any recommended non-materiel options and, if not adequately stated, determines the performance thresholds so they can be testable for assessment of the minimal set of performance parameters required to adequately reduce the capability gap.

To achieve the performance requirements, including R&M, a tailored acquisition strategy will be developed. This strategy should be brief and contain only essential information, such as resourcing needs and sources; key deliverables; performance parameters; key reliability and maintainability risks and mitigation approaches; a production schedule; a fielding schedule;

contracting methodology and key terms; and preliminary plans for performance assessment of the capability and its supportability, to include software.

The MDA approves the PM's planned testing approach. A normal TEMP is generally unnecessary as TEMPs are usually not appropriate for efforts using UCA procedures when there is minimal development work and minimal test and evaluation to execute. Some test planning is usually required, however, in collaboration with the supporting developmental or operational test organization. The MDA may require a highly tailored and abbreviated test plan that will include schedule, test types and environment, and assets required. If the UCA effort is under Director of Operational Test and Evaluation (DOT&E) oversight, a full TEMP is usually not required, but the PM, in collaboration with the supporting operational test organization, should prepare operational and live-fire test plans for DOT&E approval. An operational test plan for the required pre-deployment performance assessment is generally adequate.

The MDA will approve any appropriate waivers to statute or regulation and specify any additional authority the PM may use to modify the acquisition approach without the specific approval of the MDA. Such decisions will be documented in an Acquisition Decision Memorandum (ADM).

3.3.2 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 hydraulic 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 required under a set of carefully specified test conditions and using different sets of 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.

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

When an RFP is used, a SOW is required. The SOW is used to define the work to be performed by contractors in support of acquisition programs. Preparation of the SOW, therefore, is an important step in planning and defining the acquisition process and work responsibilities. The description of any R&M activity deemed necessary and practical for a UCA program must be integrated into the proposed SOW. These contractually defined activity descriptions 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 3-3. This format is generally applicable to all acquisition phases. See MIL-HDBK-245D for additional information on SOW format and content.

Table 3-3. Statement of Work Outline

SOW Section	Content
1. Scope	Brief description of SOW coverage; must not discuss data requirements, direct contractors to perform work activities, or identify deliverable products.
2. Applicable Documents	Lists only documents referenced in Section 3, Requirements. Contractual citing of standards, specifications, and other documents needed to clarify the work activity must be limited to available documents in effect when the contract is executed. Documents must be cited specifically and directly by number and title. Listing documents in this section without referencing them in Section 3 can adversely affect program costs by adding unnecessary data requirements.
3. Requirements (activities and tasks)	Includes specific work tasks (activities) contractors 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.

The sample SOW language provided in this document applies to R&M engineering activities that are fully integrated within the program's systems engineering process. When appropriately tailored, the sample language can be used for contracts at any stage of an UCA acquisition. The R&M program plan should address the entire life cycle, but the contractor's execution of the plan is limited to those activities that can be accomplished during the contract period of performance.

It is assumed that the quantitative (or qualitative) 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. The language should be tailored based on the maturity of the solution selected (i.e., existing vs. new development) and equipment type.

3.4.1. R&M Engineering Activities

In UCA acquisitions, program-related R&M activities involve R&M analyses and tests; program plans, subcontract management and controls; problem and discussion of risk identification and mitigation measures; failure and material review processes and forums; and other program-related requirements that are essential for an effective R&M engineering program; however, in a UCA acquisition, many activities may be limited in scope or eliminated altogether due to the compressed schedule. A more complete discussion of tailoring R&M activities will be covered in 3.4.2, Tailoring R&M Activities for the UCA Pathway.

Although the development phase for a UCA program includes an assessment of the performance, safety, suitability, survivability, and supportability, it is not required that all identified deficiencies be resolved before production or deployment.[8] The MDA will, in consultation with the user community and the requirements validation authority, determine which deficiencies must be resolved and what risks can be accepted. The accepted risks will allow the user community to develop tactics, techniques, and procedures to help minimize the operational risks. In addition, the SOW must address the need for contractors to have a process for identifying the residual engineering necessary to resolve any such deficiencies and the proposed manner for addressing these deficiencies after fielding.

A program can avoid problem areas by implementing R&M best practices early in the life cycle. Such activities provide statistical evidence that the specified quantitative requirements have been achieved. Activities associated with reliability design such as math models, allocations, FMECA, parts selection, and derating criteria help ensure the inclusion of reliability-enhancing features in the system design from its inception. Again, the compressed schedule for a UCA program and the willingness to accept more risk (by not resolving all deficiencies before production or deployment) means that the imposition of all activities is impossible or impractical for a UCA program.

