NOT MEASUREMENT SENSITIVE

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DEPARTMENT OF DEFENSE
JOINT SERVICE SPECIFICATION GUIDE

AIR SYSTEM

This specification guide is for guidance only.

Do not cite this document as a requirement.

AMSC N/A FSC 15GP

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FOREWORD

JSSG Release Notice

This specification guide supports the Acquisition Reform initiative and is predicated on a Performance Based Business Environment approach to product development. As such, it is intended to be used in the preparation of performance specifications. It is the top tier in a set of specification guides. This "B" revision is the third release of this guide.

1. During the 1970's, the Department of Defense (DoD) and the Defense Science Board (DSB) investigated the cost of DoD acquisition development programs. DoD results were reported in a 1975 memorandum from the Deputy Secretary of Defense, which cited the blanket application and unbounded subtiering of development specifications and standards as a major cost driver. The DSB investigation concluded that, rather than specifying functional needs, the documents dictated design solutions. It also noted that blanket application of layer upon layer of design specifications actually represented a bottom-up versus a top-down process, which not only failed to develop systems responsive to user operational needs but also inhibited technical growth. As a result of these findings, DoD directed that policies be established to require tailored application of development specifications on all new system acquisitions. The June 1994 Memorandum from the Secretary of Defense regarding “Specifications & Standards—A New Way of Doing Business” further emphasized these policies.

2. In response to acquisition reform, a set of eight Joint Service Specification Guides (JSSGs) has been developed to support performance-based aviation acquisition. These JSSGs are generic documents intended to provide a best starting point for tailoring a specification for development program applications. Furthermore, they are intended for common use among the services. This not only facilitates joint programs but also provides industry a single, consistent approach to defining requirements.

3. A Joint Service Specification Guide itself never goes on contract. It is, as its title reads, a guide. It is the tailored derivative of the specification guide, with its program-peculiar system identification number, that becomes part of the system definition and, in the case of specifications intended for contractual application, part of the acquisition package.

4. This Joint Service Specification Guide is intended to assist Government and contractor personnel in developing an air system specification tailored to an acquisition development program. To tailor the document to the specific application, the applicable requirements must be selected and the blanks within those requirements filled in appropriately for the air system being developed. For each of the requirements selected, the associated verifications are examined and tailored as needed.

5. The fundamental objectives of this document are to provide consistent organization and content guidance for describing air system requirements as translated from validated needs. Air system requirements must be

Meaningful in terms of meeting user operational needs;

Performance-based and avoid specifying the design;

Measurable during design, development, and verification; and

Achievable in terms of performance, cost, and schedule.

6. The systems engineering approach is emphasized to ensure the air system is the complete, integrated, and balanced solution to customer needs, and accounts for all inputs and outputs. The up-front integration of requirements defined in the context of the air system life cycle helps ensure a complete air system definition and enables a disciplined top-down flow of requirements to lower-tier specifications.

7. The unique features of this document that help to satisfy operational requirements include

a. Specifying in section 3 the conditions, scenarios, and mission descriptions against which the air system performance requirements are defined, for both peacetime and wartime operations.

b. Expressing performance requirements for the air system in technically based, quantitative, user-oriented terms.

c. Defining external air system interfaces.

d. Providing representative incremental verifications in section 4 at program milestones to help confirm progressive compliance with section 3 requirements.

8. The complete set of JSSGs establishes a common framework to be used by Government-industry program teams in the aviation sector for developing program-unique requirements documents for air systems, air vehicles, and major subsystems. Each JSSG contains a compilation of candidate references, generically stated requirements, verifications, and associated rationale, guidance, and lessons learned for program team consideration. The JSSGs identify typical requirements for a variety of aviation roles and missions. By design, the JSSG sample requirements are written as generic templates, with blanks that need to be completed in order to make the requirements meaningful. Program teams need to review the rationale, guidance, and lessons learned found in the JSSG handbook (Part II) to 1) determine which requirements are relevant to their program; and 2) fill in the blanks with appropriate, program-specific requirements.

9. This specification guide is still in development. Previous versions of the guide focused on ensuring the requirements and verifications, and their guidance, are adequate for application to manned tactical fighter and attack types of air systems. This version incorporates a wider range of fixed-wing and rotary-wing air systems, including unmanned air vehicles and unmanned combat air systems.

10. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to:
ASC/ENOI, 2530 Loop Road West, Wright-Patterson AFB, OH 45433-7101 or via e-mail to Engineering.Standards@wpafb.af.mil.

CONTENTS

CONTENTS (Continued)

Paragraph Page

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

TABLES

CONTENTS (Continued)

APPENDICES

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1. SCOPE

1.1 Scope

This Joint Service Specification Guide (JSSG) establishes general requirements and verification parameters, integration, performance, and functions for the preparation of an air system program-unique specification. The program specification developed from this JSSG will be used for contractual commitments between the Government and the prime contractor for the procurement of an air system.

1.2 Air system specification

When this JSSG is tailored for a particular air system, the resulting section 1 Scope should include an introduction such as the following:

"This specification establishes the performance and verification requirements for the ___(1)___ air system to perform the ___(2)___ mission(s). Other significant features of the air system include___(3)___."

GUIDANCE (1.2)

This summary description is intended to provide an overview definition of the air system that the Government intends to procure.

Blank 1. Enter the name or designation of the air system to be procured.

Blank 2. Enter the planned mission(s) of the air system. Mission examples might include an entry such as surveillance, combat air patrol or tanker, or combinations thereof.

Blank 3. Complete based on other required characteristics of the air system, such as support (facilities, personnel), training, and weapons to be included with the system. Include any additional language necessary to describe the scope of the system specification.

The air system specification characterizes the system in terms of technical requirements, which are engineered to become design solutions that provide the needed capability throughout the system's life cycle. Specification developers must keep in mind that, while a system specification focuses on the capabilities expected in products for use in specific environments, systems engineering accounts for the system's entire life cycle, encompassing all of the people, products, and processes involved (including hardware, software, facilities, data, materials, services, and techniques).

The system specification is the basis for design, development, and fabrication of, or modification to, any equipment and software, as applicable for the system. In general, most programs have a system specification and the Government is responsible for defining all system-level, essential performance requirements in performance terms in the program-specific, system-level specification. This is true whether a specific development program is for the entire air system or an upgrade or modification to that system which only involves some portion of the system. The reason for defining the required performance at the system level is to attain the installed, operational capability needed by the warfighter.

1.2.1 Air system definition

For the purposes of this Joint Service Specification Guide, an air system may include an air vehicle plus the training and support systems for the air vehicle, and any weapons to be employed on the air vehicle.

1.3 Understanding this Joint Service Specification Guide

This specification guide is neither designed nor intended to be placed in its entirety on contract. A Joint Service Specification Guide is a tool that can be used to develop program-specific specifications. It is intended to capture the knowledge base and lessons learned for the various requirements associated with developing air systems. The guide contains a compilation of potential technical requirements for a class of like items. The candidate requirements must be tailored to generate a complete and consistent set of requirements to meet program objectives.

This JSSG is a template for developing a program-unique performance specification. As a generic document, it contains requirement statements for the full range of aviation sector applications. It must be tailored by deleting non-applicable requirements to form the program-unique specification. In addition, blanks within the selected requirements must be filled in to define the performance details for the program-unique specification.

As a guide, this document provides the rationale, guidance, and lessons learned relative to each requirement statement. Each section 3 paragraph provides a requirement rationale section explaining why and when the requirement should be considered, a requirement guidance section to assist in tailoring the requirement (including how to complete applicable blanks), and available lessons learned related to the requirement. Each section 3 requirement is followed by a section 4 paragraph addressing air system verification information, including sample milestone guidance, tailorable final verification criteria statements, and verification lessons learned for that particular requirement.

1.4 Use of this JSSG

The specification guidance provided in this guide is intended to be tailored for a particular air system program development specification. Subparagraphs should be added as required.

All specifications for development and production of air systems may be tailored from the requirements and format of this specification guide. The JSSG itself, and documents cited within the guidance herein cannot be put on contract as is. The requirement templates provided herein are to be tailored to a specific air system application, creating a program-unique specification. Supplemental information provided in this document is authorized for release as indicated on the JSSG cover.

1.4.1 Adding lower tier requirements

When a known moderate- to high-risk characteristic exists (for example, a requirement in a third tier JSSG), the specific requirement would be extracted from the lower-tier source, tailored as necessary, and added to the air system specification. To avoid over-specification, the second or third tier document will not be referenced unless needed for parenthetically noting the source document by number and paragraph. Risk criteria will be established by the program manager.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

GUIDANCE (2.1)

Paragraph 2.1 is to appear as written in the tailored, program-unique specification. When this specification guide is tailored for a particular program application, list in section 2 those document references cited in sections 3, 4, and 5 of the tailored program specification. Do *not* list in section 2 documents that are cited only in sections 1, 2, or 6.

