Department of Defense Report to Congress Implementation of Recommendations on Total Ownership Cost for Major Weapon Systems

Report for the Congressional Defense Committees

September 2009

Office of the Under Secretary of Defense
Acquisition, Technology & Logistics

Department of Defense Report
Implementation of Recommendations on
Total Ownership Cost for Major Weapon Systems

PL 110-181, SECTION 818

This report responds to the National Defense Authorization Act (NDAA) for Fiscal Year 2008 (PL 110-181), section 818, entitled: Report on Implementation of Recommendations on Total Ownership Cost for Major Weapon Systems

Congressional Language

1) "(a) Report Required - Not later than 180 days after the date of the enactment of this Act, the Secretary of Defense shall submit to the congressional defense committees a report on the extent of the implementation of the recommendations set forth in the February 2003 report of the Government Accountability Office titled "Setting Requirements Differently Could Reduce Weapon Systems' Total Ownership Costs".

   (b) ELEMENTS — The report required by subsection (a) shall include the following:

1) For each recommendation described in subsection (a) that has been implemented, or that the Secretary plans to implement

   a) a summary of all actions that have been taken to implement such recommendation

   b) a schedule, with specific milestones, for completing the implementation of such recommendation.

2) For each recommendation that the Secretary has not implemented and does not plan to implement:

   (a) the reasons for the decision not to implement such recommendation;

   (b) a summary of any alternative actions the Secretary plans to take to address the purposes underlying such recommendation.

3) A summary of any additional actions the Secretary has taken or plans to take to ensure that total ownership cost is appropriately considered in the requirements process for major weapon systems."

Government Accountability Office Recommendations

The February 2003 report (GAO-03-57) of the Government Accountability Office (GAO) titled "Setting Requirements Differently Could Reduce Weapon Systems' Total Ownership Costs" made these recommendations:

"...we recommend the Secretary of Defense:

- revise the Chairman of the Joint Chiefs of Staff Instruction 3170.01B on the requirements generation process to include total ownership cost, especially operating and support cost, and weapon system readiness rates as performance parameters equal in priority to any other performance parameters for any major weapon system before beginning the acquisition program.

- revise the current policy governing the operation of the defense acquisition system (currently under revision) to require that the product developer establish a firm estimate of a weapon system's reliability based on demonstrated reliability rates at the component and subsystem level no later than the end of the system integration phase, coinciding with the system-level critical design review, before proceeding into the system demonstration phase of product development; and at the system level no later than the full-rate production decision.

- structure DOD contracts for major systems acquisitions so at Milestone B the product developer has incentives to ensure proper trades are made between reliability and performance prior to the production decision. One option is to provide specific clauses in the development contract to address reliability growth."

Introduction

In 2006, the Department of Defense (DoD) acted to address the lack of system requirements for ownership cost and reliability, and an increasing trend in numbers of acquisition systems evaluated as "unsuitable" following completion of Initial Operational Test and Evaluation.

DoD established a mandatory Sustainment Key Performance Parameter (KPP) requirement for acquisition systems. The KPP includes three factors: system availability, reliability, and ownership cost. Instituted in 2006, Sustainment KPP has carrried through to the most recent Chairman of the Joint Chiefs of Staff Instruction for Joint Capabilities Integration and Development System, CJCSI 3170.01G dated March 1, 2009 and the accompanying manual. CJCS instructions can be found at: http://www.dtic.mil/cjcs_directives/cjcs/instructions.htm#3000

DoD also chartered a Defense Science Board (DSB) task force to examine the cause of the increasing trend in "unsuitable" systems. The DSB task force published its report in May 2008, with this primary recommendation: "The single most important step necessary to correct high suitability failure rates is to ensure programs are formulated to execute a viable systems engineering strategy from the beginning, including a robust RAM program, as an integral part of design and development. No amount of testing will compensate for deficiencies in RAM program formulation." The Defense Science Board task force report can be found at: http://www.acq.osd.mil/sse/docs/DSB-Rpt-DTE-May2008.pdf.

To implement the DSB task force recommendations, DoD chartered a Reliability Improvement Working Group (RIWG). The RIWG operated for 6 months and published its report on September 4, 2008. A primary product was DoD acquisition policy for system reliability. Other products are discussed later in this report. At the request of Office of the Secretary of Defense (OSD) oversight executives, the military departments presented in September, and again December, 2008, their plans to implement the reliability policy. The intent of these senior reviews was to achieve a "stake-in-the-sand" position across the department, to institutionalize reliability policy implementation across the change in administration. The RIWG report (3 sections) can be found at:
http://www.acq.osd.mil/sse/docs/RIWG-memo-signed.pdf;
http://www.acq.osd.mil/sse/docs/RIWG-Report-VOL-I.pdf;
http://www.acq.osd.mil/sse/docs/RIWG-Report-VOL-II.pdf.