AAF pathways always require some R&M tailoring. The program selects, modifies, and imposes only those activities that are applicable, cost-effective, and necessary to achieve the specified quantitative R&M requirements. For the UCA pathway, tailoring will be quite extensive, as discussed in section 3.4.2.

3.4.2. Tailoring R&M Engineering Activities for the UCA Pathway

The R&M engineer must understand the life cycle phase, program type, and the anticipated R&M engineering, acquisition, and program challenges to cost-effectively tailor R&M engineering activities. Not only do different R&M engineering activities apply to the different phases of a program depending on the phase being addressed, but the same activities also may be limited in scope or even eliminated depending on the nature of the equipment type and schedule constraints.

Because of the objective of fielding a capability within 2 years of the validation of the urgent need, additional tailoring applies to the UCA pathway. It is essential that the R&M engineer identify any risks associated with the limitations imposed on the R&M activities by the compressed schedule. The R&M engineer should coordinate with the logistics community to

[8] In accordance with DODI 5000.81, Urgent Capability Acquisition, 31 December 2019.

ensure that the program identifies the potential impact of unresolved deficiencies on provisioning of spares and maintenance assets.

- *By Program Phase* – As the UCA program advances through its four phases (Pre-Development, Development, P&D, and O&S), the current program phase at any time is the first discriminator that establishes the type of R&M engineering activities to be applied. For example, in the pre-development phase, a FRACAS and other activities would not be required as the purpose of this phase is to assess and select a course or courses of action to field a quick-reaction capability and develop an acquisition approach. During development, the R&M activities would be selected based on the acquisition strategy and program baseline. Furthermore, all identified deficiencies including those related to safety are not required to be resolved before production or deployment. R&M engineering would need to identify the R&M risks and recommend techniques and procedures to help minimize the operational risks.
- *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 CI[9] 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.

  Ideally, MDAs and PMs use mature technologies or proven equipment for this pathway. Less risk is associated with the use of proven technologies, GFE, COTS, and NDI, and the reliability program can be tailored accordingly.

  If newly designed equipment, unproven technologies, or modified equipment are being used, reliability risks increase, requiring a more intensive, comprehensive reliability program. In such cases, the PM should address any associated risks in the acquisition strategy. Likewise, the R&M engineer should ensure that the tailored R&M program plan (a subset of the Systems Engineering Plan) addresses these risks to the extent possible given schedule constraints.

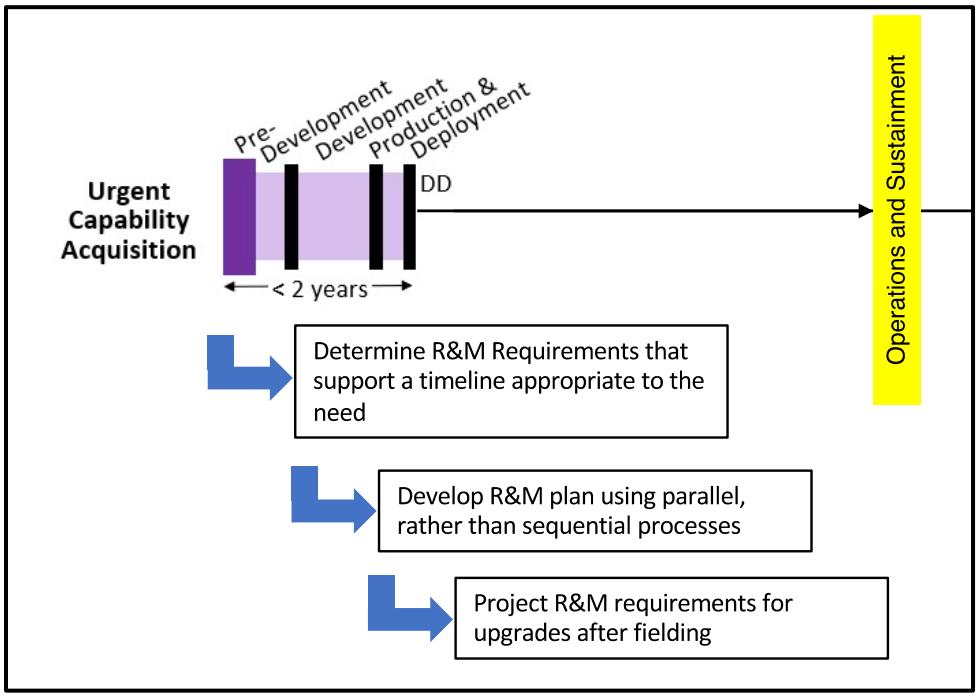
[9] A COTS item must be a commercial item sold in the exact form in substantial quantities. A single change or a new design will result in the item being simply a CI.