In addition, where a document is referenced within a requirement in the tailored specification, the applicable paragraph(s) within the referenced document should be cited by its heading title within the reference (e.g., "…shall be as specified in MIL-PRF-XXXX, paragraph titled "Materials"….). These become the contractually binding references to be listed in section 2 under the appropriate subparagraph and category as shown by the template provided in 2.2 through 2.3 below (see 2.4 for tiering implications).

2.2 Government documents

2.2.1 Specifications, standards, and handbooks

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues of these documents are those cited in the solicitation or contract.

INTERNATIONAL STANDARDIZATION AGREEMENTS

Document Number	Document Title

FEDERAL SPECIFICATIONS

Document Number	Document Title

DEPARTMENT OF DEFENSE SPECIFICATIONS

Document Number	Document Title

DEPARTMENT OF DEFENSE STANDARDS

Document Number	Document Title

DEPARTMENT OF DEFENSE HANDBOOKS

Document Number	Document Title

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or www.dodssp.daps.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

GUIDANCE (2.2.1)

In the tailored program specification, list in section 2 only those specifications, standards, and handbooks called out in section 3 and 4 of the final specification. Users of specifications have found it useful to identify, for each document referenced in section 2, the number of the paragraph(s) containing the reference.

2.2.2 Other Government documents, drawings, and publications

The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues are those cited in the solicitation or contract.

(Document Category)	
Document Number	Document Title

(Copies of specifications, standards, handbooks, drawings, publications, and Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

GUIDANCE (2.2.2)

Other Government documents, drawings, and publications called out in the final specification are listed in this section, by category and alphanumerically within each category.

2.3 Non-Government publications

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues of these documents are those cited in the solicitation or contract.

Non-Government Standards (NGS) Organization Name	
Document Number	Document Title

(Application for copies should be addressed to [insert the name and address of the source under the list of documents for each NGS body; include a URL for online ordering, if available].)

GUIDANCE (2.3)

Non-Government standards and other publications called out in the final specification are listed here. These are normally available from the organizations that prepare or distribute the documents. The address for obtaining the document(s) should be provided below each NGS category. These documents also may be available in or through libraries or other informational services.

2.4 Document tiering

When the air system specification is directly referenced in the contract, it is a first-tier specification and is applicable. Documents referenced in the (first-tier) specification are applicable as follows:

a. Second Tier - All documents directly referenced in the first-tier specification are only applicable to the extent specified.

b. Lower Tier - All documents directly referenced in second- or lower-tier documents are for guidance only unless otherwise directed by the contract.

GUIDANCE (2.4)

Control of document tiering has become a primary way of controlling contractual applicability of referenced documents. Care must be taken to ensure that each referenced document is appropriately applicable in first-tier references (including those references cited in the contract, which themselves would become first-tier references and, thus, their second tier would become contractually applicable as well). Exceptions to tiering applicability are generally defined by DoD policy.

2.5 Order of precedence

In the event of a conflict between the text of this specification and the references cited herein the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

GUIDANCE (2.5)

This paragraph is used as written in the tailored, program-unique specification to establish the precedence of the completed specification when applied to the program.

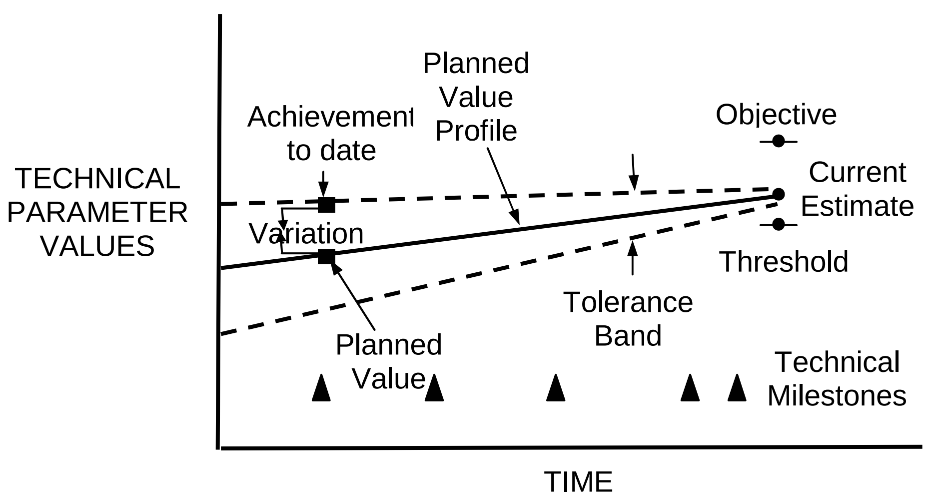
3. REQUIREMENTS / 4. VERIFICATIONS

The following portion of this guide combines section 3 requirements with section 4 verifications. Each requirement is written as a generic template, with blanks that need to be completed in order to make the requirements meaningful. Program teams should review the rationale, guidance, and lessons learned to determine which requirements are relevant to their program, and tailor those requirements with appropriate, program-specific details.

Each section 3 requirement is supported by a section 4 sample verification addressing air system verification information, including sample milestone guidance, tailorable verification criteria, and verification lessons learned for that particular requirement. To enable a user to select only those requirements (and associated verifications) needed for a particular program specification, this JSSG handbook is arranged with each section 4 verification immediately following its section 3 requirement.

Section 4 consists of sample verifications which have been established for each of the requirements specified in section 3. To facilitate the selection of only those requirements and associated verifications needed for a particular program specification, this JSSG has been arranged by placing each section 4 verification paragraph immediately following its corresponding section 3 requirement. In the tailored program specification, however, section 4 paragraphs traditionally comprise a discrete section that follows the last consecutive section 3 paragraph.

The sample verifications contained in this JSSG are intended to result in a progressive, in-process review of design maturity consistent with key milestones of the system development and demonstration program schedule. Each verification includes method(s) employed similarly in past programs, which ensure that product performance complies with specified levels at the conclusion of the development effort. Each sample provides incremental verification methods intended to ascertain that the product design is maturing according to the plan profile established by the program, as shown in the example incremental verification profile below. The incremental verifications are intended to ensure the required performance will be achieved at full maturity. As the product design matures, the fidelity of the incremental verifications improves and the uncertainty in the completed product's performance decreases.



Example incremental verification profile

Incremental verification methods and timing must not be imposed in the performance specification; rather, they are defined through other tools in the developer's toolbox. These tools include the statement of work, the integrated master plan (IMP) or equivalent program management planning tool, the test and evaluation master plan (TEMP) or verification plan, the program master plan (PMP), system engineering plan (SEP) and associated contract/program management processes. Acceptance criteria and supporting data should be documented in these tools, allowing effective evaluation of system performance maturity throughout the development program.

Verification of compliance to requirements for complex systems constitutes a significant element of the development cost. As such, the procuring agency should solicit innovative, cost effective verification methods from potential developers during source selection.

For each 3.XXX requirement, a 4.XXX incremental verification should be developed. This verification will consist of an incremental verification table, such as that shown below, and a discussion paragraph. The incremental verification table will consist of requirement elements from the requirements paragraph, associated measurands for each requirement element, and the recommended incremental verification method(s) for each requirement element at each program milestone.

4.XXX Incremental verification table (example format).

Requirement Elements	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Element A						
Element B						
Element C						
Element D						

Development of the section 4.XXX incremental verification table:

Requirement Element: If the section 3.X.X.X statement contains multiple requirement elements, they may be either grouped, when feasible, or identified as a distinct requirement element in the associated 4.X.X.X incremental verification table. Criteria for grouping are based on elements sharing common verification measurands and techniques across all milestones of the program. There must be a one-to-one correlation between the requirement elements in section 3 and section 4.

Measurands: Each section 4.X.X.X incremental verification table identifies the specific performance measurands recommended for use with each requirement element. A measurand is a parameter that can be measured in order to verify a required system/end item feature or characteristic.

Verification Methods: Specific verification methods should be identified for each milestone for the requirement elements. A blank cell is acceptable if no incremental verification is anticipated for a specific milestone.

The following tables describe the milestones and verification methods used in the JSSG incremental verification tables. See 6.3.31 Verification definitions and 6.4 Verification by milestones for more detailed definitions of typical milestones and verification methods.

TABLE 4-I. Milestones.

Milestone	Description
SRR/SFR	System Requirements Review/ System Functional Review
PDR	Preliminary Design Review
CDR	Critical Design Review
FFR	First Flight Review
SVR	System Verification Review

TABLE 4-II. Verification methods for the air system specification.

Method	Description
I	Inspection
A	Analysis*
S	Simulation
D	Demonstration
T	Test *

*** Note:** When the verification effort consists of reviewing/analyzing test data from lower level tests, the verification method to be used at the higher level should be “Analysis” (i.e., analysis of lower level test data). For instance, if an air system requirement is to be verified by a lower tier avionics test, the air system verification would call out an "A" and the lower tier avionics verification would call out a "T."