The reliability policy was published in the DoD Instruction 5000.02, December, 2008. It states: "PMs for all programs shall formulate a viable Reliability, Availability, and Maintainability (RAM) strategy that includes a reliability growth program as an integral part of design and development. RAM shall be integrated within the Systems

Engineering processes, documented in the program's Systems Engineering Plan (SEP) and Life-Cycle Sustainment Plan (LCSP), and assessed during technical reviews, test and evaluation (T&E), and Program Support Reviews (PSRs)." The DoDI 5000.02 can be found at: http://www.dtic.mil/whs/directives/corres/pdf/500002p.pdf.

Follow through on the recommendations of the RIWG, and sustained implementation of DoD reliability policy is a work in progress. Oversight is the responsibility of the DoD Systems and Software Engineering (SE) Forum led by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics. The SE Forum has instituted a process for DoD components to report progress quarterly. These quarterly reports are briefed and discussed at the SE Forum. The initial review occurred on March 24, 2009. Calendar year 2009 should be sufficient time to determine the extent to which DoD components are implementing the reliability policy.

Implementation of Recommendations

This portion of the report responds to the request in PL 110-181, Section 818. OSD has implemented all of the GAO recommendations. All recommendations are complete.

1. GAO report recommendation one:

"revise the Chairman of the Joint Chiefs of Staff Instruction 3170.01B on the requirements generation process to include total ownership cost, especially operating and support cost, and weapon system readiness rates as performance parameters equal in priority to any other performance parameters for any major weapon system before beginning the acquisition program."

DoD established a mandatory Sustainment Key Performance Parameter (KPP) requirement for acquisition systems. The KPP includes three factors: availability, reliability, and ownership cost. Since 2006, that Sustainment KPP has carried through to the most recent Chairman of the Joint Chiefs of Staff Instruction for Joint Capabilities Integration and Development System, CJCSI 3170.01G dated March 1, 2009, and the accompanying manual. The current specification for the Sustainment KPP is attached at the end of this report (attachment I).

DoD has published a handbook, called: The Reliability, Availability and Maintainability, and Ownership Cost (RAM-C) Manual. This manual explains how to develop specific values for the different elements of the Sustainment KPP. The RAM-C manual provides detailed guidance on how to develop the ownership cost requirement. The RAM-C manual can be found at: http://www.acq.osd.mil/sse/docs/DoD-RAM-C-Manual.pdf

2. GAO report recommendation two:

"revise the current policy governing the operation of the defense acquisition system (currently under revision) to require that the product developer establish a firm estimate of a weapon system's reliability based on demonstrated reliability rates at the component and subsystem level no later than the end of the system integration phase, coinciding with the system-level critical design review, before proceeding into the system demonstration phase of product development; and at the system level no later than the full-rate production decision."

The DoD reliability policy recommended by the DoD Reliability Improvement Working Group (RIWG) was directed by the Under Secretary of Defense for Acquisition, Technology and Logistics in July 2008. The policy now appears in the December 2008, issue of DoD Instruction 5000.02. It states: "PMs for all programs shall formulate a viable Reliability, Availability, and Maintainability (RAM) strategy that includes a reliability growth program as an integral part of design and development. RAM shall be integrated within the Systems Engineering processes, documented in the program's Systems Engineering Plan (SEP) and Life-Cycle Sustainment Plan (LCSP), and assessed during technical reviews, test and evaluation (T&E), and Program Support Reviews (PSRs)." The DoDI 5000.02 can be found at: http://www.dtic.mil/whs/directives/corres/pdf/500002p.pdf.

The DoD RIWG recommended tools for use across DoD in early planning to enable system reliability. One tool is a scorecard developed by the Army. The tools use is to qualitatively score elements of a Reliability Program, and thereby assess planning by the government program office, or the prime contractor, for system reliability. Sometimes called the "AMSAA Scorecard," it includes these focus areas:

(1) Reliability Requirements and Planning
(2) Reliability Testing
(3) Failure Tracking and Reporting
(4) Verification and Validation

Scoring criteria are presented in the complete scorecard for each area can be found at: https://acc.dau.mil/CommunityBrowser.aspx?id=210483&lang=en-US

The DoD RIWG report also proposed detailed considerations for OSD to assess program reliability by phase of development. The OUSD(AT&L) Systems and Software Engineering office applies a complete, detailed methodology to assess overall program progress. That methodology ("Defense Acquisition Program Support Methodology") includes the RIWG considerations for reliability. Assessment questions include, for example:

- "How does the PM ensure that the reliability requirements are achievable and verifiable within program schedule and budget?"

- "What is the program's phased exit criteria for demonstrated reliability?"

- "How does the program plan to evaluate production processes to ensure that the inherent reliability of the design is maintained throughout production?"