In addition, during the O&S phase, the PM or the user community may propose urgently needed improvements to the capability. If improvements are within the scope of the initial requirements document, procedures in a subsequent issuance of the document may be used to acquire the improvements. If outside the scope of the validated or approved requirements document, a new or amended requirements document may be required. The R&M engineer should identify expanded or additional R&M activities to improve the performance of the system.

Software development is of special concern on UCA programs. DoD policy requires programs using the Software pathway to use requirements processes tailored to support Agile software development, including streamlined documentation and continuous user engagement. Agile software development includes the use of automated tools for designing capabilities within a digital engineering ecosystem, can accelerate engineering activities, and reduce the time to develop and field systems. In view of the very short time to develop and deploy a system using the UCA pathway, implementing an Agile development approach for any embedded software is essential.

3.4.3. Tailoring Guide

Figure 3-1 depicts how the entire set of potential R&M engineering activities is tailored to what is required based on the UCA pathway (focusing on UONs) to achieve a cost-effective R&M program.



Source: Adapted from DoDI 5000.81.

Figure 3-1. Tailoring Flow Diagram for the UCA Pathway.

In selecting the activities to be performed by the contractor, the R&M engineer should assess the requirements to determine the following.

1. 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.
2. All plans and activities include and address software being developed for the program.
3. 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 that would be required of the contractor(s).
4. What the contractor(s) will need to provide or share with the community of stakeholders.
5. The R&M technical and acquisition risks that need to be mitigated in part through contractual requirements.

Table 3-4 provides a guide for tailoring R&M tasks by the UCA program phase and type of equipment. The latter includes new development items, modified GFE, CIs, NDIs, and COTS. 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.

Table 3-4 identifies the engineering activities called out in DoDI 5000.02 as well as additional lower-level activities that support the overall R&M engineering program. Checkmarks indicate that tailoring is required to address the type of equipment, unique requirements of the system, the compressed schedules associated with UON acquisitions, and the unique objectives of that path. Other UCA acquisitions follow a similar path.

Table 3-4. Tailoring Guide for the UCA Pathway

SOW Paragraph	R&M Discipline	5000.02	UCA Program Phase				Equipment Type		
			Pre-Development	Development	P&D	O&S	CI & GFE: New Design "Major"	CI & GFE: Modified "Minor"	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			♦5	♦5	♦5			
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	•		♦7	♦7	♦7	✓7	✓7	✓1
3.19.2.3	Maintainability (M(t)) and BIT Allocations, Predictions and Analysis	•		♦7			✓7	✓7	✓2
3.19.2.4	FMECA and Reliability Critical Items	•		♦7	♦7		✓7	✓4	✓3
3.19.2.5	Worst Case/Sneak Circuit Analysis			♦7			✓7		
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			♦6			✓7		
3.19.3.2	Subsystem/Equipment Level BIT Assessment Tests			♦6			✓7		
3.19.3.3	System-Level Reliability, Maintainability and BIT Demonstration			♦6			✓7	✓7	✓7
3.19.3.4	Manufacturing Screening				♦		✓	✓	
3.19.3.5	System Test Monitoring			♦			✓	✓	✓
3.19.3.6	FRACAS			♦	♦		✓	✓	✓

Notes for Table 3-4.

Legend:
- • Identifies activity listed as an R&M engineering activity in DoDI 5000.88.
- ❖ Key task for sole source award
- ✓ Identifies activity that should be performed during a specific program phase or for a specific equipment type
- ♦ Indicates activity must be done in parallel with one or more other activities or eliminated entirely

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.
5. Limited.
6. Very limited prior to fielding.
7. Activity may be limited in scope or impractical to complete in a compressed schedule - associated risks need to be identified to management.