<u>Discussion Section</u>: The discussion section should provide supporting background or justification for the reasoning behind the overall verification process. This section should also provide

a. Clarification of the requirement elements to support verification methods chosen, types of data required, relationships to other requirements, and special test conditions.

b. Clarification of the verification method chosen for each milestone, with identification of alternatives, if applicable, and definition of expectations regarding what verification means for that phase of the program.

c. A sample final verification criteria statement which establishes the specific verification tasks and methods which could be employed in verifying that product performance complies with specified levels at the conclusion of the development effort.

d. Lessons learned that apply to this particular verification.

The discussion section should only address the effort required to verify the specific section 3 requirement. Related verifications that are not required for specific compliance with the requirement, but rather address broader or related issues, should be avoided.

3.1 Operations

This is a paragraph header facilitating document organization.

REQUIREMENT RATIONALE (3.1)

This section of the Air System JSSG translates typical warfighter requirements into system-specific characteristics needed to accomplish military tasks effectively in the mission element. These requirements are documented in the Mission Needs Statement (MNS) and further detailed in the Capability Development Document (CDD). More specifically, operations deals with those requirements directly bearing on the successful accomplishment of mission objectives and tasks in peacetime and wartime environments, planned or expected.

REQUIREMENT GUIDANCE (3.1)

This section is organized into a nominal mission sequence, preceded by a description of roles, missions, and unit organization, and followed by other operational characteristics that may be determined to be essential to full operational success. The organization of these requirements is consistent with the definition of system effectiveness as a function of the system's availability for use, dependability in use, and capability as used. A system’s availability for use is typically expressed as a sortie rate to demonstrate utilization. System dependability describes a system’s ability to consistently conduct a given job or task. It has been characterized in terms of mission reliability and survivability. System capability describes a system’s ability to execute the primary mission task, such as the destruction of targets or reconnaissance of a given area.

REQUIREMENT LESSONS LEARNED (3.1)

To Be Prepared

3.1.1 Roles and missions

The system shall perform as needed to conduct the roles and missions within the scenarios and conditions stipulated in table 3.1.1-I.

TABLE 3.1.1-I. Air system roles and missions.

ID	Scenario	Role	Mission	Vignette	Mission/ Vignette Mix	Peace/ War	Threat	Basing Location	Years	Remarks

REQUIREMENT RATIONALE (3.1.1)

This section defines the roles and missions against which system requirements are defined. Roles and mission need to address a complete representation of what the system is expected to do. These would include peacetime operations, wartime operations, and conditions other than war. While it may be impossible to predict with certainty all the conditions that a system might be called upon to perform, the descriptions provided should be suitable for establishing a requirement/design point for system definition and be a sufficient representation for life cycle requirements and management. Without this definition of the stressing elements, the performance requirements are incomplete and the context for the allocated parameters cannot be established. In addition, wartime and peacetime deployment locations, as well as other required information, are provided as a basis from which to derive infrastructure and some environment requirements.

REQUIREMENT GUIDANCE (3.1.1)

Including thorough scenario, threat, and basing location information in a table may not be feasible. If not, cite appropriate reference documents or provide the information in paragraph form.

Guidance for completing table 3.1.1-I follows:

ID: This paragraph (and table) is extensively referenced throughout the document. A unique identifier (a line number or electronic bookmark) will assist document users in locating the appropriate reference.

Scenario: Separate data may be needed for each unique scenario. A system may have more than one role or mission in a given scenario (or vice versa). Generally, a system must be capable of performing effectively in multiple scenarios. For example, peacetime training and wartime conflicts constitute two scenarios. Training conducted by dedicated training assets will be a different scenario than training conducted by operational units. Scenario information is not limited to bed downs and locations. Operational factors such as decision processes, rules of engagement, and mission tasking can also be scenario dependent. Be sure to provide complete information.

Role: Enter the general description of the task(s) to be accomplished. Valid entries, for example, would be air to air, air to ground, aerial refueling, antisubmarine warfare, reconnaissance, and training.

Mission: Identify the mission (for example, combat air patrol or troop transport) and provide a mission description. The description includes a generic mission profile identifying reference points (loiter reference points, orbit location(s) reference points, profile/speed/altitude change reference points, etc.). Depending on the operational requirements and their translation into a system specific specification, the profile(s) could be as simple as “launch, climb, cruise to within XX miles of the forward line of troops (FLOT), dash to target area, deliver weapons, dash out from target area, cruise to descend point, descend, land.” The profile may also be a bit more complex, identifying some minimum speed conditions and/or altitude bands; for example, “launch, climb to medium altitude (defining the altitude range), cruise to within XX miles of the FLOT, dash at mach XX or better to the target area, deliver weapons at medium altitude, supersonically, etc.” (or leave the table column blank). The intent is to provide sufficient information to scope the mission. The more specific the profile, the more constrained the resulting air vehicle solution. Provide sufficient latitude. Do not specify what is not necessary to meet operational requirements. Focus on the objective, not on the air vehicle characteristics that may satisfy the objective. The profile will be refined in the air vehicle specification to provide specific speeds and altitudes along with specific aircraft capabilities. Missions address those planned or expected in peacetime conditions, wartime conditions, and conditions other than war. A reference to 3.1.7.5 System reach, would be appropriate.

Vignette: A mission may have multiple vignettes. To minimize ambiguity, repeat the mission and other information (on a new row in the table) for each vignette.

A vignette (sometimes referred to as a mini-scenario) can be viewed as a single-mission segment of a campaign. It is a two-sided situation that encompasses system employment conditions. It describes starting and ending conditions, the numbers of systems involved, their tactics and operating conditions, the targets and their location, the relationships between systems, factors of the natural environment (including weather conditions and terrain), conditions of the operational environment (including dust and smoke) and any other operationally significant factors. It must be sufficiently broad to assess the interactions between like air vehicles in the flight and accommodate the interactions with systems external to the flight. Each vignette needed in the definition of the system should be incorporated into the descriptions and conditions defined in paragraph, 3.1.1 Roles and missions. A vignette can also describe a variety of specific characteristics associated with the air vehicle operations to be conducted. Note that a vignette used to explore candidate system definitions at the start of initial product definition could be substantively different from that used in a system specification.

Some specific survivability conditions (see 3.1.6.2.1 Mission and one-on-one survivability) to include in the vignettes are the overall threat distribution and density. For example, assume that the mission involves a single air vehicle penetrating enemy airspace at low altitude. Further, assume that the air vehicle would enter the engagement envelope of only 10 threat systems out of the 100 threat systems in the overall scenario. The vignette must be sufficiently encompassing to ensure that the air vehicle's threat detection capabilities are not limited to just the 10 threat systems that are engaging it, but also the other 90 in the scenario. That is, the air vehicle's survival capability may be strongly influenced by its ability to assess the entire environment and focus pertinent survival equipment and operating modes on the 10 percent that reflect the danger to this mission.

Mission/Vignette Mix: Enter the percentage of each mission/vignette type expected for the specified role and mission. This is the percentage of the total mission mix expected to be flown for the indicated mission.

Peace/War: If the scenarios, roles, and missions identified are valid during peacetime, conditions other than war, and wartime, enter "all"; otherwise, indicate "peacetime," "conditions other than war," or "wartime," as appropriate.

Threat: This entry requires the system to be effective in defined threat environment. The various subsystem elements may encounter different threats. The known threat(s) against the system are found in an intelligence community validated threat description document. DoD 5000.2 refers to the threat description document as System Threat Assessment Report (STAR). Threat information in the system specification should describe the threat tactics for the defined threat and establish the threat environment in which the total system must provide the specified performance. The campaign and engagement simulations used to design and verify the parameters should appropriately represent the threat as described in the STAR or other valid threat documents. The recommended method for specifying threat information is to attach a threat appendix (or create and reference a separate document) that defines threat characteristics and engagement rules in sufficient detail to serve as a basis for establishing conditions for lower-tier requirements, design, and system verification. This extension of the STAR should have an endorsement by the user's intelligence community affirming that the suggested implementation is consistent with the STAR and with tactics and doctrine of the enemy. The STAR extension should be the basis for all simulations and analyses. Threat data needs to include target and other information necessary to support assessment and verification of the requirements in the specification. Examples of required data are target vulnerability information to support lethality assessments; and air defense numbers, locations, and capabilities to support survivability assessments and verifications.

Basing Location: Any characteristics of particular locations in the scenarios should be clearly identified.

Years: Identify the years in which the requirements apply.

Remarks: Enter any additional information that does not fall into the categories defined by the column titles but which further defines system requirements.