The entire reliability portion of the methodology is attached at the end of this report (attachment II). The complete methodology can be found at: http://www.acq.osd.mil/sse/docs/DAPS_V2.0_Methodology.pdf

System reliability requirements, acquisition policy for reliability, planning tools and assessment methodology to reveal evidence of program progress, by themselves, are not sufficient to assure systems are fielded with their required reliability. Acquisition decision makers must take appropriate action when programs do not properly plan and contract for reliability growth, allocate resources, and demonstrate through testing the requisite reliability during design and development. OUSD(AT&L) requires programs to report, at periodic Program Reviews, their status toward achieving life cycle sustainment metrics which directly relate to the sustainment KPP. Such visibility should go far toward program decisions to assure proper system reliability.

3. GAO report recommendation three:

"structure DOD contracts for major systems acquisitions so that at Milestone B the product developer has incentives to ensure that proper trades are made between reliability and performance prior to the production decision. One option is to provide specific clauses in the development contract to address reliability growth."

The RIWG proposed contract language for use in requests for proposal and subsequent contracts for system design and development. Included with the language is a method to evaluate the proposals of prospective contractors. That contract language is available at: https://acc.dau.mil/CommunityBrowser.aspx?id=219127&lang=en-US

This proposed contract language is powerful, as it is based upon the recent industry standard, ANSI/GEIA-STD-0009 "Reliability Program Standard for Systems Design, Development, and Manufacturing." The standard addresses, for example, the step of "Reliability Verification." The intent is to ensure that the achievement of reliability requirements is verified during design, and reliability does not degrade during production or after fielding. A Reliability Requirements Verification Strategy/Plan may be an integral part of the systems engineering verification, coordinated and integrated across all phases. Verification would be based on analysis, modeling & simulation, testing, or a mixture, and be operationally realistic. The verified System-Level Operational & Environmental Life-Cycle Loads as well as the Failure Definition Scoring

Criteria should be used. It is desirable, where practical, that products of the JCIDS process enable success for these activities by specifying mission conditions, environmental loads, failure criteria, modeling considerations, and so on.

The contracting language is referenced in the Defense Acquisition Guidebook (DAG) which provides non-mandatory amplification to acquisition policy. Clearly, real progress in developing reliable systems is dependent upon the extent to which this language (or similar language) is used in contracting processes. The incentive necessary for prime contractors to develop reliable systems is a funded contractual requirement to do so. The DAG can be found at: https://akss.dau.mil/DAG/

CONCLUSION

At the Department level, policy and guidance is in place to set requirements for acquisition program reliability and ownership cost, to develop systems using a reliability growth program as an integral part of design and development, and to suggest including best practices for reliability in defense contracts for major systems acquisitions. The OSD acquisition and test oversight processes emphasize reliability. Follow-through across the military departments varies in terms of component acquisition policy and implementation. Workforce education, personnel resources, contracting, system design tradeoffs, and acquisition decision making are areas for continued emphasis.

All GAO recommendations have been implemented and no additional actions have been taken. As the department continues efforts to improve system reliability and the resulting total cost of ownership, it looks forward to opportunities to report progress to Congress.

REFERENCES

Report GAO-03-57 "Setting Requirements Differently Could Reduce Weapon Systems' Total Ownership Costs"
http://www.gao.gov/new.items/d0357.pdf

CJCSI 3170 - JCIDS
http://www.dtic.mil/cjcs_directives/cjcs/instructions.htm

RAM-C Manual
http://www.acq.osd.mil/sse/docs/DoD-RAM-C-Manual.pdf

Report of the Defense Science Board Task Force on Developmental Test & Evaluation
http://www.acq.osd.mil/sse/docs/DSB-Rpt-DTE-May2008.pdf.

Report of the Reliability Improvement Working Group
http://www.acq.osd.mil/sse/docs/RIWG-memo-signed.pdf
http://www.acq.osd.mil/sse/docs/RIWG-Report-VOL-I.pdf
http://www.acq.osd.mil/sse/docs/RIWG-Report-VOL-II.pdf

DoDI 5000.02
http://www.dtic.mil/whs/directives/corres/pdf/500002p.pdf

DAPS Methodology
http://www.acq.osd.mil/sse/docs/DAPS_V2.0_Methodology.pdf

ATTACHMENT 1

Extraction from CJCSI 3170 Manual: Sustainment KPP.

There are three factors which are used to fully define system Sustainment.

