AEROSPACE REPORT NO.
TOR-2007(8583)-6414
Volume 1
Revision 1

Technical Reviews and Audits for Systems, Equipment, and Computer Software

30 January 2009

L. B. (Sam) Peresztegy,[1] Charles E. O'Connor[2]

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Prepared for:

Space and Missile Systems Center
Air Force Space Command
483 N. Aviation Blvd.
El Segundo, CA 90245-2808

Contract No. FA8802-09-C-0001

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Approved by:

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Foreword

This Aerospace Technical Operating Report, TOR-2007(8583)-6414 Volume 1, represents an update to MIL-STD-1521B (USAF) Technical Reviews and Audits for Systems, Equipments and Computer Software, and will be **reissued as an interim USAF Space and Missile Systems Center (SMC) standard (STD) for planning and execution of key system engineering reviews and audits for active and new space system acquisition programs.** In addition, this TOR documents a process and associated criteria designed to take advantage of current technological advancements and management procedures in conducting reviews and audits of System Acquisition Programs.

This TOR is composed of two volumes:

Volume 1 – Defines a generic set of technical reviews and audits for systems, equipment, and computer software end items (EI) for the following reviews:

SRR	-	System Requirements Review
SFR	-	System Functional Review
SAR	-	Software Requirements and Architectures Review
PDR	-	Preliminary Design Review
CDR	-	Critical Design Review
TRR	-	Test Readiness Review
FCA	-	Functional Configuration Audit
PCA	-	Physical Configuration Audit
SVR	-	System Verification Review
M/PRR	-	Manufacturing and Production Readiness Review

Volume 2 – Provides specific and unique supplemental criteria content for the core technical reviews (SRR, SFR, SAR, PDR, and CDR) in Volume 1 for Space Systems specific equipment, and computer software EI.

This update also identifies and delineates criteria for selected disciplines and specialty areas in varying detail and the associated work that shall be performed and documented in support of the core reviews. In addition, this update also defines the required quality attributes, sufficiency, and progress of the contractor's documented accomplishments, along with the engineering disciplines and specialty processes, to be presented as specific evidence of the contractor's accomplishments for each core review.

Acknowledgment

This document is the result of contributions received from many individuals representing a wide spectrum of technical disciplines and subject matter experts (SMEs). The principal contributors and SMEs name, their expertise, and their organizational affiliation are listed below.

Aerospace	Expertise	Aerospace	Expertise
Adams, R.	Software	Kerner, J.	Software Engineering and Interoperability
Ang, V.	Batteries and Space Power Systems	Klein, C.	EO/IR/RF Counter Measures
Baxter, M.	Modeling and Simulation	Knight, F.	Systems Engineering
Benson, R.	Control Analysis	Kruse, W.	Mass Properties
Bletsos, N.	Guidance Systems	Ladner, T.	Data Storage
Campbell, S.	Space Debris Management	Landis, D.	Electrical Power Systems
Chang, J. B.	Architecture & Structures	LeDoux, C.	Software, Digital Processing
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Courter, B.	Ground and Human Systems Integration	Luey, K.	Contamination
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Dupuis, J.	Security, Information Assurance, Program Protection	Patel, N.	Structures
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Eslinger, S.	Software Systems Engineering	Reed, B.	Solar Cells and Arrays
Fisher, T.	Test Equipment	Russell, R.	EO/IR Surveillance
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Watland, G.	Logistics		
Zambrana, M.	Software		

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1. Scope

This document describes the objective requirements for the conduct of Technical Reviews and Audits on such end items (EIs) as a system, equipment, distributed and embedded Software Configuration Item (SWCI), Hardware Configuration Item (HWCI), and/or a combination thereof.

This document is an update to MIL-STD-1521B (USAF) Technical Reviews and Audits for Systems, Equipments and Computer Software, and will be issued as a USAF Space and Missile Systems Center (SMC) standard (STD) for planning and execution of key system engineering reviews. This update also documents a desired process and associated criteria for technical reviews and audits.

This document is composed of two volumes:

Volume 1 – defines a generic set of technical reviews and audits for systems, equipment, and computer software EIs and the guidance for the cost effective application and tailoring of this standard for the reviews described in Appendixes A through K:

Appendix A	System Requirements Reviews (SRR)
Appendix B	System Functional Reviews (SFR)
Appendix C	Software Requirements and Architecture Review (SAR)
Appendix D	Preliminary Design Reviews (PDR)
Appendix E	Critical Design Reviews (CDR)
Appendix F	Test Readiness Review (TRR)
Appendix G	Functional Configuration Audit (FCA)
Appendix H	Physical Configuration Audit (PCA)
Appendix I	System Verification Review (SVR)
Appendix J	Production and Manufacturing Readiness Review (P/MRR)
Appendix K	Application Guide for Tailoring MIL-STD-1521

Volume 2 – provides specific and unique supplemental criteria content for the core technical reviews (SRR, SFR, SAR, PDR, and CDR) in Volume 1 for Space Systems specific equipment, and computer software end items (EIs) to be implemented per the contract Statement of Work (SOW). These criteria also include parts, materials, structures; systems engineering, tests and processes.

This update provides the Government’s requirements for criteria-based technical reviews, specified under the following five major categories:

1. Systems engineering and architecture development
2. System, segment and subsystem design
3. System verification and validation
4. Engineering disciplines and specialty engineering
5. Integrated technical risk and mitigation

of the end item (EI) development maturity and operational utilization objectives in greater detail at the following core reviews:

Appendix A	System Requirements Review (SRR)
Appendix B	System Functional Review (SFR)
Appendix C	Software Requirements and Architectures Review (SAR)
Appendix D	Preliminary Design Review (PDR)
Appendix E	Critical Design Review (CDR)

The update also identifies and delineates criteria for selected disciplines and specialty areas in varying detail and the associated work that shall be performed and documented in support of the above core reviews in terms of generic requirements criteria examples across all DoD systems developments. In addition, this update also defines the required quality attributes, sufficiency, and progress of the contractor's documented accomplishments, along with the engineering disciplines and specialty processes, to be presented as specific evidence of the contractor's accomplishments.

Terms and definitions related to general technical reviews are described in Section 3 of this document. The general technical criteria required for all reviews are provided in Section 4. Section 5 describes the typical working relationships and roles and responsibilities between contractor and contracting agents, which encompass process steps that can be taken in preparation for and closure of each technical review. The content of Section 5 is intended as source material for planning and negotiations for conduct of the technical reviews between the contracting agents.

1.1 Purpose

The technical reviews and audits are necessary systems engineering (SE) activities performed to assess technical progress within a program, relative to contractual requirements and developmental maturity.

Technical reviews of program progress shall be event-driven and conducted when the system under development meets the review entrance criteria as documented in the Systems Engineering Plan (SEP). The technical reviews and audits shall include participation by subject matter experts who are independent of the program (i.e., peer review), unless specifically waived by the SEP approval authority as documented in the SEP.

The technical reviews are conducted by the contractors and subcontractors, also referred to as primes and subs at logical transition points in the development and design efforts, for an idealized EI in various phases of an EI's development to:

1. Determine the contractor's technical progress achieved to date
2. Compare the EIs' performance against the requirements
3. Identify potential impediments and risks to each EI's design execution
4. Determine mitigation plans to avert program schedule delays and unplanned resource expenditures.

The contracting agency shall perform initial tailoring of this document in accordance with (IAW) Appendix K Application Guide for Tailoring MIL-STD-1521, to require only what is needed for each individual acquisition, and address appropriate program scope, program size, and technical progress within the acquisition life cycle.

Technical Reviews and Audits defined herein shall be conducted in accordance with this standard to the extent specified in the contract clauses, Statement of Work (SOW), Compliance Standards List, and the Contract Data Requirements List that is based on the Government's need for technical data required to support the acquisition and life cycle support strategies. Guidance in applying this standard is provided in Section 4 and 5.

These technical reviews provide a method and forum for the primes and subs and the contracting agency to assess whether the status of the end item under development and the supporting documentation have met contract requirements and expectations, with an appropriate level of maturity, to continue to the next phase of the program with manageable risk.

1.2 Objectives of Technical Reviews

DoDI 5000.02 Operation of the Defense Acquisition System (December 2008) instruction, require that the contracting agent schedule and conduct technical reviews and audits (Table 1) with the objectives of enabling means, methods, and forum that provide for timely and critical insight, evaluation and assessment of the contractors technical progress for an evolving system design. Specifically, ascertain that:

1. The product and EI of the technical effort:

a. Will satisfy the intended system's performance requirements and mission objectives

b. Is in compliance with security, environmental safety and occupational health (ES&OH) objectives

c. Is producible, testable, deployable, operable, supportable, maintainable, and reliable

2. The design and development process of the contractor(s) provide for incremental, realistic, measurable and achievable milestones for contractual deliverables

3. Methodologies are in place to identify potential problems or failures, associated risks to program resources (i.e., cost, schedule, and technical), and prevention or their mitigation thereof

This standard provides the contractor(s) with content to establish and maintain a technical review process that meets the contracting agent's expectations and intent.

1.3 Classification

The following technical reviews and audits shall be selected by the program manager at the appropriate phase of program development. Each review and/or audit is defined in Appendixes A through J:

SRR	-	Appendix A	System Requirements Review
SFR	-	Appendix B	System Functional Review
SAR	-	Appendix C	Software Requirements and Architectures Review
PDR	-	Appendix D	Preliminary Design Review
CDR	-	Appendix E	Critical Design Review
TRR	-	Appendix F	Test Readiness Review
FCA	-	Appendix G	Functional Configuration Audit
PCA	-	Appendix H	Physical Configuration Audit
SVR	-	Appendix I	System Verification Review
M/PRR	-	Appendix J	Manufacturing and Production Readiness Review

In order to achieve the generic technical review objectives outlined in Section 4.0, procedures, planning, and all other documentation and data that make up the reviews process shall be defined and made available to the contracting agent for review, assessment, and concurrence at a mutually agreed-upon time, prior to the conduct of each EI review. Roles and responsibilities for the preparation, conduct, and acceptance of each review are described in more detail in Section 5.

Table 1. Acquisition Policy Examples of Specific Technical Review and Audit Objectives

Technical Review or Audit	Objective	DoDI 5000.02 Phase
Analysis of Alternatives (AoA)	Concept Selection, System CONOPS	Material Solution Analysis
System Requirements Review (SRR)	Review SE Program Foundation and Approval of the Initial Requirements Baseline	Technology Development
System Functional Review (SFR)	Review and Approval of the System Architecture and Functional Requirements Baseline	Technology Development
Software Requirements and Architecture Review (SAR)	Review and Approval of the Software Architecture and Functional Requirements Baseline	Technology Development
Preliminary Design Review (PDR)	Approval of the Allocated Baseline	Engineering and Manufacturing Development
Critical Design Review (CDR)	Approval of the Design Baseline	Engineering and Manufacturing Development
Test Readiness Review (TRR)	Verification of the Contractor's Readiness to Begin a Formal Verification Testing	Engineering and Manufacturing Development
Functional Configuration Audit (FCA)	Qualification of the Design	Production and Deployment
Physical Configuration Audit (PCA)	Approval of the Product Configuration Baseline	Production and Deployment
Manufacturing Readiness Review (MRR)	Readiness for Production, Training, Deployment, Ops, Support, and Disposal	Production, Deployment, Operations and Support
Production Readiness Review (PRR)	Authorize Follow-On Procurement of Additional System EIs Complete Initial Small Quantity / Large Quantity Production-Centric Procurement	Production, Deployment, Operations and Support

1.4 Application

The technical reviews and audits defined herein and designated by the contracting agency as called out in the contractual agreements shall be conducted in accordance with this standard to the extent specified in the contract clauses, Statement of Work (SOW), and the Contract Data Requirements List (CDRL) that defines the associated technical data package (TDP) type, elements and data management products required at the appropriate phases of program development. Scheduling of an EI technical review and the actual timing of the review activities shall be tailored for each program, using acquisition strategy and tailoring guidance provided in Section 4 and Appendix K.

1.5 Scheduling of Technical Reviews

The scheduling of a specific technical review is extremely important. If it is conducted too early, the end item for review will not be adequately defined. Conversely, if the review is too late, the program commitments could have been made erroneously, and correction will be both difficult and costly. Scheduling and planning are program management functions and must be addressed in detail in the negotiated Integrated Management Plan (IMP) and Integrated Master Schedule (IMS) after the appropriate SE requirements have been tailored to the type of program contracted, e.g.:

a. Technology Development and/or Technology Demonstration (TD)

b. System Development and Demonstration (SDD)

c. Engineering Development (ED)

d. Risk Reduction and Design Development (RRDD), etc.

In accordance with the practice of good systems engineering principles, SRR and SFR shall be conducted as “top-down” reviews, where the requirements are established and appropriately allocated to the lower elements of the system under review. Conversely, PDR and CDR shall be conducted as “bottom-up” reviews from the lowest elements, culminating in an overall system review. SAR typically follows SFR on a build-by-build basis for an individual Software Configuration Item (SWCI) or a collection of SWCIs.

A good method for scheduling technical reviews is to relate them to the documentation requirements, e.g., schedule a PDR after the availability of hardware development specification or software architecture and detailed design and software test plans, since the essence of the PDR is to assess the contractor’s approach to meeting the requirements of these documents. Scheduling of technical reviews is dependent not only on documentation availability but also on hardware and software availability and the completion of the acceptance qualification tests.

Although a time frame for reviews is defined in the DoDI 5000.02 Operation of the Defense Acquisition System (08 Dec 2008) instruction, the review date for a given program may vary. The initial timing of each EI review shall be provided to the contracting agency by the qualified bidders as part of their proposal or IMP and IMS or as part of their systems engineering management plan (SEMP).

2. Documents

Documents named or referenced within this standard, whether they are specifications, standards, handbooks, guides, drawings, CDRLs or Data Item Descriptions (DIDs), are **NOT** to be considered as compliance documents unless called out specifically by contract Statement of Work (SOW) or compliance documents list for the preparation and conduct of the design reviews. The SOW shall be referenced for applicable documents. (Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the contracting agency or as directed by the contracting officer).

The following list of documents were used as source material in preparation of this document

1. AFR 66-14, Equipment Maintenance Policies, Objectives, and Responsibilities
2. AFSPC Manual 91-710 Range SW Safety STD (1 May 2004)
3. ANSI/EIA 649A National Consensus Standard for Configuration Management (2006)
4. ASC/EN GUIDE – USAF Aeronautical Systems Center Technical Reviews/Audits for Aeronautical Weapon System Acquisition (19 Jul 2006)
5. DoD 5000.4M Cost Analysis Guidance and Procedures (Dec 1992)
6. DoD Defense Acquisition Guidebook (14 October 2004)
7. DoD-D-1000B - Drawings, Engineering And Associated Lists (28 October 1977)
8. DoD Directive 5000.1 “The Defense Acquisition System,” (13 May 2003)
9. DoDI 5000.02 “Operation of the Defense Acquisition System” (08 Dec 2008)
10. DoD MIL-STD 498 Software Development & Documentation (Dec 1994)
11. DoDAF v 1.0 DoD Architecture Framework (AF) Volumes 1 and 2 (9 Feb 2004)
12. DoDD 4630.5 “Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)” (23 Apr 2007)
13. DoD MIL-STD-1833 Test Requirements For Ground Equipment And Associated Computer Software Supporting Space Vehicles (13 Nov 1989)
14. DoD Risk Management Guide for Acquisition, Sixth Edition, v 1.0 (Aug 2006)
15. DoD Systems Engineering Plan (SEP) Preparation Guide Version 1.02 (10 February 2006)
16. DoD Technology Readiness Assessment (TRA) Deskbook – DUSD(S&T) (May 2005)
17. IMP & IMS Preparation and Use Guide Version 0.9 (21 October 2005)
18. ISO/IEC STD 15939 Software engineering - Software measurement process (11 Jul 2002)
19. MIL-STD-882D DoD Standard Practice for System Safety (10 Feb 2000)
20. MIL-STD-961E Defense and Program-Unique Specifications Format and Content (Aug 2003)
21. MIL-STD-963B Data Item Descriptions (DIDs) Practice (31 August 1997)
22. MIL-STD-1472F DoD Design Criteria STD for Human Engineering (23 August 1999)
23. MIL-STD-1521B (USAF) Military Standard, Technical Reviews and Audits for Systems, Equipments, and Computer Software (4 Jun 1985) including Notices 1 and 2
24. MIL-DTL-31000C Detail Specification Technical Data Packages (9 Jul 2004)
25. SMC Systems Engineering Primer and Handbook, 2nd Edition (29 Apr 2005)
26. SMCS-S-002 Configuration Management (13 June 2008)
27. System and Software Reviews Since Acquisition Reform, Southern California SPIN (2 Apr 2004)
28. Systems Engineering Plan (SEP) Preparation Guide, v 1.02 (12 Feb 2006)
29. TOR-2004(3909)-3537 Rev. B Software Development Standard for Space Systems

30. TOR-2006(8506)-5749, Mission Assurance Tasks for Software (30 Apr 2007)

3. Definitions of Technical Reviews and Audits

The terms defined in this section are included to augment the understanding of the dialog and discourse contained in this document, by providing context elaboration and clarification and consistency.

3.1 System Requirements Review (SRR)

The SRR is a multifunctional technical review or a series of reviews that shall be conducted to ensure that all system and performance requirements are derived from the Initial Capabilities Document (ICD) or draft Capability Development Document (CDD) and are defined and consistent with cost (program budget), schedule (program schedule), risk, and other system constraints.

The SRR assesses the system requirements captured in the system specification and ensures the consistency between the system requirements and the preferred system solution and available technologies.

The SRR is typically held well in advance of Milestone B to allow time for issue resolution and proper executive-level concurrence on process and results. The SRR can convene prior to program initiation or during technology development and is typically convened during system development and demonstration when a significant portion of the system functional requirements has been established.

3.2 System Functional Review (SFR)

The SFR is a multidisciplinary technical review or a series of reviews that shall be conducted, to ensure that the system under review can proceed into preliminary design, and that all system requirements and functional performance requirements derived from the Capability Development Document are defined and are consistent with cost (program budget), schedule (program schedule), risk, and other system constraints. Generally this review assesses the system functional requirements as captured in system specifications (functional baseline), and ensures that all required system performance is fully decomposed and defined in the functional baseline. System performance may be decomposed and traced to lower-level subsystem functionality that may define hardware and software requirements. The SFR determines whether the system's functional definition is fully decomposed to a low level, and whether the Integrated Product Team (IPT) is prepared to start preliminary design.

Completion of the SFR shall provide:

1. An established system functional baseline
2. An updated risk assessment for the System Development and Demonstration phase
3. Current data to update the Cost Analysis Requirements Description (CARD) document, based on the contractor's proposed system functional baseline
4. An updated program development schedule including system and software critical path drivers
5. An approved SWCI with updates applicable to this phase

The SFR determines whether the system's lower-level performance requirements are fully defined and consistent with the mature system concept, and whether lower-level systems requirements trace to top-level system performance and the Capability Development Document. A successful SFR is predicated upon the IPTs determination that the system performance requirements, lower-level performance requirements, and plans for design and development form a satisfactory basis for proceeding into preliminary design.

The program manager shall tailor the review to the technical scope and risk of the system, and address the SFR in the Systems Engineering Plan. The SFR is the last review that ensures that the system is credible and feasible before more technical design work commences.

Typical SFR success criteria include affirmative answers to the following exit questions:

1. Can the system functional requirements, as disclosed, satisfy the Capability Development Document?

2. Are the system functional requirements sufficiently detailed and understood to enable system design to proceed?
3. Are adequate processes and metrics in place for the program to succeed?
4. Are the risks known and manageable for development?
5. Is the program schedule executable (technical and cost risks)?
6. Is the program properly staffed?
7. Is the program with the approved functional baseline executable within the existing budget?
8. Is the updated Cost Analysis Requirements Description consistent with the approved functional baseline?
9. Does the updated cost estimate fit within the existing budget?
10. Has the system Functional Baseline been established to enable preliminary design to proceed with proper configuration management?
11. Is the software functionality in the approved functional baseline consistent with the updated software metrics and resource loaded schedule?

3.3 Software Requirement and Architecture Review (SAR)

The Software Requirements and Architecture Review (SAR) consists of a series of multidisciplinary reviews of the software requirements, architecture, and test planning of technical products, software development processes, and the current state of the software development for all software items. SAR is a review of the finalized Software Item (SI) requirements and operational concept. The SAR shall be conducted when SI requirements have been sufficiently defined to evaluate the contractor's responsiveness to and interpretation of the system, subsystem, or prime item-level requirements. A successful SAR is predicated upon the contracting agency's determination that the Software Requirements Specification(s), Interface Requirements Specification(s), and Software Test Plan Operational Concept Document form a satisfactory basis for proceeding to preliminary software design cycle. See Appendix C for additional SAR information. **Note:** Software Configuration Item (SWCI) and software item (SI) have the same meaning and are used interchangeably throughout the technical community.

3.4 Preliminary Design Review (PDR)

The PDR is the formal culmination of a series of multidisciplinary PDRs of the system and of a series of reviews of individual Configuration Items (CIs) that shall be conducted to ensure that the system under review can proceed into detailed design and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints.

Typical PDR outcomes include:

1. The assessment that the system preliminary design as captured in performance specifications for each configuration item in the system, the allocated baseline (ABL), and ensures that each function in the functional baseline (FBL) has been allocated to one or more of the configuration items. Configuration items shall consist of hardware and software elements and include such items as airframes, avionics, weapons, crew systems, engines, trainers and training, etc.
2. The determination of the compatibility of the CIs with performance and engineering specialty requirements of the Hardware Configuration Item (HWCI) development specification
3. The evaluation that the degree of definition and assess the technical risk associated with the selected manufacturing methods and processes
4. The establishment of the existence and compatibility of the physical and functional interfaces among the configuration item and other items of equipment, facilities, computer software, and personnel

5. The measurement of the progress, consistency, and technical adequacy of the selected top-level SWCI designs and test approaches

6. The assessment of the compatibility between software requirements and SWCI(s) preliminary design

7. The PDR's evaluation of the preliminary version of the SWCI(s) operation and support documents

3.5 Critical Design Review (CDR)

The CDR is a multidisciplinary technical review of the system and of a series of CDRs of individual CIs that shall be conducted for each configuration item when detailed design is essentially complete, with the objective to ensure that the detailed design of each individual configuration item that is an integral part of the system under review can proceed into fabrication, system integration, demonstration, and test, and can meet the stated performance and engineering specialty requirements of the configuration item development specifications within cost (program budget), schedule (program schedule), risk, and other system constraints.

1. The CDR establishes the detailed design compatibility among the configuration item and other items of equipment, facilities, computer software and personnel

2. The CDR assesses configuration item risk areas (on a technical, cost, and schedule basis)

3. The CDR assesses the results of the producibility analyses

4. The CDR focuses on the determination of the acceptability of the detailed design, performance, and test characteristics of the design solution, and on the adequacy of the operation and support documents

5. The CDR assesses the system final design as captured in product specifications for each configuration item in the system (product baseline), and ensures that each product in the product baseline has been captured in the detailed design documentation, e.g., product specifications for:

    a. Hardware, to enable the fabrication of configuration items, and include production drawings

    b. Software, (e.g., software architecture and detailed design documents) of one or more Software Configuration Item (SWCI), to the extent specified in the Software Development Plan (SDP) based on the selected life cycle model(s)

6. For complex systems, the contractor may conduct a CDR for each subsystem or configuration item. These individual reviews would lead to an overall system CDR. When individual reviews have been conducted, the emphasis of the overall system CDR shall focus on configuration item functional and physical interface design, as well as overall system detailed design requirements

7. The System CDR determines whether the hardware, human, and software final detailed designs are complete to the extent specified in the SDP based on the selected life cycle model(s), and whether the contractor is prepared to start system fabrication, demonstration, and test

3.6 Test Readiness Review (TRR)

The Test Readiness Review (TRR) is a multifunctional and multidisciplinary review and process assessment that shall be conducted, to verify the contractor's readiness to begin a formal verification testing event for an end item (EI). It is conducted for each EI to determine whether the test procedures are complete and to assure that the contractor is prepared for formal EI testing. Test procedures are evaluated for compliance with respective test plans and descriptions, and for adequacy in accomplishing test requirements. At TRR, the contracting agency also reviews the results of development testing and any updates to the operation and support documents. A successful TRR is predicated on the contracting agency's determination that the test procedures, environment, and previous test results form a satisfactory basis for proceeding to formal EI testing.

3.7 Functional Configuration Audit (FCA)

The Functional Configuration Audit (FCA) is a verification process that shall be convened periodically to ascertain that the actual performance of a CI meets the requirements stated in its performance specification and to certify that the CI has met those requirements.

1. The FCA is convened to verify that the actual performance of the system meets the requirements stated in the system performance specification. For very large, complex CIs/systems, the audits can be accomplished in increments. Each increment shall address a specific functional area of the CI/system and document any discrepancies that are found in the performance capabilities of that increment
2. The FCA also reviews the completed operation and support documents
3. A formal FCA is performed to validate that the development of a configuration item has been completed satisfactorily and that the configuration item has achieved the performance and functional characteristics specified in the functional or allocated configuration identification
4. A summary FCA can be convened to address the status of all of the action items that have been identified by the incremental FCAs, in order to document and certify their completion

3.8 Physical Configuration Audit (PCA)

The PCA is a technical examination of a designated configuration item that shall be performed, to verify that the configuration item "As Built" conforms to the technical documentation that defines the actual configuration of an item being produced.

1. The PCA verifies that the design documentation matches the EI as specified in the contract
2. The PCA confirms that the manufacturing processes, quality control system, measurement and test equipment, and training are adequately planned, tracked, and controlled. The PCA also validates many of the supporting processes used by the contractor in the production of the item, and verifies other elements of the item that may have been impacted or redesigned after completion of the System Verification Review (SVR)
3. The PCA is convened prior to the full-rate production decision or when the Government plans to control the detailed design of the item it is acquiring via the Technical Data Package. When the Government does not plan to exercise such control or purchase the item's Technical Data Package (e.g., performance-based procurement), the contractor shall conduct an internal PCA to define the starting point for controlling the detailed design of the item and establishing a product baseline
4. The PCA is considered complete when the design and manufacturing documentation matches the item as specified in the contract

3.9 System Verification Review (SVR)

The SVR is a test, inspection, or analytical process by which a group of configuration items that make up the system shall be verified to have met specific contracting agency contractual performance requirements (specifications or equivalent). This review does not apply to hardware or software requirements verified at FCA for the individual configuration item.

3.10 Manufacturing Readiness Review (MRR)

MRRs shall be conducted by the prime contractor, to ensure readiness to build a quality product that inherently embodies defense-unique and/or defense-critical manufacturing capabilities characteristic of a desired defense contractor, as appropriate for the program under review, before commencing manufacture of a unit or other contractually designated configuration items by the prime contractor, subcontractor, or critical component supplier.

3.11 Production Readiness Review (PRR)

PRRs shall be conducted to assist the Government in the evaluation of the production risks and the contractor's methodology to manage those risks and the determination that the contractor, their sub-contractors, and suppliers have resolved to the satisfaction of the Government the PRRs' findings and specific actions prior to executing a production go-ahead decision.

1. PRRs are accomplished in an incremental fashion during the Full-Scale Development phase (usually two initial reviews and one final review) to assess the risk in exercising the production go-ahead decision. In its earlier stages the PRR concerns itself with gross-level manufacturing concerns such as the need for identifying high-risk and low-yield manufacturing processes or materials or the requirement for manufacturing development effort to satisfy design requirements. The reviews become more refined as the design matures, dealing with such concerns as adequate production planning, facilities allocation, incorporation of producibility-oriented changes, identification and fabrication of tools and test equipment, long-lead item acquisition, etc.
2. The PRR examines risk; it determines if production or production preparations incur unacceptable risks that might breach thresholds of schedule, performance, cost, or other established criteria
3. The PRR evaluates the full, production-configured system to determine if it correctly and completely implements all system requirements
4. The PRR determines whether the traceability of final system requirements to the final production system is maintained
5. Timing of the incremental PRRs is a function of program posture and is not specifically locked in to other reviews

4. Technical Review Objectives

Technical reviews are necessary systems engineering activities designed to assess progress within a project relative to its planned technical and/or contractual objectives. These reviews:

1. Serve as a technical review guide for the contracting agency and Government (also interchangeably referred to as "contracting agent") from program definition through EI development
2. Assure that technical reviews are conducted at logical transition points in the development effort to assess program health and readiness to proceed to subsequent phases with acceptable risk
3. Assure that technical reviews provide a method for program teams to determine progress achieved to date, assess predicted or actual performance against the requirements, identify potential problems and risks, and determine the need for mitigation plans to avert schedule delays and cost growth to the program
4. Assure that technical reviews facilitate contractor and contracting agent concurrence on technical progress, and help ensure a successful review against a mutually agreed-to set of criteria
5. Assure that the technical reviews criteria defined for each review are based on candidate criteria identified in Section 6
6. Assure that, during each review, all criteria elements will be reviewed against the program technical requirements and their associated impacts to program cost and schedule
7. Assure that the components of this document are tailored by the contracting agent in context of the acquisition agent's program objectives and resources to execute the end item development effort and take into account to the maximum extent possible the existing capabilities and resources that are already in place at the contractor's and subcontractor's facilities to support these reviews

These objectives are applicable at all levels of the enterprise (e.g., prime contractor, subcontractor, and vendor levels). Government customer involvement in reviews and audits shall vary according to the needs of the specific program.

4.1 Reviews Specified

The following reviews and audits shall be conducted:-

SRR	-	Appendix A	System Requirements Review
SFR	-	Appendix B	System Functional Review
SAR	-	Appendix C	Software Requirements and Architectures Review
PDR	-	Appendix D	Preliminary Design Review
CDR	-	Appendix E	Critical Design Review
TRR	-	Appendix F	Test Readiness Review
FCA	-	Appendix G	Functional Configuration Audit
PCA	-	Appendix H	Physical Configuration Audit
SVR	-	Appendix I	System Verification Review
M/PRR	-	Appendix J	Manufacturing and Production Readiness Review

4.2 Technical Review Criteria

Technical Review Criteria (TRC) for all reviews shall be composed of all items necessary to illustrate that the program is technically progressing according to plan and ready to move into the next phase or event. Figure 1 illustrates the generic flow of the review process to be conducted as a joint activity between the Contractor officer's representative and the Contractor, Subcontractor, and EI developer.

The list of TRCs that the contractor needs to provide at technical reviews shall include but not be limited to:

1. A list of measurable metrics and accomplishments that demonstrate contractor-planned progress and developmental maturity for the review conducted
2. Risk assessments for all items or issues that are on a critical path, e.g.:
    a. No high-risk items that would prevent a "move forward" decision
    b. Any high-risk items to be presented must be accompanied by an appropriate mitigation plan
3. Data that demonstrates performance that is accumulated and ready for review
4. Key decisions that are complete, executable, and fully supportable
5. Other items as specified by the contracting agent or as tailored by contract, prior to and specifically for each review or audit event
6. Elements that correspond with relevant events or items as contractually defined, incorporated, or expanded, i.e.:
    a. The program Integrated Master Plan (IMP) and Integrated Master Schedule (IMS)
    b. The Statement of Objectives or Statement of Work (SOW)
    c. The Requirements Allocation Document (RAD)
7. Action items from previous technical reviews are completed and closed

The TRC list is prepared to ensure that the reviews culminate in a determination of readiness, or a direct plan for achieving readiness to move forward. As such, qualification for entrance into the review implies that all criteria elements have been performed or adequately addressed for a given review milestone and are fully ready for presentation and assessment.

4.3 Technical Review Success

Technical review success is achieved when all criteria elements have been demonstrated by the contractor to the satisfaction of the contracting agency, against a mutually agreed-to set of "Acceptance Criteria**"** by:

1. Concluding and verifying that the end state of a criteria item has been accomplished
2. Correlating each end state to a specific requirement(s)
3. Defining the basis of measurement or metrics used to substantiate and confirm that the end state of the criteria item has been adequately met

"Acceptance Criteria" are objective evidence of accomplishment, and when realized, they provide sufficient evidence to the contracting agency's satisfaction and acceptance that demonstrates that the design solution selected and the completion criteria elements assigned by the contractor to each design review milestone:

1. Are traceable to all technical requirements
2. Correspond to the system architecture
3. Can be synthesized into an EI design that is realistic and physically producible
4. Can be implemented to satisfy the user's operational needs for a reasonable cost and acceptable risk
5. Have review criteria for the assessment of technical progress that:
    a. Are appropriately tailored to reflect pertinent acquisition strategy
    b. Are appropriately tailored to reflect major risk drivers peculiar or unique for each program
    c. Allow for the preparation of documented evidence of progress

d. Are sufficient to allow for an informed judgment of readiness and contracting agency's approval to proceed to program execution for the next level of design maturity

General guidance for the "Acceptance Criteria", generic to any developmental DoD program, is provided in Appendices A through E specific to SRR, SFR, SAR, PDR, and CDR.

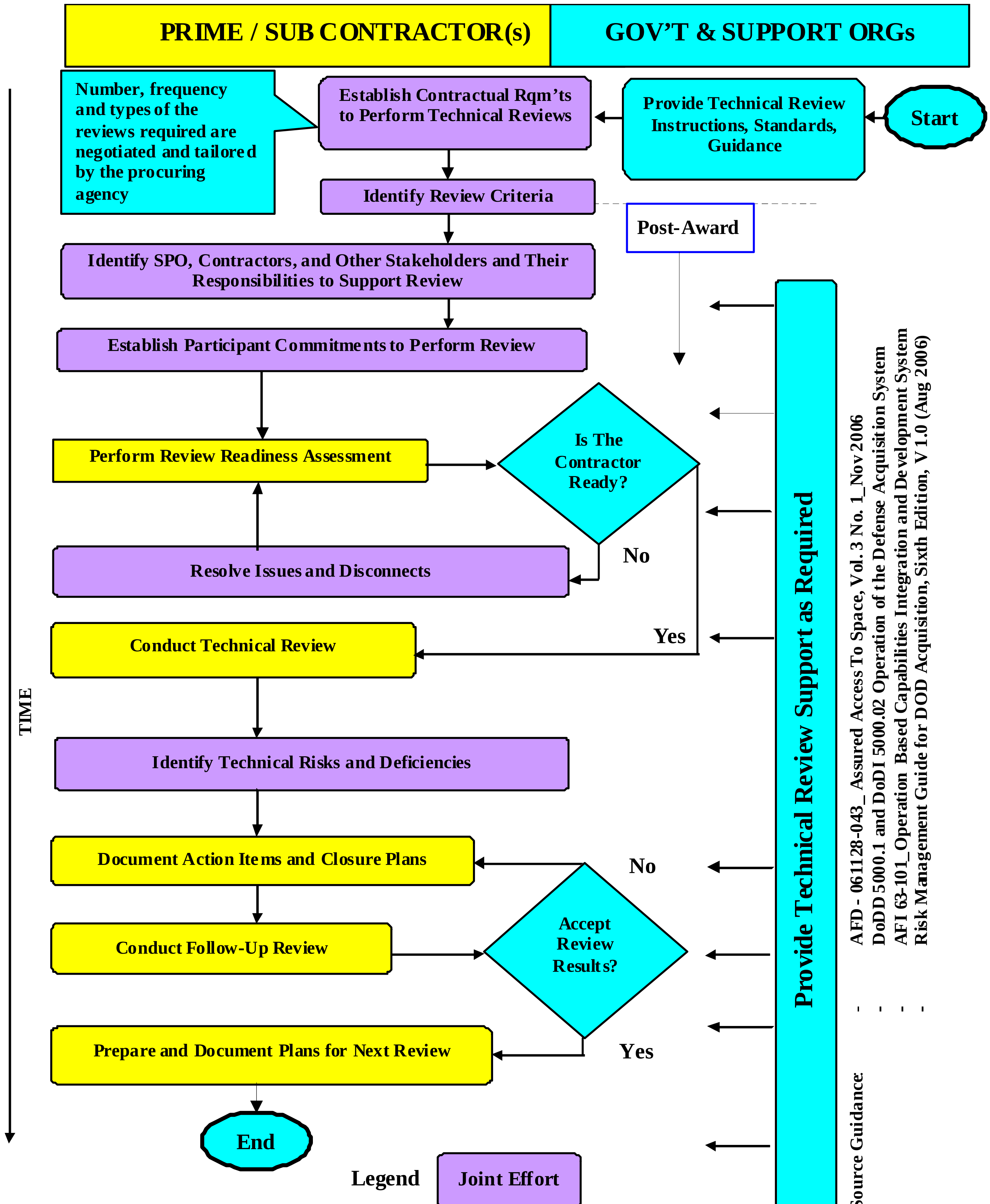

Figure 1. Generic Technical Review Process Map.

5. Roles, Responsibilities, and Authority

This section describes the typical roles, responsibilities, and decision authority relationships between the contractor(s) and the contracting agency.

Technical review planning and execution responsibility are shared equally by the contracting agency or the Procuring Contracting Officer (PCO), and the contractor or the contractor's program manager.

5.1 Contractor Participation and Responsibilities

The contractor shall be responsible for conducting the Technical Reviews and Audits in accordance with the following requirements except as amended by the contract.

5.1.1 Subcontractors and Suppliers

The contractor shall be responsible for ensuring that subcontractors, vendors, and suppliers participate in formal reviews and/or audits, as appropriate.

5.1.2 Chairperson

The chairperson for the technical review shall be the contractor's program manager or his and her designee. The chairperson is responsible for publishing the meeting agenda, recording and publishing the meeting minutes, maintaining a list of attendees, meeting location selection, and coordination, and all administrative items associated with each technical review.

5.1.3 The Contractor Requirements

The contractor shall be responsible for conducting the Technical Reviews and Audits in accordance with the following requirements.

The contractors shall be responsible for establishing the time, place, and agenda for each Review and Audit in consonance with the master milestone schedule, subject to coordination with the contracting agency.

This shall be accomplished sufficiently, well in advance of each review and/or audit to allow adequate preparation for the meeting by both the contractor and the contracting agency.

5.1.3.1 Review, Audit Schedules, and Available Information

The contractors shall ensure that each Review and Audit schedule is compatible with the availability of the necessary information and contract articles, e.g., system engineering data, trade study results, producibility analysis results, risk analysis results, specifications, manuals, drawings, reports, hardware, software, or mock-ups.

5.1.3.2 Review and Audit Preparation

The contractors shall prepare for each Review and Audit in sufficient detail consistent with the scope and magnitude of the Review and Audit.

5.1.3.3 Review and Audit Conduct

The contractors shall designate a co-chairperson for each Review and Audit. Participating contractor and subcontractor personnel or those chosen to make presentations shall be prepared to discuss in technical detail any of the presented material within the scope of the review.

Specifically, the contractor's co-chairperson or his and her designee shall be responsible for the following:

1. The planning, organization, coordination, and delivery of each review
2. The preparation and approval of the list of individuals participating, representing, and acting on behalf of the contractor at the reviews
3. The preparation of "Acceptance Criteria" to be used for review and approval by the PCO
    a. The contractor program manager must assure that the recommended and mutually agreed-to "Acceptance Criteria" can be demonstrated to initiate the review
    b. The contractor shall prepare for each review, supporting data, in sufficient detail as objective evidence of accomplishments, consistent with the scope and magnitude of

the review per the mutually agreed-to "Acceptance Criteria" under the following five major categories:

i. Systems Engineering and Architecture Development

ii. System, Segment, and Subsystem Design

iii. System Verification and Validation

iv. Engineering Disciplines and Specialty Engineering

v. Integrated Technical Risk and Mitigation

4. The participation by subcontractors, vendors, and suppliers as appropriate, to ensure presentation of objective evidence of accomplishments in all relevant areas of acceptance

5. Technical reviews of program progress shall be event driven and conducted when the system under development meets the review "Acceptance Criteria" as documented in the SEP. Technical reviews shall include participation by subject matter experts who are independent of the program (i.e., peer review), unless specifically waived by the SEP approval authority as documented in the SEP and in agreement with the program IMP and IMS, subject to coordination with the contracting agency. This shall be accomplished sufficiently in advance, to allow for development of "Acceptance Criteria" for the review and adequate preparation time for the meeting, by both the contractor and the contracting agency

6. Establishing that each review schedule is compatible with the availability of the necessary information and contract articles

7. Providing the necessary resources and materials to perform the review effectively. This can include, to the extent appropriate and tailored for the type and scope of review required by the contract, e.g.:

   a. Meeting agenda and plans

   b. Conference room(s)

   c. Applicable systems engineering data, e.g., specifications, drawings, manuals, reports, schedules, design and test methods and data, risk analysis, and specialty study and trade study results

   d. Architecture products, system interfaces, list of applicable standards, producibility analysis results, hardware, software, and mock-ups

   e. System Verification Cross Reference Matrix (VCRM)

   f. Previous technical review action items, etc.

   g. A system to capture, record, track, and disposition review action items (AIs

8. Designating a chairperson for each review. This person is responsible for publishing the meeting agenda, recording, consolidating, and publishing the meeting minutes, maintaining a list of attendees, meeting location selection and coordination, and all administrative items

5.1.3.4 Meeting Minutes

The co-chairperson shall provide an acceptable method to record input to official meeting minutes, e.g.:

1. Minutes be recorded as dictated by the chairperson and include, as a minimum, significant questions and answers, action items, deviations, conclusions, recommended courses of action resulting from presentations or discussions, etc.