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

3.4.4. Examples of Tailoring for the UCA Pathway

Regardless of the contracting strategy (i.e., letter contract, RFP, BPA, task order, etc.), tailoring of requirements is essential. It is impossible to generalize the tailoring that should be made to all programs following the UCA acquisition pathway. Tailoring must take into consideration the type of system being developed, the technologies being considered, the specific schedule, the system requirements, and many other factors. It is possible, however, to give some examples of the tailoring required for the UCA system acquisition pathway.

Example 1: FMECA[10] and Design

As is true for any program, a FMECA is performed for a UCA program to improve the design in the following ways.

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

A tailored FMECA in a UCA needs to focus on safety and mission-critical functions because the schedule for bringing a solution to the field is compressed and therefore the time available to conduct even a limited FMECA is short. Even assuming that time is available for identifying critical failure modes, there may not be time to implement design changes for anything other than mission- and safety-critical modes. The risks in a UCA acquisition include developing a solution that does not perform as planned, a solution that meets short-term but may not meet

[10] For software, only an FMEA is conducted; a criticality analysis cannot be meaningfully performed because estimating (predicting) reliability is not well suited for software acquisitions.

longer-term needs, and inadequate sustainment planning that may result in requirements for multiple upgrades, more costly improvements, or increases in O&S costs.

Although the development phase for a UCA program includes an assessment of the performance, safety, suitability, survivability, and supportability, because of the urgency, UCA programs are not required to eliminate all deficiencies before P&D.

When the FMECA must be limited or delayed, other tools are available to the design and reliability engineers to minimize risk:

1. Robust design techniques to reduce the sensitivity of a component to potential failure modes.

2. Accelerated testing to find failure modes more quickly.

3. Capitalizing on FMECAs performed for GFE, COTS, and NDI, only modifying the analysis as necessary to account for differences in environment, application, etc.

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 run into thousands of hours. Even for MCA programs, the time can be incompatible with the program schedule. (Program schedules should be developed to provide the needed capability in a timely manner while providing time to reduce risks to an acceptable level.)

For a UCA program, there may be insufficient time to implement a conventional reliability growth program. To address this constraint, RGT should be focused on critical components and equipment. RGT at the system-level (depending on how complex and large the system) is seldom possible.

In addition, one or more of the following may be implemented to supplement and RGT that is both feasible and practical.

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

2. Highly Accelerated Life Testing (HALT) can be used. HALT is a form of accelerated testing used to determine whether an item (e.g., components) can withstand environmental stresses. Early in the development phase of a UON program, HALT can be conducted 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 is continued until the limit of the technology is reached (an extreme example is that despite adding cooling, the device eventually melts). Stresses applied during HALT are typically temperature and/or vibration; however, other stresses, such as electrical or mechanical, are also 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.
    a. The objective is not (nor is possible) to measure reliability.
    b. No attempt is made to avoid introducing failures that would not occur at normal conditions.
3. Robust Design Techniques can be implemented. Sometimes referred to as Taguchi Methods, robust design is intended to make the item in question insensitive to variations in environmental stress. Robust design makes it possible to:
    a. Improve processes and products that are to be used in a broad variety of environments in their life cycle and making processes and products reliable and durable.
    b. Decrease the sensitivity to factors of noise (e.g., aging, product deterioration, environmental factors, customer usage, manufacturing variation) that reduce reliability and other measures of performance.
    c. Adjust or develop formulas and design processes for a product to achieve the desired result at a reduced cost in the shortest turnaround time.
    d. Make designs easier and processes at a reduced cost.

In addition to the preceding tailoring guidance and considering the objective to use proven technologies as much as possible, the FMECA should focus on unproven or high-risk technologies being considered.

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, data from surrogate sources.[11] As testing begins, additional data regarding failure modes and mechanisms become available. Physics of failure (PoF)[12] models are used 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.

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

Contractors should be required 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 values should be based 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 contractor shall provide a table with all elements contributing to critical weaknesses of the system reliability model (SRM. Each SRM element shall include its associated R&M metric and risk criteria (low, medium, high) based upon the following guidance:

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[11] 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.

[12] A technique under the practice of Design for Reliability that leverages the knowledge and understanding of the processes and mechanisms that induce failure to predict reliability and improve product performance. Other definitions of PoF include:

- A science-based approach to reliability that uses modeling and simulation to design-in reliability. It helps to understand system performance and reduce decision risk during design and after the equipment is fielded. This approach models the root causes of failure such as fatigue, fracture, wear, and corrosion.
- An approach to the design and development of reliable product to prevent failure, based on the knowledge of root cause failure mechanisms. The PoF concept is based on the understanding of the relationships between requirements and the physical characteristics of the product and their variation in the manufacturing processes, and the reaction of product elements and materials to loads (stressors) and interaction under loads and their influence on the fitness for use with respect to the use conditions and time.