(1) Availability KPP: Availability will consist of two components: Materiel Availability and Operational Availability. The components provide availability percentages from a corporate, fleet-wide perspective and an operational unit level, respectively. The Operational Availability metric is an integral step to determining the fleet readiness metric expressed by Materiel Availability. The following provides guidance for development of both metrics:

(a) Materiel Availability: Materiel Availability is a measure of the percentage of the total inventory of a system operationally capable (ready for tasking) of performing an assigned mission at a given time, based on materiel condition. This can be expressed mathematically as number of operational end items/total population. The Materiel Availability addresses the total population of end items planned for operational use, including those temporarily in a non-operational status once placed into service (such as for depot-level maintenance). The total life-cycle timeframe, from placement into operational service through the planned end of service life, must be included. This is often referred to as equipment readiness. Development of the Materiel Availability metric is the program manager's responsibility.

(b) Operational Availability: Operational Availability indicates the percentage of time that a system or group of systems within a unit are operationally capable of performing an assigned mission and can be expressed as (uptime/(uptime + downtime)). Determining the optimum value for Operational Availability requires a comprehensive analysis of the system and its planned use as identified in the CONOPS, including the planned operating environment, operating tempo, reliability alternatives, maintenance approaches, and supply chain solutions. Development of the Operational Availability metric is the requirements manager's responsibility.

(2) Reliability KSA: Reliability is a measure of the probability that the system will perform without failure over a specific interval. Reliability must be sufficient to support the warfighting capability needed. Considerations of reliability must support both Availability metrics. Reliability may initially be expressed as a desired failure-free interval that can be converted to a failure frequency for use as a requirement (e.g., 95 percent probability of completing a 12-hour mission free from mission-degrading failure; 90 percent probability of completing 5 sorties without failure). Specific criteria for defining operating hours and failure criteria must be provided together with the Reliability. Single-shot systems and systems for which other units of measure are appropriate must provide supporting analysis and rationale. Development of the Reliability metric is the requirements manager's responsibility.

(3) **Ownership Cost KSA:** Ownership Cost provides balance to the sustainment solution by ensuring that the operations and support (O&S) costs associated with Availability are considered in making decisions. For consistency and to capitalize on existing efforts in this area, the Cost Analysis Improvement Group O&S Cost Estimating Structure will be used in support of this KSA (http://dcarc.pae.osd.mil/reference/osd_ces/index.aspx). As a minimum the following cost elements are required: 2.0 Unit Operations (2.1.1 (only) Energy (fuel, petroleum, oil, lubricants, electricity)); 3.0 Maintenance (All); 4.0 Sustaining Support (all except 4.1, System Specific Training); 5.0 Continuing System Improvements (all). Fuel costs will be based on the fully burdened cost of fuel. Costs must be included regardless of funding source. The O&S value should cover the planned lifecycle timeframe, consistent with the timeframe used in the Materiel Availability metric. Sources of reference data, cost models, parametric cost estimating relationships, and other estimating techniques or tools must be identified in supporting analysis. Programs must plan for maintaining the traceability of costs incurred to estimates and must plan for testing and evaluation. The planned approach to monitoring, collecting, and validating operating and support cost data to support the O&S must be provided. Development of the Ownership Cost metric is the program manager's responsibility."

ATTACHMENT 2 Reliability portion of DAPS Methodology.

EXTRACT

Defense Acquisition Program Support Methodology V2.0

SUB-AREA 5.2 – SUITABILITY

Description: The ultimate goal of an acquisition program is to produce a system that is effective for its intended purpose, suitable for use in the anticipated environment, and affordable to acquire and operate. Acceptable suitability requires the system to be reliable during use (mission reliability), ready when needed (operational availability), have a low overall failure rate (logistics reliability and materiel availability), be easy to repair (maintainability), and require minimal support (reduced logistics footprint).

Scope: The evaluation of this sub-area involves determining the adequacy and depth of the program's plans for reliability, availability, and maintainability (RAM) during concept development; ensuring that requirements are reasonable, achievable, effective for the warfighter, and affordable during Technology Development; evaluating the achieved RAM or establishing a process to achieve the necessary RAM during system development and demonstration; assessing actual RAM achieved, while implementing any corrective actions necessary to ensure that the system is suitable for use, during production and deployment; and ultimately collecting data and performing analyses to calculate actual in-service RAM performance attained.

Perspective: The program manager (PM) should establish RAM objectives early in the acquisition cycle and address them as a design parameter throughout the acquisition process. The PM develops RAM system requirements based on the Initial Capabilities Document or Capabilities Development Document and total ownership cost (TOC) considerations, and states them in quantifiable, operational terms, measurable during Development Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E). RAM system requirements address all elements of the system, including support and training equipment, technical manuals, spare parts, and tools. These requirements are derived from and support the user's system readiness objectives. Reliability requirements address mission reliability and logistics reliability. The former addresses the probability of carrying out a mission without a mission critical failure. The latter is the ability of a system to perform as designed in an operational environment over time without any failures. Availability requirements address the readiness of the system. Availability is a function of the ability of the system to perform without failure (reliability) and to be quickly restored to service (a function of both maintainability and the level and accessibility of support resources).