2. Conclusions from discussions conducted during side meetings summarized in the main meeting, and appropriate comments read into the official minutes

3. Recommendations not accepted, recorded with the reason for non-acceptance

4. Action items of each daily session summarized daily by both the contractor and contracting agency personnel at the conclusion of each day's session

5.1.3.5 Review of Minutes and Designation of Action

All action items shall be recorded in the technical review minutes, identifying whether contracting agency or contractor action (or both) is required for its agreed resolution and disposition. Minutes shall include a recording of discussions and rationale for rejected actions, e.g., beyond scope, addressed elsewhere (citing location), duplicate of action XYZ, etc.

A sample action item form is provided in Table 2.

5.1.3.6 Minutes Publication

The contractor shall be responsible for publishing and distributing official minutes.

5.2 Procuring Contracting Officer (PCO) Participation and Responsibility

5.2.1 Procuring Contracting Officer (PCO) Role

The Procuring Contracting Officer (PCO) or his and her designee is the co-chairperson for each Review and Audit. The co-chairperson acts as the single point of contact between the contracting agent and the contractor and responsible for approving the meeting agenda and meeting minutes.

The co-chairperson is also responsible for the following:

1. "Review Team" (the reviewing authority) membership selection, i.e.:
    a. The "Review Team" may establish appropriate groups to accomplish all or parts of each review listed in this STD
    b. The organization of these groups is at the discretion of the program manager and/or the reviewing authority
    c. Membership of the reviewing authority may include the acquisition activity, activity technical leadership, contractor senior management, the user community, and subject matter experts from outside agencies, as necessary
2. Approving the review schedule, location, agenda, outline and content, attendee invitation list
3. Preparing the measurable metrics for assessment and rating of the contractor's accomplishment and progress per mutually (contracting agent and contractor) agreed-on criteria
4. Preparing review evaluation and rating and issuing the authorization to proceed with decision
5. Preparing daily review and approval of action items (AIs) to ensure that:
    a. AIs are documented on the AI form (Table 2)
    b. The action items reflect all significant contracting agency inputs
    c. Action items are properly composed
    d. Importance and time-critical aspects are assessed
    e. Top-level plan of action is defined and agreed to
    f. Responsible agent is designated
    g. Closure dates are defined and agreed to

5.2.2 Review Panel and Participant Selection

The co-chairperson shall prepare, approve, and provide a list of the names, organizations, and verified security clearances of the review panel and participating individuals to the contractor prior to each review.

Table 2. Sample Action Item Form

AI CONTROL NUMBER: _________________ PROGRAM NAME: _________________________

ISSUE DATE:_____________________________

ACTION DESCRIPTION and DEFINITION:	Originator's Name and Org:
____ ____ ____	
ASSIGNEE: ________________________________ _________________________ CONTRACTOR'S ORG, and IPT:	
CATEGORY (check): ISSUE __, CONCERN__ CRITICALITY CLASS (check): 1__, 2__, or 3__ SECURITY CLASSIFICATION (check): U__, C__, S__, TS__ ____ CRITICALITY DESCRIPTION: ____ ____ DEPENDENCY (P000 or WBS): A -____ B -____ C - ____ SUSPENSE DATE:____________ NEED DATE: _________________ STATUS (check): CANCELLED__, OPEN__, CLOSED__, PENDING__, REASSIGNED TO or COMBINED WITH AI: _____________________ AI RESOLUTION and CLOSURE (OBJECTIVE EVIDENCE – DATA, REPORT, ETC.): ____ RATIONALE FOR REJECTION: ____	
COMPLETION DATE:	ASSIGNEE SIGNATURE:
TECHNICAL APPROVAL (CHIEF ENG) ___________________ _____________________ SIGNATURE & DATE	TECHNICAL APPROVAL (SPO) ___________________ _____________________ SIGNATURE & DATE

CONTRACT NO.	TECHNICAL REVIEW (circle): SRR / SFR / SAR / PDR / CDR	STATUS DATE:

5.3 Formal Acknowledgment

This standard prescribes the requirements for conducting Technical Reviews and Audits on Systems, Equipments, and Computer Software. Official acknowledgment by the contracting agency of the accomplishment of a Review and Audit is not to be interpreted as approval of statements made in the minutes or of matters discussed at the Review and Audit and does not relieve the contractor from requirements that are a part of the contract.

The Procuring Contracting Officer (PCO) provides formal acknowledgment to the contractor of the accomplishment of each review after receipt of review minutes and disposition of the AIs. The contracting agency establishes the adequacy of the contractor's review performance by notification of:

1. Approval: to indicate that the review was satisfactorily completed
2. Contingent approval: to indicate that the review is not considered accomplished until the satisfactory completion of resultant action items, which may require submission of a mitigation plan(s) by the contractor for PCO review, negotiation, and approval, in order to proceed, or
3. Disapproval: to indicate that the review was seriously inadequate

5.4 Data Requirements List and Cross Reference

When this standard is used in an acquisition that incorporates a DD Form 1423, Contract Data Requirements List (CDRL), the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved CDRL incorporated into the contract. When the provisions of the DoD FAR clause on data requirements (currently DoD FAR Supplement 52.227-7031) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this standard is cited in the following paragraphs.

Paragraph No.	Data Requirement Title	Applicable DID No.
5.1.2	Conference Agenda	DI-ADMN-81249A
5.1.3.4	Conference Minutes	DI-ADMN-81250A

Up-to-date DIDs and MIL-STDs can be located on the Web at: http://assist.daps.dla.mil/quicksearch/

6. Relevant Technical Review and Audit Items

6.1 Source Authority and Material

Source authority or material, that define specific reviews and the resources required to execute them for EI acquisitions compliance, are incorporated directly, or by reference into the program execution structure by way of the contract statement of work (SOW).

6.2 ACAT Programs and Contractual Guidance

Instructions for the Operation of the Defense Acquisition System for the Acquisition Category (ACAT) program levels I through III and the corollary Milestone Decision Authority (MDA) for each level is defined by DoDI 5000.02. This DoDI identifies statutory and regulatory information requirements for all milestones and phases, Earned Value Management (EVM) implementation policy, the statutory and regulatory policy for Acquisition Program Baselines (APBs), and program categories with unique decision forums or policies. These policies include the specific statutory and regulatory requirements applicable to information technology (IT) programs, National Security Systems (NSS); detailed specific test and evaluation (T&E) procedures; detailed policy for resource estimation, Human Systems Integration (HSI), acquisition of services, Defense Business Systems and Systems Engineering, along with the administrative and international policy applicable to all acquisition programs.

Technical reviews for each phase of the acquisition program are identified as major milestone events in the Integrated Master Plan (IMP), with clearly defined "Acceptance Criteria" for each event. Specific schedules are developed jointly by the contracting agent and the contractor for each review and the supporting lower-tier review activities for incorporation into the contractor's Integrated Master Schedule (IMS).

Technical reviews can be tailored appropriately (Appendix K – Application Guide for Tailoring MIL-STD-1521) to suit individual program scope and complexity. Tailoring or elimination of reviews shall be coordinated with the engineering and logistics functional discipline leadership, and documented in the program's SEP.

The core purpose of integrating technical reviews into the Systems Engineering Plan (SEP) is to design, develop, and field systems that meet the contractual specifications and performance requirements of the User Agency.

All ACAT programs shall include in the SEP the following essential technical reviews[1] or gated events[2] (as applicable):

I. Initial Technical Review (ITR)[1]
II. Alternative Systems Review (ASR)[1]
III. Integrated Baseline Review (IBR)[2]
IV. System Requirements Review (SRR)[1]
V. System Functional Review (SFR)[1]
VI. Software Requirements and Architecture Review (SAR)[1]
VII. Technology Readiness Assessment (TRA)[2]
VIII. Preliminary Design Review (PDR)[1]
IX. Critical Design Review (CDR)[1]
X. Test Readiness Review (TRR)[1]
XI. System Verification Review (SVR)[1]
XII. Production Readiness Review (PRR)[1]
XIII. Operational Test Readiness Review (OTRR)[2]
XIV. Physical Configuration Audit (PCA)[1]
XV. In-Service Review (ISR)[1]

Programs need not conduct technical reviews that do not apply, given the structure of the program, and/or where in the acquisition cycle the program will enter. This tailoring shall be updated as part of setting the review agenda and participants, in conjunction with the program engineers, logisticians, and their functional discipline leadership.

6.3 "Acceptance Criteria"

Appendices A, B, C, D, and E address "Acceptance Criteria" that shall be given special consideration by both the developing agency and the contractor, as objective evidence of accomplishments, for entry into and successful exit from the SRR, SFR, PDR, and CDR reviews. Entrance into the review requires that the contractor has appropriately addressed the criteria elements and can successfully exit from the review with the concomitant implication that all criteria elements are properly decomposed to the satisfaction of the contracting agency. The specific "Acceptance Criteria" for SRR, SFR, SAR, PDR, and CDR shall be organized as delineated in Appendices A, B, C, D, and E as examples of objective evidence of accomplishments under the following five major categories:

1. Systems Engineering and Architecture Development
2. System, Segment, and Subsystem Design
3. System Verification and Validation
4. Engineering Disciplines and Specialty Engineering
5. Integrated Technical Risk and Mitigation

The developing agency and the contractor shall jointly develop unique "Acceptance Criteria" for the technical reviews F through J, using these five major category criteria examples.

6.4 Systems Engineering Process Objectives

The systems engineering process is an iterative process starting with requirements analysis, proceeding to functional (logical) analysis and requirements allocation, and then to design solution (synthesis). Iteration occurs via feedback loops, systems analysis, and control throughout the systems engineering process with top-down recursions and increasing levels of detailed and bottom-up recursion during assembly and integration in the normal course of complex systems development.

Appendices A, B, C, D, and E describe in expanded detail typical systems engineering processes, tasks, and products for any system that are performed in preparation and demonstration with appropriately identified criteria at the five core design reviews. The tasks identified are to be performed throughout the system life cycle; however, the detail and maturity produced by these tasks in demonstration of "Acceptance Criteria" identified within will be highly dependent on the state of the EI's maturity in its life cycle.

It is the joint responsibility of the contractor/developer and contracting and customer agencies to integrate the systems engineering process with the design review process, with tailoring of compliance documentation, standards, and reference guides and handbooks as mutually agreed and specified by contract in accordance with (IAW) Appendix K.

As an integral and inherent part of the design review processes, the developer with the support and approval of the customer can develop, refine, and update with an increased level of maturity such user requirements and objectives as:

a. The statements of capability need thresholds and objectives corresponding to identified capability gaps
b. The architectural products, including the applicable views (Operational, System, and Technical) as directed by the customer IAW the DoD Architecture Framework (DoDAF)
c. The identification of alternative materiel approaches and, for the selected material approaches, alternative operational and system concepts that could fill capability gaps that offer potential for further refinement and subsequent development
d. The Warfighter's capability gaps in the Operational Scenarios and Concept of Operations (CONOPS) as well as in the operational and system needs under consideration while assuring consistency between the CONOPS and the contractor's Operations Concept (OPSCON)

e. The assessment of the relationship between capabilities and evolutionary growth in capabilities, on the one hand, versus the life cycle cost, schedule, and risk for the materiel approaches or system concepts that could provide the capabilities, on the other hand, to highlight those capabilities that drive cost, schedule, or risk

f. The development of approaches for transitioning from a current system, if any, that is ultimately to be replaced, curtailed, or supplemented by the new capability

g. The definition of technology developments and other risk mitigation steps for potential future action toward the development of promising system concepts

h. Sustainment strategies

i. Definition of the threat environment (based on and referenced to Defense Intelligence Agency (DIA) or Service Technical Intelligence Center–approved documents)

j. Operational test planning

By doing so, the developer can identify any inconsistencies between the system's requirements, user needs, or operational capability requirements process and arrive at a baseline system design configuration that is producible and supportable and meets desired objectives that for example:

i. Accurately and completely reflect the functional and performance requirements in the requirements baseline, including the minimum or threshold required operational capabilities consistent with concepts of operation, system behavior, and required functionality

ii. Accurately model the system behavior to include all sequencing, concurrency, and timing requirements

iii. Sufficiently define the basis for detailed and precise functions or logical elements and their allocated or derived performance and functional requirements at the next lower level

iv. Decompose requirements to lower levels so that each can be related to elements of the physical hierarchy to form the allocated baseline, and the allocation of the top-level performance requirements and design constraints to the lower levels is complete

v. Can include the relationships to the physical solution and be documented in the decision database

vi. Can include the definition of both the internal and external interfaces, and addresses the physical implementation, as well as the logical issues such as data formats, data semantics, etc.

vii. Can be validated through customer participation and concurrence, for example:

    a) Comply with desired system attributes

    b) Allow for two-way traceability between each element of the requirements baseline and each element of the functional architecture

The design review and associated supporting processes and data thus provide assessment and validation with a high degree of confidence against agreed-to criteria that the system effectiveness, life cycle cost, schedule, risk, and evolutionary growth potential of the baseline design are feasible and affordable.

6.5 Technology Readiness Assessment (TRA)

TRA is a regulatory information requirement for all acquisition programs. The TRA is a systematic, metrics-based process that assesses the maturity of critical technology elements (CTEs), including sustainment drivers. CTE is considered that technology or its application, either new or novel, which a platform or system depends on to meet system operational threshold requirements in development, production, or operation.

Each TRA shall score the current readiness level of selected system elements, using defined Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs). The TRA shall highlight those critical technologies (including critical manufacturing-related technologies) and other potential technology risk areas that may adversely affect milestone decision dates or relevant decision points.

Each TRA shall be conducted concurrently with other Technical Reviews, specifically the SRR, PDR, and the PRR. The relationships of TRA to TRL, MRL, individual technical reviews, and milestone decision points in the Systems Acquisition cycle are illustrated in Figure 2.

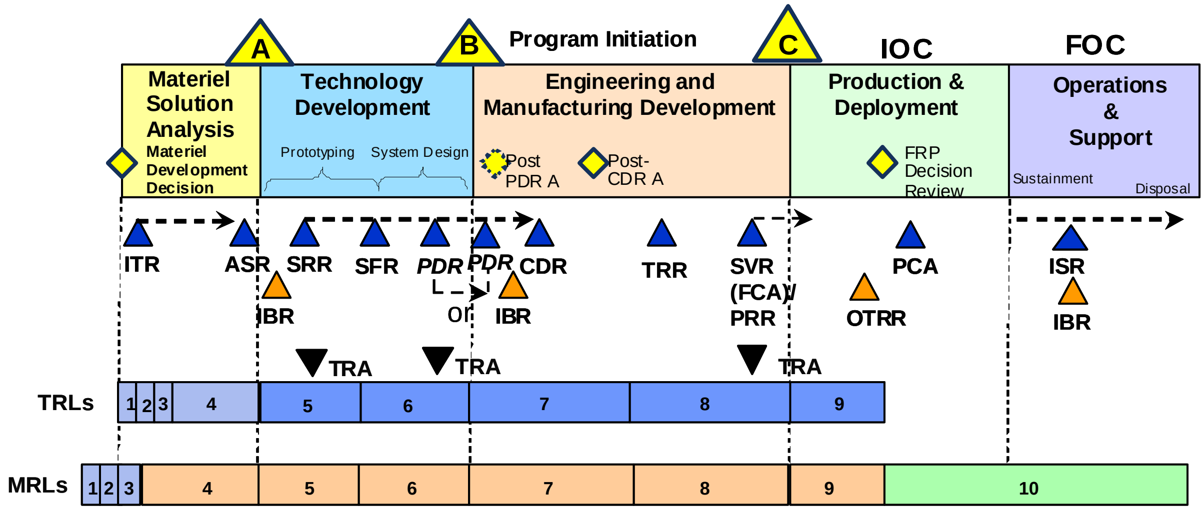

Figure 2. TRA Relationship to Systems Acquisition Gates, Milestones, and Events

Technical Reviews and Audits
for
Systems, Equipment, and Computer Software

Appendixes

Appendix A - System Requirements Review (SRR)

10. System Requirements Review (SRR)

The SRR is a multifunctional and multidisciplinary technical review and systems engineering (SE) process assessment that is used to verify that all requirements (operational and system) contracted for development are derived from the Capability Development Document (CDD) and as defined:

a. Are consistent with program cost, budget, schedule, risk, user, and/or other constraints

b. Are captured in the system specification

c. Are sufficiently mature to proceed into system architecture trades and concept definition

d. Are consistent with available technologies for the preferred system solution

e. Can meet the program objectives with manageable risk

An SRR may be convened several times, e.g., prior to program initiation, during Technology Development Phase (TDP) and during system development and demonstration and tailored to the technical scope and risk of the system to be developed.

10.1 General

The SRR shall be conducted by the contractor after the accomplishment of functional analysis and preliminary requirements allocation (e.g., operational, maintenance, training, Hardware Configuration Items (HWCIs), Software Configuration Items (SWCIs), facility CIs, manufacturing considerations, personnel and human factors) to determine initial direction and progress of the contractor’s Systems Engineering Management effort and the convergence upon an optimum and complete configuration. At SSR, a significant portion of the system requirements has been established and baselined, and, depending upon the nature and complexity of the system, individual SRRs are scheduled for the segments, subsystems or CIs. Key SRR elements include the assessment that:

a. The majority of the key performance parameters (KPPs) are consistent with System Requirements as documented by the CONOPS, analysis of alternatives (AoA) results, Initial Capabilities Document (ICD), and capabilities development document (CDD) and system performance specifications

b. The system requirements, KPPs, and supporting technical performance measures (TPMs) are defined and documented in the requirements allocation document (RAD)

c. Baseline System Requirements are consistent with:

   i. Cost (program budget and funding profile)

   ii. Interoperability

   iii. Other specified system constraints

   iv. Risk

   v. Schedule (program schedule and Integrated Master Schedule (IMS))

d. Form, fit, functional, and performance (FFF&P) baselines are established for each system design concept and CI, consistent with mission and user objectives

10.2 Purpose

At SRR, the total Systems Engineering Management activity and its output shall be reviewed for responsiveness to the Statement of Work, system, subsystem and CI requirements. The SRR is a key element of the pre and post Systems Acquisition phase of System Development and Demonstration, to verify that the contractor’s derived design requirements fully satisfy the customer’s requirements, which result in a system that will satisfy the stakeholder needs and will include the following:

a. Verification that the contractor's derived design requirements and proposed preliminary system design support the acquisition program baseline (APB) and fully implement the system and interface requirements that are captured in the:

   i. The Initial Capabilities Document (ICD)

   ii. The Capabilities Development Document (CDD)

   iii. The Systems Engineering Plan (SEP)

   iv. The Test and Evaluation Master Plan (TEMP)

   v. The Programmatic ES&OH Evaluation (PESHE)

   vi. The Program Protection Plan (PPP)

   vii. The Technology Readiness Assessment (TRA)

b. Verification that the proposed preliminary system design is consistent with the user's:

   i. CONOPS

   ii. Environmental safety and occupational health (ES&OH) requirements

   iii. Integrated Support Plan (ISP)

   iv. Inter-Operability needs

   v. KPPs

   vi. Operational Architecture (OA)

   vii. System Performance Specifications

   viii. The system support and maintenance objectives and requirements

Of critical importance to this review is the understanding of the risks inherent in the contractor's proposed system concept and products and processes, and, that the SRR finds the risks to be at an acceptable level consistent with the integrated management plan (IMP), integrated master schedule (IMS), and risk manageable by the acquisition agency.

10.3 Objective

The SRR is conducted to assess the adequacy of the contractor's systems engineering management plans and processes, through review of the analytical and design engineering efforts, tailored to deliver the APB objective and to establish a preliminary functional baseline (BL) for the system. These assessments can include such analytical and SE efforts as:

a. Studies

   i. Concepts

   ii. Designs

   iii. Requirements allocation

   iv. System interface

   v. Trades (e.g., functions, mission, support, hardware, firmware, software, etc)

b. Analysis and Synthesis

   i. Functional flow

   ii. Human factors

   iii. Life cycle cost

   iv. Logistics support

   v. Manpower requirements and personnel

vi. Mission and requirements

vii. Program risk

viii. Requirements development

ix. Specialty Engineering (i.e., Hardware and Software Reliability, Maintainability, Producibility, Armament Integration, Electromagnetic Compatibility, Survivability, and/or Vulnerability (Including Nuclear), Inspection Methods and Techniques, Energy Management, Environmental Considerations)

x. System architecture development

xi. System cost effectiveness

xii. Training and facility requirements

c. Assessments

i. Industrial base capability and maturity for key technologies and components

ii. Technology maturity

d. Plans and Planning

i. Configuration management

ii. Data management

iii. Engineering integration

iv. Initial Programmatic ES&OH Evaluation (PESHE) compliance

v. Initial test and evaluation

vi. Integrated test

vii. Milestone schedules

viii. Preliminary manufacturing

ix. Producibility analysis

x. Specification generation

xi. System safety

xii. Technical Performance Measurement (TPM)

xiii. Technology readiness and management

Key SRR products shall include, for example:

a. A comprehensive risk assessment for system development and demonstration

b. A preliminary allocation of system requirements to hardware, human, and software subsystems

c. An affirmation that the system requirements, preferred system solution, available technology, and program resources (funding, schedule, staffing, and processes) form a satisfactory basis for proceeding to the System Development and Demonstration (SDD)

d. An approved preliminary system performance specification

e. An approved product support plan (PSP) with updates

f. An approved system development and demonstration phase systems engineering plan (SEP) that addresses cost and critical path drivers

g. Software components identification (tactical, support, deliverable, nondeliverable, etc.)

The most important take-away from the SRR is a clear understanding of the impacts that the defined requirements will have on program development cost, schedule, and the delivered system performance capability in the context of the APB objectives.

10.4 SRR "Acceptance Criteria"

At SRR, all major program elements and risk drivers of the systems engineering management activities shall be considered. A prime expectation of the SRR is that the review will result in an approved technical baseline that can be brought under change control and a determination that baseline can be implemented within constraints of the cost, schedule, and performance requirements. In preparation for and scheduling of an SRR, the contractor shall demonstrate to the satisfaction of the contracting agency that:

a. All applicable engineering activities properly performed in support of each criterion

b. Most and all of the SSR criteria elements agreed to have been successfully addressed

c. All criteria elements are properly decomposed

d. The baseline system requirements are robust, supportable, and documented to the satisfaction of the contracting agency

The SRR "Acceptance Criteria" shall be organized under the following five major categories:

1. Systems Engineering and Architecture Development (10.4.21)
2. System, Segment, and Subsystem Design (10.4.2)
3. System Verification and Validation (10.4.3)
4. Engineering Disciplines and Specialty Engineering (10.4.4)
5. Integrated Technical Risk and Mitigation (10.4.5)

This review shall serve as objective evidence of the contractor's technical effort that supports the basic and agreed-to SRR "Acceptance Criteria", e.g.:

a) Can the system requirements, as disclosed, satisfy the Initial Capabilities Document or draft Capability Development Document?

b) Are the system requirements sufficiently detailed and understood to enable system functional definition and functional decomposition?

c) Is there an approved system performance specification?

d) Are adequate processes and metrics in place for the program to succeed?

e) Have Human Systems Integration requirements been reviewed and included in the overall system design?

f) Are the risks known and manageable for development?

g) Is the program schedule executable (technical and/or cost risks)?

h) Is the program properly staffed?

i) Is the program executable within the existing budget?

j) Does the updated cost estimate fit within the existing budget?

k) Is the preliminary Cost Analysis Requirements Description consistent with the approved system performance specification?

l) Is the software functionality in the system specification consistent with the software sizing estimates and the resource-loaded schedule?

m) Did the Technology Development phase sufficiently reduce development risks?

n) Have all IMP and IMS tasks associated with this review been successfully closed?

Appendix A

The following sections address the minimum, but not all-inclusive, list of criteria that shall be accomplished, as specifically tailored by contract, along with all applicable engineering activities to be reviewed

10.4.1 Systems Engineering and Architecture Development

Evidence of Systems Engineering and Architecture Development requirements maturity criteria examples at SRR:

A. Systems Engineering and Architecture Development

1. The system requirements are complete, clearly stated, feasible, and verifiable. KPP and system requirements derived from the system CONOPS, the system performance document (SPD), and the AoA studies, etc., e.g., KPP and system requirements correlated with the system performance specifications and the Interface Control Documents (ICDs)
2. Systems engineering methodology practices are thorough, practical, and comprehensive
3. System requirements synthesized into conceptual architecture concept(s), e.g.:
    a. Architectural concepts demonstrate level of program compliance with system requirements, e.g., applied modeling and synthesis methodologies are based on proven practices
    b. The architectural view(s) is constructed for each system (system of systems, family of systems, segments, and subsystems) concept(s):
        (1) The system architecture view(s) implements the system and internal and external interface requirements and contractor operational concepts
        (2) The system architecture view(s) is feasible and extensible
        (3) Candidate architectural views are developed, derived, and evaluated for each system (system of systems, family of systems, segments, and subsystems) concept(s) in terms of form, fit, and function (FF&F) and KPPs
        (4) An operational view (OV) is developed that identifies tasks and activities, performance requirements by system components elements and organizational owners and operators
        (5) A systems view (SV) is developed that identifies functional interface requirements by system components, elements and organizational owners, and operators
        (6) Critical Technical Standards View are developed that define standards and conventions that may be necessary to implement the design concept
4. Conceptual system design solutions (including alternatives) are developed and assessed in the context of engineering trade space, technical requirements, system performance, risks (technical, programmatic, schedule, cost), life cycle cost (LCC) and cost as an independent variable (CAIV) studies, etc., e.g.:
    a. Key technical and programmatic details are developed and derived for each candidate system design solution and correlated with the CDD, System Performance Specification and other derived requirements, e.g., the contractor's operational concepts are consistent with the Warfighter needs and concept of operations (CONOPS)
    b. Proposed system design solutions are assessed with respect to program performance, cost, and schedule risks and mitigation strategies
    c. Demilitarization and disposal at end of life (EOL) are considered for system design solutions (including alternatives)
5. Candidate external system interfaces are identified, and initial and conceptual interface requirements developed, e.g.:
    a. Critical external system interfaces are developed and derived that identify key performance and interface requirements, consistent with and referenced by the draft System Specification

b. The contractor's operational concepts are consistent with the system and external interface requirements

c. Impacts to internal and external systems and system requirements are identified

d. System and external interface requirements meet all contract provisions, including contractually imposed specifications and standards

e. System requirements, as understood and integrated into system design solution, satisfy the initial capabilities document (ICD) or capability development document (CDD)

6. Preliminary System Requirement Baselines are established for each design concept, e.g.:

   a. Conceptual system design concepts and solutions are documented in terms of preliminary mission and system requirement baselines

   b. Conceptual system design concepts and solutions are documented in terms of preliminary functional baselines

   c. All proposed and recommended necessary system requirements are documented

7. Preliminary life cycle cost (LCC) and cost as an independent variable (CAIV) studies are developed in support of each (design) concept, e.g.:

   a. LCC and CAIV modeling and analyses are applied and correlated for each design concept, e.g., cost models depicting projected program development, and operational and sustainment costs completed, as well as projected cost impacts to other "external" systems

   b. LCC and CAIV methodology is presented that demonstrates that valid trade studies were conducted

8. System development cost and schedules are established, e.g.:

   a. Appropriate cost models have been used to estimate system development cost and schedules

   b. Realistic system development cost drivers, such as complexity and other parameters, and assumptions are documented and have been used in validated system development cost models to develop cost and schedule estimates

   c. The life cycle cost estimate adequately includes system support

   d. All of the developmental and support tasks are included in the life cycle cost estimates

   e. Preliminary system development estimates are supportable and based on history, e.g., the preliminary system development cost and schedule estimates have enough margin to cover the estimated risk appropriate at SRR

9. Traceability of system architecture and design concept(s) to KPPs is documented and demonstrated in an acquisition agency–approved and designated database and data repository, e.g.:

   a. System architecture(s) and design concept(s) trade studies are captured

   b. System architecture(s) and design concept(s) have traceability to KPPs and are validated by system trade studies

   c. Preliminary system internal and external interface requirements are consistent with system interoperability requirements and the Initial Capabilities Document

   d. The system internal and external interface requirements are baselined and are under configuration management for each system architecture and design concept

10. The Preliminary System Performance Specification is developed and demonstrated to meet mission requirements for each system design concept, e.g., for each design concept, evidence is provided using models, simulations, analyses, and test results from analogous systems to ensure that key mission and performance requirements (CONOPS, ICD, and KPPs) are met.

B. Interoperability Architecture Development

1. Justify the selected DoD Information Standards Repository (DISR) standards to meet system and mission interoperability requirements for each system (System of Systems, Family of Systems, Segments, and Subsystems) design concept, i.e., system designs must be DISR compatible and compliant
2. New or unique standards outside DISR are submitted for approval and DISR consideration (e.g., new data formats, data exchange protocols and schemas, Ethernet alternatives)
3. A preliminary interoperability system architecture is defined for each design concept implemented, by the system and external interface requirements
4. Preliminary interoperability analyses are completed, ensuring compatibility and defining interrelationships between users and operators
5. Interoperability trade studies and requirements analyses are completed, e.g.:
    a. Interoperability performance and design parameters and drivers are derived from requirements analysis and trade studies
    b. Results are integrated into all system baselines and models
    c. A methodology is presented that demonstrates all critical and major requirements assessed
6. The preliminary system architecture supports implementation of operational concepts and interoperability objectives
7. System operational concepts include, e.g.:
    a. Both nominal and off-nominal scenarios from a hardware and software perspective, e.g., processor failover, redundancy management consistent with the system architecture
    b. Elaborated time lines for nominal and off-nominal scenarios consistent with the system architecture
    c. Management of satellite vehicle, constellation, and mission, as appropriate
    d. Identification of operations and maintenance staffing, e.g., numbers, skills, roles, and positions, consistent with the system architecture
8. The preliminary system architecture fully implements the system and external interface (I/F) requirements
9. The preliminary system I/Fs to the Global Information Grid (GIG) are identified
10. Applicable GIG key interface profiles (KIPs) are identified

10.4.2 System (System of Systems, Family of Systems), Segment, and Subsystem Design

Evidence of System, Segment, and Subsystem Design Concepts maturity criteria examples at SRR:

A. System, Segment, and Subsystems Design

1. The Preliminary System, Segment, and Subsystem is identified; preliminary design concepts are established and major and critical performance parameters are defined
2. System, Segment, and Subsystem conceptual design solutions are assessed, considering performance requirements, engineering trade space, technology status and deficiencies, and technical, programmatic, schedule, and cost risks, e.g.:
    a. Engineering analysis adequately demonstrates that the system architecture is capable of meeting the key performance parameters and driving requirements
    b. The contractor’s proposed set of technical performance measures (TPMs) include all key performance parameters (KPPs) and critical design parameters necessary for adequately assessing the evolving system capability

c. The contractor's metrics and TPM processes reflect sound, state-of-the-art practices, techniques, and tools

d. Engineering analysis demonstrates sound use of engineering principles and techniques

3. System(s) (System of Systems, Family of Systems, Segments, and Subsystems) performance parameters, characteristics, design challenges, and risk assessment are completed and integrated into the system risk model

4. Critical performance and functional requirements are included in individual System(s) (System of Systems, Family of Systems, Segments, and Subsystems) design concept solutions

5. System(s) operational sustainment requirements are defined and derived, e.g.:

   a. Critical system performance requirements are derived and are traceable to program requirements and CONOPS

   b. LCC modeling is developed for each concept solution with traceable justification

6. System(s) Command, Control, Communication, Computer, and Intelligence (C4I) Requirements Analyses are assessed and preliminary performance is allocated across segments and subsystems, e.g.:

   a. Preliminary C4I strategy identifies battle management and information technology (IT) needs and dependencies between system(s) (System of Systems, Family of Systems, Segments, and Subsystems)

   b. Preliminary net-centric (i.e., network) interface trade studies are completed and candidate architectures and information environments defined, including interoperability requirements

   c. Preliminary C4I performance requirements ensure interoperability, interconnectivity, supportability, synchronization, and sufficiency for each design concept

7. Threat scenarios are completed and threat environments defined, enveloped, and correlated with system(s) design concepts, e.g.:

   a. Threat scenarios and environments are defined and evaluated; performance parameters are defined, and system design concepts are established and traceable to threats

   b. Demonstrates that threat operational criteria are incorporated into system design concepts

8. Environments (e.g., natural thermal, humidity, transport) are defined and performance parameters derived and enveloped, e.g.:

   a. Environmental parameters are derived from known source data, system functional analysis using proven methodology

   b. Environmental parameters are incorporated into system design concepts

B. Performance requirements of major components are identified and assessed for each candidate system (System of Systems, Family of Systems, Segments, and Subsystems) solution, e.g.:

1. All major components are identified based on system design concepts, including use of heritage systems, components, and technology, as well as new designs

2. Key parameters and information are developed and assessed for each major component:

   a. Major performance parameters are identified

   b. Critical technologies are identified, including deficiencies

3. Critical design and manufacturing requirements and challenges are identified, including COTS and diminishing manufacturing source (DMS)

4. Preliminary reliability, availability, maintainability, and testability requirements are defined and design factors established, e.g.:

a. Critical performance parameters are defined and derived from requirements analysis and proven methodologies

b. Solution concepts required to meet performance parameters are established and assessed (including verification and analysis methodologies)

c. Major component reliability, availability, maintainability, and testability design factors for hardware and software are incorporated into system design concepts, e.g., allocation and fault detection and isolation capabilities are defined between elements of built-in test, fault detection and isolation subsystem, separate support equipment, and manual procedures

d. Preliminary technology system performance requirements are analyzed, concept(s) trade studies are accomplished, Technology Readiness Level (TRL) assessments are completed, and a development strategy is established, e.g.:

(1) TRL demonstrated or technology development strategies are defined, including resource and schedule requirements

(2) Program (Cost, Schedule, and Technical) risks are identified, characterized, and prioritized, and mitigation strategies and Burn Down Plans (BDP) are developed and integrated into the IMS and System Risk Model

5. Preliminary Industrial Base (IB) assessment is completed and risk areas identified and prioritized against assessment results, e.g.:

a. IB assessment data is delineated and risk areas identified

b. Mitigation strategies are developed, including resource and schedule requirements

Note: The following examples are intended to provide clarification of the types of data and level of detail expected to be addressed at SRR. It is intended that the contractor will identify those subsystems and components applicable to the type of system being developed and the appropriate criteria for each subsystem and component necessary to effectively evaluate and assess the proposed system concept and technical, cost, and schedule parameters, e.g.:

⇒ For Electrical Power:

- Preliminary Electrical Power Distribution System (EPDS) performance requirements, characteristics, and operational criteria are defined, including initial power budgets, total power demand with allowable margins, and modes of operation (frequency and duration)
- Preliminary selection and evaluation of the type(s) of power supply sources being considered, including their specific technology and topology
- Preliminary battery (or energy storage) power requirements identified and modes of operation defined (frequency and duration)
- Beginning-of-life (BOL), and end-of-life (EOL) battery life requirements, and other unique requirements that may impact battery selection or design are identified
- Candidate battery cell technologies are identified and battery architectures defined

⇒ For software:

- Conceptual software architecture is developed, including modularity structure to demonstrate software producibility, adaptability, maintainability
- Initial processing capacity and throughput requirements are established
- Reprogrammability criteria and capability are defined
- A preliminary estimate of equivalent source lines of code (ESLOC) is made
- Preliminary software risk management and mitigation processes are defined

  - o System and program risks include preliminary critical software risks as appropriate, e.g., complexity, size, processing speed, throughput, schedules, COTS availability, legacy reuse suitability, and software development processes and tools
  - o Software risk management processes are part of the software development and integrated with the System Risk Management Model
- The conceptual software architecture addresses the use of open systems standards and satisfies all appropriate interoperability-related requirements

10.4.3 System, Segment, and Subsystem Verification and Validation

Evidence of System, Segment, and Subsystem Design Concepts verification and validation (V&V) requirements maturity criteria examples at SRR:

A. Preliminary System, Segment, and Subsystem V&V strategies, concepts, and methodologies are developed:

1. Conceptual strategies are established to verify and validate system(s) performance requirements and parameters, e.g.:

a. V&V strategy and methodology for System, Segment, and Subsystem and component

b. V&V strategy methodology and techniques, e.g.:

(1) Analytical, modeling and simulation (M&S), and testing

(2) Use of new technology, qualification practices, system(s)-level demonstrations and tests

(3) External organizations and/or facilities and resource requirements and support

(4) Use of proven practices

B. System, Segment, and Subsystem operational functions environments are identified and defined, and are traceable to operations and FBL through analysis and trade studies:

1. Preliminary system(s) V&V test environments are defined and are traceable to system(s) functions and specification requirements

2. Demonstrates environmental parameters correlated with V&V strategies and methodology

C. Overall Development, Test, and Evaluation (DT&E) elements are defined for each conceptual solution with rationale for their selection

D. Preliminary OT&E requirements analyses completed and test criteria defined traceable to operational T&E trade results:

1. Analysis includes input and requirements from all potential stakeholders

2. V&V test requirements are derived and integrated into program planning and design concept

3. Resource and programmatic requirements and issues are identified that may impact program technical, cost, or schedule parameters

E. Preliminary test requirements and results, traceable to operational requirements via specifications defined by the V&V cross-reference matrix (VCRM).