REQUIREMENT LESSONS LEARNED (3.1.1)

To Be Prepared

4.1.1 Roles and missions verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission/Vignette a	Mission Performance	A,S	A,S	A,S		S,T
Mission/Vignette b	Mission Performance	A,S	A,S	A,S		S,T
Mission/Vignette …	Mission Performance	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.1)

Roles and missions are campaign-level requirements that are difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using actual performance data obtained from testing of lower-level system elements.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Roles and mission requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements provide the required performance.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can perform the specified roles and missions.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures, confirms that the system can perform the stated roles and missions.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can perform the roles and missions specified.

Sample Final Verification Criteria

Roles and missions shall be verified through ___(1)___ analyses, ___(2)___ simulations, and ___(3)___ system-level tests for the conditions specified in 3.1.1 Roles and missions section utilizing data obtained from performance testing of the lower-level system elements.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.1)

To Be Prepared

3.1.2 Organization

The system shall perform as specified in this document when the operational elements of the system are employed in the organizational units described in table 3.1.2-I.

TABLE 3.1.2-I. Organizational units.

Unit	Air Vehicle Quantity	Conditions	Remarks

REQUIREMENT RATIONALE (3.1.2)

This paragraph requires the operational elements of the system to provide the specified performance when operating in the quantity of air vehicle(s) per operating unit planned for the system. The quantities and locations prescribe requirements for the second-tier support and training elements. The intended organization of equipment provides the employment basis for mission operations and defines the bounds for application of support and maintenance assets. For example, collocation of assets may reveal dependencies that more closely capture actual use conditions. As a result, conditions may be uncovered that are both operational and support drivers and that impact the further definition and design of the system.

REQUIREMENT GUIDANCE (3.1.2)

For composite squadrons or wings, identify the planned wing structure including support infrastructure.

Guidance for completing table 3.1.2-I follows:

Unit: Identify the type of organizational unit. Examples include squadron(s), wing(s), flight, etc.

Air Vehicle Quantity: Identify the types and quantity of different air vehicles in the squadron, wing, and flight. If these vary for different composite structures, use the next column to explain. For unmanned air vehicles (UAVs) or unmanned combat air vehicles (UCAVs), a separate column may be required to identify the number of control stations required.

Conditions: Explain in this column the variations in the numbers of air vehicles (and UAV or UCAV control stations, if applicable) under different scenarios. For example, if the composite wing structure varies for different scenarios, then there would be a separate entry for each, and the conditions column would specify when the numbers apply.

Remarks: Use where further constraints or clarifications are necessary.

NOTE: If tabular presentation of this information is unwieldy, it may be more practical to present the information textually.

REQUIREMENT LESSONS LEARNED (3.1.2)

To Be Prepared

4.1.2 Organization verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Unit Composition a	Performance characteristics specified in other air system performance requirement paragraphs.	A	A	A		A
Unit Composition b	Performance characteristics specified in other air system performance requirement paragraphs.	A	A	A		A
Unit Composition …	Performance characteristics specified in other air system performance requirement paragraphs.	A	A	A		A

VERIFICATION DISCUSSION (4.1.2)

This requirement delineates the conditions that must be considered in developing all air system performance requirements and verifications. In the event that unit composition requirements are defined or modified in other specific air system performance requirements, the text of said, specific requirements should take precedence over this requirement for that particular performance. The verification approach defined below assumes that the performance of the air system in the specified unit composition will be verified via the performance requirements specified elsewhere.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates that unit composition requirements are defined. Analysis indicates that unit composition will support the specified operations and missions.

PDR: Analysis indicates that unit composition requirements are finalized and incorporated in the applicable design requirements.

CDR: Analysis confirms that design requirements incorporate unit composition considerations.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis confirms that unit composition conditions have been applied appropriately and consistently to the air system verifications.

Sample Final Verification Criteria

Analysis of verification criteria for each air system performance requirement specified herein confirms that the unit composition requirements have been applied in defining the specific operational requirements/conditions for each air system performance requirement.

VERIFICATION LESSONS LEARNED (4.1.2)

To Be Prepared

3.1.3 Deployment and mobilization

The system shall be capable of being mobilized and deployed as presented in table 3.1.3-I. The system must be deployable, configured as defined in table 3.1.3-II, for the duration indicated and shall require not more than ___(1)___ to deploy, excluding personnel. Deployment time for training exercises and wartime missions shall be not greater than indicated in table 3.1.3-II. Deployments with full capability and performance shall require not greater than ___(2)___ (or equivalent); ___(3)___ aerial refueling. Deployment and mobilization requirements shall ___(4)___.

TABLE 3.1.3-I. Deployment and mobilization scenarios.

Role/ Mission	Peace/ War	Basing	Runway	Available Support Structure	Applicable Year(s)	Config-uration	Remarks

TABLE 3.1.3-II. Deployment configurations and durations.

Configuration	Personnel	Duration	Quantity	Remarks

REQUIREMENT RATIONALE (3.1.3)

The locations in which the system is deployed (both peacetime and wartime) provide bounds on the infrastructure and environment in which the prescribed performance is required. Without this definition of the infrastructure and stressing elements, the performance requirements are incomplete and the context for the allocated parameters cannot be established. Additionally, identification of deployment requirements provides critical requirements on the allowed size of the support package, including supplies, available for use for the durations specified.

REQUIREMENT GUIDANCE (3.1.3)

Guidance for completing table 3.1.3-I follows:

Role/Mission: Identify the role and mission to be performed. This should match one of the roles and missions identified in 3.1.1 Roles and missions.

Peace/War: If the deployment identified is valid during peacetime, conditions other than war, and wartime, enter “all”; otherwise, indicate “peacetime,” “conditions other than war,” or “wartime,” as appropriate.

Basing*: Main operating bases (MOBs), remote operating bases (ROBs), aircraft carriers, amphibious ships, and air capable ships, either within or outside CONUS. Rotary wing or UAV basing may need to be specified in more detail to describe accurately the environment where they may be based.

Runway*: Runway surface length and strength for the air vehicle and other system assets. For rotary wing air vehicles and small UAVs, this column may need to be modified to reflect the requirements for planned launch and recovery methods.

Available Support Structure*: If the user needs to employ the system only at prepared and prestocked locations, this should be clearly explained. If the locations are differently stocked for MOB, ROB, and carrier, or CONUS and non-CONUS sites, identify the differences in this column.

Applicable Year(s): Identify the years in which the requirements apply. Some requirements/conditions, such as basing type, weapons/stores (that is, configuration), transport aircraft, etc., change over time. This can result in either a more or less stringent requirement. Applicable years can also stress different aspects of the system solution.

Configuration: Air vehicle configuration (or identifier) to link to the appropriate row in table 3.1.3-II. For UAVs/UCAVs, this configuration may need to specify the applicable control station configuration, as well.

Remarks: Provide additional information as needed.

> *The basing, runway, and available support structure information should be supplemented, to the extent appropriate, to provide more definitive information concerning the specifics of the bed down locations. Bed down results in the first use of the system in its new home or normal peacetime operational environment. These requirements will differ from those resulting from deployments and mobilizations that occur after bed down. Note that some of the resulting requirements may be more appropriately capture in the section 3.4 Interfaces.

The ability of the system to be fully operational under either scenario depends on the physical and functional characteristics of the site, camp, post, station, or commercial facility, and hence the available infrastructure, selected by the user. This infrastructure becomes a part of the environment from which the total system is defined. Using any existing and planned additions to infrastructure enables systems developers to minimize the amount of new or system-unique equipment needed for achieving a total system capability.

The following are some common basing characteristics (or functions) to consider when staging or basing any system from any site. One set of characteristics should be identified for each site listed. The infrastructure of each base should be well known and should be documented by base civil engineering. Base civil engineering should also have information on planned work to be done to improve facilities (for example, MILCON).

Functions/Characteristics
Subcharacteristics/Attributes

a. Launch/landing
b. Geographical position
c. Surface mechanical conditions-launch
d. Surface mechanical conditions-landing
e. Storage
f. Size: volume, area
g. Floor mechanical conditions
h. Composition
i. Tensile strength/load factor
j. Tiedowns
k. Servicing points
l. Transport/handling
m. Towing system
n. Safe/protect systems/equipment
o. Emergency – fire-fighting system
p. Lifting/load support systems
q. Materials handling (463L)
r. Servicing
s. Power, Electric
    (1) Hydraulic
    (2) Pneumatic
t. Conditioned air
u. Compressed gas
v. Consumables
    (1) Coolants
    (2) Cleaning mixtures
    (3) Oil
    (4) Water
    (5) Cryogenic liquid
    (6) Fuels
w. Information
x. Maintenance
y. Mechanical systems
z. Adjustment/alignment systems
aa. Electronic systems
bb. Repair
cc. Test equipment
dd. Ancillary
    (1) Stands, platforms, docks, etc.
    (2) Aids
    (3) Maintenance management
    (4) Data collection
    (5) Aircrew, maintainer debrief
    (6) Tech data delivery
    (7) Supply system management
ee. Diagnostics
ff. Manpower (see 3.3.1.3 Manpower and personnel)
gg. Personnel (see 3.3.1.3 Manpower and personnel)
hh. Training (see section 3.7 Training)
ii. Liaison
jj. Commanders: base, wing, squadron
kk. Key support structure managers (including police/fire protection, security, hospitals, training facilities, utilities, etc.)
ll. Tenants
mm. Community
nn. Security
oo. Command, control, communications, and computer
pp. Information
qq. Personnel
rr. System
ss. Operations

Blank 1. Express time required for deployment in hours, days, weeks, months, or years; this should be consistent with time specified in the CDD.