Maintainability requirements address the ease and efficiency with which servicing and preventive and corrective maintenance can be conducted; that is, the ability of a system to be repaired and restored to service when maintenance is conducted by personnel of specified skill levels and prescribed procedures and resources. Application of RAM and producibility activities during design, development, and sustainment is guided by a concise understanding of the concept of operations, mission profiles (functional and environmental), and desired capabilities. These are, in turn, invaluable to understanding the rationale behind RAM and producibility activities and performance priorities, and pave the way for decisions about necessary trade studies between system performance, availability, and system cost, with impact on the cost-effectiveness of system operation, maintenance, and logistics support. The focus on RAM should be complemented by emphasis on system manufacturing and assembly, both critical factors related to the production and manufacturing, and to the sustainment cost of complex systems. The PM plans and executes RAM design, manufacturing development, and test activities so that the system elements, including software, that are used to demonstrate system performance before the production decision reflect a mature design. Initial Operational Test and Evaluation (IOT&E) uses production representative systems, actual operational procedures, and personnel with representative skill levels. To reduce testing costs, the PM should utilize modeling and simulation (M&S) in the demonstration of RAM requirements, wherever appropriate. (See DoD 3235.1-H.)

An additional challenge associated with RAM is the stochastic nature of the performance parameter. Typically, a large proportion of system requirements is deterministic and can be easily and repeatedly measured; for example, the weight of an item is easily measured and can be repeated on a consistent basis. By contrast, a test of the reliability of an item is an evaluation of a sample, from which the population performance is inferred. The item may be performing to its average reliability requirement as specified, but the sample may return a higher or lower value. Repeated or more extensive samples would provide greater information about the underlying performance. The true reliability of the item is never really known until the item has completed its service. Until that point, the performance may be sampled, and confidence bounds determined for the population performance. Development of RAM requirements and the associated demonstration methods needs to consider the stochastic nature of these parameters.

Factor 5.2.1 – Reliability Assessment

Pre-Milestone A

Criteria

5.2.1.C1: Reliability requirements must meet user's needs and expectations while also being achievable, reasonable, measurable, and affordable.

5.2.1.C2: Materiel reliability (a sustainment key system attribute (KSA)) consists of two parts for which requirements will be indentified/established:

1. Mission reliability: Defined as the probability that the system will operate as intended without mission critical failure throughout a specified mission.
2. Logistics reliability: The mean time between failures (MTBF) of any type whether mission critical or not.

Note: Mission reliability is thus a subset of logistics reliability. Mission reliability is measured using mean time between mission affecting failures (MTBMAF), mean time between critical failures (MTBCF), mean time between system aborts (MTBSA), or other similar conditional MTBFs as required.

5.2.1.C3: Ownership cost (a sustainment KSA) is directly affected, through maintenance and support costs, by a system's logistics reliability. The relationship between the logistics reliability requirements and ownership cost must be considered from the earliest program stages.

5.2.1.C4: The level of system reliability achieved must be demonstrated during the Technology Development (TD) and System Development and Demonstration (SDD) phases to support Low-Rate Initial Production (LRIP) and Full-Rate Production (FRP) decisions Planning for, and funding of, the demonstration efforts start during the earliest program stages.

5.2.1.C5: Assumptions made when determining reliability requirements must be documented (in the Reliability, Availability, Maintainability–Cost (RAM-C) Report and the Reliability Case) and revised as necessary throughout the program's life cycle.

5.2.1.C6: Reliability related risks must be identified, documented, and mitigated throughout the program's life cycle.

5.2.1.C7: Achieved mission reliability is dependent on how the system is used. Early determination of the Operational Mode Summary/Mission Profile (OMS/MP), Operations Tempo (OPTEMPO), and related definitions of operating hours are required for effective reliability planning to occur.

5.2.1.C8: Reliability alternatives must be investigated in order to optimize system materiel availability, operational availability, and life cycle cost (LCC).

5.2.1.C9: Reliability metrics (MTBF, MTBMAF, MTBCF, etc.), either predicted or measured, are invariably estimates requiring that stochastic (i.e., confidence interval) considerations be included.

5.2.1.C10: The effect on support approaches, LCC, and ownership cost of varying reliability values must be considered throughout the program life cycle.

Note: Availability is measured using some form of the equation:

$$Availability = \frac{Uptime}{Uptime + Downtime}$$

Determination of the uptime required (MTBF) requires understanding that the uptime and downtime required are proportional for any given value of availability. Thus availability may be improved by improving the uptime, reducing the downtime, or a combination of both.

5.2.1.C11: The goals of early determination of reliability thresholds and objectives are to help set the trade-space between LCC and logistics footprint reductions. Elements to consider are increased design and acquisition costs versus reduced operating and support costs.