F. Risk areas are identified and mitigation strategies established:

1. V&V test deficiencies, including those based on technology deficiencies, are identified and characterized

2. Risk mitigation strategies are developed and integrated into a system risk model, including resource requirements

G. V&V methods for each requirement are specified, e.g., a V&V compliance matrix is developed.

10.4.4 Engineering Disciplines and Specialty Engineering

Appendix A

Evidence of Engineering Discipline and Specialty Engineering identification and assessment maturity criteria examples (categories listed in A through R below) at SRR in terms of,

1. Key performance requirements
2. Key performance parameters
3. Use of heritage systems, components, and technology
4. Use of new designs

A. Parts, Materials, and Processes (PM&P)

1. The preliminary PM&P functional requirements have been established
2. Initial assessment of environments and environmental parameters impacting parts performance for each system design concept is completed
3. Parts engineering design strategies are developed for each design solution concept, including risk assessments, technologies, sources of supply, and the common quality levels (i.e., reliability) of the parts
4. Identification of potential long-lead items and processes, and/or facility needs and impacts

B. Test and Evaluation (T&E)

1. The preliminary T&E strategy is illustrated with all test objectives, test environments, and test resources identified to ensure compliance with design and specified requirements
2. The preliminary T&E methodology(s) is defined for all test approaches addressing all system components critical to verifying system technical requirements and tailored to the characteristics, effectivity(s), and margins of each particular test item
3. Test and verification methodology(s) for data gathering, reduction, and analysis is defined, including test environment(s), operations and procedures to be performed, data acquisition requirements, documentation, methods of analysis, and pass-fail (i.e., success) criteria
4. Development, qualification, and acceptance testing of systems, subsystems, components, assemblies, including NDI and COTS, are implemented, e.g.:
    a. The qualification and verification approach is tailored to the characteristics of the particular item to be tested
    b. Development test results are available to support candidate selection

C. Survivability and Vulnerability

1. Survivability and vulnerability threat assessments are performed for each design concept establishing KPPs for each assessed threat and defining categories of expected threats, threat environments, and their likelihood of occurrence
2. A set of survivability characteristics and objectives that are critical to the mission are defined. Specifically:
    a. Criticality is defined in terms of a system that meets operational and survival objectives as defined in the Government’s Initial Capabilities Document (ICD) and System Level Concept of Operations (CONOPS)
    b. Characteristics are expressed in terms of measurable quantitative parameters
    c. Characteristics are amenable to validation by test and analysis
    d. Characteristics are reflected in the system’s configuration baseline
    e. Survivability characteristics should have evolved into discernible system hardness attributes and system design criteria

3. Preliminary system and threat interaction analysis is performed for each design concept to establish allowable margins for each threat
4. Survivability design criteria derived from threat analyses support the candidate design solutions to mitigate each assessed threat

D. Environmental Safety and Occupational Health (ES&OH)

1. Life cycle environments for each design concept are defined and assessed against system requirements
2. Sufficient data is compiled to complete Key Decision Point B (KDP-B) Programmatic Environmental Safety and Occupational Health Evaluation (PESHE) compliance objectives IAW appropriate standards as started at KDP-A, including an assessment of internal and external operational environments for each design concept
3. Critical human safety and health factors are identified and incorporated into the system safety program architecture
4. Hazardous materials management and pollution prevention tasks are identified and prioritized

E. Mass Properties

1. An initial mass properties budget is established, including mass properties and appropriate margins
2. Parameters for weight growth, center of gravity, and moments of inertia predictions are established

F. System Security Engineering (SSE), Communications Security (COMSEC), Information Assurance (IA), and Program Protection (PP)

1. SSE, IA, COMSEC, and PP security requirements are identified for each preferred design concept solution in accordance with DoD and AF policies, directives, and system specifications process and plan (i.e., DIACAP)
2. Integration of SSE, COMSEC, IA, and PP requirements is defined
3. Security SSE, COMSEC, and PP approaches anti-tamper applications, (including a preliminary security concept, threat, vulnerability and risk assessments, protection countermeasures, and test and evaluation methodology and requirements), are defined
4. Preliminary IA controls are identified for system and data protection, availability, integrity, confidentiality, and authentication, and non-repudiation for each design concept is addressed to include DIACAP certification and accreditation requirements, e.g.:
5. “Net-Centric Operations and Warfare (NCOW) Reference Model (RM)” – “NCOW RM” is presented
6. KIP compliance demonstrated
7. IA compliance demonstrated
8. Estimated costs and schedule objectives are identified for inclusion in the program’s baseline for SSE, COMSEC
9. Program Protection and Information Assurance countermeasures for the system’s life cycle activities are developed
10. Software requirements for information assurance are complete and are appropriate, e.g., information assurance standards are included in the System software Requirements
11. Associated Certification and Accreditation timelines are established

G. Interoperability

1. Preliminary DoD Information Standards Repository (DISR) standards are identified that meet the system and mission interoperability requirements (i.e., must be DISR compatible and compliant)
2. New and unique standards outside DISR are recommended for the selected design concept submitted for approval and incorporation into DISR (i.e., new data formats, data exchange protocols and schemas, Ethernet alternatives)
3. Preliminary interoperability architecture requirements are identified
4. Interoperability analysis approaches are selected

H. Reliability and Maintainability (R&M)

1. Preliminary R&M requirements and characteristics are defined (e.g., mission duration, Ao and Do, MTBF, MTTR, failure modes, single point of failure, redundancy, etc.)
2. Preliminary R&M analysis is accomplished and results are fed into the overall system architecture for each design solution concept
3. Methodologies for defining Environmental Effects Stress Screening (EESS) are established
4. Packaging, Handling, Storage, and Transportability (PHS&T) environmental requirements are incorporated into the R&M program

I. Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

1. The following EMI and EMC considerations are addressed for each design concept, e.g.:
   a. Preliminary electromagnetic interference control approaches are developed
   b. Preliminary internal and external EMI and EMC requirements are defined
   c. Preliminary EMI susceptibility requirements and constraints are identified (i.e., passive modulation, transmitter Radio Frequency Interference (RFI) with vehicle receivers and ordnance, radiated effects on power buses, lightning and surge protection)
   d. Preliminary EMI and EMC-critical environmental characteristics and sensitive elements identified
2. A summary of all significant areas addressed in the EMC Control Plan, including but not limited to program requirements tailoring and the use of heritage equipment and other NDI
3. A summary of EMC requirements verification planning to the unit level
4. The EMC staffing plan
5. All risk areas and risk mitigation closure plans

J. Human Systems Integration (HSI)

1. User interface hardware and software requirements for operators, users, maintainers, and sustainers are decomposed and derived for each design concept
2. Usability, maintainability, or supportability requirements are decomposed and derived from the system requirements for each design solution
3. Staffing, workload, and skill-level requirements are decomposed and derived for each design concept, e.g., all HSI-related requirements, standards, and standard practices flowed down to subordinate contracting activities
4. Requirements for HSI are complete and consistent with appropriate standards, e.g., description and definition of the end users, operators, maintainers, and sustainers are coordinated with the appropriate contracting agency organizations
5. Software requirements for Human Systems Integration (HSI) are complete and reference all appropriate standards (e.g., MIL-STD 1472F, DoD Human Computer Interface (HCI) Style Guide, and SMC/AXE Report No. HMRB-2001-1)

K. Manufacturing and Producibility

1. Requirements that will drive stressing design attributes and associated specialized manufacturing requirements (caused by attributes like extreme complexity, multiple, very tight tolerances, precision assembly, handling of fragile components, etc.) are identified

2. Manufacturing and producibility plans for new technologies are identified

L. Life Cycle Logistics

1. Preliminary logistics management information (LMI) is complete and validated for each design solution concept, including initial supportability trade studies and analysis results

2. System-level design factors, for selected design concept are verified for the following logistics elements: design interface, supply support, test equipment, manpower and personnel, training and training equipment, PHS&T, facilities, computer resources, technical data, and maintenance planning, e.g., supportability requirements and design factors are defined for each design concept and are traceable to CONOPS, ICD, and CDD. Design factors for the following logistics elements are identified

M. System Safety

1. System safety requirements are identified for each design concept, including preliminary safety risk analysis results and mitigation approaches

2. Preliminary hazard analysis is completed and an initial list of safety hazards is identified for the test, operation, and disposal of each design solution

3. Critical human safety and health factors are identified and incorporated into the system safety program architecture

4. An initial hazardous materials list is compiled and prioritized based on National Environmental Policy Act (NEPA) and Occupational Safety and Health Act/Administration (OSHA) criteria, i.e., permissible exposure levels (PELs), toxicity, volatility, and transportability

N. Risk Assessment

1. Risks are identified, assessed, controlled, minimized, and accepted, i.e.:

   a. Technology maturity level of selected design approach and associated mitigation plan

   b. Utilization of sole source items

   c. Number and levels of proposed redundancies

   d. Utilization of prototypes, qualification test articles, test beds, and number of test cycles with corollary schedule considerations

   e. Use and support of COTS products

O. Quality Assurance

1. Preliminary quality and product assurance requirements are defined for each design concept

2. Preliminary verification, inspection, and test approaches are identified

P. Environmental Controls

1. Preliminary operational environmental studies are completed

2. Preliminary environmental control test and evaluation strategies are developed

3. Preliminary environmental control reliability trade studies and analyses are completed

Q. Software

1. Software System Requirements, e.g.:

   a. The software requirements analysis has included complete allocation of functionality

b. All appropriate interface standards are included in the software requirements (e.g., Space to Ground Link Set (SGLS)).

c. Software requirements for dependability, reliability, maintainability, and availability are complete, based on the system requirements analysis and allocations to software and hardware

d. Software requirements for supportability are complete, based on the system requirements analysis and allocations to software and hardware

e. Software safety requirements are complete, based on the system requirements analysis and allocations to software and hardware

f. All appropriate software safety standards (e.g., EWR-127 or AFSPC Manual 91-710) are included in the system requirements

g. All appropriate information assurance standards are included in the system requirements

h. Software requirements for reprogrammability are complete for all appropriate computer resources

i. Software requirements for Human Systems Integration (HSI) are complete and reference all appropriate standards (e.g., MIL-STD 1472F, DoD HCI Style Guide, and SMC/AXE Report No. HMRB-2001-1)

j. Software requirements for interoperability with external elements are complete and reference all appropriate interoperability and open system standards

k. Software requirements for margins are complete for all computer resources (e.g., memory and storage capacity, processor throughput, and communications bandwidth)

l. Software requirements are appropriately allocated to COTS products

2. Software requirements for states and modes are defined as allocated from the system requirements

3. Software requirements for information assurance are complete and are appropriate, e.g., information assurance standards are included in the system requirements

4. Operational Concepts, e.g.:

a. System operational concepts include both nominal and off-nominal scenarios from a software perspective, e.g., processor failover, redundancy management

b. Software requirements for operations, maintenance, and training needs are complete

c. System operational concepts include identification of operations and maintenance staffing, e.g., numbers, skills, roles, and positions from a software perspective

d. Software requirements for supportability are complete and apply to both software and hardware

5. Software Metrics and Technical Performance Measures are established, e.g.:

a. Preliminary software metrics planning is sufficient for meeting the information needs for program and engineering management

b. The selected TPMs include estimates of utilization for all computer resources, e.g., processors, memory, storage, and input and output channels, buses and networks

c. Database and tools are selected for metrics and TPM tracking, trending, and reporting

R. Data Storage (Security, Access, Distribution, and Delivery)

1. Preliminary Storage System Capability, Flexibility, and Scalability requirements, e.g.:

a. Analysis identifies needed reliability, maintainability, and availability characteristics of storage systems environments

b. Capacity, flexibility, and extensibility parameters identified that support the expected life of the system

c. Key system components and requirements for redundancy identified, e.g., storage media hardware and software capabilities and types

d. Storage system management requirements are identified

e. Storage system operational environments identification and hardening requirements are stated

2. Storage System Architecture (SSA), e.g.:

   a. A preliminary storage system architecture identifies communications, and processing capacity requirements

   b. A preliminary storage system requirements are identified, e.g., centralized vs. distributed storage; online, near-line, and offline needs; archive (including hierarchical storage management, if appropriate), backup, and restore; and data replication

   c. a preliminary storage hardware components are identified, e.g., RAID, Storage Area Networks (SAN), Network Attached Storage (NAS), and Direct Attached Storage (DAS), consistent with the SSA

   d. a preliminary data management software capabilities have been identified, e.g., automatic file migration and transparent file retrieval; migration between hierarchical levels; and utilities to report on media usage, error detection, and identification

3. Security, e.g.:

   a. A preliminary level of user integrity (e.g., access control lists) is identified that supports system requirements

   b. A preliminary level of encryption needed is identified

   c. A preliminary need for specialized security capabilities, such as CDS, MLS, and Security Enclaves, has been identified and is included in the storage system so as to ensure that the system requirements are met.

4. Data Distribution Methods, e.g.:

   a. Preliminary list of data receivers has been identified, e.g., computer and human agents.

   b. Preliminary method(s) of data distributing data is identified, e.g., Subscribe and Publish, Push and Pull, and global or restricted Web-based access

   c. Preliminary data distribution methods are compatible with the storage architecture

5. Functionality, e.g.:

   a. A preliminary analysis identified the physical aspects of the functionality needed to support the mission

   b. A preliminary types of platforms (server and client) and operating systems supported are identified

   c. Preliminary data connection and transport protocols (e.g., fiber channel, infiniband, SWCI) are identified

   d. Preliminary reporting (e.g., usage) and maintenance metrics (e.g., MTBF and MTTR) are identified

   e. Preliminary mapping between metrics and system-level requirements has been completed

10.4.5 Integrated Technical Risk Management and Mitigation

Appendix A

Evidence of technical risk management (RM) process maturity criteria examples, as a key component of an integrated program (technical, cost, schedule, and performance) RM and Mitigation (RM&M) process at SRR.

A. Risk identification and risk-ranking strategies encompass such aspects as:

1. The interrelationship among system effectiveness analysis, technical performance measurement, intended manufacturing methods, and costs
2. Hardware and software elements of the system, subsystem, and component, including those elements provided by other external organizations or affected by application of design standards, etc.
3. Inherited hardware or software use
4. Dependence on external events that must be realized
5. Industrial base, technology development, engineering skills, and resources
6. Mitigation processes and procedures
7. Follow-on development and low-rate production
8. System requirements, preliminary system functional definition, and functional decomposition maturity and confidence levels
9. The dependency of business development plans on the Program IMP, IMS and WBS
10. Program schedule, technical and funding risk assessment ranking, monitoring and documentation adequacy
11. Schedule and funding risks
12. Technical risks
13. Risk management database and tools for risk metrics collection, analysis, tracking, and reporting
14. Draft mitigation processes and procedures
15. Comprehensive risk assessment for the follow-on phases
16. System requirements, as understood and integrated into system design solution
17. Initial Capabilities Document (ICD) or draft Capability Development Document (CDD)
18. System requirements maturity and confidence
19. Preliminary system functional definition and functional decomposition

B. Risk mitigation and reduction strategies, avoidance, and control encompass such items as:

1. Burn-down plans that are linked to dependencies on the Program IMP, IMS and WBS
2. Continuous risk monitoring and review, identification, assessment, and ranking
3. Technology and manufacturing readiness level (TRL and MRL) assessments and metrics that include:
    a. Preliminary (or top 5) program-level risks
    b. Preliminary risk mitigation plan formulated for top risks
    c. Requirements risk monitoring
    d. Software risk management of critical software issues, e.g., complexity, size, processing speed, throughput, schedules, COTS availability, legacy reuse suitability, and software development processes and tools

Appendix B

Appendix B - System Functional Review (SFR)

20. System Functional Review (SFR)

The SFR is a multidisciplinary technical product and SE process assessment that is used to determine whether the system design concept under review sufficiently mature to proceed into preliminary design, and that all system requirements and functional performance requirements derived from the Capability Development Document (CDD) as defined:

a. Are consistent with program cost and budget, schedule, risk, user and/or other constraints

b. Are captured in system specifications (functional baseline)

c. Are fully decomposed and defined in the functional baseline and traced to lower-level subsystem and CI functionality that may define hardware and software requirements

d. Maintain consistency with available technologies for the preferred system solution

e. Address all primary systems engineering functions, including development, manufacturing, verification, deployment, operations, support, training, and disposal, including the risks inherent in the contractor’s products and processes

f. Can meet the program objectives with manageable risk

SFR shall be tailored to address the technical scope and risk of the system and EI, and validate the Systems Engineering Plan. The SFR is the last review that ensures that the system design concept is credible and feasible before preliminary design commences

20.1 General

The SFR shall be conducted when the system definition effort has proceeded to the point where:

a. Functional and performance characteristics of the system architecture are defined and all optional design concepts are identified

b. The System’s form, fit, function, performance (FFFP), and interface (I/F) requirements have been optimized and the associated technical risks assessed

c. Engineering functions of all primary systems engineering functions, including development, manufacturing, verification, deployment, operations, support, training, and disposal have been addressed

d. Systems engineering processes that produced the technical and allocated baseline (ABL) requirements and the engineering planning for the next phase of effort have been defined

e. Technology maturity issues from manufacturing considerations are understood, issue resolution plans are in place, and production engineering requirements in subsequent phases are identified

Key elements of the review shall include but not be limited to addressing:

a. The adequacy of system and segment requirements and their allocation to hardware and software items and personnel

b. The adequacy of the system architecture to meet the system and segment requirements and the user’s Concept of Operations

c. The adequacy of system and segment verification planning

d. The adequacy of supporting engineering analyses

e. The readiness of necessary technology

f. The adequacy of engineering and management plans and processes

g. The acceptability of the remaining system and program risks

The principal goal of the SFR is to determine whether the level of residual risk is acceptable for proceeding with subsequent development activities.

The SFR addresses all primary systems engineering functions, including development, manufacturing, verification, deployment, operations, support, training, and disposal.

20.2 Purpose

The SFR is normally conducted after SRR. The purpose of the SFR is to:

a. Assess the direction and progress of the contractor's systems engineering and management processes

b. Assess the contractor's convergence upon a complete, consistent, and technically sound set of system, segment, and subsystem requirements and system architecture

The SFR confirms that:

a. The technology maturity has been demonstrated and the risk reduction efforts planned prior to the start of design have been completed and the results have been reflected in the proposed requirements and allocated baseline

b. The requirements analysis has progressed to the point that the proposed requirements baseline is accurate and comprehensive (though perhaps with a few To Be Determined(s) (TBD)s, To Be Resolved(s) (TBR)s, and To Be Supplied(s) (TBS)(s))

c. The preliminary allocated baseline reflects the proposed requirements baseline and is balanced with respect to performance, cost, schedule, risk, and potential for evolutionary growth

d. The decision database supports two-way traceability from the source of the requirements baseline to the preliminary allocated baseline and from any element to the rationale for that element

e. The assessment that the evolving allocated baseline can lead to a design that will satisfy the requirements baseline

f. The preliminary physical hierarchy, the planned or approved PWBS, and the CWBS that are in place or are proposed to be used subsequent to the SFR are all consistent

g. The life cycle cost for the evolving design is consistent with the program affordability constraints

h. The remaining risks have been identified and can be handled in the context of the planned contract and program activities

20.3 Objective

The objective of the SFR is to:

a. Evaluate the optimization, correlation, completeness, and risks associated with the allocated technical requirements

b. Assess the systems engineering process that produced the allocated technical requirements

c. Evaluate the engineering planning for the next phase of effort

d. Review that basic manufacturing considerations are identified

e. Verify that planning for production engineering in subsequent phases is addressed

A successful SFR shall provide as an example:

a. An established system functional baseline

b. An updated risk assessment for the System Development and Demonstration (SDD)

c. An updated program development schedule including system and software critical path drivers

d. An approved SWCI with updates

The most important takeaway from the SFR is a clear understanding and agreement that:

a. The lower-level performance requirements of the system(s) under review are fully defined and are consistent with the mature system concept

b. The lower-level systems requirements trace to top-level system performance and the Capability Development Document

c. The determination that the system performance requirements, lower-level performance requirements, and plans for design and development form a satisfactory basis for proceeding to preliminary design

20.4 SFR "Acceptance Criteria"

At SFR all major systems engineering management elements and activities that are program risk drivers are considered. The intent of the SFR is to ascertain that:

a. An accurate and comprehensive requirements baseline (RBL) can be approved

b. A final functional baseline (FBL) can be established

c. Effective and efficient progress is made towards:

   i. Meeting all technical performance requirements

   ii. Buying down risk by the application and utilization of mature technologies

   iii. The capability to track, monitor, status and achieve TPMs

   iv. Associated cost and schedule objectives

Each criterion shall be deemed successfully accomplished upon demonstrating to the satisfaction of the contracting agency that all applicable engineering activities have been properly conducted in support of the criterion. Entrance into the review requires that the contractor appropriately address the requirements criteria elements, and demonstrate a viable technical and program risk management strategy. Successful exit from the review implies that all criteria elements have been demonstrated to the satisfaction of the contracting agency.

The SFR "Acceptance Criteria" shall be organized under the following five major categories:

1. Systems Engineering and Architecture Development (20.4.1)
2. System, Segment, and Subsystem Design (20.4.2)
3. System Verification and Validation (20.4.3)
4. Engineering Disciplines and Specialty Engineering (20.4.4)
5. Integrated Technical Risk and Mitigation (20.4.5)

This review shall serve as objective evidence of the contractor's technical effort that supports the basic and agreed-to SFR "Acceptance Criteria," e.g.:

a) The system functional requirements, as disclosed, satisfy the Capability Development Document.

b) The system functional requirements are sufficiently detailed and understood to enable system design to proceed

c) The processes and metrics in place for the program to succeed are adequate

d) The risks are known and manageable for development

e) The program schedule is executable (technical, cost, and schedule risks)

f) The program is properly staffed

g) The program with the approved functional baseline is executable within the existing budget

h) The contractor's proposed system functional baseline is consistent with the current update of the Cost Analysis Requirements Description (CARD)

i) The updated cost estimate fits within the existing budget

j) The system Functional Baseline is established to enable preliminary design to proceed with proper configuration management

k) The software functionality in the approved functional baseline is consistent with the updated software metrics and resource loaded schedule

l) All IMP and IMS tasks associated with this review have been successfully closed

The following sections address the minimum, but not all-inclusive, list of criteria that shall be accomplished in support of the SFR, as specifically tailored by contract, along with all applicable engineering activities to be reviewed.

20.4.1 Systems Engineering and Architecture Development

Evidence of Systems Engineering, Architecture Development, and Design Development maturity criteria examples at SFR:

A. The system, segment, and subsystem functional requirements are complete, feasible, verifiable, and clearly stated

B. KPPs, system requirements, CONOPS, and the SPD are compared and correlated with the selected design concept and captured in the Requirements Allocation Document (RAD)

C. Baseline system functional requirements are derived from the architecture for the selected design concept, e.g.:

   1. The architecture demonstrates the expected level of program compliance, e.g.:

      a. Baseline system modeling and selected synthesis methodology are based on proven practices

      b. The system, segment, and subsystem functional requirements (i.e., internal and external) are under configuration management and are sufficiently mature to allow to proceed with preliminary design

   2. Architectural views for the selected System, System of Systems, and Family of Systems design concept are clearly traceable to derived KPPs, e.g.:

      a. The system architecture fully implements the selected design concept's system, segment, subsystem, and interface requirements and the contractor's operational concepts

      b. The architecture for the selected design concept is feasible and extensible

   3. An architectural view(s) for the selected design concept is established, e.g.:

      a. The necessary system view(s) is determined and established, correlating systems and characteristics to operational needs

      b. The necessary operational view(s) is determined and established, which identifies baseline functional performance requirements by system components and elements and by organizational owners and operators

      c. The necessary technical standards view(s) is determined and completed, establishing the standards definitions and conventions necessary to implement the selected design solution concept

D. The system design concept was selected in the context of engineering trade space, technical requirements, system performance, risks (technical, programmatic, schedule, cost), LCC and CAIV trade analysis, etc., e.g.:

1. The key technical and programmatic details developed and derived for the selected system design concept, e.g., the contractor's operational concepts fully implement and are consistent with the user's updated Concept of Operations (CONOPS) for the full program life cycle
2. The contractor's updated operational concepts are consistent with the system and segment, and interface requirements are baselined and under configuration management
3. Interoperability functional requirements are defined for the proposed system design concept, and performance allocations are established, e.g.:
    a. Final interoperability performance and design parameters and drivers for the selected design concept are shown to be derived from the requirements analysis
    b. Results of trade studies are shown to be integrated into the selected system design baseline and model
    c. Demonstrated interoperability requirements and functional performance criteria are incorporated into the selected design concept
    d. Requirements for demilitarization and disposal at EOL are integrated into the system design baseline

E. System external interfaces are identified and functional performance interface (both internal and external) requirements are developed for the selected design concept, e.g.:

1. System-to-system, segment-to-segment, subsystem-to-subsystem and component-to-component functional interface analyses are completed
2. Intersegment and intersubsystem interface requirements are consistent with and referenced by the System Performance and Segment and Subsystem Specifications
3. Impacts to internal and external systems and system requirements are identified for the selected design concept
4. The system and external interface functional requirements meet all contract provisions, including compliant specifications and standards for the selected design concept, e.g.:
    a. The segment, intersegment, subsystem, and intersubsystem requirements meet all compliant specifications and standards
    b. Preliminary Functional Flow Block Diagrams (FFBDs) developed demonstrate the flowdown and traceability between higher and lower-level requirements

F. Mission and System Functional Requirements Baselines are established, based on the selected design concept, e.g.:

1. Sufficient verified technical information exists that supports the establishment of mission and system requirements baselines
2. FBL, based on the design concept, is selected; details adequate to address all KPP and system performance and specification requirements, e.g., requirements flowdown trade studies and analyses from system to segment to subsystem to components are complete and traceable to accepted trade results

G. The life cycle cost (LCC) and cost as an independent variable (CAIV) assessment supports the selected design concept and the functional baseline, e.g.:

1. LCC and CAIV modeling and analyses applied and correlated with the selected design concept and the functional baseline, e.g., cost models representing projected program development, operational and sustainment costs are completed, including projected cost impacts to other "external" systems

H. Traceability of the selected design concept to system KPPs and system trade studies has been clearly shown, e.g.:

   1. Traceability of and correlation to the selected design concept to KPPs and trade study analysis results are demonstrated

   2. The system requirements and external interface functional requirements are traceable to and fully implement the contract System Performance Specification, segment, and subsystem specifications and the user's Capability Development Document (CDD), e.g., the segment, intersegment, subsystem, and intersubsystem interface requirements are traceable to and implement the system and external interface functional requirements

   3. The system and external interface functional requirements for the selected design concept is baselined and under configuration management

I. The System Performance Specification developed for the selected design concept is traceable to both the requirements and functional baselines, e.g.:

   1. Segment and subsystem specifications preliminarily are defined and traceable to the System Performance Specification

   2. The modeling and simulation capability planning and scheduling is synchronized with system, segment, subsystem, and interface design development plans and schedules

   3. System-level verification cross-reference preliminarily is defined and traceable to the verification methodology of the selected design concept

J. System integration and verification requirements analyses are completed for the selected design concept, e.g.:

   1. System-level verification planning completed with rationale for verification objectives, types, levels, and sequence of verification and verification data to be collected

K. A preliminary allocation of the technical and functional baselines are defined for the selected design concept, e.g.:

   1. Preliminary allocation baseline for the selected design concept system, its segments, and subsystems are correlated with engineering trade assessments and risk study results

   2. All preliminary Hardware Configuration Item (HWCI) and Software Configuration Item (SWCI) descriptions are developed

   3. All preliminary HWCIs and SWCIs specification requirements are defined and are traceable to the system performance specification

   4. All software components (tactical, support, deliverable, nondeliverable, etc.) are preliminarily defined and traceable to the system performance specification

20.4.2 System, Segment, and Subsystem Design

Evidence of System, Segment, and Subsystem Design Concepts maturity criteria examples at SFR:

A. System, segments, and subsystems are established for the selected design concept and major and critical performance parameters are baselined

   1. The selected design concept demonstrates traceability among all considerations, e.g.:

      a. Performance requirements

      b. Engineering trade space, technology status and deficiencies, and technical, programmatic, schedule and cost risks

      c. The adequacy of the selected design concept has been demonstrated using engineering analysis, including all relevant specialty engineering disciplines and is consistent with the TPMs and KPPs, e.g.:

(1) Engineering analysis adequately demonstrated that the allocation of functional requirements to hardware and software items and personnel will meet system requirements

(2) Engineering analysis adequately demonstrated the readiness of the design to proceed

2. System performance parameters, characteristics, design challenges, and risk assessments that form the system risk model for the selected design concept are under configuration management

3. Demonstrate that critical performance and functional requirements are incorporated in the selected design concept

B. C4I requirements analysis results and allocation across subsystem and components are completed and traceable to the selected system design concept, e.g.:

1. C4I strategy for the selected design concept solution for battle management and information technology (IT) needs and dependencies between system subsystems and the system, system of systems, and family of systems

2. Net-centric (i.e., network) trade study results demonstrated the architecture and information environments for the selected design concept

3. Demonstrate that C4I requirements ensure interoperability, interconnectivity, supportability, synchronization, and sufficiency, e.g., performance criteria are incorporated in the selected system design concept and allocated across segments, subsystems and components

C. Threat scenarios and threat environments initially defined or enveloped and correlated with the selected system design concept, e.g.:

1. Threat scenarios and environments are defined and validated

2. Performance parameters are defined and are traceable to the selected system design concept and to known and identified threats

3. Demonstrate that threat scenario operational and environmental criteria are incorporated into the selected system design concept and allocated to segments, subsystems and components

D. Environments (e.g., natural and debris, shock, vibration, thermal, humidity, vacuum) are defined and parameters correlated to the selected system design concept, e.g.:

1. Environmental parameters derived from known source (i.e., similar systems) data and system functional analyses using proven methodology, e.g., environmental models and simulations validated

2. Demonstrate that environmental parameters are incorporated into the selected system design concept and allocated to segments, subsystems and components

E. Reliability, availability, maintainability, and testability (RAM&T) requirements and design factors correlated with the selected design concept, e.g., demonstrate that the RAM&T design criteria are incorporated into the selected design concept and allocated to segments, subsystems and components

F. The system operational sustainment strategy is defined, including key performance parameters; design drivers for sustainment are integrated into the selected design concept, including all major system and program requirements, e.g.:

1. Sustainment trade study results used to baseline crucial system performance requirements for the selected system design concept are traceable to program requirements and CONOPS

2. LCC sustainment model correlates to the selected design concept

G. The development strategy to achieve the selected design concept Technology Readiness Levels (TRLs) has been implemented, e.g., risk mitigation strategies have been developed and integrated into the system risk model, including resource requirements for the selected design concept

H. Industrial Base (IB) assessment results are correlated with the selected system design concept, risk areas are identified and prioritized and mitigation strategies defined, e.g.:

   1. IB assessment data correlated with identified and implicit risk areas

   2. Mitigation strategies planned and implemented, including resources and schedule requirements

I. Performance requirements for the selected system design concept's major subsystems and components are baselined:

   1. All major subsystems and components traceable to the selected system design concept and identifies use of heritage systems, components, and technology as well as use of other new designs

   2. Key parameters and information are developed and assessed for each major subsystem and component of the selected system design concept, e.g.:

      a. Major performance parameters are identified

      b. Critical technologies are identified, including deficiencies

      c. Critical design and manufacturing requirements and challenges are identified

Note: The following examples are intended to provide clarification of the types of data and level of detail expected to be addressed at SFR. It is intended that the contractor will identify those subsystems and components applicable to the type of system being developed and the appropriate criteria for each subsystem and component necessary to effectively evaluate and assess the proposed system concept and technical, cost, and schedule parameters, e.g.:

⇒ For Electrical Power Systems

- Electrical Power Distribution System (EPDS) performance requirements, characteristics, and operational criteria are developed and baselined for the selected system design concept, including power budgets, power demand (with margins), and modes of operation (frequency and duration)
- Selection of the type(s) of power supply sources, including their specific technology and topology validated for the selected design concept
- Derived battery life requirements (BOL and EOL) and any other unique requirements that may impact battery detailed design baselined for the selected design concept
- Battery cell technology(s) selection(s) provided for the selected design concept; battery architecture(s) (including hierarchy and traceability to the system design concept performance criteria)

⇒ For Software

- Software architecture to SWCI level is defined for the selected system design concept
- SWCI external and internal interfaces are defined
- Software-related segment requirements allocation to SWCIs is defined
- Processing capacity and throughput requirements are validated for the selected design concept solution
- Reprogrammability criteria and capability are correlated with and validated for the selected system design concept
- An estimate of ESLOC to reflect software architecture and hierarchy of the selected design concept is developed and demonstrates traceability to the design concept's software performance requirements
- With the preliminary software maintenance plan complete, software maintenance supports the program logistic plan

- Software risk management plan is complete. software risk management tool shall be compatible with program risk management tools
- Software risk management and mitigation processes are validated for the selected system design concept

20.4.3 System, Segment, and Subsystem Verification and Validation

Evidence of System, Segments, and Subsystem Design Concepts V&V requirements maturity criteria examples at SFR:

A. System V&V strategies, concepts, and methodologies are validated for the proposed design concept solution with acceptance rationale:

1. Design concept strategies established to demonstrate and verify major system performance requirements and parameters, e.g.:

a. V&V strategy and methodology addresses system, segment, and subsystem and component-level verification approaches for the selected design concept

b. V&V strategy and methodology addresses analytical, modeling and simulation, and testing strategies and techniques for the selected design concept, e.g.:

(1) Analytical, modeling and simulation (M&S) and testing

(2) Use of new technology qualification practices, system(s)-level demonstrations and tests

(3) External organizations and/or facilities, and resource requirements for the selected design concept and support

(4) Uses of proven practices are defined with references

2. Updated system VCRM is complete and consistent with system requirements and external interface requirements, e.g.:

a. Segment and subsystem VCRMs are complete, consistent with segment and subsystem

b. Requirements are traceable to the system VCRM

c. The updated system VCRM and the segment and subsystem VCRMs are baselined and under configuration management

d. Verification methods in the system and segment and subsystem VCRMs are adequate to verify system, segments, and subsystems

B. System, Segment, and Subsystem operational functions and environments for the selected design concept are identified are defined and are traceable to the contractor's operations concept and the Functional Baseline:

1. System V&V test environments are defined and traceable to the system performance specification for the selected design concept

2. Demonstrate that environmental parameters are correlated with verification strategies and methodology for the selected design concept

C. DT&E elements are defined for the selected system design concept and execution strategy developed

D. OT&E requirements analyses are completed and test criteria defined (in conjunction with AF Operations Test and Evaluation Center (AFOTEC)) for the selected system design concept traceable to operational T&E trade study results:

1. Analysis results are traceable to inputs and requirements from all potential stakeholders

2. V&V test requirements are derived and integrated into program planning and design concept

3. Resource and programmatic requirements and issues are identified that may impact program technical, cost, or schedule parameters, e.g.:

a. Requirements and architecture(s) of test beds and test facilities are documented and proven suitable for the selected design concept's system, segment, and subsystem, and interface requirements verification (V&V)

b. For critical hardware and software items, V&V resources (e.g., simulators, test beds, test facilities) are identified and plans and schedules are in place for their development or procurement

E. Test requirements and test data collected to date for the selected design concept are traceable to operational requirements via specifications defined by the V&V cross-reference matrixes (VCRMs), e.g., use of comparative test data to anchor representative system models and simulations to real-world environments and system functional performance requirements is demonstrated

F. V&V risk areas and mitigation strategies are baselined for the selected design concept:

1. V&V test deficiencies, including those based on technology deficiencies are identified and characterized for the selected design concept

2. Risk mitigation strategies are developed and integrated into the system risk model, including resource requirements for the selected design concept

20.4.4 Engineering Disciplines and Specialty Engineering

Evidence of Engineering Discipline and Specialty Engineering identification and assessment maturity criteria examples (categories listed in A through R below) at SFR in terms of, e.g.:

1. Key performance requirements
2. Key performance parameters
3. Use of heritage systems, components, and technology
4. Use of new designs

A. Parts, Materials, and Processes (PM&P)

1. PM&P functional requirements are validated for the selected design concept

2. Assessment of environments and environmental parameters impacting parts performance for the selected system design concept is completed

3. Parts engineering design strategy for the proposed design solution is selected, including risk assessments, technologies, sources of supply, and the common quality levels (i.e., reliability) of the parts

B. Test and Evaluation (T&E)

1. T&E strategy is initially developed, correlated with the selected design solution concept illustrating all test objectives, test environments, and test resources to ensure compliance with design and specified requirements

2. T&E methodology(s) is correlated with the selected design concept, e.g., test methodology(s) outlines all test approaches for the system components critical to verifying system technical requirements and is tailored to the characteristics, effectivity(s), and margins of each particular test item

3. Test and verification methodology for data gathering, reduction, and analysis for the selected system design concept is validated, including test environment(s), operations, and procedures to be performed, data acquisition requirements, documentation, methods of analysis, and pass-fail (i.e., success) criteria, e.g.:

a. Evaluation of integration and verification test planning

b. Integration and test plan from unit to system level for dynamics environment testing

c. Identification of development tests necessary to evaluate system and subsystem requirements

d. Assurance that verification planning is adequate at system and segment levels

e. Selection of test facilities

C. Survivability and Vulnerability

1. Survivability and vulnerability threat assessments for the selected design concept and KPPs are validated for each assessed threat defining the categories of expected threats, threat environments, and their likelihood of occurrence
2. System and threat interaction analyses are performed for the selected system design concept to establish allowable margins for each threat
3. Survivability design criteria are derived from threat analyses validated to support the selected design concept solution to mitigate each assessed threat

D. Environmental Safety and Occupational Health (ES&OH)

1. Life cycle environments for the selected design concept are fully defined with rationale and are traceable to the system requirements baseline and performance criteria
2. Data compiled to complete Programmatic Environmental, Safety and Occupational Health Evaluation (PESHE) compliance objectives is validated for the selected system design concept
3. Hazardous materials management and pollution prevention tasks are identified and prioritized for the selected system design concept
4. Environmental and health evaluations of hazardous materials have been conducted

E. Mass Properties

1. A mass properties budget is validated for the selected system design concept, including mass properties growth allocations and metrics
2. Parameters for weight growth, center of gravity, and moments of inertia predictions are validated for the selected system design concept

F. System Security Engineering (SSE), Information Assurance (IA), Communications Security (COMSEC), and Program Protection (PP) for (SFR):

1. Requirements implementation into the selected design concept IAW DoD and AF policies, directives, and system specifications are verified
2. Design implementation for program protection measures includes integration within the selected system design concepts and includes SSE, IA, and COMSEC requirements
3. System security approaches includes an acquisition team, a security specification, and updates of security concept, threat, vulnerability and risk assessments, protection countermeasures, and security test and evaluation requirements
4. Information Assurance and COMSEC approaches, to include certification and accreditation using the DIACAP, sufficiently address system and data protection, availability, integrity, confidentiality, authentication, and nonrepudiation for the selected design
5. Program baseline cost estimates for SSE, COMSEC, Program Protection, and Information Assurance implementation and sustainment are refined

G. Interoperability

1. DoD Information Standards Repository (DISR) standards selected for the selected design concept are shown to meet the system and mission interoperability requirements (i.e., must be DISR compatible and compliant)
2. New and unique standards outside DISR recommended for the selected design concept are submitted for approval and incorporation into DISR (i.e., new data formats, data exchange protocols and schemas, Ethernet alternatives)

3. Interoperability architecture requirements are defined for the selected system design concept
4. Interoperability analyses for the selected design concept are completed and results shown to ensure compatibility and define interrelationships between users and operators

H. Reliability, Dependability, and Maintainability (RD&M)

1. R&M requirements and characteristics are correlated with and validated against requirements for the selected design concept (i.e., Mean Mission Duration (MMD), Availability (Ao) and Dependability (Do), MTBF, MTTR, failure modes, single point of failure, redundancy, etc.)
2. R&M analyses are completed and results fed into overall system architecture for the selected design concept, e.g.:
   a. Methodologies for defining environmental and thermal stress screening (ESS and TSS) are baselined and validated for the selected design concept
   b. Packaging, handling, storage, and transportability (PHS&T) environmental requirements are baselined and incorporated into the R&M program for the selected design concept
3. A functional FMECA is provided for the update system architecture, e.g., identify the measurement parameters and anomalous limits for supporting acceptance test and integration test and ADR

I. EMI and EMC

1. Electromagnetic interference control approaches are correlated with and validated for the selected design concept
2. Internal and external EMI and EMC requirements are baselined and validated for the selected design concept
3. EMI susceptibility requirements and constraints are correlated with and validated for the selected design concept (e.g., passive modulation, transmitter RFI with vehicle receivers and ordnance, radiated effects on power buses, lightning and surge protection)
4. EMI and EMC critical environmental characteristics and sensitive elements are baselined and validated for the selected design concept

J. Human Systems Integration (HSI)

1. User interface hardware and software requirements for operators, users, maintainers, and sustainers are allocated to the selected design concept
2. Usability, maintainability, operability, and/or supportability requirements are decomposed from system functional requirements and allocated to the selected design concept
3. Operational manning, workload, and skill-level requirements are allocated for the selected design concept
4. All HSI-related requirements, standards, and standard practices are allocated to all subordinate contracting activities for the selected design concept
5. HSI standards for predetermined requirements are incorporated into the selected design concept

K. Manufacturing and Producibility

1. Manufacturing and producibility engineering studies are completed; application of derived results are shown to satisfy the selected design concept, e.g., one best method, operation instructions, assembly aids, jigs and fixture designs, short interval schedules, factory and bench layout
2. Producibility trade studies for the selected design concept demonstrate that the manufacturing processes chosen satisfy the design concept
3. Producibility analysis results derived for the selected design concept indicate a cost-effective, producible, and testable product design