1. Low Risk – Test data or R&M analysis of comparable systems (under OMS/MP conditions).
2. 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
3. High Risk – Subject matter expert (SME) engineering estimates

Contractors should be required 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. The contractor should provide the Government all mitigation plans upon development.

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

1. Comparison to field data for similar systems where each environmental and use factor has been adjusted for differences (the source of the field data shall be verifiable including those parameters) (preferred).
2. Empirical prediction following the guidance of the governing document such as MIL-HDBK-217, 217Plus, or equivalent (data supported justification for any deviation from the governing document; requires approval for use).
3. A mixture of the preceding two methods with other methods such as PoF, provided each source of data is justified and the method(s) is used correctly.

The prediction process also must be tailored to account for the equipment type in question. For COTS/NDI/GFE, for example, sufficient data from previous field experience with equipment in prior use may be available to make predictions without the need for extensive testing; however, these data must be evaluated for their applicability to what may be a very different environment and different stress levels. The R&M engineer would have to use some judgment in how to adjust any predictions made with field data to account for these differences. For GFE, field data should be available. Again, the R&M engineer would have to adjust predictions made with the data to account for differences in environment and stress levels.

Maintainability predictions should include all levels of maintenance and follow guidance of MIL-HDBK-470A or equivalent.

Once reliability and maintainability test results or field data from the current program are available, they must be used to update the R&M predictions (results will not be to the component level so the prediction may still be used to apportion the high-level results to the lower-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. To report the details of the prediction activity, an R&M Prediction Report should be included in the CDRL.

If robust design has been used, HALT for example, predictions may not be possible (using HALT, the design is as reliable as it can be, given the technology). In such cases, limited statistical testing may be used to establish a lower bound on reliability at a stated confidence. If the lower bound is equal to or higher than the requirement, the reliability is adequate.

For UCA programs, there may be insufficient time to conduct enough testing to develop even lower bound reliability predictions at a high level of confidence. Robust design techniques, as previously discussed in Example 2, should be used. Although techniques such as HALT do not allow predictions to be made, they do result in reliable components and equipment. It may be possible then to use ALT to make quantitative predictions of the achieved level or reliability.

Example 4: Mission Profile and Environmental Characterization

The program cannot achieve adequate levels of reliability unless the R&M engineers and design engineers have acquired full knowledge of all non-operating and operating environments to which a system and its lower-level indentured items (subsystems, major components, assemblies, and parts) will be exposed. The process of environmental characterization must be tailored to the specific system. An example would be a mobile ground-based radar and a main battle tank main gun.

1. The ground-based radar must be transported to a site, installed, and then operated continuously. The R&M engineer must determine which of these “phases” of the fielding and operation of the radar pose the highest level of stress, which may be the transport and installation rather than the actual operation.

2. In the case of the main gun for a main battle tank (MBT), the process becomes much more involved. The gun will experience all the stresses encountered by the MBT in transport (e.g., rail, ship, or aircraft); in different climates (ranging from hot desert with driving sandstorms to cold regions with snow and ice); and in different terrains (open filled with streams, muddy areas, and hardscaped roads or urban areas on dirt or paved roads). In addition, the gun will be exposed to the shock and wear of firing explosive rounds. Hence, the MBT main gun will be exposed to a variety of environments and may react or perform quite differently in each. In addition, the electronics, fuel system, and engine may see environmental stress in each environment that differ from that seen by the system.

Likewise, when a system has different mission phases, such as for an aircraft, the R&M engineer must evaluate the reliability performance of a system in each mission phase.[13] In addition, various subsystems on an aircraft will have different duty cycles and maintenance requirements. For example, a high-power amplifier may be used only during certain mission phases, while an ejection seat will have scheduled maintenance requirements that are different than for the engine.

In view of the short time in which a capability must be fielded under a UON acquisition, characterizing the environment will likely focus on what the R&M engineer determines is the most critical mission. When the capability involves only one mission, the R&M engineer should focus on identifying the environment for the most critical phase of the mission.

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.