5.2.1.C12: The Analysis of Alternatives (AoA) performed during the Concept Development phase must include evaluation and optimization of the relationships between availability, reliability, support, and LCC (including ownership cost) at a rough level for all candidate approaches until the preferred approach is selected. The analysis of the preferred approach is then further refined and included in program documentation (Initial Capabilities Document (ICD), RAM-C Report, etc.) as required.

5.2.1.C13: The program manager (PM) is responsible for ensuring that established reliability requirements are met. The PM also is responsible for evaluating the achieved level of reliability throughout the program's life cycle.

Note: Some ways for the PM to ensure that the requirements are met include:

- *A robust systems engineering process throughout the life cycle*
- *Reliability experts involved throughout the life cycle*
- *A corrective action system in place*

- *Development testing at the component, subsystem, and system levels*
- *A reliability growth program*
- *Reliability enhancement testing (Highly Accelerated Life Testing (HALT), Accelerated Life Testing (ALT), etc.)*
- *Modeling and simulation (M&S)*

Some ways for the PM to evaluate the achieved level of reliability include:

- *Reliability demonstration testing*
- *Operational testing*
- *Data collection and analysis (Data Collection Analysis and Corrective Action System (DCACAS)/Failure Reporting, Analysis and Corrective Action System (FRACAS))*
- *Updated reliability modeling and analysis throughout the life cycle*

Focus Questions

[Pertinent criteria numbers follow each question.]

5.2.1.Q1: How does the mission reliability requirement meet the user's needs? [5.2.1.C1]

5.2.1.Q2: What mission reliability needs have been identified (thresholds and objectives) and incorporated into the ICD? [5.2.1.C2]

5.2.1.Q3: What logistics reliability requirements have been identified (thresholds and objectives) and incorporated into the ICD? [5.2.1.C2]

5.2.1.Q4: What rationale forms the basis for mission and logistics reliability requirements? [5.2.1.C2]

5.2.1.Q5: How does the logistics reliability requirement affect the planned support system and ownership cost? [5.2.1.C3]

5.2.1.Q6: What reliability cost drivers are incorporated into the Cost Analysis Requirements Description (CARD) (or CARD-like document)? [5.2.1.C3]

5.2.1.Q7: What validation plans are in place to evaluate the reliability requirements? [5.2.1.C4]

5.2.1.Q8: What are the reliability related assumptions and supporting rationale? [5.2.1.C5]

5.2.1.Q9: What are the identified reliability risks and mitigations of those risks? [5.2.1.C6]

5.2.1.Q10: What is the expected OMS/MP? [5.2.1.C7]

5.2.1.Q11: What OPTEMPO is being planned for? [5.2.1.C7]

5.2.1.Q12: How are operating hours documented? [5.2.1.C7]

5.2.1.Q13: What reliability alternatives were investigated? [5.2.1.C8]

5.2.1.Q14: How has the probabilistic nature of reliability been accommodated in the requirements? [5.2.1.C9]

5.2.1.Q15: How have the reliability requirements been incorporated into the support plans? [5.2.1.C10]

5.2.1.Q16: What are the rough estimates for cost-to-design in various levels of reliability? [5.2.1.C11]

5.2.1.Q17: What are the estimated reductions in life cycle costs and logistics footprint for the chosen level of reliability? [5.2.1.C11]

5.2.1.Q18: How were reliability considerations incorporated into the AoA? [5.2.1.C12]

5.2.1.Q19: How does the PM ensure that the reliability requirements are achievable and verifiable within program schedule and budget?

- How does the PM ensure that reliability experts are involved throughout the life cycle?
- What is the planned corrective action system?
- What development test events are anticipated?
- What M&S work is planned? [5.2.1.C13]

5.2.1.Q20: How does the PM plan to evaluate the achieved reliability of the system?

- What reliability demonstration test (DT) events are planned?
- How will DT and operational test (OT) event results be used to update reliability analyses?
- What is the program's plan for collecting data to evaluate reliability?
- What analyses are planned to ensure that reliability meets requirements? [5.2.1.C13]

Pre-Milestone B

Criteria

5.2.1.C15: The Request for Proposal (RFP) includes contractual language related to reliability. *Note: Contractual reliability requirements must be translated from the user's stated requirements. For example, if the user's mission reliability requirement is "...a 90% chance of completing a 10-hour mission without a mission affecting failure," the required MTBMAF is found by solving*

$0.90 = e^{-\frac{10 hours}{MTBMAF}}$ *for MTBMAF. The translation is* $MTBMAF = -\frac{10\,hours}{\ln 0.90} = 94.91\,hours$.