Blank 2. Identify the number and aircraft type(s) required to deploy a squadron (usually) of air vehicles and support infrastructure.

Blank 3. Indicate if the requirement is to be met with or without aerial refueling.

Blank 4. Indicate if the deployment and mobilization requirements vary by configuration or location.

Adjust as necessary to reflect actual deployment conditions. For example, if the deployment is conducted by transport aircraft or ship, the aerial refueling requirement should be deleted.

Guidance for completing table 3.1.3-II follows:

Configuration: Characterize the deployment in terms of air vehicle configuration.

Personnel: Identify skill types and quantities available for the deployment, as they may be different for some situations.

Duration: State how long the deployment will exist without resupply (usually stated in days).

Quantity: State the number of air vehicles to be deployed.

Remarks: Provide additional information as needed.

REQUIREMENT LESSONS LEARNED (3.1.3)

To Be Prepared

4.1.3 Deployment and mobilization verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mobilization Scenario a	Deployment and mobilization performance	A,S	A,S	A,S		S,T
Mobilization Scenario b	Deployment and mobilization performance	A,S	A,S	A,S		S,T
Mobilization Scenario …	Deployment and mobilization performance	A,S	A,S	A,S		S,T

VERIFICATON DISCUSSION (4.1.3)

Mobilization scenarios are a campaign-level requirement and are difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Unit mobilization requirements have been decomposed to lower-tier requirements. Analyses and simulations indicate that lower-tier requirements provide the required performance.

PDR: Analysis of preliminary air system designs, and simulations using analytically predicted measures of performance, indicate that the system can perform the specified unit mobilizations.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures, confirms that the system can perform the stated unit mobilizations.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable- specific air-system-level testing, confirm that the air system can perform the stated unit mobilizations.

Sample Final Verification Criteria

Unit mobilization capability shall be verified through ___(1)___ analyses, ___(2)___ simulations, and ___(3)___ system-level tests for the conditions specified in 3.1.3 Deployment and mobilization utilizing data obtained from performance testing of lower-level system elements.

Blank 1. List the type and scope of analyses to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the system-level tests to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.3)

To Be Prepared

3.1.4 Mission planning

The system shall provide a mission planning capability that presents the operational mission data for use in, or for, the air vehicle, and where applicable, the UAV or UCAV control station. The mission planning function shall utilize the ___(1)___ as defined in ___(2)___. Mission planning shall include ___(3)___ and replanning, and it shall support the mission mix requirements in this document.

REQUIREMENT RATIONALE (3.1.4)

Modern air systems employ a variety of management information systems and networked resources to accomplish mission planning. Mission planning includes weight and balance, armament selection and programming, menu selection sequencing, navigation waypoints, threat advising, threat avoidance, etc. This requirement affects support structure and training requirements and, hence, provides the top-level requirement for mission planning.

REQUIREMENT GUIDANCE (3.1.4)

Blank 1. Identify the MPS and the specification if the CDD or PMD directs the use of a particular Mission Planning System (MPS) or stipulates an interface to a particular MPS.

Blank 2. Indicate the applicable ICDs. Completely identify the documents and their exact date.

Blank 3. Indicate a requirement for in-flight planning.

If there is no directed solution, delete the sentence containing blanks 1 and 2.

Note: if the mission planning capability is not developed as part of the system, then this requirement should be an interface requirement.

REQUIREMENT LESSONS LEARNED (3.1.4)

To Be Prepared

4.1.4 Mission planning verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission Planning Capability	Mission plan existence Time to make mission plan available (including in-flight update time)	A	A	A		D

VERIFICATION DISCUSSION (4.1.4)

Mission planning includes air vehicle weight and balance, armament selection and programming, menu selection sequencing, navigation waypoints, threat advising, threat avoidance, etc. Offboard mission planning capability and the ability to transfer mission-planning data to the air vehicle (and the UAV/UCAV control station, where applicable) are critical to mission effectiveness, both during preflight and in-flight phases of a mission. The air system (and the control station) must have timely access to intelligence (threat and target), geographical (target, threat, routing) and performance (air vehicle and weapons) information in order to meet mission requirements. The air system specification must take into account the capability to accept mission planning inputs such as navigation waypoints, threat areas, threat libraries, target profiles, etc.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Mission planning requirements have been decomposed to the physical and functional elements of the mission planning system architecture. Requirements defining the time allocated to generate mission planning information are derived from the mission mix and the integrated combat turnaround time requirements.

PDR: Analysis of the preliminary design of the mission planning system indicates that the interface between the air vehicle and the mission planning system is defined and being incorporated into preliminary design solutions. The algorithms to convert mission planning data (navigation, threat, weapons, etc.) into air vehicle mission plans are defined. Definition of the functional and physical architecture for the mission planning system is complete.

CDR: Analysis of the detailed design of the mission planning system confirms the functionality of the interface between the air vehicle (and the UAV/UCAV control station) and the mission planning system and confirms the efficacy of the algorithms to convert mission planning data (navigation, threat, weapons, etc.) into air vehicle mission plans.

FFR: No unique verification action occurs at this milestone.

SVR: Demonstrations confirm that the mission plan/data required to perform the specified mission mix are generated. Demonstrations also confirm that the mission plan/data are available in sufficient time to enable mission accomplishment.

Sample Final Verification Criteria

Mission planning capability shall be verified by ___(1)___ demonstrations. This requirement shall be fulfilled when demonstrations confirm that the mission data is generated within ___(2)___.

> Blank 1. Identify the type and scope of demonstrations required to provide confidence that the requirement has been satisfied.

Blank 2. Specify the time period permitted for the air system to generate the mission data while satisfying mission objectives.

VERIFICATION LESSONS LEARNED (4.1.4)

To Be Prepared

3.1.5 System usage

This is a paragraph header facilitating document organization.

REQUIREMENT RATIONALE (3.1.5)

Fundamentally, system usage addresses the question, “are aircraft (and as applicable, UAV or UCAV control stations) available in sufficient numbers to accomplish assigned missions to the degree tasked?” Critical measures of system usage are mission dependent and may include the fraction of the aircraft (and control stations) available to perform a given mission, the number of sorties expected from each aircraft per day for a given duration, or other parameters, as appropriate. Those missions vary depending on the readiness state of the force and the function the system is intended to perform for those missions. Thus, there are different measures for nominal peacetime conditions and wartime conditions. However, even in peacetime conditions, there are operational missions to be performed (as opposed to simply training). Thus, some parameters may need to be addressed in both states. For example, airlift aircraft perform operational roles in both peacetime and wartime. Some of the missions they perform are different and some the same. But the mission expectations can be different in peacetime vs. wartime for the same mission, in addition to differences in the tempo of operations and availability of maintenance personnel.

REQUIREMENT GUIDANCE (3.1.5)

While the requirements in the following subparagraphs are nominally grouped into peacetime and wartime conditions, the intent of the grouping is to communicate force readiness conditions. Select requirements appropriate to the missions the aircraft is intended to perform and adjust the conditions as necessary to reflect the expected state of force readiness. Based on the specific missions to be conducted, it may be prudent to adapt a mission from one state or another to reflect best the specific mission of the aircraft. Some missions under peacetime actually fall in the transition period from nominal peacetime conditions to wartime conditions.

Caution: It may be possible to select nearly all of the requirements for certain aircraft types and conditions. However, select only those requirements essential to satisfy life cycle requirements and tailor those requirements as needed to reflect operational requirements. Some requirements may be dispensed with, in the sense that users are willing to accept the risk consequences of not specifying a given requirement (that is, the warfighter/developer is willing to accept the fallout capability that the system provides). Keep in mind, however, that an aircraft usage profile is used to establish the durability characteristics of the design. For example, the peacetime mission capable rate may not be a driving factor in satisfying an operational requirement, but the resulting usage rate is important in constructing a life cycle profile of aircraft (and control station) use.

Many of the paragraphs in this section have been expressed in terms of system utilization, typically as a sortie rate. Other parameters, such as schedule effectiveness, alert rate, launch rate, and so forth can be used to express availability. However, a system integrity approach relies heavily on developing a utilization profile for the system. Such an approach is necessary and cannot be built by using requirements that do not include a measure of system utilization.