3.5. Contract Section C – Sample Statement of Work Language

The following pages present SOW language that could be used for R&M activities on a variety of programs. It can be tailored by the user to meet the specific requirements for the program. For UCA programs, some activities and associated DIDs may be limited or eliminated to ensure a capability can be fielded in 2 years. Section 3.4 of this addendum describes the tailoring needed for UCA programs. Most if not all the activities will need to be conducted in parallel, again to achieve fielding within 2 years.

The CDRL and included DIDs for a UCA program must align with the R&M activities planned for the program and must be tailored to be consistent with the activities as planned.

The R&M engineer should tailor the SOW language in Table 3-5 for UCA phase and equipment type based on Table 3-4. The items in bold at the end of the paragraphs in Table 3-5 are CDRL (DD Form 1423) deliverables. The associated sample CDRLs are shown in “Exhibit A” after Section 3.6 “Contract Section J – List of Attachments” of this document. The paragraph numbering is shown for illustration only.

[13] An aircraft may have several missions. A multi-mission aircraft might be used in an air intercept role, a ground attack role, or in a reconnaissance role.

Table 3-5. Sample Statement of Work Language

3.19 Reliability, Maintainability (R&M) and Built-In Test (BIT) Program requirements.
3.19.1 General. Schedule permitting, the contractor shall have an active R&M engineering program during the **[Program phase]**. This program shall be directed toward ensuring R&M is considered during 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, time permitting, 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 balanced against the acquisition schedule 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 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 as allowed based on the urgency of the acquisition schedule. 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)**

Table 3-5. Sample Statement of Work Language (continued)

3.19.2.2 Environmental Effects Analysis. For critical applications, 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 will be exposed. 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]** as schedule permits. 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, schedule permitting, 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 at the level completed per urgency of the acquisition schedule.

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.

Table 3-5. Sample Statement of Work Language (continued)

(4) The operating and environmental stress factors and ratios, along with other factors used in determining part failure rates, shall be specified 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 and assembly, subsystem, or system failure rates can be tracked if urgency of schedule does not permit failure rates at the part level. 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, and from like and similar systems).

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)**

Table 3-5. Sample Statement of Work Language (continued)

3.19.2.3.1 Physics of Failure and Part Level Stress Analyses. Dependent on the urgency of acquisition and available schedule for in-depth analyses, the contractor shall conduct physics of failure (PoF) 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, 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.

3.19.2.4.1 Software Failure Modes Effects Analysis (SFMEA). The contractor shall identify, confirm, and mitigate the software failure modes affecting mission-critical functions as time permits based on the urgency of acquisition. 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 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 SFMEA 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 SFMEA. 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)**

Table 3-5. Sample Statement of Work Language (continued)

3.19.2.5 Worst Case/Sneak Circuit Analysis. The contractor should perform a worst-case analysis on **(type or category of equipment)** where functional criticality has been identified. The worst-case analysis should 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 should conduct an integrated software and hardware Sneak Circuit Analysis of mission-critical and safety-critical components/circuits. This analysis ensures 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. All results of sneak analysis shall be provided to the Government at design reviews and as required to make program decisions. **(CDRL, Electronic Parts/Circuit Tolerance Analysis Report)**

3.19.2.6 Thermal Analysis and Survey. For critical items identified in paragraph 3.19.2.3 and for safety-critical components, the contractor shall conduct a thermal analysis on **[type or category of equipment]** to ensure adequate application of parts and derating policies. The contractor shall conduct a thermal survey to verify the accuracy of the thermal and derating analyses. The results of these thermal surveys shall be coordinated with the stress analyses required in 3.19.2.3.1 to eliminate hot spots and derating non-conformances. **(CDRL, Technical Report for Studies and Services)**

3.19.2.7 Parts, Materials, and Processes (PM&P) Management Program

The contractor shall establish and maintain an effective PM&P management program as an integral part of the overall design, quality, reliability, and production efforts to ensure uniform PM&P reliability throughout the program life cycle. The PM&P program 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 hardware items that can introduce unacceptable reliability risk to fielded systems. Identify the hardware items from best practice and specific items that have been identified by the Government **[list or reference specific items]**.

(3) Performing requirement analysis, allocation, and design assessments of system element PM&P requirements. Provide traceability of requirements 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 used 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 use process control methodologies for the planning, implementation, and evaluation of the manufacturing processes for assemblies.