5.2.1.C16: Reliability requirements must be allocated from the system level down to the subsystem, assembly, sub-assembly, and component levels for any repairable or replaceable parts. These allocations start with the major subsystems during the Technology Development (TD) phase and are refined to lower levels as applicable during the System Development and Demonstration (SDD) phase.

5.2.1.C17: Department of Defense (DoD) policy mandates a robust reliability program, including reliability growth, throughout TD, SDD, and Production and Deployment (PD) phases to ensure that reliability is mature at the FRP decision. A robust reliability program includes ongoing analysis of reliability demonstrated to date.

5.2.1.C18: The reliability program is documented in a reliability program plan. The Reliability Program Plan describes in detail all reliability activities anticipated, including schedules, relating to evaluating and enhancing system reliability.

5.2.1.C19: Reliability activities are documented in the Systems Engineering Plan (SEP).

5.2.1.C20: M&S is used to evaluate predicted system reliability throughout the life cycle.

5.2.1.C21: All test event data are assessed and, where appropriate, incorporated into the reliability analyses.

5.2.1.C22: The supplier has a valid reliability program approach as demonstrated by past performance and their program specific reliability approach.

5.2.1.C23: Poor manufacturing processes can degrade the system's inherent reliability, so the PM must plan to evaluate supplier production processes and controls in order to support reliability risk management efforts.

5.2.1.C24: Human systems integration (HSI) must be addressed in order to minimize the probability of:

- Failures induced during system maintenance, operation, and handling
- Operator errors leading to mission failures

5.2.1.C25: Environmental and stress loads affect achieved reliability—which is especially true for commercial-off-the-shelf (COTS) and non-developmental items (NDI)—so the program performs lower-level stress analyses (including measurement of actual stresses when possible) in order to support reliability risk management efforts.

Focus Questions

[Pertinent criteria numbers follow each question.]

5.2.1.Q21: What contractual reliability requirements have been established and incorporated into the RFP? [5.2.1.C15]

5.2.1.Q22: How are incentives for achieved reliability incorporated into the contract? [5.2.1.C15]

5.2.1.Q23: How do the contractual reliability requirements support the user's reliability requirements (i.e., what translations were performed)? [5.2.1.C15]

5.2.1.Q24: How are the reliability requirements documented in the system specifications? [5.2.1.C15]

5.2.1.Q25: How have the reliability requirements been allocated to lower levels? [5.2.1.C16]

5.2.1.Q26: What reliability assessment and growth program approach is included in the RFP? [5.2.1.C17]

5.2.1.Q27: What are the evaluation criteria for growth program progress? [5.2.1.C17]

5.2.1.Q28: How does the program intend to demonstrate achieved reliability with an associated confidence level? [5.2.1.C17]
5.2.1.Q29: What are the program's phased exit criteria for demonstrated reliability? [5.2.1.C17]
5.2.1.Q30: What is the reliability program plan and how is it documented? [5.2.1.C18]
5.2.1.Q31: What reliability engineering and physics of failure (PoF) processes have been initiated (DCACAS/FRACAS, sneak circuit analysis, reliability enhancement testing, finite element analysis, thermal analysis, etc.)? [5.2.1.C18]
5.2.1.Q32: How is reliability incorporated into the SEP? [5.2.1.C19]
5.2.1.Q33: How has the program incorporated reliability M&S? [5.2.1.C20]
5.2.1.Q34: How has the DT plan incorporated reliability-relevant environments? [5.2.1.C21]
5.2.1.Q35: How is the reliability program evaluated (suggest using the reliability program scoring template)? [5.2.1.C22]
5.2.1.Q36: How does the program plan to evaluate production processes to ensure that the inherent reliability of the design is maintained throughout production? [5.2.1.C23]
5.2.1.Q37: How have HSI concerns been addressed to mitigate induced failures? [5.2.1.C24]
5.2.1.Q38: What component load and environmental analyses have been performed to ensure that subsystem environmental concerns are known? [5.2.1.C25]

Pre-Milestone C

Criteria

5.2.1.C26: Lessons learned during the TD and SDD phases must be fed back into the program's documentation, especially where support strategies, operational approaches, and LCC are involved.
5.2.1.C27: Reliability models must be updated throughout the development and fielding of the system in order to fully support trade-offs, system performance analyses, and system optimization efforts. Fielded reliability achieved must be evaluated and documented to allow updating of system support approaches, cost assessments, and improvement efforts.
5.2.1.C28: Reliability test results—including growth testing—must be evaluated in real time to ensure that achieved reliability is sufficient to support the FRP decision and Initial Operational Capability (IOC)/Full Operational Capability (FOC) phases.
5.2.1.C29: Proper reliability risk management requires evaluation of planned versus achieved results throughout the program's life cycle.
5.2.1.C30: Ongoing evaluation of the actual in-service environment, OPTEMPO, and achieved reliability is required to ensure that the OMS/MP and failure definitions (FD)/scoring criteria (SC) are up to date and accurately support system reliability and test analyses.