L. Life Cycle Logistics

1. Supportability requirements and design factors are validated for the selected design concept
2. System-level design factors for the selected design concept are verified for the following logistics elements: design interface, supply support, test equipment, manpower and personnel, training and training equipment, PHS&T, facilities, computer resources, technical data, and maintenance planning
3. Logistics management information (LMI) is completed and validated in support of the FBL for the selected design concept and includes all updated supportability trade studies and analysis results

M. System Safety

1. System safety requirements are validated for the selected system design concept, including refinement of system safety risk analysis results and reassessment of mitigation approaches
2. System hazard analysis is completed and a balanced list of prioritized safety hazards is established for the test, operation, and disposal of the selected design concept, e.g.:
   a. Initial Hazardous Materials Management Plan (HMMP) to eliminate, minimize, or control hazardous materials for the selected design concept
   b. Critical human safety and health factors are identified and validated for the selected system design concept incorporated into the system safety program architecture
3. A baselined hazardous materials list affecting the selected system design concept is compiled and prioritized based on NEPA and OSHA criteria, i.e., PELs, toxicity, volatility, transportability
4. Demilitarization and disposal considerations for the hazardous materials is considered

N. Contamination Control

1. Contamination control needs and approaches (i.e., normal, medium, or challenging and stressing contamination control) are validated for the selected design concept
2. Survey of materials is conducted and results evaluated to identify, validate, and prioritize outgassing properties for the selected design concept

O. Quality Assurance

1. Quality and product assurance requirements are correlated with and validated for the selected design concept
2. Verification, inspection, and test approaches are validated for the selected design concept

P. Environmental Considerations

1. Environmental studies are completed for the selected design concept, traceable to the system architecture and R&M requirements
2. A robust test program is defined for environmental effects on design, e.g.:
   a. Thermal test and evaluation strategies are developed and validated for the selected design concept
   b. Reliability thermal trade analyses are completed and made traceable to system architecture and R&M requirements

Q. Software

1. Software system architecture and design (including interfaces) are completed and validated for the selected design concept to the level of detail consistent with the software development life cycle being used, including, e.g.:
   a. Software architecture and design satisfy design requirements

b. Software requirements, architecture and design have bidirectional traceability to each other
c. Software requirements, architecture and design have bidirectional traceability to higher level requirements, architecture and design
d. Software requirements for operations, maintenance, and training needs
e. Software requirements for dependability, reliability, maintainability, and availability
f. Software requirements for supportability applicable to both software and hardware
g. Software safety requirements applicable to both software and hardware
h. Software requirements for information assurance
i. Software requirements for human systems integration (HSI)
j. Software requirements for interoperability with external elements referencing all appropriate interoperability and open system standards
k. Software requirements for margins (e.g., memory and storage capacity, processor throughput, and communications bandwidth)
l. Use of open systems standards that satisfy all applicable interoperability-related requirements
m. Software requirements allocation to COTS (commercial items), GOTS, and reuse products
n. Non-developmental items (NDI) (e.g., COTS (commercial item), GOTS, and reuse software) have been fully integrated into the components of the system and software architectures
o. Non-developmental items (NDI) (e.g., COTS, GOTS, and reuse software) will enable the system, segment, and interface requirements to be met

2. Software architecture and design satisfy requirements for states and modes as allocated from the system requirements
3. Operational Concepts, e.g.:
   a. Software architecture and design satisfy system and software operational concepts, including both nominal and off-nominal scenarios from a software perspective, e.g., processor failover, redundancy management
   b. Software architecture and design satisfy system and software requirements for operations, maintenance, and training needs
   c. Software architecture and design satisfy system and software operational concepts, including operations and maintenance staffing, e.g., numbers, skills, roles, and positions from a software perspective
   d. Software architecture and design satisfy requirements for supportability and apply to both software and hardware
4. Analysis of software metrics and technical performance measures shows that
   a. They are sufficient to meet the needs for program and engineering management
   b. Satisfactory progress has been made to date and indicates continued satisfactory progress in the future
   c. The estimates of utilization for all computer resources, e.g., processors, memory, storage, and input and output channels, buses, and networks are within predicted values
   d. Databases and tools are selected for metrics and TPM tracking; trending and reporting are performing as planned

R. Data Storage (Security, Access, Distribution, and Delivery)

1. Storage System Capability, Flexibility, and Scalability
    a. Analysis identifies needed reliability, maintainability, and availability characteristics of storage system environments
    b. Capacity, flexibility, and extensibility parameters have been completely identified that address system design life
    c. Key system components have been fully identified. Plans for redundancy are in place and are fully identified, including storage media hardware and software capabilities and types
    d. Needs for storage system management and performance optimization (including software management tools to provide appropriate partitioning and addressability) identified
2. Design analysis identified the operational environments of the storage system Data Storage (Security, Access, Distribution and Delivery)
3. Storage System Capability, Flexibility, Scalability, e.g.:
    a. Analysis identifies needed Reliability, Maintainability, and Availability characteristics of storage system environments
    b. Capacity, flexibility, and extensibility parameters have been completely identified that address the expected life of the system
    c. Key system components have been fully identified. Plans for redundancy are in place and fully identified, including storage media hardware and software capabilities and types
    d. Needs for storage system management, performance optimization (including software management tools to provide appropriate partitioning and addressability) are completely identified
    e. Analysis has fully identified the operational environments under which the storage system must operate. Identification of hardening aspects that must be addressed is fully described
4. Storage System Architecture, e.g.:
    a. The Storage System Architecture fully addresses elements, including communications and processing capacity
    b. The types of storage system needs are identified and fully integrated into the architecture This includes items such as centralized vs. distributed storage; online, nearline, and offline needs; archive (including hierarchical storage management, if appropriate), backup, and restore; and data replication
    c. Storage hardware components such as RAID, Storage Area Networks (SANs), Network Attached Storage (NAS), and Direct Attached Storage (DAS) have been identified and fully integrated into the architecture
    d. Data management software capabilities have been identified and fully integrated into the architecture. This includes items such as automatic file migration and transparent file retrieval; migration between hierarchical levels; and utilities to report on media usage, error detection, and identification of media to be replaced
5. Security, e.g.:
    a. The level of user integrity (e.g., access control lists) has been identified that enables the system requirements to be met
    b. The level of encryption needed has been identified that enables the system requirements to be met

c. The need for specialized security capabilities, such as CDS, MLS, and Security Enclaves, has been identified and is included in the storage system so as to ensure that the system requirements are met

6. Data Distribution Methods, e.g.:

   a. A complete list of data receivers has been drawn up to include both computer and human agents

   b. The method(s) of distributing data to the various receivers has been identified. Such method may include Subscribe and Publish, Push and Pull, and global or restricted Web-based access.

   c. The data distribution methods are fully integrated into the storage architecture and will enable the system-level requirements to be met

7. Functionality, e.g.:

   a. Analysis has fully identified the physical aspects of the functionality that may be needed to support the mission

   b. The types of platforms (server and client) and operating systems supported have been fully identified

   c. The data connection and transport protocols (e.g., fiber channel, infiniband, SWCI) have been fully identified and integrated into the system architecture, enabling the system-level requirements to be met

   d. Specific reporting (e.g., usage) and maintenance metrics (e.g., MTBF and MTTR) have been identified. Preliminary mapping between metrics and system-level requirements has been completed

   e. Storage system hardening design requirements are defined and understood

8. Storage System Architecture, e.g.:

   a. The Storage System Architecture fully addresses elements, including communications, processing capacity

   b. The types of storage system needs are identified and fully integrated into the architecture. This includes items such as centralized vs. distributed storage; online, nearline, and offline needs; archive (including hierarchical storage management, if appropriate), backup, and restore; and data replication

   c. Storage hardware components such as RAID, Storage Area Networks (SAN), Network Attached Storage (NAS), and Direct Attached Storage (DAS) have been identified and fully integrated into the architecture

   d. Data management software capabilities have been identified and fully integrated into the architecture. This includes items such as automatic file migration and transparent file retrieval; migration between hierarchical levels; and utilities to report on media usage, error detection, and identification of media to be replaced

9. Security, e.g.:

   a. The level of user integrity (e.g., access control lists) has been identified that enables the system requirements to be met

   b. The level of encryption needed has been identified that enables the system requirements to be met

   c. The need for specialized security capabilities, such as CDS, MLS, and Security Enclaves has been identified and is included in the storage system so as to ensure that the system requirements are met

10. Data Distribution Methods, e.g.:
    a. A complete list of data receivers has been drawn up to include both computer and human agents
    b. The method(s) of distributing data to the various receivers has been identified. Such methods may include Subscribe and Publish, Push and Pull, and global or restricted Web-based access
    c. The data distribution methods are fully integrated into the storage architecture and will enable the system-level requirements to be met
11. Functionality, e.g.:
    a. Analysis has fully identified the physical aspects of the functionality that may be needed to support the mission
    b. The types of platforms (server and client) and operating systems supported have been fully identified
    c. The data connection and transport protocols (e.g., fiber channel, infiniband, SWCI) have been fully identified and integrated into the system architecture, enabling the system-level requirements to be met
    d. Specific reporting (e.g., usage) and maintenance metrics (e.g., MTBF and MTTR) have been identified. Preliminary mapping between metrics and system-level requirements has been completed

20.4.5 Integrated Technical Risk Management and Mitigation

Evidence of technical risk management (RM) process maturity criteria examples, as a key component of an integrated program (technical, cost, schedule, and performance) RM and Mitigation (RM&M) process at SFR:

A. Supporting data for RM&M can encompass such items as:
   1. Program schedule, technical and funding risk assessment ranking, monitoring and documentation adequacy
   2. Top five program-level risks (technical, performance, cost, and schedule)
   3. Risk management database and tools for risk metrics collection, analysis, tracking, and reporting
   4. Risk mitigation and reduction strategies, e.g.:
      a. Burn-down plans that are linked to dependencies to the Program IMP, IMS, and WBS
      b. Continuous risk monitoring and review, identification, assessment, and ranking
      c. Technology and manufacturing readiness level (TRL and MRL) assessments and metrics
      d. Requirements risk monitoring
      e. Software risk management of critical software issues, e.g., complexity, size, processing speed, throughput, schedules, COTS availability, legacy reuse suitability, and software development processes and tools
      f. A comprehensive risk assessment for the follow-on phases
      g. TRL and MRL assessments, metrics
      h. Thresholds and appropriate action plans for cases when thresholds are breached
B. The risk mitigation strategies:
   1. Are feasible, and alternative courses of action are identified
   2. Demonstrate that a degree of maturity exists in all aspects of the system, segment, interface, and program to allow the program to proceed to PDR with an acceptable risk.

Appendix B

Appendix C

Appendix C - Software Requirement and Architecture Review (SAR)

30. Software Requirement and Architecture Review (SAR)

The SAR is a formal, multidisciplinary review of the software requirements, architecture, and test planning technical products, software development processes, and current state of the software development.

The SAR shall be held for individual Software Configuration Item (SWCI) or a collection of related SWCIs, as defined by the contractor and approved by the contracting agency. The SAR shall be held after the SFR.

30.1 General

The SAR replaces the former Software Specification Review (SSR) and also was revised to reflect the modern systems' dependence on complex software for successful operation and mission execution. These systems involve complex combinations of hardware and software with complex external and internal interfaces. They are usually unprecedented (have never been built before) and have high reliability and integrity requirements. The size of the software in new systems under development can range from 10^5 to 10^7 source lines of code (SLOC).

In response to the system acquisition strategy, the supplier selects a software development life cycle model. This can be a *waterfall* model, where the supplier designs, builds, tests, and delivers the system only once, or an *incremental* or *evolutionary* model, where the supplier designs, builds, tests, and iteratively delivers multiple versions of the system with increasing capability.

The positioning of the SAR in the software development life cycle is dependent upon the life cycle model in use for the software under review. Software is always developed according to a particular life cycle model. Although other types of life cycle models are in use, the most common types are the waterfall, incremental, and evolutionary.

In the *waterfall* life cycle model (Figure 3), the software is developed in a "once through" fashion, where the sequence of software requirements definition, software architectural and detailed design, software implementation, and software testing (unit, integration, and qualification testing) occurs only once, as shown in Figure 3. In the case of the waterfall life cycle model, the SAR is positioned at the completion of the software architectural (high-level) design, as shown in Figure 3. When the software under review is developed using the waterfall life cycle model, the SAR shall be completed before the system PDR.

In the incremental and evolutionary life cycle models, software is developed in a series of builds. A *build* is a version of the software (or system) that meets a specific subset of the requirements that the completed software (or system) will meet. There are two common types of iterative life cycle models— the incremental and the evolutionary.

In the *incremental* life cycle model, the software requirements are defined first, as depicted in Figure 4. Then the software is developed in a series of builds, where each build adds to the previous build and enhances its capabilities. In the incremental life cycle model, each build consists of a once-through sequence of software requirements assessment, software architectural and detailed design, software implementation, and software testing (unit, integration, and qualification testing). Thus, while the software requirements are defined up front in this life cycle model, the software architectural design is defined iteratively as the builds proceed. Because of this, the SAR is performed iteratively at the conclusion of the software architectural design for each incremental build. The full set of software requirements for the software under review is reviewed in the Build 1 SAR, while the software architecture and other information is reviewed on an incremental basis as each build proceeds.

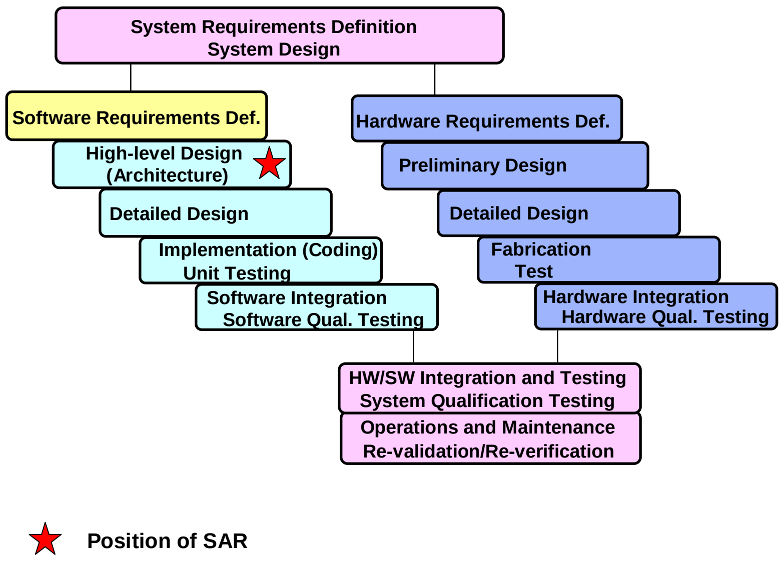

Figure 3. Waterfall Software Development Life Cycle Model

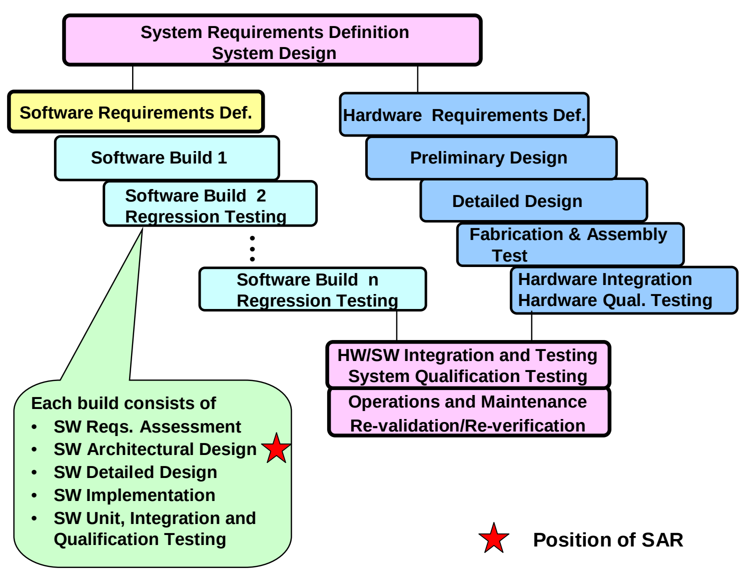

Figure 4. Incremental Software Development Life Cycle Model

The *evolutionary* life cycle model is similar to the incremental life cycle model, with the exception that, in the evolutionary life cycle model, the builds are based upon the requirements allocated to software from the parent specification, as depicted in Figure 5. Then each build consists of a once-through sequence of software requirements definition, software architectural and detailed design, software implementation, and software testing (unit, integration, and qualification testing). The distinction between the incremental and evolutionary life cycle models is thus whether or not the software requirements are defined up front (incremental) or within each build for that build only (evolutionary). (Note that the waterfall life cycle model can be thought of as an evolutionary life cycle model that has only one build.). For the evolutionary life cycle model, the SAR is performed iteratively at the conclusion of the software architectural design for each build, and the software architecture and other information is reviewed on an iterative basis as each build proceeds.

For iterative life cycle models, each SAR shall review the technical products and state of the software for the current build, the impact of the previous builds upon the current build, and the impact of the current build upon subsequent builds. For iterative life cycle models, each SAR shall address the collection of SWCIs that integrate together to form the builds.

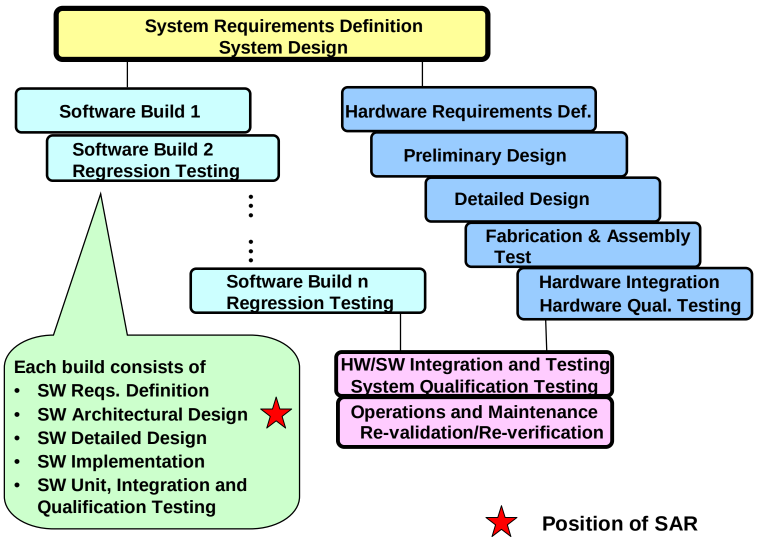

Figure 5. Evolutionary Software Development Life Cycle Model

There are other life cycle models in addition to these three basic types, and there are life cycle models that are combinations of two or more of these basic types. The placement of the SAR for these three life cycle models as described above should be tailored for life cycle models other than these three basic patterns and for combinations of two or more of these basic patterns. The software life cycle model(s) in use, the positioning of the Software Requirements and Architecture Review(s) within the life cycle model(s), and the relationship of the positioning of the SAR(s) with respect to the other major reviews defined in this standard (as tailored by the contract) are described in the Software Development Plan (SDP). The requirements for the SDP are specified in the Software Development Standard for Space Systems - Aerospace TOR-2004(3909)-3537, a.k.a. SMC-S-012.

30.2 Objective

The SAR shall be held after SFR. The SAR shall be a formal review of an SWCI's requirements and architecture as specified in the Software Requirements Specification (SRS) and the Interface Requirements Specification(s) (IRS(s)), and Software Architecture Description (SAD), IAW SMC-S-012.

Prior to and in preparation for the SAR, the developer is to define and record the software requirements based on the analysis of system requirements, the system design, and other considerations to be met by each software item, along with the methods and levels for verifying each requirement, and the traceability between the software item requirements and their parent requirements. Traceability shall be bidirectional. The result is to include all applicable items in the Software Requirements Specification (SRS) DID and Interface Requirements Specification (IRS) DID, as defined in the Software Development Plan (SDP).

A collective SAR for a group of configuration items, treating each configuration item individually, may be held when such an approach is advantageous to the contracting agency. Its purpose is to establish the allocated baseline for preliminary SWCI design by demonstrating to the contracting agency the adequacy of the SRSs, IRSs, and Operational Concept Description (OCD).

The objectives of the SAR are to determine whether:

a. The software requirements and architectural design are adequate for meeting the higher-level requirements allocated to software

b. The software requirements and architectural design are sufficiently mature to proceed with dependent software and system development activities

c. The software processes are sufficiently defined, mature, and effective for developing the software needed to meet system requirements and operational needs, and are suitable for the program scope and complexity

d. The software test plans are sufficiently robust to ensure thorough testing of the software products to demonstrate that the software requirements are verified in the target environment

e. The software development and test environments are established and have adequate capability and capacity to meet the software development and test requirements and schedules

f. The software development risk is manageable

g. The software development costs and schedules are consistent with program costs and schedules.

30.3 Items To Be Reviewed

The contractor is to present the following items for review by the contracting agency for the software under review:

A. Requirements

1. Higher-level (parent) requirements allocated to software

2. Software requirements and software interface requirements

3. Software-related external and intersegment or element interface requirements

4. ICDs with software-to-software and software-to-hardware interface requirements

B. Operational Concepts

1. Software operational concepts

C. Software Architectural Design

1. Software architectural design description

2. Top-level computer system hardware-software architectural design description

D. Engineering Analyses

1. Software engineering analyses, trade studies, modeling and simulation results

2. Hardware-to-software engineering analyses, hardware vs. software trade studies, modeling and simulation results

E. Integration and Verification

1. Software master build plan (allocation of requirements, functionality, and architectural components to builds)

2. Software qualification test plans

F. Traceability

1. Bidirectional traceability between:

   a. Higher-level requirements (including interface requirements) allocated to software and software requirements (including software interface requirements)

   b. Traceability between software requirements (including software interface requirements) and software architecture components

c. Traceability between software requirements (including software interface requirements) and software qualification tests

d. Traceability between requirements and verification methods and verification integration levels

e. Traceability between builds and software requirements, software architectural components, and software qualification tests

G. Risk Management

1. Software risk information, including identification, prioritization, and risk-handling plans (mitigation or other techniques) and status

H. Costs and Schedules

1. Software size, effort, cost, schedule, and staffing estimates
2. Software Resources Data Reporting: Initial Developer Report and Data Dictionary (SRDR-I)
3. Software Resources Data Reporting: Final Developer Report and Data Dictionary (SRDR-F) for any builds completed
4. Software schedules
5. Higher-level schedules, including the IMS
6. Updates to the life cycle cost (LCC) and cost as an independent variable (CAIV) studies presented at the SRR in support of each software architecture concept, e.g.:
   a. LCC and CAIV modeling and analyses are applied and correlated with each software architecture concept, e.g., cost models depicting projected program development, operational and sustainment costs completed, as well as projected cost impacts to other "external" systems
   b. LCC and CAIV methodology is presented that demonstrates that valid trade studies were conducted

I. Engineering and Management Plans

1. Software Development Plan (SDP)
2. Other software-related program plans (e.g., Systems Engineering Management Plan, Risk Management Plan, Integrated Master Plan, Configuration Management Plan, Quality Assurance Plan)
3. System (hardware and software) specialty engineering plans (e.g., reliability, safety, supportability, security (information assurance), and human systems integration plans)
4. Plans and status of the software engineering environment
5. Plans and status of the software test environments, including test beds, test facilities, hardware, software, simulators, and other testing tools

J. Metrics and Technical Performance Measures

1. Software metrics reports
2. Software-related TPM reports
3. Software problem and deficiency report status

30.4 SAR "Acceptance Criteria"

At SAR, all major program elements and risk drivers of the Systems Engineering Management activities are to be considered. A prime expectation of the SAR is that the review will result in an approved software requirement and architecture baseline that can be brought under change control and a determination that the approved baseline can be implemented within constraints of the cost, schedule, and performance requirements. In preparation for and scheduling of the SAR, the contractor shall demonstrate the following minimum, but not all-inclusive, list of "Acceptance Criteria," as specifically tailored by contract, along with all applicable engineering activities, to the satisfaction of the contracting agency:

A. Requirements

1. The higher-level requirements allocated to software are complete and stable
2. Software requirements (including software interface requirements) have been specified to the level of completeness called for in the software development plan based on the selected software life cycle model
3. Software requirements (including software interface requirements) are correct, complete, consistent, feasible, verifiable, and clearly and unambiguously stated
4. Software requirements (including software interface requirements) are traced to and fully implement their parent requirements
5. Software requirements include necessary requirements derived from the system and software architecture, system operational concepts, trade studies, or design decisions
6. Each software requirement, including software interface requirements, has one or more valid verification methods and verification levels specified, and those methods and levels are sufficient to fully verify the requirement

B. Operational Concepts

1. Software operational concepts include nominal and off-nominal scenarios from a software perspective (e.g., start-up, initialization, shutdown, processor failover, redundancy management, recovery and restoral) consistent with the system and software architectures
2. Software operational concepts include information exchange with external interfacing systems
3. Software operational concepts include scenarios for operational workloads
4. Software operation concepts are consistent with system operational concepts

C. Architecture and Design

1. The software architecture has been defined to the level of completeness called for in the software development plan, based on the selected software life cycle model
2. The software architecture views, including the physical, logical, developmental, process, and behavioral (user) views, are correct, complete, consistent, clear, and unambiguous
3. Nondevelopmental items (NDI) (e.g., COTS, GOTS, and reuse software) have been fully integrated into the components of the software architecture
4. The software architecture, including the nondevelopmental items (NDI) (e.g., COTS, GOTS, and reuse software), will enable the higher-level requirements allocated to software, the software requirements, and the software interface requirements to be met
5. The design of each software item has been elaborated to the level of software units, consistent with the software development plan and the selected software life cycle model
6. The design of each software item is clear, correct, complete, consistent, and unambiguous, and adequately addresses the following:
    a. High-level design of all external and internal interfaces

   b. High-level design of all files, databases, shared memory, etc., and their storage and access methods
   c. High-level design of user interface screens and human and system interactions
   d. Source for each unit of the software item (i.e., COTS, unmodified reuse, modified reuse, or newly developed code) and programming language(s) to be used
   e. Selected COTS software products and installation and configuration design decisions

7. The high-level design of each software item properly implements all applicable standards (e.g., interface standards, graphical user interface (GUI) standards)
8. The software architecture adequately addresses use of open systems standards and satisfies all applicable interoperability-related requirements
9. The software architecture adequately addresses end-to-end processing (including timelines and capacity)
10. The software architecture adequately addresses operational database management and control
11. Computing resources (e.g., processors, cache, memory, buses, and networks) are selected and appropriately incorporated into the top-level computer system hardware and software architecture, and will enable higher-level requirements allocated to software, the software requirements, and the software interface requirements to be met
12. The software architecture meets appropriate functional and performance requirements for each state and mode
13. The architecture adequately addresses supportability, including integrated hardware-software diagnostics, fault detection, isolation, localization, restoral, and repair
14. The software architecture adequately addresses reliability, maintainability, and availability requirements allocated to the computer hardware and software subsystems

D. Engineering Analysis

1. Engineering analyses, models, and simulations adequately demonstrate that the software architecture, together with the computer resources (hardware and software) that have been selected, will meet the Key Performance Parameters (KPPs) and driving requirements
2. Reliability, maintainability, and availability analyses are consistent with the software architecture and with the computer resources (hardware and software) that have been selected, and appropriately include the contribution of software
3. Safety, information assurance, and human systems integration analyses are consistent with the software architecture and with the computer resources (hardware and software) that have been selected, and appropriately include the contribution of software
4. Engineering analyses and trade studies adequately support software architectural design decisions about NDI (reuse, COTS, and GOTS software components), and appropriately consider the underlying, supporting computer resources (hardware and software) that have been selected
5. Human systems integration engineering analyses and trade studies (e.g., operability, operator workload analysis) demonstrate the adequacy of the software architecture and the computer resources (hardware and software) that have been selected, for the operators to perform their required roles within the required timelines
6. Preliminary performance analysis demonstrates that the software architecture, together with the computer resources (hardware and software) that have been selected, meet performance requirements with adequate margins for this point in the life cycle

7. Engineering analyses and trade studies demonstrate the adequacy of the software architecture, together with the computer resources (hardware and software) that have been selected, for meeting the computer resource margin requirements
8. All the above analyses take into account actual performance of existing software (e.g., prototypes, earlier builds, NDI) on the selected hardware
9. Engineering models and simulations have been used to demonstrate the adequacy of the algorithms to be implemented in software

E. Integration and Verification

1. Software qualification test plans have been defined to the level of completeness called for in the Software Development Plan, based on the selected software life cycle model
2. Software qualification test plans are valid, complete, stable, consistent with the software architectures and with higher-level test plans, and consistent with the qualification requirements for test methods and test levels for the software requirements and software interface requirements
3. Software requirements are fully allocated to the tests described in the software qualification test plans where they will be verified
4. The master software build plan is complete, feasible, executable, and consistent with the software requirements, software architecture, software qualification test plans, and higher-level schedules

F. Traceability

1. All traceability information is correct, bidirectional, and consistent with the higher-level requirements allocated to software, software requirements, software interface requirements, software architectural components, and software qualification test plans
2. All traceability information is defined to the level of completeness defined in the Software Development Plan, based on the selected life cycle model

G. Risk Management

1. The software risk assessment includes the following software risks as appropriate:
   a. Risks related to software size and complexity
   b. Risks related to requirements allocated to software
   c. Risks related to the software aspects of the system and software architectures
   d. Risks related to selection and use of NDI (COTS, reuse, GOTS)
   e. Risks related to selection and use of computing resources (e.g., processors, cache, memory, buses, and networks)
   f. Risks related to growth margins for computing resources
   g. Risks related to software schedules
   h. Risks related to software development, integration, and verification processes and tools
   i. Risks related to population, update, control, and validation of databases
   j. Risks related to software and computer hardware technology
2. A sound software risk management plan is part of the Software Development Plan and is integrated with program Risk Management Plan
3. An effective program risk management process, including the software risk management process, has been demonstrated to be functioning

4. Effective software risk-handling plans are in place, and risk-handling activities are being performed in accordance with the plans

H. Costs and Schedules

1. Software cost models have been calibrated with actual data (both from the current project as well as past history) and used to update software cost and schedule estimates
2. Realistic software cost drivers, such as complexity and other parameters, and assumptions are documented, validated with documented project data, and used in software cost models to develop updated cost and schedule estimates
3. Software size estimates are supportable, based on history, and consistent with the software and interface requirements and software architecture
4. Software cost and schedule estimates have enough margins to cover the estimation risk appropriate to this point in time
5. Software schedules are consistent with higher-level schedules, including the IMS

I. Engineering and Management Plans

1. The SDP is consistent with the IMP, systems engineering management plan, and other management and engineering plans
2. The SDP addresses the full software development life cycle
3. The SDP describes an integrated set of effective processes, methodologies, tools, and environments that cover all software team members, are suitable for the domain, and are appropriate for program scope and complexity
4. The SDP describes selected software development life cycle models that are feasible, appropriate for program scope and complexity, and used consistently by all team members
5. Software processes, standards, procedures, and conventions for use throughout the life cycle are documented, validated, and included with the SDP
6. The existing and planned software engineering environments integrate with the systems engineering environments across all software team members for the software under review
7. The software development and test environments are established and have adequate capability and capacity to meet the software development and test requirements and schedules
8. The contractor has demonstrated that the software processes, standards, procedures, and conventions are being followed, as appropriate to this point in the life cycle

J. Metrics and Technical Performance Measures

1. The software metrics are sufficient for meeting the information needs for program and engineering management and incorporate lessons learned from the metrics experience to date
2. Software metrics are being collected, analyzed, reported, and used for management and technical decision-making, including risk management, as appropriate to this point in the life cycle
3. Adequate corrective actions have been defined to address the underlying problems indicated by software metrics that are outside of documented thresholds
4. TPMs are being collected, analyzed, reported, and used for managing the utilization of all critical computer resources, e.g., processors, memory, storage, and input and output channels and networks
5. TPMs are being collected, analyzed, reported, and used for managing the software-related KPPs and driving requirements, including response time and timeline requirements

6. Adequate corrective actions have been defined to address the underlying problems indicated by software TPMs that are outside of documented thresholds
7. The contractor has demonstrated that, for metrics or TPMs outside of thresholds, corrective actions have been initiated, managed, and tracked to closure
8. The software problem and deficiency report status indicates that adequate progress is being made in implementing and verifying solutions to documented problems, and that the documented problems are being addressed in accordance with their severity

30.5 Post Review Action

After completing the SAR, the contractor shall publish and distribute copies of Review Minutes. The contracting agency officially acknowledges completion of the SAR.

Appendix D - Preliminary Design Review (PDR)

40. Preliminary Design Review (PDR)

The PDR is a multidisciplinary technical product and SE process conducted to assess whether the preliminary system and configuration item (CI) or a functionally related group of end items design under review are sufficiently mature to proceed into detailed and critical design, e.g.:

a. Is consistent with the Capability Development Document (CDD) as defined

b. Can meet the stated performance requirements within program cost, budget, schedule, risk, user, and other constraints

c. Is fully captured in the performance specifications for each configuration item in the system and allocated baseline

d. Has each function in the functional baseline allocated to one or more system CI, consisting of hardware and software elements and deliverables

For complex systems, a series of PDRs for each subsystem or configuration item shall be conducted, leading to an overall system PDR. For software items a series of SARs will be conducted according to the software development plan (SDP) based on the selected life cycle model(s) (see Appendix C). When individual reviews have been conducted, the emphasis of the overall system PDR shall focus on configuration item functional and physical interface design, as well as overall system design requirements. The PDR determines whether the hardware, human, and software preliminary designs, to the extent specified in the SDP based on the selected life cycle model(s), are complete, and whether the Integrated Product Team is prepared to start detailed design and test procedure development.

Each PDR shall be tailored for the review of the technical scope and risk of the system, segment, subsystem, and CI, and made an integral part of the Systems Engineering Plan.

The PDR shall be conducted only when all major hardware design issues have been resolved and work can begin on hardware detailed design. For software, design issues will be resolved to the extent specified in the SDP based on the selected life cycle model(s) and by the SAR and software build reviews.

40.1 General

PDRs shall be held to assess that the set of subsystem or CI requirements baselined at SRR and SFR correctly and completely implement all system requirements allocated to the segment, subsystem, and CI. The PDR also determines whether segment, subsystem, and CI requirements trace with the system design.

A PDR is held for each CI or aggregation of CIs in the specification tree. Individual CI PDRs should ensure that:

a. The CI architecture is complete

b. The CI development specification is complete, or development specification is approved

c. The allocated baseline is complete, or allocated baseline approved

d. The software requirements and architecture are complete to the extent specified in the SDP based on the selected life cycle model(s)

A system PDR shall be held after completion of all hardware CIs and aggregate of hardware CI PDRs. After completion of all software SARs specified in the SDP, and after the individual PDRs and software SARs have been conducted, the emphasis of the overall system PDR shall focus on:

a. The configuration item functional and physical interface design, as well as overall system design requirements

b. The maturity of the hardware, human, and software preliminary designs

c. The maturity of the system and EI design, to demonstrate that the design has progressed to the point that the contractor is prepared to start detailed design and test procedure development

d. The progress, technical adequacy, and risk resolution (on a technical, cost, and schedule basis) of the selected design approach

e. The compatibility of the Hardware Configuration Item (HWCI) development specification with performance and engineering specialty requirements

f. The degree to which each EI definition has been baselined and assess the technical risk associated with the selected manufacturing methods and processes for each EI

g. The existence and compatibility of the physical and functional interfaces among the configuration item and other items of equipment, facilities, computer software, and personnel

h. The evaluation of the progress, consistency, and technical adequacy of the Software Configuration Items (SWCIs), to the extent specified in the SDP based on the selected life -cycle model(s), e.g.:

    i. The selected top-level software design and test approach

    ii. Compatibility between software requirements and preliminary design

    iii. The preliminary version of the operation and support documents

i. The results of peer reviews of requirements and preliminary design documentation

j. The determination that the subsystem requirements, subsystem preliminary design, results of peer reviews, and plans for development and testing form a satisfactory basis for proceeding into detailed design and test procedure development

The PDR shall also confirm that the:

a. Detailed system design approach (as an integrated composite of people, product, and process solutions) satisfies the allocated functional baseline

b. Remaining risks are mitigated with closure plans and establishment of a baseline design for the system, subcomponents, or support elements

c. Technology is mature enough (minimum TRL 5) for development to proceed or whether alternate technologies should be considered primary

40.2 Purpose

The purpose of the PDR is to evaluate the set of subsystem requirements and determine whether they correctly and completely implement all system requirements allocated to the subsystem. In addition, it must be determined whether subsystem requirements trace with the system design, and that the plans for development and testing form a satisfactory basis for proceeding into detailed design and test procedure development.

Specifically, the purpose of the PDR is to address and resolve critical, systemwide issues, e.g.:

a. Establish a baseline design for every Hardware Configuration Item (HWCI) and for every SWCI as specified in the SDP based on the selected life cycle model(s)

b. Evaluate the progress, technical adequacy, and risk resolution (on a technical, cost, and schedule basis) of the selected design approach

c. Determine design approach compatibility with performance and engineering specialty requirements of each configuration item development specification

d. Evaluate the degree of definition and assess the technical risk associated with the selected manufacturing methods and processes

e. Establish the existence and compatibility of the physical and functional interfaces among the configuration items and other items of equipment, facilities, computer software, and personnel

f. For SWCIs, this review will focus on:

   i. The evaluation of the progress, consistency, and technical adequacy of the selected top-level design and test approach

   ii. The compatibility between software requirements and preliminary design, and on the preliminary version of the operation and support documents

40.3 Objective

The objective of the PDR is for the Contractor and the Acquisition agency to:

a. Review any changes to the functional baseline (FBL)

b. Review and confirm the functional architecture

c. Review and confirm the physical hierarchy

d. Review and confirm the allocated baseline for each configuration item, including the completeness and compatibility of interfaces between the items and between the items and other systems, facilities, and personnel

e. Review and confirm the two-way traceability from the source of the FBL to the allocated baseline and back

f. Review and confirm and verify that the allocated baseline can meet the system requirements

g. Review and confirm the validity of the updated risk assessment for system development and demonstration

h. Review and validate the basis and the balance between performance, cost, schedule, and risk for each element in the architectures and each requirement in the baseline

i. Review and validate that the contractor's system-allocated baseline supports the updated cost analysis requirements description (CARD)

j. Review and validate the updated program schedule, including system and software critical path drivers

k. Review and validate the approved SWCI

Additionally, an assessment will be conducted on each prototype (as applicable and specific to each development program) to:

a. Evaluate the progress, technical adequacy, and risk resolution of the selected design approach

b. Determine its alignment with the evolving FBL and architecture

c. Demonstrate the compatibility of the allocated baseline with the physical and functional interfaces and other items, facilities, and personnel

40.4 PDR "Acceptance Criteria"

At PDR all major systems engineering management elements and activities that are program risk drivers are considered. "Completion" when used in reference to software indicates that the activity or product is complete to the extent specified in the SDP based on the selected life cycle model(s).

The intent of the PDR is to ascertain that:

a. The hardware functional decomposition has been completed

b. An accurate, comprehensive allocation baseline has been approved

c. The hardware baseline design has been established

d. The software architectural design has been completed to the extent specified in the SDP based on the selected life cycle model(s)

In preparation for and scheduling of a PDR, the contractor shall demonstrate to the satisfaction of the contracting agency that:

a. The contractor has appropriately addressed the requirements criteria elements

b. All applicable engineering activities have been properly conducted in support of the criterion

c. A viable technical and program risk management strategy have been demonstrated to the satisfaction of the contracting agency

d. Effective and efficient technical progress is made towards meeting all cost, schedule, and technical performance requirements

The PDR "Acceptance Criteria" shall be organized under the following five major categories:

1. Systems Engineering and Architecture Development (40.4.1)
2. System, Segment, and Subsystem Design (40.4.2)
3. System Verification and Validation (40.4.3)
4. Engineering Disciplines and Specialty Engineering (40.4.4)
5. Integrated Technical Risk and Mitigation (40.4.5)

This review shall serve as objective evidence of the contractor's technical effort that supports the basic and agreed-to PDR "Acceptance Criteria," e.g.:

a) Does the status of the technical effort and design indicate operational test success (operationally suitable and effective)?

b) Can the preliminary design, as disclosed, satisfy the Capability Development Document?

c) Has the system-allocated baseline been established and documented to enable detailed design to proceed with proper configuration management?

d) Are adequate processes and metrics in place for the program to succeed?

e) Have human integration design factors been reviewed and included, where needed, in the overall system design?

f) Are the risks known and manageable for development testing and operational testing?

g) Is the program schedule executable (technical and cost risks)?

h) Is the program properly staffed?

i) Is the program executable with the existing budget and with the approved system-allocated baseline?

j) Does the updated cost estimate fit within the existing budget?

k) Is the preliminary design producible within the production budget?

l) Is the updated cost analysis requirements description consistent with the approved allocated baseline?

m) Is the software functionality in the approved allocated baseline consistent with the updated software metrics and resource-loaded schedule?

n) Are the verification plans and resources in place to continue to CDR?