Table 3-5. Sample Statement of Work Language (continued)

(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. If Reliability Growth Tests **[specify which test: Accelerated Life Test, Highly Accelerated Life Test, Highly Accelerated Stress Test, conventional reliability growth tests]** are 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. If conducted, 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. Before such testing, a test readiness review is to be conducted. The contractor is expected to submit a test procedure for approval. When conducted, the test procedure should 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 have 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. If BIT assessment tests are conducted on **[type of category of equipment]**, they shall be 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 any BIT assessment tests. **(CDRLs, Reliability and Maintainability Test Plan, Maintainability and BIT Demonstration Test Procedure, and Maintainability, and BIT Demonstration Test Report)**

Table 3-5. Sample Statement of Work Language (continued)

3.19.3.3 System-Level Reliability, Maintainability and BIT Demonstration. The contractor shall incorporate into system test articles corrective actions identified from all 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's 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 System Test Monitoring. The contractor shall monitor R&M parameters on systems and equipment required to meet the requirements of the **[Program Name]** 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 Failure Reporting, Analysis, and Corrective Action System (FRACAS). 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 Failure Reporting. 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 Failure Analyses. The contractor should 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.

Table 3-5. Sample Statement of Work Language (continued)

3.19.3.6.3 Corrective Actions. The contractor, in conjunction with the failure analysis effort, should 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.

3.6. Contract Section J – List of Attachments

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

3.6.1. CDRLs and DIDs

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

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

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

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

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

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

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

3.6.2. Exhibit A: Sample Contract Data Requirements Lists (DD Form 1423)

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

Note that even when an RFP with a SOW and CDRL are used initially or during contract definitization, it may not be possible to include all the following DIDs, even with tailoring. The R&M engineer, in consultation with the Lead System Engineer, must identify those DIDs that are essential and tailor them to be consistent with the program schedule.

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BLOCK 12: Submission is due 60D prior to SRR

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Environment Effect Analysis</td></tr>
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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></td><td></td><td>Reg</td><td>Repro</td></tr>
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Reliability and Maintainability Block Diagrams and Mathematical Models Report</td></tr>
<tr><td colspan="3">4. AUTHORITY (Data Acquisition Document No.)
DI-SESS-81496B</td><td colspan="3">5. CONTRACT REFERENCE

SOW Para: 3.19.2.3</td><td colspan="3">6. REQUIRING OFFICE</td></tr>
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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: Submission is due 60D prior to SRR

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Reliability and Maintainability Allocation Report</td><td colspan="3">3. SUBTITLE</td></tr>
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Reliability and Maintainability Predictions Report</td><td colspan="2">3. SUBTITLE</td></tr>
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BLOCK 12: Submission is due 60D prior to SRR

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Failure Modes, Effects, and Criticality Analysis (FMECA)</td><td colspan="3">3. SUBTITLE</td></tr>
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DI-SESS-81495B</td><td colspan="4">5. CONTRACT REFERENCE

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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></td><td></td><td>Reg</td><td>Repro</td></tr>
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Electronics Parts/Circuits Tolerance Analysis Report</td><td colspan="3">3. SUBTITLE</td></tr>
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SOW Para: 3.19.2.5</td><td colspan="3">6. REQUIRING OFFICE</td></tr>
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DI-SDMP-81748</td><td colspan="4">5. CONTRACT REFERENCE

SOW Para: 3.19.2.7</td><td colspan="3">6. REQUIRING OFFICE</td></tr>
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Reliability and Maintainability Test Plan</td><td colspan="3">3. SUBTITLE</td></tr>
<tr><td colspan="3">4. AUTHORITY (Data Acquisition Document No.)
DI-SESS-81585C</td><td colspan="3">5. CONTRACT REFERENCE

SOW Para: 3.19.3.1 and 3.19.3.2</td><td colspan="3">6. REQUIRING OFFICE</td></tr>
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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.</td><td></td><td></td><td>Reg</td><td>Repro</td></tr>
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N00019-01-XXXX</td><td colspan="3">F. CONTRACTOR
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Reliability Test Procedure</td><td colspan="3">3. SUBTITLE</td></tr>
<tr><td colspan="3">4. AUTHORITY (Data Acquisition Document No.)
DI-SESS-81629B</td><td colspan="4">5. CONTRACT REFERENCE