5.2.1.C31: Reliability testing during DT and Director, Operational Test and Evaluation (DOT&E) events must be planned, reviewed, documented, and the results evaluated for inclusion into the program's reliability documentation.

5.2.1.C32: Poor manufacturing processes can degrade the system's inherent reliability, so the program must plan to evaluate supplier production processes and controls in order to support reliability risk management efforts.

5.2.1.C33: The PM is responsible for ensuring that established reliability requirements are met. The PM also is responsible for evaluating the achieved level of reliability throughout the program's life cycle.

Note: Some ways for the PM to ensure that the requirements are met include:

- A robust systems engineering process throughout the life cycle
- Reliability experts involved throughout the life cycle;
- A corrective action system in place
- Development testing at the component, subsystem, and system levels
- A reliability growth program
- Reliability enhancement testing (HALT, ALT, etc.)
- M&S

Some ways for the PM to evaluate the achieved level of reliability include:

- Reliability demonstration testing
- Operational testing
- Data collection and analysis (DCACAS/FRACAS)
- Updated reliability modeling and analysis throughout the life cycle

Focus Questions

[Pertinent criteria numbers follow each question.]

5.2.1.Q39: How have reliability lessons learned been incorporated into the SEP and the Reliability Program Plan? [5.2.1.C26]

5.2.1.Q40: How have the outputs of engineering and PoF analyses been used to improve the achieved reliability of the system? [5.2.1.C26]

5.2.1.Q41: What are the updated reliability estimates, risks, and mitigations? [5.2.1.C27]

5.2.1.Q42: What is the demonstrated reliability (system, subsystem, or components) to date and documented in the Capability Production Document (CPD)? [5.2.1.C27]

5.2.1.Q43: What are the results of updated reliability M&S? [5.2.1.C27]

5.2.1.Q44: How have updated reliability models been incorporated into the supportability analysis? [5.2.1.C27]

5.2.1.Q45: What are the results of all completed reliability tests, and do they support the planned reliability? [5.2.1.C28]

5.2.1.Q46: What additional reliability testing is planned? [5.2.1.C28]
5.2.1.Q47: What is the status of the reliability growth program? [5.2.1.C28]
5.2.1.Q48: What rationale supports the analysis of the reliability growth program? [5.2.1.C28]
5.2.1.Q49: What logistics footprint reductions have been realized? [5.2.1.C29]
5.2.1.Q50: What is the evaluation of the contractor's reliability program (suggest using the reliability program scoring template)? [5.2.1.C29]
5.2.1.Q51: What is the in-service environment? [5.2.1.C30]
5.2.1.Q52: How was the in-service environment characterized? [5.2.1.C30]
5.2.1.Q53: How has the OMS/MP been affected by the in-service environment? [5.2.1.C30]
5.2.1.Q54: What are the documented FD/SC? [5.2.1.C30]
5.2.1 Q55: How is reliability testing addressed in the Test and Evaluation Master Plan (TEMP)? [5.2.1.C31]
5.2.1.Q56: How will maintenance be performed during system DT/OT? [5.2.1.C31]
5.2.1.Q57: What are the planned reliability assessment methods for DT/OT? [5.2.1.C31]
5.2.1.Q58: How are the test requirements related to user needs (i.e., is there a traceability matrix)? [5.2.1.C31]
5.2.1.Q59: How does operationally realistic subsystem and system testing support the reliability growth assessment? [5.2.1.C31]
5.2.1.Q60: What are the key manufacturing factors affecting reliability? [5.2.1.C32]
5.2.1.Q61: What manufacturing optimization efforts are under way? [5.2.1.C32]
5.2.1.Q62: What have been the results of pilot manufacturing line efforts? [5.2.1.C32]
5.2.1.Q63: What evidence of manufacturing capability and process maturity has been developed? [5.2.1.C32]
5.2.1.Q64: How are DCACAS/FRACAS and Test, Analyze, and Fix (TAAF) resourced throughout production? [5.2.1.C33]

Post-Milestone C

Criteria

5.2.1.C34: Under the concept of total life cycle planning, the PM is responsible for evaluating how the system performs once fielded.

Focus Questions

[Pertinent criteria numbers follow each question.]
5.2.1.Q65: How does the system's Initial Operational Test and Evaluation (IOT&E) performance compare with user requirements (OT report, reliability case, updated risk management, etc.)?

[5.2.1.C34]

5.2.1.Q66: What reliability risk mitigation plans are in place? [5.2.1.C34]

5.2.1.Q67: What are the in-service reliability monitoring and trend analyses results? [5.2.1.C34]

5.2.1.Q68: What is the program plan for obsolescence? [5.2.1.C34]

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