The 3.1.5 System usage section is subdivided into peacetime operations and wartime operations. It contains availability and integrated combat turnaround requirements and their associated subparagraphs. It facilitates multiple requirement options for describing system utilization requirements. The intent is to provide flexibility in expressing requirements, since not all systems or usage conditions are best characterized by a uniform usage description. Tailor out any unnecessary requirements to avoid redundancy in specifying the requirements or over-specifying requirements for a given condition and mission (for example, use of sortie rate in one requirement and availability in another).

3.1.5.1 Peacetime operations

This is a paragraph header facilitating document organization.

REQUIREMENT RATIONALE (3.1.5.1)

Peacetime operations of the system reflect the capability of the system to provide training; to be deployable from a nominal stateside location to a combat location; and to perform other operational missions such as transport, refueling and surveillance in peacetime conditions. It also reflects the system's ability to move aircraft (very expensive articles) and, where required, UAV control stations from potential hostile locations (whether the hostile in question is threat, terrorist, or the natural environment) to a safe location.

3.1.5.1.1 Training missions

The system shall be capable of successfully conducting the training missions identified in table 3.1.5.1.1-I at ___(1)___ while sustaining a ___(2)___ mission capable rate for ___(3)___ missions for a ___(4)___.

TABLE 3.1.5.1.1-I. Training mission types.

Mission Type	Frequency	Conditions

REQUIREMENT RATIONALE (3.1.5.1.1)

Establish that the system is available to the extent needed for training. The requirement can be constructed to provide latitude between aircraft/ UAV control station training versus other training mechanisms such as simulators.

REQUIREMENT GUIDANCE (3.1.5.1.1)

If there is a need to reflect differences in training and utilization between training conducted by dedicated training assets and training conducted within operational units, this requirement should be stated separately for each case.

Blank 1. Suggested alternatives:

a. “an average utilization rate per aircraft per month of XX,” where XX reflects the planned flying hour program. Any additional training needed would be conducted by other methods."

b. “an average utilization rate per aircraft per month not to exceed YY and not less than ZZ,” where YY reflects the maximum average utilization and ZZ reflects the minimum average utilization."

For UAVs or UCAVs requiring a control station, the alternatives might include:

c. “an average utilization rate per control station per month of X,” where X reflects the planned hours of operation per month. This figure includes/does not include additional operational hours required for additional training and/or maintenance activities."

This requirement provides that some minimum amount of training/proficiency is conducted by flying the aircraft with an upper limit on utilization. It provides latitude to enable greater trade space between in-aircraft (or in-control station) versus in-simulator training. It would be expected that the utilization rate would be established after trade studies of simulator versus training missions are completed and requirements established in lower-tier specifications. Note that maintenance training is impacted along with aircrew training, so that as the utilization rate per aircraft decreases, supplemental training for maintenance crews may need to increase.

Blank 2.

a. Blank 1 requires successful sorties. Thus, as long as the sorties can be conducted, it may be preferable to delete blank 2, the mission capable rate (MCR) requirement. The implications are that for a sufficiently low utilization rate in a sufficiently large unit, it could be possible to conduct all required training missions with a small fraction of the unit. This might not be acceptable or operationally prudent. However, there are other requirements (such as deployment) that can provide the bounding conditions to ensure that aircraft are available. A key factor to consider in the use (or nonuse) of a particular MCR value is whether the unit doing the training is also conducting operational missions. If so, explicit linkages between the training requirement and the peacetime operational requirement will be needed. Or a composite requirement may need to be constructed that reflects mission mix and utilization rates across the set of the training and operational missions conducted by the unit.

b. Mission capable rate is the percent of aircraft capable of performing at least one and potentially all of its designated missions.

Blank 3. If a percent is entered in blank 2, then a mission list needs to be provided in blank 3. This mission list could be “all designated missions” but would normally be limited to the training mission(s) and other designated missions to be performed from the basing location from which the training is conducted.

Blank 4. Specify the type of unit (for example, squadron, wing) and its size, or reference 3.1.2, which defines unit organization, as appropriate.

In table 3.1.5.1.1-I, identify the training mission type in the column “Mission Type” (which should correlate to one or more of the missions identified in 3.1.1 Roles and missions), establish the percentage of the training missions for this type, and define the reference conditions for the mission. Conditions include (but are not limited to):

a. Operating environment(s);

b. The mix between day, night, and in-weather sorties;

c. Maintenance shifts employed, such as two eight-hour shifts;

d. Ground rules, such as mission flight size and impacts if one of the air vehicles in the flight needs to abort the mission;

e. Definition of the configuration; and/or

f. Aircraft staging rules which can, for example, define that some number of aircraft (and where applicable, UAV control stations) are maintained in a ready (that is, ready to conduct this mission) state in the event that an aircraft (or control station) assigned to conduct the mission is forced to abort (for example, in-flight failure of mission-essential equipment).

Cite the references either here, in a separate document, or someplace else in the specification. The conditions should contain a reference to 3.1.1 Roles and missions.

REQUIREMENT LESSONS LEARNED (3.1.5.1.1)

To Be Prepared

4.1.5.1.1 Training missions verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Training mission type a	(2)	A,S	A,S	A,S		S,T
Training mission type b	(2)	A,S	A,S	A,S		S,T
Training mission type …	(2)	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.1.1)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements provide the required mission capable rate (MCR) performance.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the air system can perform the specified training mission and achieve the required MCR.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures, confirms that the air system can perform the stated training missions and achieve the required MCR.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the air system can perform the stated training missions and achieve the required MCR.

Sample Final Verification Criteria

Training mission capability shall be verified through ___(1)___ analyses and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified in the 3.1.5.1.1 Training missions paragraph.

Note: The type and scope of verification activities should be based on an established methodology for predicting mission capable rate.

Blank 1. List the type and scope of analyses to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.1.1)

To Be Prepared

3.1.5.1.2 Operational deployment

The system shall be capable of deployment from ___(1)___ to ___(2)___ within ___(3)___ of notification; shall be capable of flying the missions indicated in ___(4)___ within ___(5)___ hours of arrival; and shall achieve a mission capable rate of ___(6)___ within ___(7)___ hours of arrival.

REQUIREMENT RATIONALE (3.1.5.1.2)

The system needs the capability of transitioning between nominal peacetime and nominal wartime conditions. Section 3.1.1 Roles and missions defines the operational roles and missions; 3.1.2 Organization defines the organizational structure; and 3.1.3 Deployment and mobilization identifies the nominal requirements for deployment. This paragraph describes the transition between the nominal peacetime and wartime conditions.

REQUIREMENT GUIDANCE (3.1.5.1.2)

Blank 1. Identify the nominal location from which the deployment would occur. For example, CONUS locations.

Blank 2. Identify the nominal location of wartime operations. For example, Southwest Asia locations.

Blank 3. Identify the time available from notification until the deployment starts. This may be specified in terms of days or weeks.

Blank 4. Provide a reference to the type of missions that must be conducted within some specified period after arrival. This may be a reference to one or more of the missions identified in 3.1.1 Roles and missions.

Blank 5. Identify the amount of time the aircraft (and where applicable, the UAV/UCAV control stations) have from arrival until they are expected to be flying “operational” missions.

Blank 6. Identify that mission capable rate to be achieved and the missions to which it apples. Mission capable rate is the percent of aircraft capable of performing at least one and potentially all of its designated missions. This is a nominal rate that reflects a ramp up to a fully operational rate. For unmanned air vehicles requiring control stations, the mission capable rate for the control stations should also be identified.

Blank 7. Identify the amount of time the unit has to achieve the mission capable rate.

REQUIREMENT LESSONS LEARNED (3.1.5.1.2)

To Be Prepared

4.1.5.1.2 Operational deployment verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Deployment	(3)	A,S	A,S	A,S		S,T
Flying missions	(5)	A,S	A,S	A,S		S,T
Mission capable rate	(6) (7)	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.1.2)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: Analysis indicates requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements achieve the required time to deploy, start operations, and achieve mission capable rate performance.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can achieve the required time to deploy, start operations, and achieve mission capable rate performance.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures, confirms that the system can achieve the required time to deploy, start operations, and achieve mission capable rate performance.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can achieve the required time to deploy, start operations, and achieve mission capable rate performance.

Sample Final Verification Criteria

Operational deployment capability shall be verified through ___(1)___ analyses, and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified in the 3.1.5.1.2 Operational deployment requirement.

Note: The type and scope of verification activities should be based on an established methodology for predicting mission capable rate.

Blank 1. List the type and scope of analyses to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.1.2)

To Be Prepared

3.1.5.1.3 Operational missions in peacetime

The system shall be capable of the mission capabilities listed in table 3.1.5.1.3-I for the mission scenarios identified in table 3.1.5.1.3-II at the mission mix specified.

TABLE 3.1.5.1.3-I. Peacetime mission response.