SOW Para: 3.19.3.1 and 3.19.3.3</td><td colspan="3">6. REQUIRING OFFICE</td></tr>
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BLOCK 12 and 13: Submit 90 days prior to each reliability test. Revisions submitted 30 days after receipt of Government comments.</td><td colspan="2" rowspan="3">Reg</td><td rowspan="3">Repro</td></tr>
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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</td><td colspan="3"></td><td></td><td></td><td>Reg</td><td>Repro</td></tr>
<tr><td colspan="3"></td><td>Other offices: logistics and safety</td><td></td><td></td><td></td></tr>
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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: Submit preliminary 60D prior to PDR for Government review and comment. Submit final 60D prior to CDR. Updates as required to address changes in test program.</td><td></td><td></td><td>Reg</td><td>Repro</td></tr>
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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 colspan="2"></td><td colspan="2"></td><td></td><td></td><td>Reg</td><td>Repro</td></tr>
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BLOCK 8: Government has 30 days to review and approve.

BLOCK 12: Deliver 60 days prior to CDR

BLOCK 13: Revisions 30 days after receipt of Government comments. Final due 60 days before first test.</td><td></td><td></td><td>Reg</td><td>Repro</td></tr>
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BLOCK 8: Government has 30 days to review and comment.

BLOCK 12: First report is due 30 days after start of testing.</td><td></td><td></td><td>Reg</td><td>Repro</td></tr>
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3.7. Contract Section L – Proposal Instructions (Notice to Offerors)

Section L is not used in letter contracts because sole-source awards are made (i.e., no RFP and no proposals or proposal evaluation).

10 U.S.C. 4328 (formerly 10 U.S.C. 2443) requires that sustainment factors, including R&M, be given ample emphasis in the process for source selection and encourages the use of objective R&M criteria in the evaluation of competitive proposals. Programs address this requirement in section L and M of 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."

3.7.1 Instructions for Use

If after definitization of the letter contract, a proposal is required, Section L will be included. 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. 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.

3.7.2 Sample Language

Table 3-6. Sample Section L Language[14]

(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]**

[14] This Sample Section L Language will need to be tailored to what is possible within a rapid schedule typical of a UCA pathway acquisition.

Table 3-6. Sample Section L Language (Continued)

(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]** (i) 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]** (j) 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]** (k) 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]**

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

Section M is not used in letter contracts because sole-source awards are made (i.e., no RFP and no proposals or proposal evaluation).

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

3.8.1 Instructions for Use

If, after the letter contract is definitized, a proposal is required and it includes a Section L, the proposal must also include a Section M. Section M should contain short and concise evaluation factors listed in order of priority and 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. The R&M engineer should ensure Section M aligns with Section L.

3.8.2 Sample Language

Table 3-7. Sample Section M Language[15]

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.

[15] The sample Section M Language will need to be tailored to what is possible within a rapid schedule typical of a UCA pathway acquisition.

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
DoDD	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 and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOSS	Free and Open Source Software
FPGA	Field Programmable Gate Array
FRACAS	Failure Reporting, Analysis, and Corrective Action System
FRB	Failure Review Board
FRP	Full-Rate Production
GFE	Government-Furnished Equipment
GFS	Government-Furnished Software
GOTS	Government-Off-the-Shelf
HALT	Highly Accelerated Life Testing
JCIDS	Joint Capabilities Integration and Development System
LSE	Lead Systems Engineer

MBT	Main Battle Tank
MCA	Major Capability Acquisition
MDAP	Major Defense Acquisition Program
MSA	Materiel Solution Analysis
MTA	Middle Tier of Acquisition
MTBF	Mean Time Between Failures
NDI	Non-Developmental Item
O&S	Operations and Support
OEM	Original Equipment Manufacturer
OMS/MP	Operational Mode Summary/Mission Profile
P&D	Production and Deployment
PM	Program Manager
PM&P	Parts, Materials, and Processes
PoF	Physics-of-Failure
R&M	Reliability and Maintainability
RAM	Reliability, Availability, and Maintainability
RAM-C	Reliability, Availability, Maintainability, and Cost
RCM	Reliability-Centered Maintenance
RFI	Request for Information
RFP	Request for Proposal
RGT	Reliability Growth Testing
SFMEA	Software FMEA
SME	Subject Matter Expert
SOW	Statement of Work
SRM	System Reliability Model
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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DoD Directive 5000.01, "The Defense Acquisition System, Under Secretary of Defense for Acquisition and Sustainment," September 9, 2020.

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

August 2025

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https://www.cto.mil/sea/