The primary PDR data is the Decision Data Base (DDB) documenting or demonstrating these items.

40.4.1 Systems Engineering and Architecture Development

Evidence of Systems Engineering and Architecture Development requirements maturity criteria examples at PDR:

A. Systems Engineering Review Criteria

1. The system, segment, subsystem, and component allocated requirements are complete, feasible, verifiable, and clearly stated, e.g.:
    a. Preliminary System Design is correlated with and reflected in the Allocated Requirements Baseline
    b. Preliminary design of the system, segments, subsystems, and components is correlated with the system architecture views and descriptions and is traceable to the Functional and Allocated Baselines
    c. Preliminary design considers end-to-end processing capabilities for the system, segments, subsystems, and components architectures, including timelines and capacities for production, integration, operations, maintenance, training, demilitarization, and disposal
    d. Preliminary design data (e.g., drawings, specifications, etc.) for the system, segments, subsystems, and components are complete and placed under configuration control
    e. End-to-end data flow for the system is complete
    f. Preliminary design HW and SW prototypes, and their analyses and results, are documented and placed under configuration control
    g. All external dependencies are identified and documented
2. System Requirements Functional Decomposition Completed, e.g.:
    a. Requirements flowdown and derivation from system to segment and from segment to subsystem are complete and traceable (no TBDs, TBSs, and TBRs)
    b. Requirements flowdown and derivation from subsystem to component are complete and traceable (all TBDs, TBSs, TBRs, and deferrals are identified)
    c. Requirements flowdown and derivation for intersegment and inter-subsystem interfaces are complete and traceable (all TBDs, TBSs, TBRs, and deferrals are identified)
    d. Design-to allocated requirements for the system, segments, and subsystems are validated by specialty engineering
    e. Functional flow block diagrams (FFBDs) are completed for the system, segments, subsystems, hardware components, and intersegment, and inter-subsystem interfaces, demonstrating flowdown and traceability between higher- and lower-level allocated requirements
    f. The system and segment, subsystem, and component design specifications are under configuration management without any major TBDs or open items
    g. Preliminary long-lead production requirements are developed and documented
3. Allocated baseline established is based on and traceable to the approved Mission and System Functional Baselines, e.g.:
    a. Allocated baseline is consistent with the physical hierarchy and design-to functional performance requirements for all products in the hardware hierarchy
    b. System functional and performance requirements are allocated to all system segments, subsystems, and components, e.g., system, segment, subsystem, and component-level allocation performance analyses are completed and traceable to accepted trade results

c. Interoperability functional performance requirements are allocated to all system, segment, and subsystem preliminary designs

B. Interoperability Architecture

1. Demonstrate that the system design satisfies the operational architecture
2. The system design identifies all operational nodes (OV-2) and associated connectivity, e.g., is able to address systems that constitute the operational nodes such as satellites, ground antennas, command and control equipment, mission data user equipment, etc.
3. The system design demonstrates it provides required information to the organizational relationships between system operators and users described by OV-4
4. The system design identifies systems and subsystems that support all operational activities during the entire life cycle from acquisition to EOL operations described by OV-5
5. The system design is able to provide traceability between operational activities and system functions (SV-5)
6. The system design reflects a complete set of data exchanges necessary between internal and external interfaces (SV-6)
7. System design interfaces incorporate the set of DISR interoperability standards shown in TV-1; all unique interfaces, data formats, etc., have been approved by the contracting agent
8. The system design is consistent with NCOW-R, KIP Compliance, and IA Compliance

C. All design trade studies include LCC and CAIV analyses results supporting the allocated technical and functional baselines

1. Results of LCC and CAIV analyses include sensitivity of allocated performance parameters to cost
2. LCC and CAIV models representing planned and approved program development, operational, and sustainment costs are baselined, including cost impacts to other "external" systems
3. LCC and CAIV modeling and analyses, as applied and correlated with each SW design, depict projected program development, and operational and sustainment costs, as well as projected cost impacts to other "external" systems
4. LCC and CAIV methodology is presented, and demonstrates that valid trade studies were conducted

D. System integration and verification functional performance requirements are allocated to all segments, subsystems, and components

1. Segment, subsystem, and component-level verification planning is completed with rationale for verification objectives, types, levels and sequence of verification, venues, and verification data to be collected
2. Segment, subsystem, and component-level integration and test planning are completed with rationale for test objectives, type, levels and sequence of testing, test venues, and test data to be derived
3. Processes and procedures are developed for system integration and verification
4. Preliminary processes and procedures are defined for segment, subsystem, and component integration and verification
5. Segment, subsystem, and component-level cross-reference requirements are baselined and completed

E. System, segment, subsystem, and component-level interfaces are baselined

1. Preliminary internal (segment-to-segment, subsystem-to-subsystem and component-to-component) interfaces are designed and placed under configuration control
2. External interfaces (system, system of systems, and family of systems) design is completed and put under configuration control
3. All physical and functional interfaces between HWCI and other items of equipment, software and firmware, and facilities are defined and documented
4. All interfaces between SWCI and other configuration items (both internal and external) are defined and documented

F. Allocated decomposition is completed for each HWCI and SWCI

1. Decomposition for HWCIs and SWCIs is traceable to the requirements and functional baselines
2. Allocated decomposition for all HWCIs and SWCIs is under configuration control, e.g., all changes to the requirements and functional baselines are identified, tracked, and documented
3. The preliminary physical (also known as (a.k.a.) product) baseline is developed for all HWCIs and SWCIs

G. System performance (design) specification is traceable to the allocation baseline, e.g., segment, subsystem, and component specifications are developed and traceable to the system performance specification

40.4.2 System, Segment, and Subsystem Design

Evidence of System, Segment, and Subsystem Design Concepts maturity criteria examples at PDR:

A. System, segment, subsystem, and component preliminary design is completed and baselined.

1. The preliminary design demonstrates traceability among all considerations, i.e.:
   a. Between allocated requirements, engineering trade study results, technology selections, and technical, programmatic, schedule, and cost risks
   b. The adequacy of the preliminary design has been demonstrated using ongoing engineering analyses, considering all relevant specialty engineering disciplines, e.g.:
      (1) Engineering analyses adequately support the allocated decomposition of requirements to hardware and software items for system segments, subsystems, and components
      (2) Engineering analyses results adequately demonstrated the readiness of the design to proceed to CDR
2. Demonstrate that the preliminary design is traceable to and correlated with all critical allocated requirements
3. Appropriate margins and allowances are established at the segment, subsystem, and component levels
4. Design development planning is completed and baselined, e.g., preliminary design drawings are under configuration control
5. Preliminary electrical, mechanical, and functional performance schematics are available, including Functional Flow Block Diagrams (FFBDs) for inter- and intra-segments and subsystems
6. Preliminary GSE-identified and preliminary design concepts are developed traceable to the system functional and allocated requirements baselines and to the system architecture
7. Critical components of the system are identified

B. C4I allocations are incorporated into the preliminary design across segments, subsystems, and components

1. Allocations include battle management and information technology (IT) needs, dependencies, and interrelationships between system segments, subsystems, and the system, system of systems, and family of systems
2. Allocations ensure C4I interoperability, interconnectivity, supportability, synchronization, and sufficiency

C. Preliminary design is correlated with the threat scenarios and threat environment parameters, e.g.: threat scenario operational and environmental allocations are incorporated into the preliminary design traceable to all segments, subsystems, and components

D. Environmental, e.g., natural, thermal, humidity, transport parameters are correlated with the preliminary design

E. Environmental allocations incorporated into the preliminary design are traceable to all segments, subsystems, and components

F. Reliability, availability, maintainability, and testability (RAM&T) allocated requirements are incorporated into the preliminary design, e.g., RAM&T allocations are traceable to segments, subsystems, and components

G. System operational sustainment key performance parameters are incorporated into the preliminary design, including all major system and program requirements, e.g., the LCC sustainment model is correlated with the preliminary design

H. Risk mitigation solutions in the system risk model are traceable to and correlated with the preliminary design

I. Ongoing Industrial Base (IB) assessment results are correlated with the preliminary design; new risk areas (not identified at SFR) are prioritized and the mitigation processes defined, including resources and schedule requirements, e.g.:

1. IB assessment data (e.g., DMSMS [Diminishing Manufacturing Sources and Material Shortages], parts obsolescence) is correlated with identified and implicit design risk areas
2. Mitigation strategies are planned and implemented, including resources and schedule requirements

J. Key allocated performance requirements are traceable to the preliminary system design for all major subsystems and components, e.g.:

1. All major subsystem and component allocations are incorporated into the preliminary design
2. Key parameters and information (developed and assessed at SFR) are implemented for each major subsystem and component preliminary design, e.g.:
   a. Major performance parameters are incorporated
   b. Critical technologies are under development
   c. Critical design and manufacturing requirements and challenges (identified at SFR) are correlated with preliminary design

Note: The following examples are intended to provide clarification of the types of data and level of detail expected to be addressed at PDR. It is intended that the contractor will identify those subsystems and components applicable to the type of system being developed and the appropriate criteria for each subsystem and component necessary to effectively evaluate and assess the preliminary system design and its technical, cost, and schedule parameters, and demonstrate that the design includes identification and recovery from known failure modes, i.e.:

⇒ For Electrical Power:

- Preliminary Electrical Power Distribution System (EPDS) performance requirements, characteristics, and operational criteria are defined, including initial power budgets, total power demand with allowable margins, and modes of operation (frequency and duration)
- Preliminary selection and evaluation of the type(s) of power supply sources being considered, their specific technology and topology
- Preliminary battery (or energy storage) power requirements are identified and modes of operation defined (frequency and duration)
- Battery life requirements (BOL and EOL) and other unique requirements that may impact battery selection or design
- Candidate battery cell technologies are identified and battery architectures defined

⇒ For Software:

- The "Acceptance Criteria" for software detailed in Appendix C, sections 30.4 SAR "Acceptance Criteria" (paragraphs A, B, C, D, F, G, H, I, and J) are satisfied to the extent specified in the SDP based on the selected life cycle model(s).

40.4.3 System, Segment, and Subsystem Verification and Validation

Evidence of System, Segment, and Subsystem Design Concepts V&V requirements maturity criteria examples at PDR:

A. System, Segment, Subsystem, and hardware Component V&V approaches are developed for the preliminary design

   1. Preliminary design demonstrates that major system, segment, subsystem, and hardware component–allocated requirements can be verified and validated, e.g.:

      a. V&V approaches are developed for the preliminary design address system of systems, system, segment, subsystem, and hardware component levels

      b. V&V approaches include analytical, modeling and simulation, and testing processes and procedures for preliminary design

      c. V&V processes and procedures address new technology, verification, and qualification technical practices, system-level demonstrations and tests, support required from external organizations and/or facilities, and resource requirements for the preliminary design

      d. V&V processes and procedures for the preliminary design are based on proven, referenced practices

      e. Updated subsystem and component VCRMs are complete and consistent with system and segment allocated requirements and internal and external interface allocated requirements, e.g.:

         (1) Segment, subsystem, and component VCRMs are traceable to the system VCRM

         (2) The updated subsystem and component VCRMs are baselined and under configuration management

         (3) V&V methods in the system, segment, subsystem, and hardware component VCRMs are adequate to verify the system and its segment, subsystem, and hardware component

      f. The completion of software test and qualification plans and the allocation of requirements to tests are detailed in Appendix C, 30.4 SAR "Acceptance Criteria" paragraph E

B. System operational functions and environments for the preliminary design are traceable to the contractor's operations concept (OpsCon) and the allocated baseline

  1. Demonstrate that the system V&V test environment allocations are traceable to the system performance specification for the preliminary design
  2. Demonstrate that the preliminary design is correlated with and traceable to all initially identified allocated and physical environmental parameters, verification approaches, and processes

C. DT&E elements are correlated to the preliminary design

D. OT&E allocated requirements are incorporated into the preliminary design

E. Test bed(s) and test facilities chosen based on the preliminary design are deemed adequate to perform system, segment, subsystem, and interface requirements verification, e.g.: for critical hardware and software items, arrangements for procuring and/or scheduling the use of V&V resources (simulators, test beds, test facilities) have been demonstrated

F. Test requirements and test data collected to date for the preliminary design are traceable to operational requirements via specifications and V&V cross-reference matrices (VCRMs), e.g., use of comparative test data to anchor representative system, segment, subsystem models, and simulations to real-world environments and allocated requirements are demonstrated

G. V&V risk approaches, processes, and procedures are developed for the preliminary design

H. V&V test deficiencies, including those based on technology deficiencies established at SFR, are correlated with the preliminary design and the impact assessed

I. Risk mitigation approaches developed and integrated into the system risk model at SFR, including V&V resource requirements are correlated with the preliminary design. Software risk management activities are detailed in paragraph 30.4 SAR "Acceptance Criteria" paragraph G of Appendix C

40.4.4 Engineering Disciplines and Specialty Engineering

Evidence of Engineering Discipline and Specialty Engineering identification and assessment maturity criteria (categories listed in A through R below) at PDR in terms of, e.g.:

  1. Key performance requirements
  2. Key performance parameters
  3. Use of heritage systems, components, and technology
  4. Use of new designs

A. Parts, Materials, and Processes (PM&P)

  1. PM&P allocated requirements are incorporated into the preliminary design
  2. Environments and environmental parameters impacting parts performance are incorporated into the preliminary design
  3. Parts engineering design analyses are completed for the preliminary design addressing risk assessments, long-lead items, technologies, sources of supply, and the common quality levels (i.e., reliability) of the parts
  4. Results of preliminary design analyses are used to develop preliminary parts list

B. Test and Evaluation (T&E)

  1. Initial T&E planning is traceable to the preliminary design correlating all test objectives, test environments, and test resources with allocated requirements
  2. Selected T&E approaches are correlated with the preliminary design, e.g.:
     a. Test approaches are developed into preliminary test processes and procedures for verifying the system, segments, subsystems, and components-allocated requirements

   b. T&E processes and procedures capture the characteristics, effectivity(s), and margins for each particular test item

3. Test and verification data gathering, reduction, and analysis processes for the preliminary design are developed, including test environment(s), operations, procedures to be performed, data acquisition requirements, documentation, methods of analysis, and pass-fail (i.e., success) criteria

C. Survivability and Vulnerability

1. Survivability and vulnerability threat allocations incorporated into the preliminary design are traceable to the categories of expected threats, threat environments, and their likelihood of occurrence
2. System and threat interaction analyses are completed; threat margins are established and baselined for the preliminary design
3. Survivability design solutions are correlated with and incorporated into the preliminary design to mitigate each known threat

D. Environmental Safety and Occupational Health (ES&OH)

1. Life cycle environmental allocations are incorporated into the preliminary design
2. Data compiled for PDR Programmatic ES&OH Evaluation (PESHE) compliance objectives is correlated with the preliminary design, including an assessment of the interrelationships and interdependency of the operational environments
3. Hazardous materials management and pollution prevention processes and procedures are developed and correlated with the preliminary design
4. Critical human safety and health factors are correlated with the preliminary design

E. Mass Properties

1. Mass properties margins (average or complex) are established for PDR and correlated with the preliminary design, including allowable growth allocations and metrics
2. Calculated weight growth, center of gravity, and moments of inertia parameters are allocated to the preliminary design

F. System Security Engineering (SSE) Communications Security (COMSEC), Information Assurance (IA), and Program Protection (PP):

1. SSE, COMSEC, IA, and PP security requirements are allocated and incorporated into the preliminary design IAW DoD and AF policies, directives, and system specifications
2. Implementation of program protection countermeasures is addressed
3. SSE, COMSEC, IA, and PP requirements based on updated threat, vulnerability, risk, and countermeasure assessments are addressed in preliminary design
4. Information Assurance requirements are included in the preliminary system design along with certification and accreditation requirements and schedules using the DIACAP
5. Program baseline costs for SSE, COMSEC, IA, and PP implementation and sustainment are updated

G. Interoperability

1. Allocated system and mission interoperability requirements are incorporated into the preliminary design
2. Allocated requirements from new and unique standards approved for inclusion in DISR (i.e., new data formats, interdependency, data exchange protocols and schemas, Ethernet alternatives) are correlated with and incorporated into the preliminary design

3. Allocated interoperability requirements for all interrelationships and interdependency are incorporated into the preliminary design

H. Reliability and Maintainability (R&M)

1. R&M allocated requirements are incorporated into the preliminary design
2. R&M analyses results are correlated with the preliminary design, e.g.:
   a. Approaches and processes are developed for implementing environmental and thermal stress screening (ESS and TSS) for the preliminary design
   b. Packaging, Handling, Storage, and Transportability (PHS&T) environmental allocated requirements in the R&M program are incorporated into the preliminary design
3. Conduct hardware FMECA for the preliminary system design at the appropriate level (e.g., box-pin level or piece-part level), e.g.:
   a. Justify that hardware FMECA level is consistent with the intended usage for the results
   b. Demonstrate that hardware FMECA is consistent with the equipment physical construction and the analysis is supported by circuit schematics
   c. Identify methods for detecting the postulated failure modes for ground test and for operation and identify possible means for failure mitigation
   d. Prepare critical items list and single-point failures list
   e. Identify any safety issues and associated analyses as appropriate, including system reliability for EOL disposal

I. EMI and EMC

1. Electromagnetic interference control processes and procedures are developed for the preliminary design
2. Internal and external EMI and EMC allocated requirements are incorporated into the preliminary design
3. EMI susceptibility allocated requirements and constraints are incorporated into the preliminary design
4. EMI and EMC critical environmental characteristics and sensitive elements are correlated with the preliminary design

J. Human Systems Integration (HSI)

1. User interface hardware and software allocated requirements for operators, users, maintainers, and sustainers are incorporated into the preliminary design
2. Usability, maintainability, operability, and/or supportability allocated requirements decomposed from system functional requirements are incorporated into the preliminary design
3. Operational manning, workload, and skill level allocated requirements are incorporated into the preliminary design, e.g., user interface is consistent with the scenarios in CONOPS

K. Manufacturing and Producibility

1. Manufacturing and producibility approaches and processes are developed and correlated with the preliminary design
2. Producibility approaches selected for the preliminary design demonstrate that the manufacturing processes that were chosen support the preliminary design

L. Life Cycle Logistics

1. Supportability allocated requirements are incorporated into the preliminary design

2. System-level logistics elements are correlated with the preliminary design, including design interface, supply support, test equipment, manpower and personnel, training and training equipment, PHS&T, facilities, computer resources, technical data, and maintenance planning
3. Logistics Management Information (LMI) is completed and validated in support of the allocated baseline for the preliminary design

M. System Safety

1. System safety allocated requirements are incorporated into the preliminary design
2. Segment and subsystem hazard analyses are completed, and an updated balanced list of prioritized safety hazards are established for the test, operation, and disposal of the preliminary design
3. Critical human safety and health factors are correlated with the preliminary design
4. The baselined hazardous materials list (compiled and prioritized at SFR) are correlated with and updated as required for the preliminary design

N. Contamination Control

1. Contamination control processes and procedures are developed for the preliminary design
2. Material outgassing survey results (from SFR) are correlated with and updated as required for the preliminary design

O. Quality Assurance

1. Quality and product assurance allocated requirements are correlated with and incorporated into the preliminary design
2. Verification, inspection, and test processes and procedures are developed for the preliminary design

P. Environmental Considerations

1. Environmental study results (from SFR) are correlated with the preliminary design
2. Environmental test and evaluation approaches and processes are developed for the preliminary design
3. Reliability-environmental allocation requirements are incorporated into the preliminary design

Q. Software

1. Evidence of Software Engineering Discipline and Specialty Engineering identification and assessment maturity criteria are detailed in Appendix C, 30.4 SAR "Acceptance Criteria"

R. Data Storage (Security, Access, Distribution, and Delivery)

1. Storage system capability, flexibility, scalability, and preliminary design maturity, e.g.:
   a. Analysis identifies needed reliability, maintainability, and availability characteristics of storage systems environments
   b. Capacity, flexibility, and extensibility parameters have been completely identified that address system design life
   c. Key system components have been fully identified. Plans for redundancy are in place and fully identified, including storage media hardware and software capabilities and types.
   d. Needs for storage system management and performance optimization (including software management tools to provide appropriate partitioning and addressability) are completely identified
   e. Analysis has fully identified the operational environments under which the storage system must operate. Identification of hardening aspects that must be addressed is fully described.

2. Storage System Architecture, e.g.:
    a. The Storage System Architecture fully addresses elements, including communications and processing capacity
    b. The types of storage system needs are identified and fully integrated into the architecture. This includes items such as centralized vs. distributed storage; online, near-line, and offline needs; archive (including hierarchical storage management, if appropriate), backup, and restore; and data replication.
    c. Storage hardware components such as RAID, Storage Area Networks (SANs), Network Attached Storage (NAS), and Direct Attached Storage (DAS) have been identified and fully integrated into the architecture
    d. Data management software capabilities have been identified and fully integrated into the architecture. This includes items such as automatic file migration and transparent file retrieval; migration between hierarchical levels; and utilities to report on media usage, error detection, and identification of media to be replaced.
3. Security, e.g.:
    a. The level of user integrity (e.g., access control lists) has been identified that enables the system requirements to be met
    b. The level of encryption needed has been identified that enables the system requirements to be met
    c. The need for specialized security capabilities, such as CDS, MLS, and Security Enclaves, has been identified and is included in the storage system so as to ensure that the system requirements are met
4. Data Distribution Methods, e.g.:
    a. A complete list of data receivers has been drawn up to include both computer and human agents
    b. The method(s) of distributing data to the various receivers has been identified. Such methods may include Subscribe and Publish, Push and Pull, and global or restricted Web-based access.
    c. The data distribution methods are fully integrated into the storage architecture and will enable the system-level requirements to be met
5. Functionality, e.g.:
    a. Analysis has fully identified the physical aspects of the functionality that may be needed to support the mission
    b. The types of platforms (server and client) and operating systems supported have been fully identified
    c. The data connection and transport protocols (e.g., fiber channel, infiniband, SWCI) have been fully identified and integrated into the system architecture, enabling the system-level requirements to be met
    d. Specific reporting (e.g., usage) and maintenance metrics (e.g., MTBF and MTTR) have been defined. Preliminary mapping between metrics and system-level requirements has been completed.

40.4.5 Integrated Technical Risk Management and Mitigation

Evidence of technical risk management (RM) process criteria, with an increased level of fidelity and maturity of identified risk items and elements, is provided for the recommended system design as a key component of an integrated program (technical, cost, schedule, and performance) RM and Mitigation (RM&M) process for PDR.

Appendix D

A. RM&M data supports PDR level maturity, e.g.:

1. Significant program-level risks impacting technical and performance, cost, and schedule
2. Risk management database and tools for risk metrics collection, analysis, tracking, and reporting
3. Risk mitigation and reduction strategies, burn-down plans that are linked to dependencies to the Program IMP, IMS, and WBS
4. Continuous risk monitoring and review, identification, assessment, and ranking
5. Technology and manufacturing readiness level (TRL and MRL) assessments and metrics
6. Requirements risk assessment metrics
7. Critical risk management of software issues, e.g., complexity, size, processing speed, throughput, schedules, COTS availability, legacy reuse suitability, and software development processes and tools
8. A comprehensive risk assessment for the follow-on phases
9. TRL and MRL assessments, and metrics
10. Thresholds and appropriate action plans for cases when thresholds are breached
11. The risk mitigation strategies are feasible, and alternative courses of action are identified

B. A demonstrated degree of RM&M in all aspects of the system, segment, interface, and program exists to allow with an acceptable risk to proceed to CDR

Appendix D

Appendix E

Appendix E - Critical Design Review (CDR)

50. Critical Design Review (CDR)

The CDR is a multidisciplinary technical product. SE processes are normally held during new Systems Development & Demonstration (SDD) to assess whether the system and configuration item or an aggregation and functionally related group of CIs in the specification tree under review is sufficiently mature to proceed into fabrication, demonstration, and test, e.g.:

a. Can meet the stated performance requirements within program cost, budget, schedule, risk, and other user constraints

b. The flowdown of requirements from the functional baseline to the lowest-level CI for each end item in the specification tree is complete and captured in each configuration item detailed design

c. The system final design is captured in product specifications for each configuration item in the system baseline

d. Each CI in the product baseline has been captured in the detailed product specification and design documentation

e. The CI specifications and associated drawings for hardware are sufficiently mature to enable the fabrication of configuration items

f. The software architectural and detailed design for all software items under review are complete to the extent specified in the SDP, based on the selected life cycle model(s)

For complex systems, a series of CDRs for each subsystem or configuration item are conducted, leading to an overall system CDR. When individual reviews have been conducted, the emphasis of the overall system CDR shall focus on configuration item functional and physical interface design, as well as overall system detailed design requirements. The CDR determines whether the hardware, human, and software (to the extent specified in the SDP based on the selected life cycle model(s)) final detailed designs are complete, and whether the Integrated Product Team is prepared to start system fabrication, demonstration, and test.

Each CDR shall be tailored for the review of the technical scope and risk of the system, segment, subsystem, CI, and used to update the Systems Engineering Plan.

50.1 General

A CDR shall be conducted when the "build-to" baseline has been achieved, allowing the final deliverable hardware EI(s) production to proceed. A rule of thumb is that 75% to 90% of the manufacturing and hardware, build-to drawings, and associated instructions are complete, and that 100% of all critical component (e.g., critical safety items and critical application items) drawings are complete.

System CDR shall be conducted prior to fabrication, production, and coding release to assess that:

a. The detailed design solutions, as reflected in the Hardware Product Specification, Interface Design Document(s), IDD(s), and engineering drawings satisfy requirements established by the System Specification

b. The overall design and manufacturing risks associated with each configuration item are manageable within program cost and schedule

c. All design items have advanced as a minimum to technology readiness level 6 (TRL 6) and manufacturing readiness level 6 (MRL 6)

For software, the CDR assesses the state of the software and the software risk for all software in the EI under review. Readiness to proceed to CDR for software is determined by:

a. The results of the SARs (i.e., satisfaction of the SAR "Acceptance Criteria" per Appendix C) held prior to the CDR for the software under review

b. Completion of detailed design for all software builds for which the SDP specifies such completion by CDR, based on the selected life cycle model(s)

50.2 Purpose

The purpose of the CDR is to address and resolve critical detailed designs issues, e.g.:

a. Determine whether the design details correctly and completely implement all system requirements allocated to the subsystem, and whether the traceability of final subsystem requirements to final system detailed design is maintained

b. Verify that the finding by peer reviews on requirements and final detailed design documentation have been captured and implemented in the detailed design

c. Determine that the detailed design of the CI under review satisfies the performance and engineering specialty requirements of the CI development specifications

d. Establish the detailed design compatibility among the configuration item and other items of equipment, facilities, computer software, and personnel

e. Assess producibility and CI risk areas (on a technical, cost, and schedule basis)

f. Review the critical and long-lead HWCI product specifications and review of the software detailed design for critical software functionality

g. Determine the acceptability of the detailed design, performance, and test characteristics of the HWCI and SWCI design solutions, e.g.:

   i. Determine the adequacy of the operation and support documents

   ii. Review any outstanding and unresolved deviations, waivers, and deferrals

   iii. Updated design information, as applicable

h. Assess results obtained during in-house testing, including problems encountered and solutions implemented or proposed

i. Assess the results of the producibility analyses conducted on system hardware

j. Validate that the latest estimates of cost (development, production, and support) are consistent with the detailed design

k. Confirm that the results of peer reviews of subsystem requirements, subsystem detailed design, and plans for testing form a satisfactory basis for proceeding into system fabrication, demonstration, and test

50.3 Objective

The objective of the CDR is for the Contractor and the Acquisition agency to review and assess:

a. The status of any changes to the functional baseline, architecture, and allocated baseline since they were established

b. The design baseline for each configuration item, including the completeness and compatibility of interfaces between the items and between the items and other systems, facilities, and personnel

c. The basis for each element in the design baseline in terms of requirements and objective, comprehensive, quantitative design trades

d. The balance between performance, cost, schedule, and risk for each element in the selected design baseline

e. The two-way traceability from the source of the functional and allocation baselines to the design baseline and back

f. That the verification that the design baseline can meet the contract requirements

g. That the subsystem detailed designs are evaluated to determine:

   i. Whether they correctly and completely implement all system requirements allocated to the subsystem

   ii. Whether the traceability of final subsystem requirements to final system detailed design is maintained

h. The results of peer reviews on requirements and final detailed design documentation are folded into the latest estimates of cost (development, production, and support) and are consistent with the detailed design

i. The plans for testing form a satisfactory basis for proceeding into system fabrication, demonstration, and test

Completion of the CDR shall provide:

a. An established system product baseline

b. An updated risk assessment for System Development and Demonstration

c. Validation that the contractor's system-allocated baseline is consistent with the updated cost analysis requirements description (CARD)

d. An updated program development schedule including fabrication, test, and software development critical path drivers

e. An approved SWCI with updates applicable to this phase

Additionally, a review shall be conducted on each prototype to:

a) Evaluate the progress, technical adequacy, and risk resolution of the detailed design

b) Determine its alignment with the evolving functional architecture and allocated baseline, including compatibility of the physical and functional interfaces among the item and other items, systems, facilities, and personnel. Note: a configuration item may consist of hardware and software elements, and include items such as an airframe.

50.4 CDR "Acceptance Criteria"

At CDR all major systems engineering management elements and activities that are program risk drivers are considered. The intent of the CDR is to ascertain that:

a. The allocation baseline for each CI has been confirmed

b. The physical (a.k.a. product) baseline has been approved

c. A design release baseline has been established and baselined. For software, these baselines are complete to the extent specified in the SDP based on the selected life cycle model(s)

In preparation for and scheduling of a CDR, the contractor shall demonstrate to the satisfaction of the contracting agency that:

a. All requirements criteria elements are addressed

b. All applicable engineering activities have been properly conducted in support of the criterion

c. Each criterion shall be deemed successfully accomplished

d. A viable technical and program risk management strategy is in place

e. Effective and efficient technical progress is made towards meeting all cost, schedule, and technical performance requirements

f. CDR objectives are met and the data is available for review and reside in the decision database

The CDR "Acceptance Criteria" shall be organized under the following five major categories:

1. Systems Engineering and Architecture Development (50.4.1)
2. System, Segment, and Subsystem Design (50.4.2)
3. System Verification and Validation (50.4.3)
4. Engineering Disciplines and Specialty Engineering (50.4.4)
5. Integrated Technical Risk and Mitigation (50.4.5)

This review shall serve as objective evidence of the contractor's technical effort that supports the basic and agreed-to CDR "Acceptance Criteria," e.g.:

a) Does the status of the technical effort and design indicate operational test success (operationally suitable and effective)?

b) Does the detailed design, as disclosed, satisfy the Capability Development Document or any available draft Capability Production Document?

c) Has the system product baseline been established and documented to enable hardware fabrication and software development to proceed with proper configuration management? That is, is the software product baseline complete to the extent specified in the SDP based on the selected life cycle model(s)?

d) Has the detailed design satisfied Human Systems Integration (HSI) requirements?

e) Are adequate processes and metrics in place for the program to succeed?

f) Are the risks known and manageable for developmental testing and operational testing?

g) Is the program schedule executable (technical and cost risks)?

h) Is the program properly staffed?

i) Is the program executable with the existing budget and the approved product baseline?

j) Is the detailed design producible within the production budget?

k) Are Critical Safety Items and Critical Application Items identified?

l) Does the updated cost estimate fit within the existing budget?

m) Are the schedules for completion of software development consistent with status of the software design at the time of the CDR?

n) Have key product characteristics having the most impact on system performance, assembly, cost, reliability, or safety been identified?

o) Have the critical manufacturing processes that impact the key characteristics been identified and their capability to meet design tolerances determined?

p) Have process control plans been developed for critical manufacturing processes?

q) Have all IMP and IMS tasks associated with this review been successfully closed?

The program manager shall conduct the CDR when the hardware "build-to" baseline has been achieved, allowing production to proceed.

50.4.1 Systems Engineering and Architecture Development

Evidence of Systems Engineering and Architecture Development requirements maturity criteria examples at CDR:

A. The system, segment, subsystem, and component allocated and physical requirements for each CI are complete, feasible, verifiable, and clearly stated.

   1. Critical System Design is correlated with and reflected in the Allocated and Physical Baselines, e.g., critical design of the system, segment, subsystem, and component correlated with the system architecture views and descriptions is traceable to all baselines and maintained under configuration control
   2. End-to-end processing capability of the system, segment, subsystem, and hardware component architectures (including timelines and capacities) for production, integration, operations, maintenance, and training is verified and baselined, e.g.:
      a. Critical design of the system, segments, subsystems, and components considers the physical hierarchy extended to identify all additional products necessary to manufacture, verify, integrate, deploy, train, operate, support, sustain, and dispose of the system, its constituent elements, and components over its life cycle
      b. Final technical design includes all build-to (including drawings, and processing and assembly instructions), buy-to, or verify-to (including design qualification and delivery acceptance verifications as well as tests for workmanship); integrate-to, deploy-to (including verifications of operational readiness), train-to, operate-to (including tech orders and operating instructions), support and sustain-to (including maintenance and support tests), and/or dispose-to requirements for each product (except government property) satisfying requirements, functional allocated and physical baselines
   3. Final design data (e.g., drawings, specifications, etc.) for the system, segments, subsystems, and components is completed down to their constituent element and unit levels, e.g., separable documentation exists for each element and component of the physical hierarchy, and for each additional system product or integrated grouping of products that is separately manufactured, procured, authored (in the case of manuals and other written and drawn products), verified, integrated, deployed, trained for, operated, supported, or disposed of, and any others as required by the customer
   4. The source requirement and tradeoff or other basis for each design solution or other element of the design release baseline is captured in the decision database and linked to the element

B. System Requirements Allocation is completed and verified for all CIs

   1. Requirements flowdown and derivation from subsystems down to component elements and unit levels are complete and traceable (no TBDs, TBSs, TBRs, or deferrals are identified)
   2. Design-to and off-the-shelf (OTS) specifications are completed and validated by production, verification, and operations organizations and by specialty engineering groups
   3. Final functional flow block diagrams (FFBDs) are completed down to the hardware component, element, and unit level for the system, segments, subsystems and all interfaces (internal and external) demonstrating flowdown and traceability between higher- and lower-level allocated requirements
   4. The system component, element, and unit design specifications are under configuration management without any major TBDs or open items
   5. Final production requirements are developed and documented

C. Physical Baseline is established and traceable to the approved Mission, System Functional, and Allocation Baselines.

   1. Physical baseline includes all allocated and derived design-to requirements and design constraints for each product in the physical hierarchy
   2. System physical requirements are allocated to all system segments, subsystems, and hardware components
   3. System, segment, subsystem, hardware, and component-level physical analyses are completed, down to the element and unit level, and are traceable to accepted trade results (design choices)
   4. Interoperability physical requirements are allocated to all system, segment, subsystem, hardware component, and external interface critical designs
   5. Physical baseline complies with CONOPS and the contractor's OpsCon

D. Baseline (BL)

   1. Life cycle cost analysis results include sensitivity of physical parameters to cost
   2. Cost models representing final approved program development, operational, and sustainment costs are baselined and include cost impacts to other systems
   3. Results from life cycle cost and systems performance trade studies are maintained and rationale for changes identified

E. System integration and verification physical requirements are allotted down to the component, element, and unit level

   1. Component, element, and unit-level verification planning is completed with rationale for verification objectives, types, levels and sequence of verification, venues, and verification data to be collected
   2. Component, element, and unit-level integration and test planning is completed with rationale for test objectives, type, level and sequence of testing, test venues, and test data to be derived
   3. Processes and procedures are completed for system integration and verification, e.g., final processes and procedures are verified and baselined for segment, subsystem, and component integration and verification down to the element and unit levels.
   4. Segment, subsystem, and component-level cross-reference requirements are completed and baselined down to the element and unit levels.

F. System, Segment, Subsystem, and Component-level interfaces are completed

   1. Final internal interfaces design (component-to-component, unit-to-unit) is completed
   2. Final external interfaces design (system, system of systems, and family of systems) is completed

G. Physical descriptions and parameters are completed for each HWCI and SWCI

   1. Physical baseline for HWCIs and SWCIs is traceable to the requirements, functional, and allocation baselines
   2. Physical baseline for all HWCIs and SWCIs is under configuration control, e.g., all changes to the requirements, functional, and allocation baselines are identified, tracked, and documented

H. System performance (design) specification is traceable to the allocated and physical baselines, e.g., all specifications down to the component, element, and unit are developed and are traceable to the system performance specification

I. Design Release Baseline is defined for the critical design and is traceable to the functional, allocated, and physical baselines

   1. Adequate information exists (e.g., design drawings, design specifications, test and analysis data) to support a final design release baseline

2. The design release baseline was developed iteratively, based on tradeoffs and planning, monitoring, decisions, and control; adequate tradeoffs were performed to support each final design selection
3. The physical (a.k.a. product) configuration baseline is used for building, or buying, and then integrating the development products to verify that the requirements in the allocated baseline were achieved and to validate that the integrated system fulfills the users' capabilities needed

J. Development of long-lead production specifications is completed and baselined
   1. Production specifications are traceable to the allocated and physical baselines
   2. Critical production (shop) drawings, Fabrication and Assembly, Integration and Test (F/A, I&T) processes and procedures are baselined and put under configuration control

K. The nondevelopmental software and hardware items (NDI) (e.g., COTS, GOTS, and reuse software) are reviewed to ensure that they do not add additional constraints on the system

50.4.2 System, Segment, and Subsystem Design

Evidence of System, Segment, and Subsystem Design Concepts maturity criteria examples at CDR:

A. System, segment, subsystem and component critical design (down to the element and unit levels) is completed
   1. Critical design demonstrates traceability among all considerations: allocated and physical requirements, engineering trade study results, technology selections, and technical, programmatic, schedule, and cost risks, e.g.:
      a. The adequacy of the critical design has been demonstrated using ongoing engineering analyses, considering all relevant specialty engineering disciplines
      b. Engineering analyses adequately support the physical (a.k.a. product) requirements for hardware and software configuration items down to the component, element, and unit levels.
      c. Engineering analysis results adequately demonstrated the readiness of the design to proceed to production
      d. Engineering analysis, modeling, and simulation results supporting critical design capabilities and solutions are verified and baselined
   2. Demonstrate that the critical design is traceable to and correlated with all critical allocated and physical requirements
   3. Physical requirements derived from the allocation baseline for segments and subsystems represent a complete and optimal synthesis of the component-, element-, and unit-level requirements design
   4. Appropriate margins, allowances, and contingencies are established at the segment, subsystem, and component levels down to their elements and units
   5. Design development planning is executed and tracked, e.g., critical design drawings put under configuration control (at PDR) are maintained, and changes are documented with supportive rationale
   6. Final electrical, mechanical, and functional performance schematics are available, including functional flow block diagrams (FFBDs) for inter- and intra-segments and subsystems down to their component elements and unit levels
   7. Ground Support Equipment (including common, peculiar, flight, and nonflight test support equipment and tooling) selections are baselined and initial designs are completed, e.g.:
      a. GSE make-or-buy decisions are baselined
      b. Initial GSE Hardware Allocation Listing (HAL) is completed

8. Government-furnished equipment (GFE) and ancillary test hardware are verified and baselined for their intended use

B. C4I physical and software allocations (to the extent specified in the SDP based on the selected life cycle model(s)), are incorporated into the critical design across segments, subsystems, and hardware components, in addition to system interrelationships and interdependency:

   1. Physical allocations include battle management and information technology (IT) needs, dependencies, and interfaces between system segments, subsystems, and the system, and system of systems and family of systems

   2. Physical allocations ensure C4I interoperability, interconnectivity, supportability, synchronization, and sufficiency

C. Threat scenarios and threat environment parameters correlated with the critical design, e.g., the threat scenario, the operational and the environmental allocations incorporated into the critical design are traceable to all segments, subsystems, and components down to their elements and unit levels

D. Environmental (e.g., natural, thermal, humidity, transport) parameters correlated to the critical design, e.g., the environmental allocations are incorporated into the critical design and are traceable to all segments, subsystems, and components down to their element and unit levels

E. Reliability, availability, maintainability, and testability (RAM&T) allocated requirements are incorporated into the critical design, e.g., RAM&T allocations are traceable to segments, subsystems and components down to their elements and unit levels for hardware and to the SWCI for software

F. System operational sustainment key performance parameters are incorporated into the critical design, including all major system and program requirements, and the updated LCC and CAIV modeling and analysis studies presented at the PDR, e.g.:

   1. LCC and CAIV modeling and analyses are applied and correlated for each HW and SW design

   2. They accurately depict projected program development, operational and sustainment costs, as well as projected cost impacts to other "external" systems

G. LCC sustainment model is correlated with the critical design

H. Risk mitigation solutions in the system risk model are traceable to and correlated with the critical design

I. Ongoing Industrial Base assessment results are correlated with the critical design; new risk areas (not identified at PDR) are prioritized and the mitigation process(es) are defined, including resources and schedule requirements

   1. IB assessment data (e.g., DMSMS, parts obsolescence) are correlated with identified and implicit design and production risk areas

   2. Mitigation strategies are planned and implemented, including resources and schedule requirements

J. Key allocated performance requirements are traceable to the critical system design for all major subsystems and components

   1. All major subsystem and component allocations are incorporated into the critical design

   2. Key parameters and information (developed and assessed at PDR) are implemented for each major subsystem and component critical design, e.g.:

      a. Major performance parameters are incorporated

      b. Critical technologies are under development

      c. Critical design and manufacturing requirements and challenges (identified at SFR) are correlated with critical design

Appendix E

Note: The following examples are intended to provide clarification of the types of data and level of detail expected to be addressed at CDR. It is intended that the contractor will identify those subsystems and components applicable to the type of system being developed and the appropriate criteria for each subsystem and component necessary to effectively evaluate and assess the critical system design, its technical, cost, and schedule parameters, and demonstrate that the design has incorporated recovery modes for all failure modes identified at PDR, e.g.:

⇒ For Electrical Power:

- Electrical Power Distribution System (EPDS) performance requirements, characteristics, and operational criteria are defined, including initial power budgets, total power demand with allowable margins, and modes of operation (frequency and duration)
- Selection and evaluation of the type(s) of power supply sources are being considered, along with their specific technology and topology
- Battery (or energy storage) power requirements are identified and modes of operation defined (frequency and duration)
- Battery life requirements (BOL and EOL) and other unique requirements that may impact battery selection or design are defined
- Battery cell technologies are identified and battery architectures defined

⇒ For Software:

- The “Acceptance Criteria” for software detailed in Appendix C, Sections 30.4, e.g., SAR “Acceptance Criteria” (paragraphs A, B, C, D, F, G, H, I, and J) are satisfied to the extent specified in the SDP based on the selected life cycle model(s).