Mission	Sortie Rate	Launch Readiness	Air System Start	Preparation for Alert

TABLE 3.1.5.1.3-II. Peacetime mission scenarios.

Mission	% Missions	# Alert Aircraft	Conditions

REQUIREMENT RATIONALE (3.1.5.1.3)

This paragraph addresses the requirements to conduct operational missions in a peacetime environment. Nominally, when aircraft deploy the unit shifts from a peacetime to an operational tempo. Many aircraft, however, have operational roles that they fulfill in peacetime although possibly not at the same tempo as in wartime. Nominally, the requirements for this mission are in addition to any requirements for training missions identified in 3.1.5.1.1 Training missions.

REQUIREMENT GUIDANCE (3.1.5.1.3)

Depending on the aircraft and the roles it is intended to perform, it is possible that some "peacetime operational" missions also serve a training function. Thus some merging and harmonization of requirements between 3.1.5.1.1 Training missions and this paragraph may be needed. It is recommended, however, that missions conducted solely for training be contained in 3.1.5.1.1 Training missions. There will be a need to establish an aircraft life cycle utilization profile and, for example, repeated maneuvers conducted during dedicated training flights can stress the aircraft in different ways than the addition of some training tasks during other missions. Note that, consistent with the concept of peacetime operations, the sortie rate expected from the system assumes a steady-state condition that can be sustained indefinitely.

Guidance for completing table 3.1.5.1.3-I follows:

<u>Mission</u>: Identify the mission(s) to be performed. This should include a reference to 3.1.1 Roles and missions for mission specifics.

<u>Sortie rate</u>: Specify the sustained sortie rate to be achieved.

<u>Launch Readiness</u>: Specify the amount of time allowed from notification of requirement to launch until the alert aircraft are launched (that is, sorties in the air). For unmanned air vehicles which require a control station, the time required to activate a backup control station may need to be included in the time increment. Air system start is a time sub-increment included in launch readiness.

<u>Air system start</u>: Specify the maximum amount of time allowed to start up the air system in a powered-down alert status to a powered-up ready-for-flight status. This includes time for crew to man-up; start electric and air-bleed power sources external or internal to the air vehicle; start-up and utilize any other external ground support and control equipment necessary for launch,; remove before-flight safeties and covers; close doors, hatches, or canopies as required; engine start; and transition from external to internal power if required; and bring air vehicle and mission systems required on-line and set for flight. This time increment ends when the air system is ready for brake release to taxi or lift-off from a parked location, or ready for catapult launch when standing alert on the catapult.

<u>Preparation for alert</u>: Specify the maximum amount of time allowed to prepare a 100% mission capable air vehicle, assuming all fuel, mission equipment, ground support vehicles, and required personnel appropriate for one air vehicle consistent to manning in paragraph 3.3.1.3, are ready next to the air vehicle.

Guidance for completing table 3.1.5.1.3-II follows:

> NOTE: The information in this table establishes the conditions under which the sortie generation rate is to be achieved.

<u>Mission</u>: Identify the mission(s) to be performed. This should include a reference to 3.1.1 Roles and missions for mission specifics.

% Missions: If the system is intended to provide sorties over multiple different missions, enter the percentage of total missions for each mission to be performed. If there is only a single mission to be performed, enter 100 percent

Alert aircraft: Specify the number of aircraft to be maintained in alert status in the event of a mission abort by the aircraft conducting the missions. For unmanned air vehicles, the number of control stations available may need to be specified.

Conditions. Specify the conditions for both operations and support including environmental factors. Operations conditions include factors such as the flight size, mission specific parameters such as aerial refueling, and length of the operational day. Support factors include parameters such as maintenance availability; for example, 2 maintenance shifts per day at 8 hours per shift.

REQUIREMENT LESSONS LEARNED (3.1.5.1.3)

To Be Prepared

4.1.5.1.3 Operational missions in peacetime verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Sortie generation rate (per the conditions of table 3.1.5.1.3-I)	Mission 1: Sortie rate Mission 2: Sortie rate Mission (…): Sortie rate	A,S	A,S	A,S		S,T
Launch readiness (per the conditions of table 3.1.5.1.3-II)	Mission ’1’: Time Mission ‘2’: Time etc	A,S	A,S	A,S		S,T
Air system start (per the conditions of table 3.1.5.1.3-II)	Mission ’1’: Time Mission ‘2’: Time etc	A,S	A,S	A,S		S,T
Preparation for alert (per the conditions of table 3.1.5.1.3-II)	Mission ’1’: Time Mission ‘2’: Time etc	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.1.3)

Air system sortie generation and launch readiness are campaign-level requirement elements and are difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements. Air system start is a sub-increment of launch readiness that can be more directly applied to and substantially affected by the air system design. Preparation for alert is not a sub-increment of launch readiness, but is an important factor and also can be directly applied to and substantially affected by the air system design.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements achieve the required sortie generation rate performance and mission responses under the conditions of table 3.4.5.1.3-II.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can achieve the required sortie generation rate and mission responses within specified conditions.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures, confirms that the system can achieve the required sortie generation rate and mission responses within specified conditions.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level demonstrations and tests, confirm that the system can achieve the required sortie generation rate and mission responses within specified conditions.

Sample Final Verification Criteria

Operational missions in peacetime capability shall be verified through ___(1)___ analyses, and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified in 3.1.5.1.3 Operational missions in peacetime.

Note: The type and scope of verification activities should be based on an established methodology for predicting mission generation rates and responses.

Blank 1. List the type and scope of analyses to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.1.3)

To Be Prepared

3.1.5.1.4 Base escape

___(1)___ air vehicles out of ___(2)___ shall be capable of achieving a base escape separation distance of ___(3)___ within ___(4)___ of warning. These air vehicles shall be capable of performing the ___(5)___ mission. ___(6)___ air vehicles out of the remaining ___(7) ___ air vehicles shall be capable of achieving a base separation distance of ___(8)___ within ___(9)___ of the initial warning. These air vehicles shall be capable of performing the ___(10)___ mission. Conditions for this mission are ___(11)___.

REQUIREMENT RATIONALE (3.1.5.1.4)

The applicability and need for this requirement must be carefully considered. The degree of its utility was greater during heightened tensions between the United States and the former Soviet Union. Derivatives of the base escape mission are, however, also applicable to conditions such as relocation of air vehicle away from severe weather conditions or, in concept, to potential actions that threaten base security. It may be preferable to accept a fallout capability. If it is desired to specify multiple conditions (for example, a base escape requirement and a weather escape requirement) this paragraph should be repeated and tailored for the specific conditions required.

REQUIREMENT GUIDANCE (3.1.5.1.4)

The requirements in this paragraph are tied to the organizational structure specified in 3.1.2 Organization.

Blanks 1-5. These generally apply to air vehicles on alert status or maintained in a high degree of launch readiness.

Blank 1. Specify the number of air vehicles that must clear the base area promptly.

Blank 2. Specify the number of air vehicles in the unit maintained in alert status and in a mission capable (near mission capable) condition that are expected to clear the base area promptly.

Blank 3. Specify the separation distance that must be attained.

Blank 4. Specify the amount of time to launch all the air vehicles identified in blank 1 and for those air vehicles to achieve the separation distance identified in blank 3.

Blank 5. This requirement is applicable only if the air vehicles are to be launched with the capability to perform the stated mission. This requirement must be correlated to a mission identified in 3.1.1 Roles and missions.

Blanks 6-10. These generally apply to the remaining air vehicles in the unit. These air vehicles may be mission capable or not, as appropriate.

Blank 6. Specify the number of remaining air vehicles that must clear the base area.

Blank 7. Specify the number of remaining air vehicles in the unit (for example, if the unit size were 24 air vehicles and if blank 1 were 8, blank 7 would be 16).

Blank 8. Specify the separation distance that must be attained. (This requirement is provided if, for example, the separation distance is different from that of the first set of air vehicles).

Blank 9. Specify the amount of time allowed from first notification until this set of air vehicles is expected to reach the separation distance specified in blank 8.

Blank 10. This requirement is applicable only if the air vehicles are to be launched with the capability to perform the stated mission. This requirement must be correlated to a mission identified in 3.1.1 Roles and missions.

Blank 11. Specify any mission and support conditions applicable. For example, a heightened increase in readiness been instigated and air vehicles are undergoing accelerated maintenance to maximize the number of air vehicles available for launch. Also identify conditions such as threat and weather environments, conditions for taxi and takeoff, example airfield layout, etc.

For air systems which include unmanned air vehicle control stations which are relocatable, there may be need to expand this requirement to establish a base escape for the control station(s) as well.