50.4.3 System, Segment, and Subsystem Verification and Validation

Evidence of System, Segment, and Subsystem design concepts verification and validation (V&V) requirements maturity criteria examples at CDR:

A. System, Segment, Subsystem, and Component V&V approaches developed for the critical design

1. Critical design demonstrates that major system-, segment-, subsystem-, and component-allocated requirements can be verified and validated, e.g.:

   a. V&V approaches are developed for the critical design address system of systems, system, segment/subsystem, and component down to their element and unit levels

   b. V&V approaches include analytical, modeling, and simulation and testing processes and procedures for critical design

   c. V&V processes and procedures address new technology, verification, and qualification technical practices, system-level demonstrations and tests, support required from external organizations and/or facilities, and resource requirements for the critical design

   d. V&V processes and procedures for the critical design based on proven, referenced practices

   e. Updated subsystem and component VCRMs are complete and consistent with system- and segment-allocated requirements and internal/external interface allocated requirements, e.g.:

      (1) Components element and unit VCRMs are traceable to the system/segment/subsystem VCRMs

      (2) The updated segment/subsystem/component VCRMs are baselined and under configuration management

      (3) V&V methods in the system and segment/subsystem/component VCRMs are adequate to verify the system and its segments/subsystems/components down to their element/unit levels

B. System operational functions and environments for the critical design are traceable to the contractor's operations concept (OpsCon), and the allocated and physical baselines.

   1. Demonstrate that the system V&V test environment allocations are traceable to the system performance specification for the critical design

   2. Demonstrate that the critical design is correlated with and traceable to all critical allocated and physical environmental parameters, V&V approaches, and processes

C. DT&E elements are correlated with the critical design

D. OT&E allocated and physical requirements are incorporated into the critical design

E. Test bed(s) and test facilities are chosen based on the critical design are deemed adequate to perform system, segment/subsystem, and interface requirements verification, e.g., critical hardware and software items procurement and scheduling are complete and in place as V&V resources (e.g., simulators, test beds, test facilities)

F. Test requirements and test data collected to date for the critical design are traceable to operational requirements via specifications and V&V cross-reference matrices (VCRMs), e.g., use of comparative test data to anchor representative system/segment/subsystem models and simulations down to their element and unit levels to real-world environments and allocated and physical requirements are demonstrated

G. V&V risk approaches, processes, and procedures are developed for the critical design.

H. V&V test deficiencies, including those based on technology deficiencies, are established at PDR, and correlated with the critical design and the impact assessed

I. Risk mitigation approaches are developed and integrated into the system risk model, including resource requirements, which are correlated with the critical design

50.4.4 Engineering Disciplines/Specialty Engineering

Evidence of Engineering Discipline/Specialty Engineering identification and assessment maturity criteria (categories listed in A through R below) at CDR in terms of, e.g.:

   1. Key performance requirements

   2. Key performance parameters

   3. Use of heritage systems/components/technology

   4. Use of new designs

A. Parts, Materials, and Processes (PM&P)

   1. PM&P allocated and physical requirements are incorporated into the critical design

   2. Environments and environmental parameters impacting parts performance are incorporated into the critical design

   3. Parts engineering design analyses are completed for the critical design addressing risk assessments, technologies, sources of supply, and the common quality levels (i.e., reliability) of the parts, e.g., results of critical design analyses used to develop final critical parts and long-lead items list are complete

B. Test and Evaluation (T&E)

   1. Final T&E planning is traceable to the critical design correlating all test objectives, test environments, and test resources to allocated requirements

   2. T&E approaches (selected at PDR) are verified and correlated with the critical design, e.g.:

      a. Demonstrate that the baselined test processes and procedures developed at PDR can verify the system, segments, and subsystems allocated and physical requirements and interfaces down to their component elements and units

   b. Baselined T&E processes and procedures capture the characteristics, effectivity(s), and margins for each particular test item down to their elements and unit levels

3. Test/verification data gathering, reduction, and analysis processes for the critical design are verified and baselined, including test environment(s), operations, and procedures to be performed, data acquisition requirements, documentation, methods of analysis, and pass-fail (i.e., success) criteria

C. Survivability and Vulnerability

1. Demonstrate that the critical design captures the survivability and vulnerability threat allocations incorporated into the preliminary design for all categories of expected threats, threat environments, and their likelihood of occurrence

2. Demonstrate that the system/threat interaction analyses that established and baselined threat margins at PDR are still adequate and complete for the critical design

3. Survivability design solutions are correlated with and incorporated into the critical design shown to mitigate each known threat

D. Environmental Safety and Occupational Health (ES&OH)

1. Life cycle environmental allocations are incorporated into the critical design

2. Data compiled for CDR Programmatic ES&OH Evaluation (PESHE) compliance objectives are correlated with the critical design, including an assessment of internal and external operational environments

3. Hazardous materials management and pollution prevention processes and procedures are verified and baselined to the critical design

4. Critical human safety and health factors are baselined and incorporated in the critical design

E. Mass Properties

1. Mass properties margins (average or complex) established for CDR are correlated to the critical design, including allowable growth allocations and metrics

2. Calculated weight growth, center of gravity, and moments of inertia parameters are allocated to the critical design

F. System Security Engineering (SSE), Communications Security (COMSEC), Information Assurance (IA), and Program Protection (PP):

1. Requirements are incorporated into the critical design IAW DoD/AF policies, directives, and system specifications, e.g., program protection planning is complete and ready for Milestone Decision Authority (MDA) approval

2. System security concept and specification implemented for the critical design include a finalized baseline security test and evaluation processes and procedures

3. Threat, vulnerability, risks assessments, and baselined protection countermeasures implementing the trusted facilities are complete

4. Information Assurance controls included in the critical design and certification and accreditation requirements are finalized following the DIACAP

5. Program baseline costs for SSE, COMSEC, IA, and PP for implementation and sustainment of the system are updated

G. Interoperability

1. Allocated and physical system and mission interoperability requirements are incorporated into the critical design

2. Allocated and physical requirements from new/unique standards approved for inclusion in DISR (i.e., new data formats, interdependency, data exchange protocols/schemas, Ethernet alternatives) are correlated with and incorporated into the critical design
3. Allocated and physical interoperability requirements for all the interrelationships and interdependency are incorporated into the critical design

H. Reliability and Maintainability (R&M)

1. R&M allocated and physical requirements are incorporated into the critical design
2. R&M analyses results are correlated with the critical design, e.g.:
   a. Approaches and processes developed for implementing Environmental/Thermal Stress Screening (ESS/TSS) at PDR are verified and baselined for the critical design
   b. Packaging, Handling, Storage, and Transportability (PHS&T) environmental allocated and physical requirements in the R&M program are incorporated into the critical design
3. Update the hardware FMECA and the RMA&D Prediction Analyses (including final Reliability Stress Analysis – with software if applicable) for final design, e.g.:
   a. Update critical items list and single-point failures list
   b. Update any safety issues and associated analyses as appropriate
   c. FMECA is to include effects of design implementation, e.g., proximity of parts, location in wire bundles, etc.

I. EMI/EMC

1. Electromagnetic interference control processes and procedures developed at PDR are verified and baselined for the critical design
2. Internal and external EMI/EMC allocated and physical requirements are incorporated into the critical design
3. EMI susceptibility allocated and physical requirements and constraints are incorporated into the critical design
4. Demonstrate that the preliminary design's EMI/EMC critical environmental characteristics and sensitive elements are correlated to the critical design

J. Human Systems Integration (HSI)

1. User interface hardware/software allocated and physical requirements for operators, users, maintainers, and sustainers are incorporated into the critical design
2. Usability, maintainability, operability and/or supportability physical requirements decomposed from system allocated requirements are incorporated into the critical design
3. Operational manning, workload, and skill level are allocated, and physical requirements are incorporated into the critical design

K. Manufacturing and Producibility

1. Demonstrate that the manufacturing and producibility approaches and processes are developed and correlated with the critical design
2. Producibility procedures and methods verified and baselined for the critical design demonstrate the manufacturing processes selected at PDR support the critical design

L. Life Cycle Logistics

1. Supportability is allocated and physical requirements are incorporated into the critical design
2. System-level logistics elements are correlated with the critical design, including design interface, supply support, test equipment, manpower and personnel, training and training equipment, PHS&T, facilities, computer resources, technical data, and maintenance planning
3. Logistics Management Information (LMI) is completed and validated in support of the Allocation and Physical baselines for the critical design

M. System Safety

1. System safety is allocated and physical requirements are incorporated into the critical design
2. Segment/subsystem hazard analyses are completed and an updated list of prioritized safety hazards established for the test, operation, and disposal of the critical design
3. Critical human safety and health factors are baselined and incorporated into the critical design
4. The baselined hazardous materials list (compiled and prioritized at PDR) correlated to and updated as required for the critical design

N. Contamination Control

1. Contamination control processes and procedures developed at PDR are verified and baselined for the critical design
2. Material outgassing survey results (from PDR) are correlated with and updated as required for the critical design

O. Quality Assurance

1. Quality/product assurance allocated and physical requirements correlated to and incorporated in the critical design
2. Verification, inspection, and test processes and procedures developed at PDR are verified and baselined for the critical design

P. Environmental Considerations

1. Environmental study results (from PDR) are correlated with and updated as required for the critical design
2. Environmental test and evaluation approaches and processes are developed for the critical design
3. Reliability-thermal allocation requirements are incorporated into the critical design

Q. Software

1. Requirements
   a. Software requirements (including software interface requirements) have been specified to the level of completeness called for in the software development plan based on the selected software life cycle model
   b. Software requirements (including software interface requirements) are correct, complete, consistent, feasible, verifiable, and clearly and unambiguously stated
   c. Software requirements (including software interface requirements) are traced to and fully implement their parent requirements
   d. Software requirements include necessary requirements derived from the system and software architecture, system operational concepts, trade studies, or design decisions

2. Each software requirement, including software interface requirements, has one or more valid verification methods and verification levels specified, and those methods and levels are sufficient to fully verify the requirement
   a. The "Acceptance Criteria" for software detailed in Appendix C, sections 30.4 SAR "Acceptance Criteria" (paragraphs A, B, C, D, F, G, H, I, and J) are satisfied to the extent specified in the SDP based on the selected life cycle model(s)
   b. Software operational concepts include nominal and off-nominal scenarios from a software perspective (e.g., start-up/initialization, shutdown, processor failover, redundancy management, recovery/restoral) consistent with the system and software architectures
   c. Software operational concepts include information exchange with external interfacing systems
   d. Software operational concepts include scenarios for operational workloads
   e. Software operational concepts are consistent with system operational concepts
3. Architecture and Design
   a. The software architecture has been defined to the level of completeness called for in the software development plan, based on the selected software life cycle model
   b. The software architecture views, including the physical, logical, developmental, process, and behavioral (user) views, are correct, complete, consistent, clear, and unambiguous
   c. Nondevelopmental items (NDI) (e.g., COTS, GOTS, and reuse software) have been fully integrated into the components of the software architecture
   d. The software architecture, including the nondevelopmental items (NDI) (e.g., COTS, GOTS, and reuse software), will enable the higher-level requirements allocated to software, the software requirements, and the software interface requirements to be met
   e. The design of each software item has been elaborated to the level of software units, consistent with the software development plan and the selected software life cycle model
   f. The design of each software item is clear, correct, complete, consistent, and unambiguous, and adequately addresses the following:
      (1) Detailed design of all external and internal interfaces
      (2) Detailed design of all files, databases, shared memory, etc., and their storage and access methods
      (3) Detailed design of user interface screens and human/system interactions
      (4) Source for each unit of the software item (i.e., COTS, unmodified reuse, modified reuse, or newly developed code), and programming language(s) to be used
      (5) Selected COTS software products and installation/configuration design decisions
      (6) Detailed design of glue code for integrating COTS and reuse software products with each other and with the newly developed code
      (7) Detailed algorithm designs for the software units, including both mathematical and procedural algorithms
      (8) Detailed design of the dynamic structure of the software items (e.g., processes/tasks, flow of execution control, priorities, sequencing, dynamic creation/deletion of process)
      (9) Detailed design of exception handling and recovery methods
      (10) Application Programming Interfaces (APIs) to be used (both standardized APIs and APIs uniquely defined for this system)

g. The design of each software item properly implements all applicable standards (e.g., interface standards, graphical user interface (GUI) standards)

h. Updated software architecture and design adequately address the use of open systems standards and satisfy all applicable interoperability-related requirements

i. Updated software architecture and design adequately address end-to-end processing (including timelines and capacity) for operations, maintenance, and training, across elements and external and internal interfaces

j. Updated software architecture and design adequately address operational database management and control

k. Updates to selected computing resources (e.g., processors, cache, memory, buses, and networks) are appropriately incorporated into the updated system and software architectures, and will enable the allocated element, subsystem, software, and interface requirements to be met

l. Updated software architecture and detailed design meet appropriate functional and performance requirements for each state and mode

m. Updated software architecture and detailed design adequately address requirements for survivability and endurability from a computer hardware and software perspective

n. Updated software architecture and detailed design adequately address supportability, including fault management and integrated hardware-software diagnostics, fault detection, isolation, localization, restoral, and repair

o. Updated software architecture and detailed design adequately address dependability, reliability, maintainability, and availability requirements allocated to the computer hardware and software subsystems

4. Engineering Analysis

a. Updated engineering analyses, models, and/or simulations adequately demonstrate that the software architecture and detailed design, together with the computer resources (hardware and software) that have been selected, will meet the Key Performance Parameters (KPPs) and driving requirements

b. Updated reliability, maintainability, and availability analyses are consistent with the software architecture and detailed design and with the computer resources (hardware and software) that have been selected, and appropriately include the contribution of software

c. Updated safety, information assurance, and human systems integration analyses are consistent with the software architecture and detailed design and with the computer resources (hardware and software) that have been selected, and appropriately include the contribution of software

d. Updated engineering analyses and trade studies adequately support software architectural and detailed design decisions about NDI (reuse, COTS, and GOTS software components), and appropriately consider the underlying, supporting computer resources (hardware and software) that have been selected

e. Updated human systems integration engineering analyses and trade studies (e.g., operability, operator workload analysis) demonstrate the adequacy of the software architecture and detailed design and the computer resources (hardware and software) that have been selected for the operators to perform their required roles within the required timelines

f. Updated performance analysis demonstrates that the software architecture and detailed design, together with the computer resources (hardware and software) that have been selected, meet performance requirements with adequate margins for this point in the life cycle

g. Updated engineering analyses and trade studies demonstrate the adequacy of the software architecture and detailed design, together with the computer resources (hardware and software) that have been selected, for meeting the computer resource margin requirements

h. All the above analyses take into account actual performance of existing software (e.g., prototypes, earlier builds, NDI) on the selected hardware

i. Updated engineering models and simulations have been used to demonstrate the adequacy of the algorithms to be implemented in software

5. Integration and Verification

   a. Updated software integration and qualification test plans and procedures have been defined to the level of completeness called for in the Software Development Plan, based on the selected software life cycle model

   b. Software qualification test plans and procedures are valid, complete, stable, consistent with the software architecture, detailed design and with higher-level test plans, and consistent with the qualification requirements for test methods and test levels for the software requirements and software interface requirements

   c. Software requirements are fully allocated to the tests described in the software qualification test plans, where they will be verified

   d. The software integration has been performed according to the integration procedures, to the level specified by the SDP according to the selected life cycle model

   e. Software requirements verification status is documented and configuration managed. The status correctly reflects the results of the verification to date, including the status of partially verified requirements, for all levels of requirements, from system through software. The verification status is traced to the appropriate qualification testing results (i.e., inspection, analysis, test, or demonstration reports)

   f. The master software build plan is complete, feasible, executable, and consistent with the software requirements, software architecture, software qualification test plans, and higher-level schedules

6. Traceability

   a. All software traceability information is correct, bidirectional, and consistent with the higher-level requirements allocated to software, software requirements, software interface requirements, software architectural and detailed design components, and software qualification test plans and procedures

   b. Software traceability information is defined to the level of completeness defined in the Software Development Plan, based on the selected life cycle model

7. Risk Management

   a. Updated risk assessment includes the following software risks as appropriate:

      1) Risks related to software size and complexity

      2) Risks related to requirements allocated to software

      3) Risks related to the software architecture and design

      4) Risks related to selection and use of NDI (COTS, reuse, GOTS)

      5) Risks related to selection and use of computing resources (e.g., processors, cache, memory, buses, and networks)

      6) Risks related to growth margins for computing resources

      7) Risks related to software schedules

8) Risks related to software development, integration, and verification processes and tools
9) Risks related to population, update, control, and validation of databases
10) Risks related to software and computer hardware technology
11) Risks related to software reliability, maintainability, and availability
12) Risks related to human systems integration, safety, and information assurance
13) Updated software risk management plan is part of the updated SDP and is integrated with the updated system risk management plan
14) Effective software risk-handling plans are in place, and risk-handling activities are being performed in accordance with the plans

8. Costs and Schedules
    a. Software cost models have been calibrated with actual data (both from the current project as well as past history) and used to update software cost and schedule estimates
    b. Realistic software cost drivers, such as complexity and other parameters, and assumptions are documented, validated with documented project data, and used in software cost models to develop updated cost and schedule estimates
    c. Updated software size estimates are supportable, based on history, and consistent with the software and interface requirements and software architecture and detailed design
    d. Software cost and schedule estimates have enough margin to cover the estimation risk appropriate to this point in time
    e. Updated software schedules are consistent with higher-level schedules, including the IMS
    f. The updated life cycle cost estimate adequately includes software support
    g. All of the software tasks are included in the updated life cycle cost estimates, e.g., COTS integration and refresh, screen definition, knowledge base, and database population
    h. The updated life cycle cost estimate is consistent with the software architecture and detailed design

9. Engineering and Management Plans
    a. The updated SDP is consistent with the updated IMP, SEMP, and other management and engineering plans
    b. The updated SDP addresses the full software development life cycle
    c. The updated SDP describes an integrated set of processes, methodologies, tools, and environments that cover all software team members, are suitable for the domain, and are appropriate for program scope and complexity
    d. The updated SDP describes selected software development life cycle models that are feasible, appropriate for program scope and complexity, and used consistently across all team members
    e. Updated software processes, standards, procedures, and conventions for use throughout the life cycle are documented and validated, and consistent with the SDP
    f. The software development and test environments integrate with the systems engineering environments across all the team members
    g. The software development and test environments are established and have adequate capability and capacity to meet the software development and test requirements and schedules
    h. The contractor has demonstrated that the software processes, standards, procedures, and conventions are being followed, as appropriate to this point in the life cycle

i. Software-related IMP accomplishments for the CDR have successfully met their accomplishment criteria

10. Metrics and Technical Performance Measures

    a. Updated definitions for the selected software metrics are documented, clear, and correct, and include reasonable thresholds for triggering corrective action

    b. Updated software metrics are sufficient for meeting the information needs for program and engineering management and incorporate lessons learned from the metrics experience to date

    c. Software metrics are being collected, analyzed, reported, and used for management and technical decision-making, including risk management, as appropriate to this point in the life cycle

    d. Adequate corrective actions have been defined to address the underlying problems indicated by software metrics that are outside of documented thresholds

    e. TPMs are being collected, analyzed, reported, and used for managing the utilization of all critical computer resources, e.g., processors, memory, storage, and input/output channels and networks

    f. TPMs are being collected, analyzed, reported, and used for managing the software-related KPPs and driving requirements, including response time and timeline requirements

    g. Adequate corrective actions have been defined to address the underlying problems indicated by software TPMs that are outside of documented thresholds

    h. The contractor has demonstrated that, for metrics or TPMs outside of thresholds, corrective actions have been initiated, managed, and tracked to closure

    i. The software problem/deficiency report status indicates that adequate progress is being made in implementing and verifying solutions to documented problems, and that the documented problems are being addressed in accordance with their severity

R. Data Storage (Security, Access, Distribution, and Delivery)

1. Storage System Capability/Flexibility/Scalability, critical design maturity, e.g.:

    a. Analysis identifies needed reliability, maintainability, and availability characteristics of storage systems environments

    b. Capacity, flexibility, and extensibility parameters are defined that meet system design life requirements

    c. Key system components are defined

    d. Plans for redundancy are defined, including storage media hardware and software capabilities and types

    e. Storage system management and performance optimization (including software management tools to provide appropriate partitioning/addressability) are defined

    f. Analysis defined the operational environments for the storage system, including hardening levels

2. Storage System Architecture, e.g.:

    a. The Storage System Architecture is defined, including communications and processing capacity

    b. The types of storage system needs are defined and fully integrated into the architecture, e.g., centralized vs. distributed storage; online, near-line, and offline needs; archive (including hierarchical storage management, if appropriate), backup, and restore; and data replication

c. Storage hardware components such as RAID, Storage Area Networks (SAN), Network Attached Storage (NAS), and Direct Attached Storage (DAS) defined and integrated into the architecture

d. Data management software capabilities are defined and integrated into the architecture, e.g., automatic file migration and transparent file retrieval; migration between hierarchical levels; and utilities to report on media usage, error detection, and identification of media to be replaced

3. Security, e.g.:

a. The level of user integrity (e.g., access control lists) is defined

b. The level of encryption is defined

c. The specialized security capabilities, such as CDS, MLS, and Security Enclaves, are defined

4. Data Distribution Methods, e.g.:

a. A complete list of data receivers is defined that includes both computer and human agents

b. The method(s) of distributing data to the various receivers defined, e.g., method to Subscribe/Publish, Push/Pull, and global or restricted Web-based access

c. The data distribution methods are defined and integrated into the storage architecture

5. Functionality, e.g.:

a. Analysis defined the physical aspects of the functionality that supports the mission

b. The types of platforms (server/client) and operating systems supported are defined

c. The data connection/transport protocols (e.g., fiber channel, infiniband, SWCI) are defined and integrated into the system architecture

d. Specific reporting (e.g., usage) and maintenance metrics (e.g., MTBF/MTTR) are defined

e. Mapping between metrics and system-level requirements is complete

50.4.5 Integrated Technical Risk Management and Mitigation

Evidence of technical risk management (RM) process criteria examples, with an increased level of fidelity and maturity of identified risk items/elements, is provided for the recommended system design as a key component of an integrated program (technical, cost, schedule, and performance) RM and Mitigation (RM&M) process for CDR, e.g.:

A. Sound risk-handling plans, including risk mitigation processes and procedures, shown to be in place and executed at PDR are being used, maintained, and updated as required for the critical design

1. The risk-handling plans include thresholds for taking action, and appropriate actions have been taken when thresholds are breached

2. The risk mitigation processes and procedures are feasible, and alternative courses of action are identified

3. Risk-handling plans demonstrate that the degree of risk in all aspects of the system, segment, interdependency, and program is acceptable to proceed to detailed design of end items

B. Integrated system-level risk reduction approaches and processes developed by PDR are verified and baselined for the critical design and can encompass such items as:

1. The significant program-level risks (technical/performance, cost, and schedule)

2. Risk management database/tools for risk metrics collection, analysis, tracking, and reporting

3. Risk mitigation/reduction strategies, burn-down plans that are linked to dependencies to the Program IMP/IMS and WBS

4. Continuous risk monitoring/review, identification, assessment, and ranking

5. Technology and manufacturing readiness level (TRL and MRL) assessments and metrics
6. Requirements risk assessment metrics
7. Critical risk management of software issues, e.g., complexity, size, processing speed, throughput, schedules, COTS availability, legacy reuse suitability, and software development processes and tools
8. A comprehensive risk assessment for the follow-on phases
9. TRL and MRL assessment metrics

Appendix F

Appendix F - Test Readiness Review (TRR)

60. Test Readiness Review (TRR)

The TRR is a multifunctional and multidisciplinary review and process assessment to verify the contractor's readiness to begin a formal verification testing event for an EI.

60.1 General

A TRR shall be conducted at the beginning of each formal verification testing event. The TRR shall occur after the test procedures for verifying the EI requirements are prepared and a successful dry run of the test procedures has occurred, and before any formal "run for the record" begins. As an alternate to or tailoring of the "dry run" followed by a "run for the record," it is acceptable to consider the use of a multidisciplinary test procedure validation team to validate (redline) a test procedure's first run while simultaneously performing the "run for the record." The TRR shall be held for an individual EI or a collection of related EIs, as defined or tailored by the contractor and approved by the contracting agency.

60.2 Objectives

The objective of the TRR is to determine whether the contractor is ready to begin a formal verification testing event for one or more EIs. This includes an assessment of whether:

a. The EI is sufficiently mature to begin testing

b. The test procedures, together with the test data, are sufficiently robust to verify the requirements

c. The test procedures have been successfully dry run

d. Disciplined test processes are in place

e. Test personnel are available, and roles and responsibilities are clearly defined

60.3 Items To Be Reviewed

The contractor shall present the following items for review by the contracting agency for the EI(s) under review:

A. Requirements

1. EI requirements are planned to be verified at this formal verification event
2. Any changes to these EI requirements that have been approved since CDR
3. Required verification methods (Inspection (I), Analysis (A), Demonstration (D), Test (T)) and verification levels for each EI requirement are planned to be verified at this formal verification event

B. Design

1. Any changes to the EI design that have occurred since CDR and that affect the EI verification testing

C. Test Plans

1. Any changes to the EI test plan that have occurred since CDR

D. Test Procedures

1. Test cases and test procedures for the formal verification event to be held, including but not limited to:
    a. Test setup procedures
    b. Test execution procedures
    c. Data capture procedures

d. Data analysis procedures

2. Description of the test data to be used with the test procedures

3. Results of dry runs, including anomalies encountered and any anticipated problems with requirements verification. Evidence of test procedure adequacy reviews or peer reviews of the test procedure is acceptable if tailored by contract as an alternative to a "dry run" if approach consists of test procedure validation concurrent with the run for the record approach

E. Traceability

1. Traceability between the test cases and test procedures to be executed and the requirements to be verified by each

F. Description of the EI

1. Description of the EI hardware and software under test

2. Configuration of the EI hardware and software under test, including the specific version or release of the software, e.g., confirmation of the configuration of the hardware and software under test by the CM organization

3. User documentation for the EI, if applicable (e.g., user manuals, handbooks)

G. EI Problems and Deficiencies

1. All known EI hardware and software problems or deficiencies as of the start of the verification event, with their severity levels

2. Expected impact of the known problems or deficiencies on the testing

H. Test Environment

1. Description of the test environment, including hardware, software, automated test equipment, test tools, simulators, emulators, drivers, etc.

2. Confirmation of the configuration of the test environment by the CM organization

3. Status of validation performed for test environment components (including hardware, software, automated test equipment, test tools, simulators, emulators, drivers, etc.) to ensure they correctly perform the functions necessary to support the verification testing event

4. All known test environment hardware and software problems or deficiencies and their expected impact on the testing

I. Processes, Roles, Responsibilities, and Authorities

1. Test personnel and their roles, responsibilities, and authorities:

a. Including CM and QA personnel as well as test team personnel

b. Including both Government and contractor

2. Test processes to be followed, including:

a. A nominal process

b. A retest process when test anomalies are encountered and corrections must be performed

c. An anomaly adjudication process to determine whether and how testing can be continued after an anomaly has occurred during execution

d. A record maintenance process of the EI requirements' verification status (fully verified, partially verified, not verified), following completion of test execution and data analysis

J. Test schedules

1. Hour-by-hour schedules for the verification test event
2. Justification for schedules based on dry-run test times

K. Test Limitations

1. Any test limitations or other conditions that might impact the testing

60.4 TRR "Acceptance Criteria"

A. Requirements

1. The requirements planned to be verified at this test verification event include all approved changes

B. Design

1. Any design changes made since CDR shall not adversely affect this test verification event

C. Test Plans

1. All changes to the test plan have been approved
2. The test plan, with all changes incorporated, remains sufficiently robust to ensure the full verification of all requirements
3. The test plan is consistent with the required verification methods and levels

D. Test Procedures

1. The test procedures for each test case, together with the test data, are correct, complete, and sufficiently robust to verify all of the requirements allocated to the test case
2. The test procedures are consistent with the required verification methods and levels
3. The test procedures are sufficiently detailed to be repeatable
4. The test procedures are in compliance with the approved test plan
5. All redlines from dry runs have been incorporated into the test procedures

E. Traceability

1. Bidirectional traceability is provided between the requirements under test and the test cases and test procedures in which the requirements will be verified
2. The traceability is correct, complete, and consistent
3. Identification of the test procedures' steps is provided where the verification of each requirement is completed

F. Description of the EI

1. The EI under test is clearly defined
2. The EI is under configuration control by the CM organization, and the configuration of each EI hardware and software component is documented

G. EI Problems and Deficiencies

1. The EI, including hardware and software, is sufficiently mature to begin the verification testing event
2. No severity 1 or 2 problems or deficiencies are open for the portion of the EI undergoing test

H. Test Environment

1. The test environment, including hardware and software, is sufficiently robust to adequately verify the requirements under test
2. Sufficient validation has occurred prior to the verification test event to ensure that the test environment, including hardware and software, will correctly perform the functions necessary to support the verification testing event
3. The test environment is under configuration control by the CM organization, and the configuration of each component of the test environment is documented

I. Processes, Roles, and Responsibilities

1. Processes to be followed during test execution are defined and documented and will result in a controlled and disciplined test execution
2. Personnel roles and responsibilities are well defined, both for the contractor and Government
3. The presence and role of QA personnel is sufficient to ensure:
   a. The test process is followed
   b. Test execution rigorously follows the test procedures with any deviations documented as redlines
   c. All problems or deficiencies encountered during testing are documented on the appropriate forms
   d. The test log faithfully documents the execution of the test, including test start, test end, interruptions, and anomalies

J. Test Schedules

1. Test schedules are feasible

K. Test Limitations

1. Any test limitations will not affect the ability to verify the planned requirements

Appendix G

Appendix G - Functional Configuration Audit (FCA)

70. Functional Configuration Audit (FCA)

For Space Systems specific guidance, see SMC STD SMCS-S-002 Configuration Management dated 13 June 2008.

70.1 General

A. The objective of the Functional Configuration Audit (FCA) is to verify that the configuration item's actual performance complies with its hardware Development or Software Requirements and Interface Requirements Specifications. Test data is be reviewed to verify that the hardware or computer software performs as required by its functional and allocated configuration identification. For configuration items developed at government expense, an FCA shall be a prerequisite to acceptance of the configuration item. For software, a technical understanding shall be reached on the validity and the degree of completeness of the Software Test Reports, and as appropriate, Computer System Operator's Manual (CSOM), Software User's Manual (SUM), and the Computer System Diagnostic Manual (CSDM).

B. The FCA for a complex configuration item shall be conducted on a progressive basis, when so specified by the contracting agency, throughout the configuration item's development and culminates at the completion of the qualification testing of the configuration item with a review of all discrepancies at the final FCA. The FCA is to be conducted on that configuration of the configuration item that is representative (prototype or preproduction) of the configuration to be released for production of the operational inventory quantities. When a prototype or preproduction article is not produced, the FCA shall be conducted on a first production article. For cases where configuration item qualification can be determined only through integrated system testing, FCAs for such configuration items will not be considered complete until completion of such integrated testing.

C. Recommendations of configuration item acceptance or nonacceptance to the local contract management agency are based upon and governed by procedures and requirements outlined in subsequent paragraphs.

D. Continuing with the results of the Critical Design Review (CDR), review engineering data as defined in Paragraph 3.27 as to the suitability for intended use. The review shall consider the checklist items discussed in Paragraph 100.6, as properly tailored.

70.2 Contract Requirements

A. The schedules for the FCA shall be recorded on the configuration item development record by the contractor. A configuration item cannot be audited without the contracting agency authentication of the functional and allocated baseline. In addition, the contractor shall submit the final draft Product Specification for the configuration item to be audited to the contracting agency for review prior to FCA.

70.3 Contractor Responsibility

A. Prior to the FCA date (for configuration items to be audited), the contractor shall provide the following information to the contracting agency (this information is to be provided in addition to the general requirements of Sections 4 and 5):

1. Contractor representation (the test manager shall be in attendance)
2. Identification of items to be audited:
    a. Nomenclature
    b. Specification identification number
    c. Configuration item number

d. Current listing of all deviations/waivers against the configuration item, either requested of, or approved by the contracting agency

e. Status of Test Program to test configured items with automatic test equipment (when applicable)

70.4 Procedures and Requirements

The contractor's test procedures and results shall be reviewed for compliance with specification requirements as mapped down to the lowest level of EI in a requirements test verification matrix (RTVM).

A. The following testing information shall be available for the FCA team:

1. Test plans, specifications, descriptions, procedures, and reports for the configuration item
2. A complete list of successfully accomplished functional tests during which pre-acceptance data was recorded
3. A complete list of successful functional tests if detailed test data is not recorded
4. A complete list of functional tests required by the specification but not yet performed. (To be performed as a system or subsystem test)
5. Preproduction and production test results

B. Testing accomplished with the approved test procedures and validated data (witnessed) should be sufficient to ensure configuration item performance as set forth in the specification Section 3 and meet the quality assurance provisions and qualification requirements contained in Section 4

C. For those performance parameters that cannot completely be verified during testing, adequate analysis or simulation shall have been accomplished. The results of the analysis or simulations will be sufficient to ensure configuration item performance as outlined in the specification.

D. Test reports, procedures, and data used by the FCA team are to be made a matter of record in the FCA minutes

E. A list of the contractor's internal documentation (drawings) of the configuration item is to be reviewed to ensure that the contractor has documented the physical configuration of the configuration item for which the test data is verified

F. Drawings of HWCI parts that are to be provisioned should be selectively sampled to assure that test data essential to manufacturing are included on, or furnished with, the drawings

G. Configuration Items (CIs) that fail to pass quality assurance test provisions are to be analyzed as to the cause of failure to pass. Appropriate corrections shall be made to both the CI and associated engineering data before a CI is subjected to requalification.

H. A checklist shall be developed that identifies documentation and hardware and computer software to be available and tasks to be accomplished at the FCA for the configuration item. See Pre-FCA check sheet.

I. Retests or additional tests shall be performed to assure compliance with paragraph 70.4.3

J. Partial completion of the FCA for those configuration items whose qualification is contingent upon completion of integrated systems testing is acknowledged

K. For SWCIs the following additional requirements shall apply:

1. The contractor is to provide the FCA team with a briefing for each SWCI being audited and delineate the test results and findings for each SWCI. As a minimum, the discussion is to include SWCI requirements that were not met, including a proposed solution to each item, an account of the ECPs incorporated and tested as well as proposed, and a general presentation of the entire SWCI test effort, delineating problem areas as well as accomplishments

2. An audit of the formal test plans, descriptions, and procedures are to be made and compared against the official test data. The results are to be checked for completeness and accuracy. Deficiencies are to be documented and made a part of the FCA minutes. Completion dates for all discrepancies are to be clearly established and documented
3. An audit of the Software Test Reports are to be performed to validate that the reports are accurate and completely describe the SWCI tests
4. All ECPs that have been approved are to be reviewed to ensure that they have been technically incorporated and verified
5. All updates to previously delivered documents are to be reviewed to ensure accuracy and consistency throughout the documentation set
6. Preliminary and Critical Design Review minutes are to be examined to ensure that all findings have been incorporated and completed
7. The interface requirements and the testing of these requirements are to be reviewed for SWCIs
8. Review database characteristics, storage allocation data and timing, and sequencing characteristics for compliance with specified requirements

70.5 Post-Audit Actions

A. After completion of a specific FCA, the contractor shall publish and distribute copies of FCA minutes. The contracting agency officially acknowledges completion of the FCA with the indication that successful performance of an FCA satisfies the requirements for the conduct of the PCA.

B. The accomplishment of the FCA shall be recorded on the configuration item Development Record by the contractor.

Appendix H - Physical Configuration Audit (PCA)

80. Physical Configuration Audit (PCA)

For Space Systems–specific guidance, see SMC STD SMCS-S-002 Configuration Management dated 13 June 2008.

80.1 General

A. The Physical Configuration Audit (PCA) shall be the formal examination of the as-built version of a configuration item against its design documentation in order to establish the product baseline. After successful completion of the audit, all subsequent changes are processed by engineering change action. The PCA also determines that the acceptance testing requirements prescribed by the documentation is adequate for acceptance of production units of a configuration item by quality assurance activities. The PCA includes a detailed audit of engineering drawings, specifications, technical data, and tests utilized in the production of HWCIs and a detailed audit of design documentation, listings, and manuals for SWCIs. The review shall include an audit of the released engineering documentation and quality control records to make sure the as-built or as-coded configuration is reflected in this documentation. For software, the Software Product Specification and Software Version Description shall be a part of the PCA review.

B. The PCA shall be conducted on the first article of configuration items, and those that are a reprocurement of a configuration item already in the inventory will be identified and selected jointly by the contracting agency and the contractor. A PCA shall be conducted on the first configuration item to be delivered by a new contractor even though PCA was previously accomplished on the first article delivered by a different contractor.

C. Formal approval by the contracting agency of the configuration item Product specification and the satisfactory completion of a PCA result in establishment of the product baseline.

D. Recommendations of configuration item acceptance or nonacceptance to the responsible contract administration office (CAO) are based upon and governed by procedures and requirements outlined in subsequent paragraphs.

E. A final review will be made of all operation and support documents (i.e., Computer System Operator's Manual (CSOM), Software User's Manual (SUM), Computer System Diagnostic Manual (CSDM), Software Programmer's Manual (SPM), Firmware Support Manual (FSM)) to check format, completeness, and conformance with applicable data item descriptions.

F. Continuing with the results of the Functional Configuration Audit (FCA), review engineering data as defined in Paragraph 3.15 as to the suitability for intended use. The review should consider the checklist items discussed in Paragraph 100.6, as properly tailored.

80.2 Contract Requirements

The schedules for the PCA shall be recorded on the configuration item Development Record by the contractor. A set of current listings shall be provided for each SWCI being audited. The contractor shall submit the final draft of the product specification for the configuration item to be audited to the contracting agency for review prior to PCA.

80.3 Contractor Responsibility

A. The contractor shall provide the following information to the contracting agency (this information shall be provided in accordance with the general instructions of Sections 4 and 5 and the contractual requirements):

1. Contractor representation (the test manager should be in attendance)

2. Identification of items to be accepted by:
   a. Nomenclature
   b. Specification identification number
   c. Configuration item identifiers
   d. Serial numbers
   e. Drawing and part numbers
   f. Identification numbers
   g. Code identification numbers
   h. Software inventory numbering system
3. A list delineating all deviations/waivers against the configuration item either requested or contracting agency approved

B. The PCA cannot be performed unless data pertinent to the configuration item being audited is provided to the PCA team at time of the audit. The contractor is to compile and make this information available for ready reference. Required information is to include:

1. Configuration item product specification
2. A list delineating both approved and outstanding changes against the configuration item
3. Complete shortage list
4. Acceptance test procedures and associated test data
5. Engineering drawing index, including revision letters
6. Operating, maintenance, and illustrated parts breakdown manuals
7. Proposed DD Form 250, “Material Inspection and Receiving Report”
8. Approved nomenclature and nameplates
9. Software Programmer’s Manuals (SPMs), Software User’s Manuals (SUMs), Computer System Operator’s Manual (CSOM), Computer System Diagnostic Manual (CSDM), and Firmware Support Manual (FSM)
10. Software version description document
11. FCA minutes for each configuration item
12. Findings and status of quality assurance programs

C. The contractor is to assemble and make available to the PCA team at time of audit all data describing the item configuration. Item configuration data is to include:

1. Current approved issue of hardware development specification, Software Requirements Specification, and Interface Requirements Specification(s) to include approved specification change notices and approved deviations and waivers
2. Identification of all changes actually made during test
3. Identification of all required changes not completed
4. All approved drawings and documents by the top drawing number as identified in the configuration item product specification. All drawings are to be of the category and form specified in the contract
5. Manufacturing instruction sheets for HWCIs are identified by the contracting agency

D. The contractor is to identify any difference between the physical configurations of the selected production unit and the Development Unit(s) used for the FCA and certify or demonstrate to the government that these differences do not degrade the functional characteristics of the selected units.

80.4 PCA Procedures and Requirements

A. Drawing and Manufacturing Instruction Sheet Review Instructions:

1. A representative number of drawings and associated manufacturing instruction sheets for each item of hardware, identified by the contracting agency co-chairperson, shall be reviewed to determine their accuracy and ensure that they include the authorized changes reflected in the engineering drawings and the hardware. Unless otherwise directed by the contracting agency co-chairperson, inspection of drawings and associated manufacturing instruction sheets may be accomplished on a valid sampling basis. The purpose of this review is to ensure that the manufacturing instruction sheets accurately reflect all design details contained in the drawings. Since the hardware is built in accordance with the manufacturing instruction sheets, any discrepancies between the instruction sheets and the design details and changes in the drawings will also be reflected in the hardware

2. The following minimum information shall be recorded for each drawing reviewed:

   a. Drawing number/title (include revision letter)

   b. Date of drawing approval

   c. List of manufacturing instruction sheets (numbers with change letter/titles and date of approval) associated with this drawing

   d. Discrepancies/comments

   e. Select a sample of part numbers reflected on the drawing. Check to ensure compatibility with the Program Parts Selection List, and examine the HWCI to ensure that the proper parts are actually installed

3. As a minimum, the following inspections shall be accomplished for each drawing and associated manufacturing instruction sheets:

   a. Drawing number identified on manufacturing instruction sheet should match latest released drawing

   b. List of materials on manufacturing instruction sheets should match materials identified on the drawing

   c. All special instructions called out on the drawing should be on the manufacturing instruction sheets

   d. All dimensions, tolerances, finishes, etc., called out on the drawing should be identified on the manufacturing instruction sheets

   e. All special processes called out on the drawing should be identified on the manufacturing instruction sheets

   f. Nomenclature descriptions, part numbers, and serial number markings called out on the drawing should be identified on the manufacturing instruction sheets

   g. Review drawings and associated manufacturing instruction sheets to ascertain that all approved changes have been incorporated into the configuration item

   h. Check release record to ensure that all drawings reviewed are identified

   i. Record the number of any drawings containing more than five outstanding changes attached to the drawing

   j. Check the drawings of a major assembly and/or black box of the hardware configuration item for continuity from top drawing down to piece-part drawing

B. Review of all records of baseline configuration for the HWCI by direct comparison with contractor's engineering release system and change control procedures to establish that the configuration being produced does accurately reflect released engineering data. This includes interim releases of spares provisioned prior to PCA to ensure the delivery of currently configured spares.

C. Audit of contractor's engineering release and change control system to ascertain that they are adequate to properly control the processing and formal release of engineering changes. The minimum needs and capabilities set forth below are required of the contractor's engineering release records system. The contractor's formats, systems, and procedures are to be used. Information in addition to the basic requirements shall be considered part of the contractor's internal system. (*)

(*) Contract Administration Office (CAO) Quality Assurance Representative (QAR) records can be reviewed for the purpose of determining the contractor's present and most recent past performance.

D. As a minimum, the following information shall be contained on one release record supplied by the contractor, subcontractor, or vendor for each drawing number, if applicable:

1. Serial numbers, top drawing number, specification number
2. Drawing number, title, code number, number of sheets, date of release, change letter, date of change letter release, engineering change order (ECO) number

E. The contractor's release function and documentation shall be capable of determining:

1. The composition of any part at any level in terms of subordinate part numbers (disregard standard parts)
2. The next higher assembly using the part number, except for assembly into standard parts
3. The composition of the configuration item or part number with respect to other configuration items or part numbers
4. The configuration item and associated serial number on which subordinate parts are used. (This does not apply to contractors below prime level who are not producing configuration items.)
5. The accountability of changes that have been partially or completely released against the configuration item
6. The configuration item and serial number effectivity of any change
7. The standard specification number or standard part numbers used within any nonstandard part number
8. The contractor specification document and specification control numbers associated with any subcontractor, vendor, or supplier part number

F. The engineering release system and associated documentation shall be capable of:

1. Identifying changes and retaining records of superseded configurations formally accepted by the contracting agency
2. Identifying all engineering changes released for production incorporation. These changes are to be completely released and incorporated prior to formal acceptance of the configuration item
3. Determining the configuration released for each configuration item at the time of formal acceptance

G. Engineering data shall be released or processed through a central authority to ensure coordinated action and preclude the unilateral release of data

H. Engineering change control numbers shall be unique

I. The difference between the configuration of the configuration item qualified and the configuration item being audited shall be a matter of record in the minutes of the PCA

J. For HWCI acceptance tests, data and procedures shall comply with product specification. The PCA team shall determine any acceptance tests to be redone, and reserves the prerogative to have representatives of the contracting agency witness all or any portion of the required audits, inspections, or tests

K. HWCIs that fail to pass acceptance test requirements shall be repaired if necessary and be retested by the contractor in the manner specified by the PCA team leader in accordance with the product specification

L. The contractor shall present data confirming the inspection and test of subcontractor equipment end items at point of manufacture. Such data shall have been witnessed by a government representative

M. The PCA team reviews the prepared backup data (all initial documentation that accompanies the configuration item) for correct types and quantities to ensure adequate coverage at the time of shipment to the user

N. Configuration items that have demonstrated compliance with the product specification are approved for acceptance as follows:

   1. The PCA team shall certify by signature that the configuration item has been built in accordance with the drawings and specifications

O. As a minimum, the following actions shall be performed by the PCA team on each SWCI being audited:

   1. Review all documents that will make up the software product specification for format and completeness
   2. Review FCA minutes for recorded discrepancies and actions taken
   3. Review the design descriptions for proper entries, symbols, labels, tags, references, and data descriptions
   4. Compare top-level software units design descriptions with lower-level software unit descriptions for consistency
   5. Compare all lower-level design descriptions with all software listings for accuracy and completeness
   6. Check Software User's Manual(s), Software Programmer's Manual, Computer System Operator's Manual, Firmware Support Manual, and Computer System Diagnostic Manual for format completeness and conformance with applicable data item descriptions. (Formal verification and acceptance of these manuals should be withheld until system testing to ensure that the procedural contents are correct.)
   7. Examine actual SWCI delivery media (card decks, tapes, disks, etc.) to ensure conformance with Section 5 of the Software Requirements Specification
   8. Review the annotated listings for compliance with approved coding standards

80.5 Post Audit Actions

A. Contracting agency acceptance or rejection of the configuration item and the configuration item product specification presented for PCA shall be furnished to the contractor in writing by the responsible contract management agency or other designated agency after completion of PCA, including appropriate corrective actions for resolution of deficiencies

B. After completion of the PCA, the contractor shall publish and distribute copies of PCA minutes. The contracting agency officially acknowledges completion of the PCA as indicated in paragraph 4.2.4

C. The accomplishment of the PCA shall be recorded on the configuration item Development Record by the contractor. Only the successful verification/validation of the FBL and close-out of corrective action can result in authorization for production go-ahead

Appendix I

Appendix I - System Verification Review (SVR)

90. System Verification Review (SVR)

System Verification Review (SVR) was previously identified as Formal Qualification Review (FQR).

90.1 General

The objective of the SVR shall be to verify that the actual performance of the configuration items of the system as determined through test comply with the hardware Development Specification, Software Requirements and Interface Requirements Specifications, and to identify the test report(s)/data that documents results of qualification tests of the configuration items. The point of government certification will be determined by the contracting agency and will depend upon the nature of the program, risk aspects of the particular hardware and software, and contractor progress in successfully verifying the requirements of the configuration items. When feasible, the SVR shall be combined with the FCA at the end of configuration item/subsystem testing, prior to PCA. If sufficient test results are not available at the FCA to ensure that the configuration items will perform in their system environment, the SVR shall be conducted (post-PCA) during System testing whenever the necessary tests have been successfully completed to enable certification of configuration items. For non-combined FCA/SVR, traceability, correlation, and completeness of the SVR shall be maintained with the FCA and duplication of effort avoided.

90.2 Requirements

A. In cases where the SVR and the FCA can be accomplished in a single combined Audit/Review, contractor and government “certification” of the configuration items shall be accomplished after completion of the FCA and such certification shall be considered an accomplishment of the SVR.

B. When the agency responsible for qualification of the configuration items at the contracting agency judges that the system is not ready for SVR at the time of FCA, the SVR will be delayed until it is determined that sufficient information on the system’s qualification is available. The SVR may be delayed up to the end of System testing if deemed necessary.

C. When a separate SVR is necessary, the contractor shall notify the contracting agency of the sufficiency of the configuration items’ test results to substantiate an SVR and coordinate the agenda with the Deputy Director for Test and Deployment. The SVR team will be assembled in the same manner as that required for the FCA team. No duplication of FCA effort shall occur at the SVR; however, the following additional efforts must be accomplished:

    9. A review of the FCA minutes must be performed and the SVR shall be considered as an extension of FCA. New/additional qualification data shall be audited and reviewed to ensure qualification of the configuration items against the System/Subsystem, Software Requirements, and Interface Requirements Specifications.

    10. Any testing accomplished against configuration item qualification during System testing shall be considered.

    11. The contractor shall, after notification of certification by the contracting agency, enter the date of system certification of qualification and the identity of the test reports/documentation that sets forth the results of the associated test(s) in the configuration item Development Record.

D. All other factors, such as agenda, team organization, review procedures, data to be reviewed, etc., shall be accomplished as delineated in the FCA and General Requirements and Procedures sections of this standard to the extent necessary to accomplish the SVR.

90.3 Post Review Action

A. After conducting the SVR, the contractor shall publish and distribute copies of SVR minutes. The contracting agency will officially acknowledge the conduct of the Review as indicated in paragraph 5.3.

Appendix J - Manufacturing Readiness Review (MRR) and Production Readiness Review (PRR)

100. Manufacturing Readiness Review (MRR) and Production Readiness Review (PRR)

100.1 General

A. Defense-unique and/or defense-critical manufacturing and production play a vital role in the development of weapons systems. Changing circumstances have significantly influenced defense manufacturing. These include:

1. Changing threats to national security
2. Declining defense budgets
3. Consolidation of the defense industry
4. The increasing globalization of industry
5. The increasing rate of change of technology
6. Requirements for environmentally compatible manufacturing

B. Defense-unique and/or defense-critical manufacturing capabilities are either broadly applicable to a number of weapons systems or specific to certain weapons systems, i.e.:

1. Composites processing and repair
2. Electronics processes
3. Information technology systems
4. Weapons system sustainment
5. Design, modeling, and simulation
6. Production processes

C. Defense manufacturing characteristics interact with each other and are composed of the following elements:

1. Manufacturing accounting, including activity-based accounting and cost-as-an-independent-variable accounting
2. Product design, including life cycle design, integrated product and process development, three-dimensional digital product models, simulation and modeling, and rapid prototyping
3. Manufacturing processes, including generative numerical control, adaptive machine control, predictive process control, high-speed machining, flexible tooling, soft tooling, tool-less assembly, embedded sensors, flip chips, nanotechnology, and biotechnology
4. Environmentally compatible manufacturing technologies, including cleaning systems, coatings, and materials selection, storage, and disposal
5. Business organization, including teaming among organizations, virtual enterprises, long-term supplier relationships, high-performance organizations, cross-functional teams, lean enterprises, adaptive enterprises, agile enterprises, and knowledge-based and learning enterprises
6. Information and communications technologies, including electronic commerce, virtual co-location of people, data interchange standards, internet technologies, intranet technologies, browser technologies, intelligent agents, seamless data environments, telecommunications, and distance learning

7. Application of advanced production processes and practices to maintenance, repair, and upgrade operations
8. Technology insertion for new and existing systems
9. Self-diagnostics for mechanical and electronic systems
10. New technologies for remanufacturing
11. Design and manufacturing methods for sustainment of weapons systems:
    a. Application of advanced production processes and practices to maintenance, repair, and upgrade operations
    b. Technology insertion for new and existing systems
    c. Self-diagnostics for mechanical and electronic systems
    d. New technologies for remanufacturing
    e. Design methods that improve sustainment
    f. Algorithms for design tradeoffs to optimize life cycle costs
    g. Parametric models that facilitate design tradeoffs at the conceptual stage
    h. Product databases that will permit simulation at various levels of resolution
12. Widespread application of commercial off-the-shelf (COTS) products:
    a. New weapons systems designed for open architecture and technology transparency
    b. A central program and mechanisms to maintain awareness of, document, and plan for new COTS technologies that can be incorporated into current and future weapons systems, as well as to disseminate this information to individual program offices
    c. Improved methods of inserting COTS products in fielded weapons systems
    d. Low-cost validation methods for determining the adequacy of COTS parts for military applications
13. Defense-unique and defense-critical processes with the broadest range of applications:
    a. Processes that enable rate-transparent production (i.e., production where the per-unit cost is independent of the production rate)
    b. Processes for the low-cost fabrication of composite structures
    c. Processes for the low-cost production and application of coatings and structures with low observability
    d. Defense-unique electronic technologies
    e. Design, information, and manufacturing technologies that provide dimensional control in the production of large, complex parts

100.2 Manufacturing Readiness Review (MRR)

A. Before commencing manufacture of a unit or other contractually designated configuration items at the prime contractor, subcontractor, or critical component supplier, the prime contractor shall conduct an MRR to ensure readiness to build a quality product that inherently embodies defense-unique and/or defense-critical manufacturing capabilities characteristic of a desired defense contractor identified in paragraph 100.1, as appropriate for the program under review.

B. Representatives from the appropriate design, manufacturing, test, parts, material, processes, quality, and other responsible organizations shall participate as a minimum. The appropriate government representatives shall be invited and allowed to participate.

C. Topics covered shall include applicable items identified in paragraph 100.1, to be mutually agreed to by the PCO and the contractor's program manager and include but not be limited to:

1. Drawing availability and acceptability
2. Configuration status
3. Producibility of parts and materials
4. Adequacy of manufacturing processes and certifications
5. Manufacturing planning
6. Current manufacturing trend data
7. Personnel experience and training and certifications
8. Tooling
9. Facilities
10. Inspection points
11. Test equipment availability and calibration status
12. Corrective action status
13. Manufacturing lessons learned from prior like hardware builds and schedule

D. Manufacturing and Test Planning: The contractor shall develop manufacturing, inspection, and test instructions for all segments of the manufacturing cycle, which shall include flowcharts or other effective alternative methods of identifying all inspection and test points. The contractor's quality assurance organization shall participate in the planning and shall review and approve the instructions prior to release. Instructions shall include or reference engineering requirements, such as drawings, material specifications, process specifications, and workmanship standards, to assure that necessary tests and inspections are effectively performed to verify that the product meets technical requirements. Test instructions shall identify the characteristics to be measured, the methods of measurement, and the point at which the test shall be performed. Any changes made to production processes, equipment, and/or test equipment/tooling shall be documented. Results of such changes shall be assessed as soon as practicable. The contractor shall address the following in developing the required manufacturing, inspection, and test instructions:

1. Sequence of all manufacturing, inspection, and test points to ensure continuity and effectiveness of all operations
2. Inspection and test performance at the optimum item indenture level to minimize repair or rework at higher indenture levels. All workmanship shall be inspected at least once and preferably twice before being covered up by subsequent operations
3. Module-level environmental testing and burn-in sufficiency
4. Cleanliness and contamination control to include foreign object control
5. The adequacy of in-house handling and packaging, including provisions for protection of electrostatic discharge–sensitive items
6. Availability and utilization of applicable drawings, specifications, and standards
7. Clear definition of acceptance or rejection criteria for each inspection or test
8. Thorough monitoring and documentation of critical items and their characteristics
9. Visual aids for inspection and assembly personnel
10. Proper selection, application, use, and control of substances, chemicals, shop aids, clothing, and expendable materials specified and used in the manufacturing process (cleaning materials, adhesives, joining material, solvents, rags, etc.)

11. Test equipment, tooling, jigs, fixtures, and other fabrication equipment to be utilized
12. Insertion of appropriate mandatory inspection points for manufacturing and quality organizations
13. Inclusion of Manufacturing Readiness Reviews (MRRs), Test Readiness Reviews (TRRs), and Hardware Acceptance Reviews (HARs) for units and other configuration items
14. Provisions to record process data, e.g., start and stop times, temperatures, torque values, etc.

E. Workmanship: The contractor shall develop methods that will assure that workmanship is adequate to meet contract end item specified requirements.

F. Standards: The contractor shall establish workmanship standards. These standards can be part of design specifications, drawings, work instructions, or other readily available specifications and standards. These standards shall be derived from industry-accepted workmanship standards and also be based on the contractor's manufacturing experience. All standards shall be aimed at delivering the highest-quality and most reliable hardware possible to the customer within the constraints of the contract. All standards shall define specific detailed acceptance or rejection criteria.

G. Visual Aids: When visual aids are used to support manufacturing or inspections, the contractor shall identify, maintain, and control the samples, graphics, or visual aids that show acceptable workmanship to ensure continued usability and proper configuration.

100.3 Production Readiness Review (PRR)

A. The PRR shall be conducted to provide a mechanism to assist the government in evaluation of the production risks and the contractor's methodology to manage those risks.

B. The four major PRR evaluation elements are:

1. Production Management, e.g., address "Organizational Assurance," focusing on how well the manufacturing organization is structured and managed
2. Production Engineering, e.g., address "Producibility Assurance," focusing on how the product has been designed for producibility, and what planning has been accomplished to ensure methods, processes, and test equipment has been defined and are available to support manufacturing operations
3. Production Operations, e.g., address "Process Assurance," focusing on how manufacturing/production will be planned and executed
4. Product Assurance, e.g., address how quality has been designed into the product and how product quality will be pursued and verified

C. Production Readiness Risk Calculations Methodology: Managing risk during the transition from development to production is a critical task in the life cycle of major system acquisition programs. For specific preparation guidance for PRR, the POC/Contractor team may elect to use the Production Readiness Review Tool User's Guide (AFSCR 84-2), which defines the risk calculation methodology for the major-element impact assessment and scoring according to the following criteria:

Impact Assessment	Impact Score
None	**0**
Insignificant	**1**
Minor	**2**
Major	**3**
Catastrophic	**4**

1. Risk score is the product of the probability assessment and the impact. For example, if the probability assessment for a given evaluation element is 70%, and the associated impact assessment is major, the calculated risk score would be 0.70 * 3 = 2.1. The result is compared to the threshold values entered by the PRR team.
2. An overall risk assessment is calculated for individual evaluation elements. This is a controversial approach; some have argued that if any evaluation element within a sub-element is high risk, then the entire sub-element should also be rated to be high risk. The counter to this argument is that the concept could itself be taken to its extreme. For example, if any evaluation element rated high risk necessitates the sub-element as high risk, then the major-element would have to be rated high risk because a sub-element is high risk, and ultimately the entire PRR would have to be rated high risk since a major-element is high risk. Since all data is available for review, rolling up the risk assessment for summary and out-brief purposes appears to be a reasonable approach, but each PRR POC and/or Contractor team should consider whether or not they wish to accept this approach.

D. Production Processing and Fabrication

1. Certification: The contractor shall establish a method to certify the qualification of the machines, equipment, and procedures used in complex, critical operations. Records shall be maintained of the qualifying tests performed and the results of such tests. Validation prior to production shall include measurements made on the first article produced for a given design. Machines, equipment, and procedures shall be recertified as indicated necessary by the results of quality trends or when major process changes are made (i.e., such items as material thickness, design, power source, capacity, voltage, or density)
2. Cleanliness, Contamination, and Corrosion Control: The contractor shall review and identify the cleanliness, contamination, and corrosion control requirements derived from hardware specifications and ensure that procedures are developed to adequately protect the hardware during manufacturing, test, storage, and transportation. Implementation of controls shall be monitored by quality assurance on a regular basis
3. Control of Physical Environment: The contractor shall ensure through periodic audit that the physical environment (such as temperature, humidity, light, arrangement of work areas, or arrangement of machines and equipment) is controlled to preclude inadvertent damage to hardware and to prevent unsafe conditions in all work and storage areas
4. Critical Item Quality Control Requirements: The contractor shall establish and maintain appropriate critical item control. Manufacturing shall include any special instructions in the appropriate planning shop folders, process plans, log books, and related documents controlling the manufacturing and movement applicable to in-house manufacturing. Components or materials selected for preferential treatment shall be conspicuously marked or tagged to alert personnel of special requirements. These items shall be segregated or have distinctively marked fixtures and locations in all stock rooms, and holding and staging areas. Such items shall be regularly and systematically inspected for condition of expired time, cycle, or calendar life. Items with expired time, cycle, or calendar life are to be identified as

nonconforming and properly dispositioned. Reviews of selected critical components shall be periodically conducted to verify the adequacy of work instructions and standards being used

5. Critical Item Verification: For each critical item, beginning at the start of assembly and at progressive levels of assembly and test, the contractor's quality organization shall verify that the contract, drawing, and specification requirements have been met for all such articles and materials, procured or produced. Anomalies, including trends, deviations from expected norms, and marginal conditions, shall be identified. Detailed assessment of the quality of these items and their manufacture shall include:
   a. Identification of potential design and layout problems that could cause latent defects or marginal performance
   b. Verification that current manufacturing test methods and controls are producing repeatable products
   c. A review of manufacturing problems, if any, that could be alleviated by additional (or revision of) engineering information
   d. Verification that critical parameters are measured and verified by applicable test procedures
   e. Decisions, dispositions, corrective actions, or recommendations are evaluated against appropriate criteria and previous history data
   f. Anomalies noted or observed during review are analyzed, evaluated, and dispositioned
   g. Records are progressively reviewed and made part of the overall "Acceptance Criteria"
   h. Identification and resolution of the differences between as-built and design documentation
   i. A review of failure and discrepancy reports to identify underlying causes (symptoms or manifestations) and a summary of overstress and induced secondary failures
6. Electrostatic Discharge Control (ESD) Program: Procedures shall be established for the surveillance of the electrostatic discharge control program implementation. This shall include identification of items susceptible to electrostatic discharge and protective features to prevent such damage. As a minimum this should include:
   a. Design criteria
   b. Protected work areas and protective clothing
   c. Process controls and workmanship standards
   d. Handling, packaging, transportation, and storage
   e. Training
   f. Marking of documentation, and hardware
   g. Audit plan for certified ESD workstations
7. Nondestructive Evaluation: Nondestructive evaluation methods and verification techniques (and attendant equipment and facilities), which are used to perform quantitative measurements, integrity analysis, and nondestructive testing, shall be controlled and integrated into the contractor's qualification, calibration, certification, and standards procedures. Nondestructive evaluations for hardware flight configurations shall be performed by personnel proficient and certified in the scientific field involved
8. Completed Item Inspection and Test: Prior to shipment or storage of a contract end item, the contractor shall review objective evidence generated during manufacturing and test of the item to ensure that all work sequences have been satisfactorily completed and that all

nonconformance issues have been resolved. The contractor shall maintain records and findings of final review.

9. Statistical Process Control: The contractor's quality assurance organization shall participate in development of techniques used to control process variability. This should consist of the independent evaluations of design disclosure technical documentation and manufacturing processes by qualified personnel. As a minimum, consider that:

   a. Critical quality characteristics are identified, measured, and verified

   b. Data is collected from points of measurement

   c. Control limits and tolerance variations are maintained within product specification limits

   d. Procedures and methods are established for preventive and corrective actions, and feedback is provided to design and manufacturing

Appendix J

Appendix K - Application Guide for Tailoring MIL-STD-1521

110. Application Guide for Tailoring MIL-STD-1521

110.1 Scope

A. This appendix sets forth guidance and shall be used for the cost-effective application of the requirements of this standard when this standard is contractually invoked during the acquisition process. This appendix serves as guidance for the activity responsible for the preparation of contract requirements and does not form a part of the contract.

Note: all references in Appendix K to MIL-STD-1521 are intend to mean this update to MIL-STD-1521B, TOR-2007(8583)-6414_Volume 1.

110.2 Purpose

A. The guidelines contained herein implement the Department of Defense Directive 4120.21, Specification and Standards Application, which requires all DoD components to apply selectively and tailor military specifications and standards prior to their contractual imposition and:

1. Eliminate inapplicable and unnecessary requirements
2. Provide for adding/modifying necessary technical review and audit factors not included in MIL-STD-1521
3. Eliminate redundancy and inconsistency with other contract specifications and standards

110.3 Objective

A. The objective of this guide is to establish the applications and limitations of tailoring MIL-STD-1521. MIL-STD-1521 is not a stand-alone document. It is dependent upon the work effort specified in the contractual requirements (e.g., SOW, etc.). The tailoring of specifications shall take place in all phases of military procurement, but is especially applicable to the initial stages of solicitation package preparation and contract negotiation. Depending upon the type of end item(s) under procurement, the reviews and audits outlined by MIL-STD-1521 may or may not be required for all programs.

110.4 Considerations for Tailoring

110.4.1 Relationship to the Statement of Work

A. The Program Manager must keep in mind that technical reviews provide visibility into the contractor's implementation of the work effort required under the terms of the SOW and the contract to assure timely and effective attention to the technical interpretation of contract requirements.

B. The key to tailoring MIL-STD-1521 is to match the MIL-STD-1521 requirements against the details of the applicable SOW and contractual task requirements. It will become immediately obvious that MIL-STD-1521 may contain technical review factors that are not applicable to the contract under consideration. (For example, if a contract does not include computer software, all references to the review of computer software materials in MIL-STD-1521 will not apply).

C. When MIL-STD-1521 is used, then a task containing the applicable requirements will be specified in the SOW. Review factors not set forth in MIL-STD-1521 but considered necessary because of the nature of the particular program shall be added in the SOW. Being subject to a careful evaluation process, the technical review and audit requirements will become program specific rather than an all-purpose document to be continually negotiated during contract performance.

110.4.2 Elimination of Redundancy and Ambiguity

A. While MIL-STD-1521 is the broad program document for technical reviews and audits, other standards in existence also require technical reviews or audits. For example, MIL-STDs for reliability, maintainability, system engineering, etc., can require reviews and/or audits. Review of these aspects of the design would also be required under MIL-STD-1521; therefore, if such standards are contractually stipulated together with MIL-STD-1521, the SOW shall include a provision to show how and whether the technical review requirements of these other standards can be combined with technical reviews or audits in MIL-STD-1521.

B. Combining reviews does not nullify other MIL-STD(s), "Plans," etc., that contain requirements for reviews and audits. The contract shall require the minimal integrated, comprehensive technical design review effort that will provide the desired visibility and assurance of contract compliance.

110.4.3 Contractor Participation in Tailoring

A. When requiring a particular review or audit, it is important that the topics to be reviewed are aligned to the program requirements. Therefore, the offeror shall be given an opportunity to recommend changes and identify topics or items he considers appropriate.

B. The program office shall request, in the instructions for proposal preparation, that the offeror recommend the MIL-STD-1521 topics or items and their related details to be covered at the various reviews or audits required by the SOW. This will allow the offeror to tailor the topics or items and details by additions and deletions for the particular review or audit.

C. In addition, it must be recognized that effective tailoring requires several points of review. The requirement, however, for the review or audit must be finalized prior to contract award.

110.4.4 Complexity

A. System, subsystem, configuration item complexity, and type of program are central in determining both the need for and the number of such reviews. When developing a small noncomplex system, some reviews may not be required, or, if required, may be limited in scope. The tailoring procedures discussed earlier should result either in the exclusion of MIL-STD-1521 or in a tailored MIL-STD-1521 that reflects a limited scope technical review effort. Conversely, in a very complex development, the review process will increase in levels and numbers of reviews.

B. In addition to the above, the degree of application is dependent upon the configuration item's state of development (for example, new design vs. commercially available) or the degree of any modifications, if involved. For example: a newly developed item may require the majority of the review topics or items and audits, while a commercially available configuration item with the appropriate documentation, i.e., verified test results, specifications, drawings, etc., may require reviews or audits limited to its application to the program and its interfaces.

C. In the case of modified designs, one must consider the degree and effect of the modifications. Reviews and audits may be limited to the modifications and their interfaces.

110.5 Scheduling of Technical Reviews and Audits

A. The schedule for Technical Reviews and Audits is extremely important. If they are conducted too early, the item for review will not be adequately defined. Conversely, if the review is too late, the program commitments could have been made erroneously, and correction will be both difficult and costly.

B. For planning purposes, a good method for scheduling technical reviews is to relate them to the documentation requirements. For example, schedule a PDR after the hardware Development Specification or software architecture and detailed design and Software Test Plan are available, since the essence of the PDR is to assess the contractor's approach to meeting the requirements of these documents.

C. Scheduling of audits is dependent not only on documentation availability, but also on hardware/software availability and the completion of the acceptance qualification tests. Table 3 contains a list of the primary documentation associated with each review or audit and the estimated time phasing.

Table 3. Scheduling Reviews and Audits

Review	Time Phase	Primary Documentation
SRR	Usually accomplished in the Concept Exploration Phase. However, may be used in other phases when the Concept Exploration Phase is not accomplished.	• System Requirement Specification • Preliminary Operational Concept Document • Systems Engineering Management Plan • System/Segment Specification • Software Development Plan • Analysis And Trade Study Reports
SFR	Usually in the Demonstration and Validation Phase	• System/Segment specification • Preliminary Operational Concept Document (OpsCon) • Preliminary Software Requirements Specifications • Preliminary Software Interface Requirements Specifications • Analyses, trade studies • Drawings Level I DoDD1000B • TDP type and element per MIL-DTL-31000C
SAR	Usually early in Full Scale Development	• Software Requirements Specifications • Software Architectural Description • External Software Interface Requirements Specifications • Internal Software Interface Requirements Specifications • Software to Hardware Interface Requirements Specifications • Engineering Analyses • Trades Studies • Technical Performance Metrics • Software Development Plan • Software Master Build Plan • Software Test Plan • Operational Concept Document (OpsCon) • Initial Software Resources Data Report (SRDR) • Life Cycle Cost (LCC) Analysis • Cost As an Independent Variable (CAIV) Studies

Appendix K

Review	Time Phase	Primary Documentation
PDR	Usually accomplished in the Demonstration and Validation and/or Full Scale Development Phase	• Development Specification • Type B Performance Specification • Drawings Level I DoDD1000B • TDP type and element per MIL-DTL-31000C • Software Top Level Design Document • Software Test Plan • Preliminary Computer Resources Integrated Support Document • Preliminary Computer System Operator's Manual • Preliminary Software User's manual • Preliminary Computer System Diagnostic Manual
CDR	Usually accomplished in the Full Scale Development phase	• Draft Product Specification • Type C Specification, and referenced documentation • Drawings Level I or II DoDD1000B • TDP type and element per MIL-DTL-31000C • Software Detailed Design Document • Hardware Interface Design Document • Software Test Description • Computer Resources Integrated Support Document • Software Programmer's Manual • Firmware Support Manual • Test Descriptions/Procedures • Software Development Documentation • Data Base Design Document(s)
TRR	Usually accomplished in the Full Scale Development phase	• Software Test Procedures • Informal Software Development Test Results • Informal Hardware Development Test Results
FCA	Usually accomplished at end of Full Scale Development	• Test Plans • Test descriptions • Test procedures • Software test reports • Computer System Operator's Manual • Software User's Manual • Computer System Diagnostic Manual

Review	Time Phase	Primary Documentation
PCA	Usually accomplished early in the initial production when the developing contractor is preselected as the production contractor. May be accomplished at the end of Full Scale Development when the developing contractor is not preselected as the Production contractor. The PCA is repeated with each subsequent contractor or break in production.	• Final Part II Specification • Type C Product Specifications • Referenced Software Product Specification Documents and Drawings • Drawings Level II or III per DoDD1000B • TDP Type and Element per MIL-DTL-31000C • Software Product Specification • Version Description Document

*** DoDD-1000B describes three drawing levels which are recommended for consideration in tailoring by Appendix K, because they were not carried forward to MIL DTL-31000, its successor document.**

110.6 Tailoring Guidance for Engineering Data Reviews

A. Engineering Data reviews are conducted as part of the formal design reviews/audits in MIL-STD-1521. Use the **Review Checklist for Engineering Data** to help prepare for and conduct these reviews and audits. Note discrepancies on the Engineering Data Discrepancy Sheet (Figure 6). Because reviews and audits are successively more detailed, more items on the checklist will apply as the program progresses. When all reviews and audits are completed, all items on the tailored checklist shall be accomplished.

Review Checklist for Engineering Data

I. The following questions and considerations shall be used prior to conducting an engineering data review. These are suggested guidelines, and should be used as such

II. Pre-briefing preparation:

1. Answer these questions:
    a. What is the purpose of the review?
    b. What does the contract require?
    c. How will the drawings be used?
2. Arrange briefings:
    a. The Contractor shall brief the team on contractual requirements and status

b. The Engineering Data Management Officer (EDMO) or Chairperson should brief the team on the review procedures

c. Discuss corrective action procedures

III. The Data Review:

1. Build the package:

   a. Select sample of top assembly drawings

   b. Look at Parts List of the top assembly or major subassembly drawings

   c. Are other subassembly drawings listed in the top parts list?

   d. Are all drawings listed in the top parts list available?

   e. Are all drawings listed in the subassembly parts list available?

   f. Is manufacturing planning documentation available?

2. Examine the engineering data for the following:

   a. Is the drawing legible and suitable for reproduction?

   b. Are processes/specifications listed?

   c. Look at notes on all drawings. Are all notes understandable? Are notes clear and concise?

   d. Are peculiar symbols, abbreviations, etc., explained?

   e. Are all dimensions and tolerances shown?

   f. Is the material identified?

   g. Are any reports referenced? If so, are they supplied in the package?

   h. Are copies of nongovernment specifications supplied as part of the package?

   i. Is the use of limited rights legends correct per Defense Acquisition Regulation (DAR) and Federal Acquisition Regulation (FAR)?

   j. Are control drawings (particularly Source and Specification Control) properly used and marked per DoD-STD-100?

   k. Are hardness-critical items and hardness-critical process markings correct?

   l. Are electrostatic discharge–sensitive (ESDS) symbology and cautions included, as appropriate?

   m. Have changes been incorporated as required in the contract?

   n. Are index and data lists available and correct?

   o. Is there a distribution statement on each piece of engineering data?

   p. Have specific marking requirements (MIL-STD-130) been defined?

   q. Are acceptance test requirements included on all subassembly/detail drawings for items that might be spared separately by competitive reprocurement?

   r. Is the proper engineering design information included for the level of drawing stated in the contract?

   s. Could a military standard or specification be used in lieu of drawings?

   t. Are applicable security classifications marked correctly?

   u. Are the contractual requirements adequate?

v. Does the drawing package appear to be adequate to support the intended end use (i.e., logistics support, competitive reprocurement, etc.)?

3. Record all deficiencies/discrepancies on the Engineering Data Discrepancy Sheet (see Figure 6) in sufficient detail to completely define the problem and action required for compliance

B. Although the time frame for reviews and audits is suggested above, it may vary, depending on the particular program. The schedule for each review or audit may be requested from the offeror as part of his proposal, or as part of the systems engineering management plan (which can be part of the proposal).

At the end of the review, the EDMO (or Review Team Chief) collects all discrepancy sheets, signs them, and determines appropriate disposition. After resolution of discrepancies, the sheets will be filed in the Engineering Data Files.

Appendix K

Sheet of

(Program Name)

ENGINEERING DATA DISCREPANCY SHEET
(To be used with the Review Checklist)

Prime and Subcontractor/Vendor Name:
Type of Review:

Reviewer's Name	*Drawing/Document Number*	*Rev.*	*Date*
Discrepancies			
Action Required/Compliance *Due Date:*			
Program Office EDMO (or Team Chief) Signature: ______________________ *Air Logistics EDMO Signature:* ______________________			
Action Agency: ☐ Contractor ☐ Program Office ☐ Contract Administration Office ☐ Other			
This block to be used by Action Agency. Discrepancies corrected by: ______________________ ___________ Signature Date			

Figure 6. Engineering Data Discrepancy Sheet

After resolution, return the Engineering Data Discrepancy Sheet to the Program Office EDMO.

Glossary

Part I – Definitions

Analysis of Alternatives (AoA)

AoA is the evaluation process of the operational effectiveness, operational suitability, and estimated costs and risks of alternative system concepts to meet a mission capability. The analysis assesses the advantages and disadvantages of alternatives being considered to satisfy capabilities, including the sensitivity of each alternative to possible changes in key assumptions or variables.

Architecture

Architecture is a structure of components, their relationship, and the principles and guidelines governing their design and evolution over time; or,

Architecture is a structure or organization that shows the elements and their relationship for a set of requirements or a system concept or both; or,

Architecture is a high-level property or attribute of a system, such as openness or interoperability or a standard containing the aforementioned.

Architecture Views

Architecture views are the standardization of the format and content of architectural products. The Department of Defense (DoD) Architecture Framework (DoDAF) defined architecture views are:

a. All (AV)

b. Operational (OV)

c. Systems (SV)

d. Technical (TV)

The operational concept (OPCON) drives the OV. The OV in turn drives the SV to identify shortfalls and system requirements, and the SV requirements drive the TV to address a common set of applicable standards, with the AV providing the overarching aspects of an architecture that relates to all three of the OV, SV, and TV. The architecture description provides the explicit linkages among various views: i.e., "interoperability" is a typical architecture focus that demonstrates the criticality of developing these relationships among the various views.

Alternative Systems Review (ASR)

The ASR is conducted to ensure that the resulting set of requirements agrees with the customers' needs and expectations and that the system under review can proceed into the Technology Development phase.

The ASR assesses the alternative systems that have been evaluated during the Concept Refinement phase, and ensures that the Technology Development plan is consistent with the preferred system solution and is adequately resourced to reduce System Development and Demonstration entry risk to an acceptable level.

The ASR ensures that the preferred system alternative is cost effective, affordable, operationally effective, and suitable, and can be developed to provide a timely solution to a need at an acceptable level of risk.

It is held well in advance of Milestone A to allow time for issue resolution and proper executive-level concurrence on process and results.

Audits and Reviews

Audits and reviews are scheduled events, usually conducted at any time after PDR, independently or as part of other reviews to validate that the development of a configuration item(s) satisfies the Form, Fit, Functional (FFF), and performance objectives of the Program. These audits and reviews can encompass but are not limited to the following:

a. Functional Configuration Audit (FCA)

b. Physical Configuration Audit (PCA)

c. System Verification Review (SVR)

d. Ship Readiness Reviews, i.e., Consent to Ship (CTS)

e. Mission, Flight, and/or Launch Readiness Reviews (M/F/LRR)

Baseline (B/L or BL)

Baseline is a specification or product that has been formally reviewed and agreed upon, that thereafter serves as the basis for further development. Baselines can be changed only through formal change control procedures that require contracting agency review and approval. The initially documented and validated system-level requirements and constraints, their allocation or assignment to the next level, and all changes thereto are approved in accordance with the contract SOW. Typically, baseline requirements are initially approved at the System Functional Review (SFR) or similar event.

Specifically, e.g., technical baselines are either:

a. Functional:

   i. Functional Baseline (FBL) is validated and approved in conjunction with physical and performance system-level requirements and associated design constraints

   ii. Allocated:

   iii. Allocated Baseline (ABL) is the physical hierarchy of an approved allocated configuration

   iv. The initially documented, validated, and approved design-to functional and performance requirements and design constraints for each system product in the hierarchy and all changes thereto approved in accordance with the contract

   v. The separable documentation identifying all design-to requirements and constraints for each component or computer software item and each separately integrated grouping of components and/or computer software items, or

b. Product (End Item/Configuration) such as:

   i. Build-to requirements for each physical element to be manufactured

   ii. Software code for each software element that has been separately designed or tested

   iii. Buy-to requirements for each physical element, part, or material to be procured

   iv. The initially documented and approved update to the design release baseline for one or more end items (EIs) after confirmation that:

      a) The EI design satisfies all performance and functional requirements and constraints in the current allocated and design release baselines

      b) The as-built, as-coded, or as-integrated product accurately reflects the baseline

      c) The hardware and software, readiness for continued production, acceptance verification, deployment, training, operations, support, and disposal and all subsequent changes

Budget/Cost

Budget and Cost terminology guidance can be found in DoD 5000.4M.

Critical Design Review (CDR)

The CDR is a multidisciplinary technical review, conducted for each configuration item when detailed design is essentially complete, with the objective of ensuring that the detailed design of the configuration item or system under review can proceed into fabrication, system integration, demonstration, and test, and can meet the stated performance and engineering specialty requirements of the configuration item (CI) development specifications within cost (program budget), schedule (program schedule), risk, and other system constraints.

a. The CDR establishes the detailed design compatibility among the configuration item and other items of equipment, facilities, computer software and personnel

b. The CDR assesses configuration item risk areas (on a technical, cost, and schedule basis)

c. The CDR assesses the results of the producibility analyses

d. The CDR focuses on the determination of the acceptability of the detailed design, performance, and test characteristics of the design solution, and on the adequacy of the operation and support documents

e. The CDR assesses the system final design as captured in product specifications for each configuration item in the system (product baseline), and ensures that each product in the product baseline has been captured in the detailed design documentation, e.g., product specifications for:

   i. Hardware, to enable the fabrication of configuration items, and may include production drawings

   ii. Software (e.g., software architecture and detailed design of a Software Configuration Item (SWCI)), to the extent specified in the SDP based on the selected life cycle model(s)

f. For complex systems, the contractor may conduct a CDR for each subsystem or configuration item. These individual reviews would lead to an overall system CDR. When individual reviews have been conducted, the emphasis of the overall system CDR shall focus on configuration item functional and physical interface design, as well as overall system detailed design requirements

g. The System CDR determines whether the hardware, human, and software final detailed designs are complete, and whether the contractor is prepared to start system fabrication, demonstration, and test

Configuration Item (CI)

A configuration item is an item that satisfies a documented set of requirements and includes any item required for logistics support or designated for separate procurement. Configuration items may consist of hardware or software, or an aggregation of both that is designated by the contracting agency as an end item (EI) or proposed by the contractor for development/functional end use and is designated for individual configuration management.

a. A configuration item is any hardware, software, or combination of both that satisfies an end use function and is designated for separate configuration management. Configuration items are typically referred to by an alphanumeric identifier that also serves as the unchanging base for the assignment of serial numbers to uniquely identify individual units of the CI (See also: Product-Tracking Base-Identifier)

b. The terms “CI” and “Product” are identified as aliases in ANSI/EIA 649 and are used interchangeably within MIL-HDBK-61A

c. A configuration item is an aggregation of hardware, firmware, computer software, or any of their discrete portions that satisfies an end use function and is designated by the Government for separate configuration management. CIs may vary widely in complexity, size, and type, from an aircraft, electronic, or ship system to a test meter or round of ammunition. Any item required for Logistics Support (LS) and designated for separate procurement is a CI [Glossary of Defense Acquisition & Terms, 2005]

Glossary

Concept of Operations (CONOPS)

CONOPS is a high-level concept whose purpose is to describe a problem that combatant commanders may encounter, identify needs, achieve objectives, capabilities, or desired effects, and sequenced actions that describe their employment.

a. CONOPS are typically developed by the operator/user with support from the acquisition agency planner or System Program Office (SPO), for employing and supporting a capability or system concept. CONOPS are used in System Technical Requirements Analysis to identify system functional requirements and design constraints

Commercial off the Shelf (COTS)

COTS is a system product that is available in the commercial marketplace that does not require unique contracting agent modifications or maintenance over its life cycle to meet the requirements.

Effectivity (E)

Effectivity is a designation, defining the point in time, an event, a capability (e.g., system, segment, SoS, IOC) or a product range (e.g., serial, lot number, model, date) at which changes or variances thereof are to be incorporated.

Engineering Data

Engineering data is the recorded scientific or technical information (regardless of the form or method of recording), including computer software documentation that defines and documents an engineering design or product configuration (sufficient to allow duplication of the original items) and is used to support production, engineering, and logistics activities that may, e.g.,:

Include:

a. All final plans, procedures, reports, and documentation pertaining to systems, subsystems, computer and computer resource programs, component engineering, operational testing, human factors, reliability, availability, and maintainability, and other engineering analysis, etc.

b. Technical data package per MIL-DTL-31000 (reprocurement package), that includes all engineering drawings per ASME Y14.100M, associated lists, process descriptions, and other accompanying documents, manufacturer specifications, manufacturing planning documentation and standards defining physical geometry, material composition, and performance procedures

c. Other information prepared by a design activity, relating to the design, manufacture, procurement, test, or inspection of hardware/software items or services

Exclude:

a. Computer software or financial, administrative, cost or pricing, or management data or other information incidental to contract administration

Flight Readiness Review (FRR)

The Flight Readiness Review (FRR) is a multidisciplinary product and process assessment that is performed to ensure that the system under review can proceed into flight test with airworthiness standards met, objectives clearly stated, flight test data requirements clearly identified, and an acceptable risk management plan defined and approved.

The FRR is convened to:

a. Ensure that proper coordination has occurred between engineering and flight

b. Ensure that all applicable disciplines understand and concur with the scope of effort that has been identified

c. Assess the adequacy of how this effort will be executed to derive the data necessary to satisfy airworthiness and test and evaluation requirements

d. Assess the sufficiency and appropriate level of detail for each configuration to be evaluated within the flight test effort

Function

A function is a task to be performed to achieve a required outcome or satisfy an operational need.

Functional (Analysis, Allocation, and Architecture)

Functional Analysis and Allocation

a. The determination of the top-level functions that are needed to accomplish the primary system functions over the life of the system, their relationship, and their decomposition to sub-functions to the point that each sub-function or set of sub-functions can be related to one and only one physical element in the allocated baseline, the allocation of the top-level requirements and constraints in the requirements baseline to determine how well each function and sub-function must be performed, and the capture of the aggregate in a functional architecture

Functional Architecture

a. The result of functional analysis and allocation

b. The hierarchical arrangement of functions, their decomposition into sub-functions, the associated timelines, and the allocation of the performance requirements and constraints in the requirements baseline to the functions and sub-functions

c. Interfaces between the functional elements

Incremental Development

a. Incremental development is a life cycle model where all desired capabilities are identified; all end-state requirements are known and understood up front but are implemented in pieces, or increments. Since all requirements are known in the beginning, all increments can be planned in advance; their implementation sequencing order and overlaps would be determined at the beginning of increment development

Information Exchange Requirements (IERs)

a. IERs are requirements that define the interoperability KPP threshold and objective values documented in Capability Development Documents (CDDs), Capability Production Documents (CPDs), and Capstone Requirements Documents (CRDs)

b. The IERs document both the information needs required by the system under consideration and the needs of other supported systems

c. The IERs document all communication and computing requirements for command, control, communications, computers, and intelligence (C4I) of the proposed system

Initial Technical Review (ITR)

The ITR is a multidisciplinary technical review that supports the program's initial Program Objective Memorandum (POM) submission.

a. The ITR assesses the envisioned requirements and conceptual approach of the proposed program and verifies that the requisite research, development, test, engineering, logistic, and programmatic bases for the project reflect the complete spectrum of technical challenges and risks

b. This review ensures that a program's technical baseline is sufficiently rigorous to support a valid cost estimate (with acceptable cost risk) and enable an independent assessment of that estimate by cost, technical, and program management subject matter experts

c. The ITR is held well in advance of the actual cost estimate submission to allow time for issue resolution and proper executive-level concurrence on process and results. The ITR may be conducted at any time prior to the ASR

Interoperability

The ability of systems, units, or forces to provide data, information, materiel, and services to and accept the same from other systems, units, or forces and to use the data, information, materiel, and services so exchanged to enable them to operate effectively together. Information technology and National Security Systems interoperability includes both the technical exchange of information and the end-to-end operational effectiveness of that exchanged information as required for mission accomplishment.

Key Performance Parameter (KPP)

KPP is the minimum attribute or characteristic considered most essential for an effective military capability.

a. KPPs are EI capabilities that must be met

b. KPPs are critical performance requirements for which the user is willing to consider cancellation of the program if a requirement is not met

Life Cycle

Life cycle is the scope of a system or upgrade evolution beginning with the determination of a mission need or identification of a system deficiency through all subsequent phases through disposal of the system.

Manufacturing

The term "manufacturing" covers a broad set of functional tasks required to harness all the elements needed to make a product. Included are such wide-ranging topics as the National Technology and Industrial Base (NTIB) capabilities to support the program, influencing the design for cost-effective manufacturing, the people and skills needed, the selection of materials, appropriate methods of production, capable machinery, scheduling, measurements, and quality assurance management systems. Manufacturing requires the support of functional specialties from a diverse set of organizations, including matrix-assigned manufacturing managers, other program office functionals, contract administration services personnel, laboratories, contractors, and commodity staff as well as depot personnel.

Manufacturing Readiness Levels (MRLs)

Manufacturing Readiness Levels (MRLs) are measures used to assess manufacturing readiness and producibility maturity from a manufacturing perspective. MRLs provide a common understanding of the relative maturity (and attendant risks) associated with manufacturing technologies, products, and processes being considered to meet requirements, identifying and mitigating manufacturing-associated risks in acquisition programs, reducing manufacturing risk and demonstrating producibility prior to full-rate production.

Table 4. DoD MRL Definitions

MRL	Definitions
Level 1–3	Manufacturing concepts identified.
Level 4	System, component, or item validation in a laboratory environment.
Level 5	System, component, or item validation in initial relevant environment. Engineering application/breadboard, brassboard development.
Level 6	System, component, or item in prototype demonstration beyond breadboard, brassboard development.
Level 7	System, component, or item in advanced development.
Level 8	System, component, or item in advanced development. Ready for LRIP.
Level 9	System, component, or item previously produced or in production, or the system, component, or item is in LRIP. Ready for Full Rate Production (FRP).
Level 10	System, component, or item previously produced or in production, or the system, component, or item is in FRP.

Table 5. DoD MRL Descriptions

MRL	Description
Level 1–3	Identification of current manufacturing concepts or producibility needs based on laboratory studies.
Level 4	This is the lowest level of production readiness. Technologies must have matured to at least TRL 4. At this point, few requirements have been validated, and there are large numbers of engineering/design changes. Component physical and functional interfaces have not been defined. Materials, machines, and tooling have been demonstrated in a laboratory environment. Inspection and test equipment have been demonstrated in a laboratory environment. Manufacturing cost drivers are identified. Producibility assessments have been initiated.
Level 5	Technologies must have matured to at least TRL 5. At this point, not all requirements have been validated, and there are significant engineering/design changes. Component physical and functional interfaces have not been defined. Materials, machines, and tooling have been demonstrated in a relevant manufacturing environment, but most manufacturing processes and procedures are in development (or ManTech initiatives are ongoing). Inspection and test equipment have been demonstrated in a laboratory environment. Production cost drivers/goals are analyzed. System-level DTC goals are set. Producibility assessments ongoing.

Level 6	During the prototype demonstration phase, requirements are validated and defined. However, there are still many engineering/design changes, and physical and functional interfaces are not yet fully defined. Technologies must have matured to at least TRL 6. Raw materials are initially demonstrated in relevant manufacturing environment. Similar processes and procedures have been demonstrated in a relevant manufacturing environment. At this point, there are likely major investments required for machines and tooling. Inspection and test equipment should be under development. Producibility risk assessments are ongoing and trade studies conducted. A production Cost Reduction Plan is developed. Production goals are met.
Level 7	Technologies must have matured to at least TRL 7. At this point, engineering/design changes should decrease. Physical and functional interfaces should be clearly defined. All raw materials are in production and available to meet the planned Low Rate Initial Production (LRIP) schedule. Pilot line manufacturing processes and procedures are set up and under test. Processes and procedures not yet proven or under control. During this phase, initial producibility improvements should be under way. DTC estimates are less than 125 percent of goals. Detailed production estimates are established.
Level 8	Technologies must have matured to at least TRL 8. At this point, engineering/design changes should decrease significantly. Physical and functional interfaces should be clearly defined. All raw materials are in production and available to meet planned LRIP schedule. Manufacturing processes and procedures have been proven on the pilot line and are under control and ready for LRIP. During this phase, initial producibility risk assessments should be completed. Production cost estimates meet DTC goals.
Level 9	During LRIP, all systems engineering/design requirements should be met, and there should be only minimal system engineering/design changes. Technologies must have matured to at least TRL 9. Materials are in production and available to meet planned production schedules. Manufacturing processes and procedures are established and controlled in production to three-sigma or some other appropriate quality level. Machines, tooling, and inspection and test equipment deliver three-sigma or some other appropriate quality level in production. Production risk monitoring is ongoing. LRIP actual costs meet estimates.
Level 10	The highest level of production readiness. Minimal engineering/design changes. System, component, or item is in production or has been produced and meets all engineering, performance, quality, and reliability requirements. All materials, manufacturing processes and procedures, and inspection and test equipment are controlled in production to six-sigma or some other appropriate quality level in production. A proven, affordable product is able to meet the required schedule. Production actual costs meet estimates.

Net-Centric

Relating to or representing the attributes of a net-centric environment. A net-centric environment is a robust, globally interconnected network environment (including infrastructure, systems, processes, and people) in which data is shared in a timely manner and seamlessly among users, applications, and platforms. A net-centric environment enables substantially improved military situational awareness and significantly shortened decision-making cycles.

Net-Ready Key Performance Parameter (NR-KPP)

The NR-KPP assesses information needs, information timeliness, information assurance, and net-ready attributes required for both the technical exchange of information and the end-to-end operational effectiveness of that exchange. The NR-KPP consists of measurable and testable characteristics and/or performance metrics required for timely, accurate, and complete exchange and use of information to satisfy information needs for a given capability.

Requirements Allocation Document (RAD)

The RAD is the documentation of the relationships between the elements of a system's architecture (i.e., SoS, segments, elements, subsystems, and lower-level HW and SW configuration items and units) and the requirements (interface, functional, quality, test, etc.) as well as program/system specific/unique conditions otherwise not stipulated in the product's technical requirements document or user requirement.

The RAD provides the evidence that the following items are observed:

a. All requirements and marginal conditions are addressed by every element of the system architecture

b. Every requirement is allocated to at least one element of the technical architecture

c. Each requirement is flowed down to the lowest element

d. Every requirement is verifiable through a defined methodology with appropriate success criteria and documented by a Requirements Verification Traceability Matrix (RVTM)

Each allocated requirement has a parent/child relationship that is bidirectionally traceable and documented by a Requirements Traceability Matrix (RTM).

Requirements

Requirements are unambiguous statements that identify a system, product, or process characteristic or constraint that can be verified and are deemed necessary for stakeholder acceptance.

Requirements are conditions or capabilities needed by a user to solve a problem or achieve an objective that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents, or a documented representation of a condition or capability at various stages of the development process.

Requirements are initially approved at the System Requirements Review (SRR) or similar event, and

can encompass but are not limited to the following types:

- Acceptability (Requirements)

  Acceptability requirements define a system that satisfies all user capabilities and requirements. All user requirements trace to system- and lower-level requirements

- Analysis (Requirements)

  Requirements analysis is the determination of a complete and verifiable system functional and technical performance requirements and design constraints, based on analyses of the needed operational capabilities, requirements, objectives (or goals), measures of effectiveness; missions; projected utilization environments; DoD policies and practices; public law; and the balance between capabilities to be provided and the evolutionary growth potential, on the one hand, and cost, schedule, and risk, on the other hand. The results of requirements analyses are documented in the requirements baseline.

- Baseline (Requirements)

  Baseline requirements are the documented, validated, and approved system-level (top-level) verifiable and allocable functional and performance technical requirements and design constraints, their allocation or assignment to the next level (and lower levels if necessary to capture the systems engineering foundation for the program), and all changes thereto approved in accordance with the contract

- Constraints (Requirement)

  Constraints are requirements that form boundaries within which other requirements must be allocated or derived and system products must be designed. The constraints may be externally imposed by an interface with another system or result from decisions internal to the program or contract. Constraints are often driven by federal law, DOD policy and direction, and or required standards and specifications

- Derived (Requirements)

  Derived requirements are requirements that are not explicitly stated in the capability need that are inferred from the nature of the proposed solution; the applicable verification, rework, storage, transportation, operating, and support environments; policy; law; best engineering practice; or some combination of the above

- Design-to (Requirements)

  Design-to requirements are the allocated and derived verifiable technical requirements and design constraints to which the design of a system product, including hardware, software, processes, data, or new or modified contracting agent facilities is to comply

- Development (Requirements)

  Requirements Development is the process of taking all input from relevant stakeholders and translating it into technical form, fit (suitability), function, and performance (FFF&P) requirements

- Functional (Requirement)

  A functional requirement is a need or a capability that must be provided by a system or end product/EI

- Interface (Requirements)

  Physical

  Functional

  Internal

  External

  Programs

- Performance (Requirements)

  Performance requirements are statements of the extent to which a function must be executed, generally measured in such terms as quantity, quality, coverage, timeliness, or readiness. See Functional Requirement

- Reference (Requirements)

A reference requirement is a higher-level requirement and/or an analysis, test, or other justification for a requirement, requirement allocation, or other baseline or functional architecture element

Risk

Risk is a potential problem or uncertainty that may occur in the future that could result in the inability to achieve an objective within defined parameters or constraints such as program goals and objectives within defined cost, schedule, and technical performance.

Risk has two components:

a. The probability/likelihood of failure to achieve a particular outcome

b. The consequences/impacts of failure to achieve that outcome

Risk Management Process

Risk management is a continuous process that is accomplished throughout the life cycle of a system. It is an organized methodology for continuously identifying and measuring the unknowns; developing mitigation options; selecting, planning, and implementing appropriate risk mitigation; and tracking the implementation to ensure successful risk reduction. Effective risk management depends on risk management planning; early identification and analyses of risks; early implementation of corrective actions; continuous monitoring and reassessment; and communication, documentation, and coordination.

The risk management process includes the following key activities, performed on a continuous basis:

a. Risk Identification

b. Risk Analysis

c. Risk Mitigation Planning

d. Risk Mitigation Plan Implementation

e. Risk Tracking

Significant Accomplishment

A significant accomplishment is a specified step or result that indicates a level of progress toward completing an event and, in turn, meeting the objectives and requirements of the contract.

Significant Accomplishment Criteria

Significant accomplishment criteria are specific, measurable conditions that must be satisfactorily demonstrated before a significant accomplishment listed in an Integrated Master Plan (IMP) is complete and before work dependent on the accomplishment can proceed.

Software Reviews

Software reviews are a set of software build reviews held to find potential problems, such as incomplete or inconsistent products or software products that would result in a system that would not satisfy its requirements or the needs of its users.

Software reviews include, for example:

a. Software Requirements and Architecture Review (SAR)

b. Software Build Plan Review (SBPR)

c. Software Build Requirements Review (SBRR)

d. Software Build Design Review (SBDR)

e. Software Build Test Readiness Review (SBTRR)

f. Software Build Test Exit Review (SBTER)

These reviews are repeated for each build.

For incremental software reviews (where the requirements are all known up front), the SBRR would be brief, focusing on the current understanding of the software requirements for the upcoming build and verify that no requirements need to change for the upcoming or future builds.

Space System

Space system is the organization and integration of a mix of ground (mobile or stationary), space (satellites with a mix of payloads), and airborne capabilities or systems into a system of systems with an operational and functions capability that is greater than the capabilities of its constituent parts.

Spiral Development

Spiral development is a process and a life cycle development model where a desired capability is identified, but the end-state requirements are not known at program initiation. Those requirements are refined through demonstration and risk management, where there is continuous user feedback and each increment provides the user the best possible capability. The requirements for future increments depend on feedback from users and technology maturation. Boehm[1] defines the spiral model as a "Risk-driven process model generator." It is used to guide multi-stakeholder concurrent engineering of software intensive systems. It has two main distinguishing features. One is a cyclic approach for incrementally growing a system's degree of definition and implementation while decreasing its degree of risk. The other is a set of anchor point milestones for ensuring stakeholder commitment to feasible and mutually satisfactory system solutions."

Synthesis

Synthesis is the process whereby the functional architectures and their associated requirements are translated into physical architectures and one or more physical sets of hardware, software, and personnel solutions.

System

The system can consist of a System of Systems (SoS), Family of Systems (FoS), Segments, Subsystems, and/or Component.

All systems consist of two elements:

a. The end products, to be used by an acquirer for an intended purpose and the set of enabling products that enable the creation, realization, and use of an end product, or an aggregation of end products

b. The enabling products, used to perform the associated process functions of the system—develop, produce, test, deploy, and support the end products; train the operators and maintenance staff is using the end products; and retire or dispose of end products that are no longer viable for use

Both the end products and the enabling products are either developed or reused, as appropriate. The system implicitly includes the personnel who develop, produce, test, operate, support, and retire the system products, as well as both those who train others involved with these system functions, and the human factors issues and concerns associated with these personnel. Such personnel and human factors issues are included in the applications of the technical review processes of this standard.

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1 Boehm, Barry. 2001. *Understanding the Spiral Model as a Tool for Evolutionary Acquisition.*

Systems Engineering (SE)

Systems engineering is the overarching process that a program team applies to transition from a stated capability need to an operationally effective and suitable system.

Systems engineering encompasses the application of systems engineering processes across the acquisition life cycle (adapted to each and every phase) and is intended to be the integrating mechanism for balanced solutions addressing capability needs and design considerations and constraints, as well as limitations imposed by technology, budget, and schedule.

Systems Engineering Processes

Systems engineering processes are iterative and recursive and are applied at lower and lower levels of the system structure to allow an orderly progression from one level of development to the next more detailed level through the use of controlled baselines.

a. The SE processes are applied early in concept definition, and then continuously throughout the total life cycle

b. The SE processes are used for the system, subsystems, and system components as well as for the supporting or enabling systems used for the production, operation, training, support, and disposal of that system

The SE processes enable the transition of requirements from design to system, and serve as an integrated framework within which the universe of requirements can be, as a collective whole, defined, analyzed, decomposed, traded, managed, allocated, designed, integrated, tested, fielded, and sustained.

System of Systems (SoS) Engineering

System of Systems engineering is a disciplined process that encompasses the planning, analysis, organization, and integration of a mix of existing and new capabilities/systems into a system of systems capability greater than the sum of the capabilities of the constituent parts.

SoS engineering is a top-down, comprehensive, collaborative, multidisciplinary, iterative, and concurrent technical management process that is used for identifying system of systems capabilities; allocating such capabilities to a set of interdependent systems; and coordinating and integrating all the necessary development, production, sustainment, and other activities throughout the life cycle of a system of systems.

System Verification Review (SVR)

The SVR is a multidisciplinary technical review conducted to ensure that the system under review can proceed into low-rate initial production (LRIP) and full-rate production (FRP) within cost (program budget), schedule (program schedule), risk, and other system constraints.

The SVR confirms that:

a. The system final product, as evidenced by its production configuration, meets the functional requirements (derived from the Capability Development Document and draft Capability Production Document) as documented in the Functional, Allocated, and Product Baselines

b. The decision database has been maintained to capture all changes and updates so that it completely and accurately captures:

   i. The current approved baselines

   ii. Deficiencies discovered during verification (DT&E) and validation (IOT&E) have been resolved and changes approved and implemented

   iii. All other approved changes have been incorporated into the affected baselines and the affected system products verified to comply

iv. The life cycle cost projections remain consistent with the program affordability constraints

v. The requisite plans, procedures, resources, and facilities are available (or on schedule) to initiate production, production verification, training, deployment, operations, support, and disposal

vi. The remaining risks have been identified and can be handled in the context of the planned program

vii. The verification data documents the system and its constituent products' compliance with the baselines and satisfies the requirements, the allocated baselines, and the design release baselines, including an assessment of the assumptions and methods used in verification by analysis

SVR is often conducted concurrently with the Production Readiness Review.

SVR provides an audit trail from the Critical Design Review.

SVR provides inputs to the Capability Production Document.

Tailoring

Tailoring is the modification of text, figures, graphs, or tables of specifications, standards, and other requirements or tasking documents to clarify the extent to which they are applicable to a specific acquisition contract.

a. Tailoring is applied at the discretion of the contracting agent. In each application, this document shall be tailored to the specific requirements of a particular program, program phase, or contractual structure as directed by the contracting agent. Tasks that add unnecessary costs, data, and any factors that do not add value to the process or product should be eliminated

b. Tailoring takes the form of deletion (removal of tasks not applicable), alteration (modifying tasks to more explicitly reflect the application to a particular effort), or addition (adding tasks to satisfy program requirements)

Tailoring of requirements and task statements may be used in preparing solicitation documents as well as by contractors in response to a draft Request for Proposal.

TBD/TBR/TBS/TBP

a. TBD – To be determined by the developer (or formally recommended to the contracting agent) based on analysis or test by a stated and documented date

b. TBR – The preliminary element shall be resolved by the developer (or recommended to the contracting agent) based on analysis or test by a stated and documented date

c. TBS – To be supplied by the contracting agent to the developer by an agreed-to and documented date

d. TBP – To be provided by the contracting agent to the developer by an agreed-to and documented date

Technical Performance Measure (TPM)

TPM is a measurement comparing the current actual achievement for technical parameters with that anticipated at the current time and on future dates and confirms progress and identifies deficiencies that may jeopardize meeting a requirement or delivery of a KPP capability.

Typical TPM candidate selections:

a. Performance parameters that significantly qualify the entire system

b. Parameters directly derived from analyses, demonstrations, or test

c. A direct measure of value derived from results of analyses or tests

d. Predicted values that have a basis (analyses, historical data)

e. Each parameter can periodically be measured and profiled to compare with predicted values and tolerances over the program life cycle

Tracking of TPMs typically begins as soon as a baseline design has been established, which ideally occurs by SFR but no later than PDR even though the full set of selected TPMs may not be available until later in the program life cycle

Technology Readiness Levels (TRLs)

TRL is a measure of the evolving technologies (materials, components, devices, etc.) maturity prior to incorporating that technology into an end item (system, subsystem, or CI).

Table 6. DoD TRL Definitions

TRL	Definitions
Level 1	Basic principles observed and reported
Level 2	Technology concept and/or application formulated
Level 3	Analytical and experimental critical function and/or characteristic proof of concept
Level 4	Component and/or breadboard validation in laboratory environment
Level 5	Component and/or breadboard validation in relevant environment
Level 6	System/subsystem model or prototype demonstration in a relevant environment (Ground or Space)
Level 7	System prototype demonstration in an operational (space) environment
Level 8	Actual system completed and (flight) qualified through test and demonstration (Ground and Space)
Level 9	Actual system (flight) proven through successful mission operations

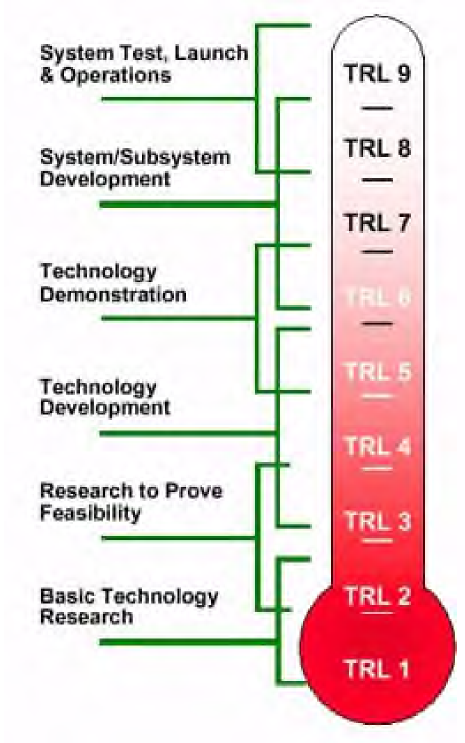

Figure 7. TRL Relationship to Systems Development Maturity

Glossary

Table 7. DoD Hardware and Software TRL Descriptions

TRL	Hardware and Software Descriptions
Level 1	Lowest level of technology readiness. Research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
Level 2	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
Level 3	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
Level 4	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
Level 5	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment. Examples include "high-fidelity" laboratory integration of components.
Level 6	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
Level 7	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment, such as in aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.
Level 8	Technology proven to work in its final form and under expected conditions. In most cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets specifications.
Level 9	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

Traceability

Traceability is the ability to relate an element of the requirements baseline, functional architecture, allocated baseline, design release baseline, and product configuration baseline or their representation in the decision database and their relationship to any other element. Traceability is inherently bidirectional:

Downward Traceability: where a master-subordinate or parent-child relationship exists

Upward Traceability: where a subordinate-master or child-parent relationship exists.

Validation

Validation is the confirmation, through the provision of objective evidence that the requirements for a specific intended use or application have been fulfilled DoDI 5000.02, e.g.:

a. The demonstration that the end item has its required attributes, that any assumptions necessary in its development are valid (i.e., acceptable to the customer), and that the effectiveness of the emerging system design can affordably satisfy the system technical requirements and constraint

b. The process of demonstrating that the EI or product component fulfills its intended use when placed in its target environment

Verification

Verification is the confirmation, through the provision of objective evidence, that specified requirements have been fulfilled [ISO 9000: 2000]. Verification of a product demonstrates that the product has been built to the validated design and performance baseline and meets the product's specified requirements. It is the process that confirms that the EI meets the design-to or build-to specification.

Waterfall Development

Waterfall development is a process and life cycle model in which all of the requirements are known at the beginning, with the requirements, architecture, design, implementation, integration, and test activities performed in that order, possibly with feedback and overlap.

Part II – Acronyms

a.k.a.	also known as
ABL	Allocated Baseline
ACAT	Acquisition Category
AFOTEC	AF Operations Test and Evaluation Center
AI	Action Item
AoA	Analysis of Alternatives
APB	Acquisition Program Baseline
ASR	Alternative Systems Review
AT	Acquisition Team
B/L	Baseline
BDP	Burn Down Plan
BL	Baseline
BOL	Beginning of Life
C4I	Command, Control, Communications, Computers, and Intelligence
CAIV	Cost As an Independent Variable
CAO	Contract Administration Office
CARD	Cost Analysis Requirements Description
CDD	Capability Development Document
CDM	Contractor Data Manual
CDR	Critical Design Review
CDRL	Contractor Data Requirement List
CDS	Contractor Data Sheet
CI	Configuration Item
CM	Configuration Management
CMMI	Capability Maturity Model Integration
COMSEC	Communications Security
CONOPS	Concept of Operation
COTS	Commercial off the Shelf
CRD	Capstone Requirements Document
CSCI	Computer Software Critical Item
CSDM	Computer System Diagnostic Manual
CSOM	Computer System Operator's Manual
CTE	Critical Technology Element
CWBS	Contract Work Breakdown Structure
DAR	Defense Acquisition Regulation

Acronyms

DAS	**Direct Attached Storage**
DDB	**Decision Data Base**
DIA	**Defense Intelligence Agency**
DIACAP	**Defense Intelligence Assessment Capability**
DID	**Data Item Description**
DISR	**DoD Information Standards Repository**
DMS	**Diminishing Manufacturing Source**
DMSMS	**Diminishing Manufacturing Sources and Material Shortages**
DoDAF	**Department of Defense Architecture Framework**
DT&E	**Development Test and Evaluation**
DUSD	**Deputy Under Secretary of Defense**
ECO	**Engineering Change Order**
ED	**Engineering Development**
EDMO	**Engineering Data Management Officer**
EESS	**Environmental Effects Stress Screening**
EI	**End Item**
EMC	**Electromagnetic Compatibility**
EMI	**Electromagnetic Interference**
EOL	**End of life**
EPDS	**Electrical Power Distribution System**
ES&OH	**Environmental Safety and Occupational Health**
ESD	**Electrostatic Discharge Control**
ESLOC	**Equivalent Source Lines of Code**
EVM	**Earned Value Management**
F/A	**Fabrication/Assembly**
FAR	**Federal Acquisition Regulation**
FBL	**Functional Baseline**
FCA	**Functional Configuration Audit**
FF&F	**Form, Fit and Function**
FFBD	**Functional Flow Block Diagram**
FFF&P	**Form, Fit (suitability), Function, and Performance**
FFFP	**Form, Fit, Function, Performance**
FMECA	**Failure Modes, Effects, and Criticality Analysis**
FoS	**Family of Systems**
FQR	**Formal Qualification Review**
FRP	**Full-Rate Production**
FSM	**Firmware Support Manual**
GFE	**Government-Furnished Equipment**

Acronyms

GIG	**Global Information Grid**
GOTS	**Government off the Shelf**
GSE	**Ground Support Equipment**
GUI	**Graphical User Interface**
HAL	**Hardware Allocation Listing**
HAR	**Hardware Acceptance Review**
HCI	**Human Computer Interface**
HMMP	**Hazardous Materials Management Plan**
HSI	**Human Systems Integration**
HW	**Hardware**
HWCI	**Hardware Configuration Item**
I&T	**Installations and Test**
I/F	**Interface**
IA	**Information Assurance**
IAW	**In Accordance With**
IB	**Industrial Base**
IBR	**Integrated Baseline Review**
ICD	**Initial Capabilities Document**
IMP	**Integrated Master Plan**
IMS	**Integrated Master Schedule**
IOT&E	**Initial Operational Test and Evaluation**
IPT	**Integrated Product Team**
IRS	**Interface Requirements Specification**
ISO	**International Organization for Standardization**
ISP	**Integrated Support Plan**
ISR	**In-Service Review**
IT	**Information Technology**
ITR	**Initial Technical Review**
IV&V	**Independent Verification and Validation**
KDP	**Key Decision Point**
KIP	**Key Interface Profile**
KPP	**Key Performance Parameter**
LCC	**Life Cycle Cost**
LMI	**Logistics Management Information**
LRIP	**Low-Rate Initial Production**
M&S	**Modeling and Simulation**
M/F/LRR	**Mission, Flight, and/or Launch Readiness Reviews**
M/PRR	**Manufacturing and Product Readiness Review**

Acronyms

MDA	Milestone Decision Authority
MIL	Military
MLS	Multilevel Secure
MRL	Manufacturing Readiness Levels
MRL	Material Requirements List
MRR	Manufacturing Readiness Review
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
NAS	Network Attached Storage
NCOW	Net-Centric Operations and Warfare
NCOW-R	Net-Centric Operations and Warfare-Reference
NDI	Nondevelopmental Item
NEPA	National Environmental Policy Act
NR-KPP	Net-Ready Key Performance Parameter
NSS	National Security Strategy
NTIB	National Technology and Industrial Base
OA	Operational Architecture
OCD	Operational Capability Demonstration
OpsCon	Operations Concept
OSHA	Occupational Safety and Health Act/Administration
OT&E	Operational Test and Evaluation
OTRR	Operational Test Readiness Review
OTS	Off-the-Shelf
OV	Operational View
PCA	Physical Configuration Audit
PCO	Procuring Contracting Officer
PCR	Physical Configuration Review
PDR	Preliminary Design Review
PEL	Permissible Exposure Level
PESHE	Programmatic Environmental, Safety, and Occupational Health Evaluation
PHS&T	Packaging, Handling, Storage and Transportability
PM&P	Parts, Materials, and Processes
POC	Point of Contact
PP	Program Protection
PPP	Program Protection Plan
PRR	Production Readiness Review
PSP	Product Support Plan
PWBS	Program Work Breakdown Structure

Acronyms

R&M	**Reliability and Maintainability**
RAD	**Requirements Allocation Document**
RAID	**Redundant Array of Inexpensive Disk**
RAM&T	**Reliability, Availability, Maintainability, and Testability**
RBL	**Requirements Baseline**
RD&M	**Reliability, Dependability, and Maintainability**
RFI	**Radio Frequency Interface**
RM	**Risk Management**
RM&M	**Risk Management and Mitigation**
RRDD	**Risk Reduction and Design Development**
RTM	**Requirements Traceability Matrix**
RVTM	**Requirements Verification Traceability Matrix**
S&T	**Science and Technology**
SAN	**Security Assistance Network**
SAR	**Software Requirement and Architecture Review**
SCAMPI	**Standard CMMI Appraisal Method for Process Improvement**
SDD	**System Development and Demonstration**
SDP	**Software Development Plan**
SEMP	**System Engineering Management Plan**
SEP	**Systems Engineering Plan**
SFR	**System Functional Review**
SGLS	**Space-to-Ground Link Set**
SGLS	**Space-to-Ground Link System**
SLOC	**Source Lines of Code**
SMC	**Space and Missile Systems Center**
SME	**Subject Matter Expert**
SoS	**System of Systems**
SOW	**Statement of Work**
SPM	**Computer Programmer's Manual**
SPO	**System Program Office**
SRDR-F	**Final Developer Report and Data Dictionary**
SRDR-I	**Initial Developer Report and Data Dictionary**
SRR	**System Requirements Review**
SRS	**Software Requirements Specification**
SSA	**Storage System Architecture**
SSE	**System Security Engineering**
STD	**Standard**
SUM	**Software User's Manual**

Acronyms

SV	**System View**
SVR	**System Verification Review**
SW	**Software**
SWCI	**Software Configuration Item**
T&E	**Test and Evaluation**
TBD	**To Be Determined**
TBR	**To Be Resolved**
TBS	**To Be Supplied**
TD	**Technology Development and/or Technology Demonstration**
TDP	**Technology Development Phase**
TDP	**Technical Data Package**
TEMP	**Test and Evaluation Master Plan**
TOR	**Technical Operating Report**
TPM	**Technical Performance Measurement**
TRA	**Technology Readiness Assessment**
TRC	**Technical Review Criteria**
TRD	**Technical Requirements Document**
TRL	**Technology Readiness Level**
TRR	**Test Readiness Review**
TV	**Technical View**
USAF	**United States Air Force**
V&V	**Verification and Validation**
VCRM	**Verification Cross Reference Matrix**
WBS	**Work Breakdown Structure**