REQUIREMENT LESSONS LEARNED (3.1.5.1.4)

To Be Prepared

4.1.5.1.4 Base escape verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Initial base escape condition at ___(3)___ distance, ___(4)___ time, and ___(11)___ conditions.	(1)	A,S	A,S	A,S		S,T
Remaining base escape condition at ___(8)___ distance, ___(9)___ time, and ___(11)___conditions.	(6)	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.1.4)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally, using real performance data from actual testing of lower-level system elements.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: Analysis indicates that system requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements achieve the required base escape numbers within the required times under the stated conditions.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can achieve the required base escape capability.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures, confirms that the system can achieve the required base escape capability.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can achieve the required base escape capability.

Sample Final Verification Criteria

Base escape capability shall be verified through ___(1)___ analyses, and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified in 3.1.5.1.4 Base escape.

Blank 1. List the type and scope of analyses to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.1.4)

To Be Prepared

3.1.5.2 Wartime operations

This is a paragraph header facilitating document organization.

REQUIREMENT RATIONALE (3.1.5.2)

Wartime operations of the system reflect the capability of the system to provide the sorties needed to satisfy its intended function in combat conditions. Combat conditions pose additional stress on sortie generation. For example, bases may be under attack, air and maintenance crews may be operating with additional protective equipment such as chem-bio gear, additional maintenance tasks may be needed such as battle damage repair or aircraft decontamination. Some types of missions are driven by productivity demands such as air-to-surface attack. Other types of missions (such as point defense) are driven by the need to maintain high degrees of launch readiness with a sudden pulse in sortie generation given an event occurs.

Additionally, there are two states of sortie generation that typically drive a unit's ability to provide mission capable aircraft. Surge combat generally represents a state where the maximum sortie generation rate possible is needed. Basically, this state reflects time-critical demands for aircraft and a greater need for missions than there are aircraft available. In surge combat conditions, maintenance actions (such as phased inspections) are frequently deferred. The focus of maintenance activity is on fixing breaks and turning mission capable aircraft. In sustained combat, there is a protracted period of hostility. Some mission types may still be operating on a launch readiness basis. Others are typically operating to a productivity demand. During sustained combat operations, maintenance actions are typically not deferred. Phased inspections and preventive maintenance actions are conducted. Our experience is that sustained combat conditions drive maintenance manpower requirements.

REQUIREMENT GUIDANCE (3.1.5.2)

The following paragraphs contain a variety of different performance parameters to describe the requirements for system usage. Some systems may be performing multiple missions. For example, close air support and interdiction. These missions place different demands on the system. It may be necessary to construct a set of composite requirements by repeating various individual requirements and "missionizing" them. When constructing a system usage requirement across different missions, the relative frequency of each mission should be established. Some aircraft may be conducting the same mission from two different locations with different support structures; for example, conduct of battlefield interdiction from a main operating base and from a forward-deployed, remote operating base. These two scenarios will likely have different expectations. As such, the requirement would be repeated for the different expectations and differing support asset availability.

3.1.5.2.1 Combat surge and sustained

The system shall be capable of generating the sortie rates indicated in table 3.1.5.2.1-I, for roles and missions ___(1)___ and unit organization ___(2)___. Other overall conditions of operation include ___(3)___.

TABLE 3.1.5.2.1-I. Wartime mission scenarios.

	Surge				Sustained			
Mission	Sortie Rate	% Missions	Days	Conditions	Sortie Rate	% Missions	Days	Conditions

REQUIREMENT RATIONALE (3.1.5.2.1)

This paragraph addresses the requirements to generate operational missions in a combat environment. Surge combat conditions emphasize factors such as air vehicle turnaround time, break rates, and fix rates. Sustained combat stresses maintenance ability to maintain combat capable aircraft over a long duration. Frequently, issues such as people, supply, and parts availability become critical. While surge combat stresses the air and maintenance crews over a short term, sustained combat requires that crews undertake additional tasks to keep aircraft functioning. Such tasks include phased inspections and preventive maintenance. When operations are conducted over protracted periods, the maintenance, parts, and supply states at the end of a surge period become significant factors in addressing the ability to maintain a sustained sortie rate.

REQUIREMENT GUIDANCE (3.1.5.2.1)

This requirement must be carefully crafted to reflect the conditions expected. Nominally expectations would be that intense combat tempos would be characteristic of the initial phase of combat operations followed by a protracted period of less intense operations. While this is the assumption used in designing table 3.1.5.2.1-I, this is not always the case. The table should be appropriately configured for the situation(s) as needed to communicate performance expectations. It will likely not be possible, or useful, to account for all potential situations. The objective is to communicate a reasonably robust set of performance expectations and conditions of operation in order to establish an appropriate “design to” point.

Depending on the variety of conditions to be described, it may be preferable to communicate these requirements as a series of paragraphs rather than attempting to define all the performance expectations and conditions in a single requirement paragraph.

Blank 1. Specify the role and mission to be conducted. This could be done by referencing a line in the table of 3.1.1 Roles and missions, which defines the roles and missions of operation. Note that most of the content of 3.1.1 Roles and missions is critical to defining the conditions of operation. It may be necessary to completely identify the role and mission at this point to eliminate ambiguity. A hypothetical example for filling in this blank could be “air-to-surface attack, battlefield air interdiction, Southwest Asia 2020 scenario, in wartime conditions, operating from main operating bases.”

Blank 2. Specify the organization to be used. This could be done by referencing a line in the table of 3.1.2 Organization. Similarly, it may be necessary to utilize some (or all) of the content of a line in that table to reduce ambiguity.

Blank 3. Identify other conditions of operation impacting the entire requirement. Such conditions could include information dealing with factors such as

a. Combat stress conditions. For example, airbase or ship under attack (the threat description under the roles and missions section should include a vignette or mini-scenario that describes these conditions, which could include runway attack, asset attack, chemical/biological attack or some combination). It may be useful to replicate the requirements set to specify a set of benign conditions (that is, no externally induced combat stress conditions) to address the basic capability of the system and a set of combat stress conditions. Such factors tend to identify the differences in expectations in air dominance vs. non air dominance situations. Other combat stress factors could include whether or not battle damage repair is to be considered.

b. Supply factors. For example, are these expectations based only on the organic assets or do they include depot repair of items (and if so, what is the nominal depot repair rate including transportation times to and from the theater of operations if appropriate)? Additionally, do the expectations reflect replenishment spares in excess of the War Reserve Spares Kit (WRSK)?

Note that the inclusion of specific information in blank 3 has a number of positive attributes. The more closely realistic conditions are portrayed, the better specific supporting parameters can be defined. The drawback is the tendency to lock in on isolated operational points that may not occur. For example, when operating in a chemical/biological environment, we might expect a lower sortie generation capability than in benign conditions. If such is the case, there would likely be a greater demand on chemical/biological equipment and supply requirements, which is a good thing to identify. However, if this were the only condition examined, we would expect a lower demand on parts and other material than would be needed in a lower stress (for example, air dominance) situation. To characterize the system’s capabilities completely, it will be necessary to define expectations with and without combat stress.

Guidance for completing table 3.1.5.2.1-I follows:

Table 3.1.5.2.1-I is portrayed in two parts under the assumption that a period of combat surge conditions will be followed by a period of combat sustained conditions. If expectations are only for combat surge conditions, delete the combat sustained portions of the table. If expectations are only for combat sustained conditions, delete the combat surge portions of the table. For some types of air systems, there may be no difference in the expectations. However, if there are differences in the conditions of operation, it may still be necessary to have a two component table (for example, the sortie generation expectation may be flat across a long period of combat, but the conditions of depot resupply and/or spare replenishment may be different).

Mission: Identify the mission(s) to be performed. This should include a reference to 3.1.1 Roles and missions for mission specifics.

Surge:

a. Sortie Rate: Enter the sortie rate expected for the unit and conditions identified.

b. Percent Missions: If the system is intended to provide sorties over multiple different missions, enter the percentage of total missions for each mission to be performed. If there is only a single mission to be performed, enter 100 percent.

c. Days: Identify either the combat days (for example, days 1 - 5) or duration (for example, 5).

d. Conditions: Specify the conditions for both operations and support. Operations includes factors such as the flight size, mission-specific parameters such as weather conditions, battle damage expectations, and length of the operational day. Support factors include parameters such as maintenance availability; for example, two maintenance shifts per day at 12 hours per shift, and any additional assets available for battle damage repair. Note that, in surge combat conditions, maintenance days are typically longer than for sustained combat. Phased/preventive maintenance is not always conducted. Crew rest can become an issue. For unmanned air vehicles requiring a control station, factors such as control station manning and maintenance requirements may become controlling factors.

Sustained:

a. Sortie Rate: Enter the sortie rate expected for the unit and conditions identified.

b. Percent Missions: If the system is intended to provide sorties over multiple different missions, enter the percentage of total missions for each mission to be performed. If there is only a single mission to be performed, enter 100 percent.

c. Days: Identify either the combat days (for example, days 6 - 50) or duration (for example, 45).

d. Conditions: Specify the conditions for both operations and support. Operations include factors such as the flight size, mission specific parameters such as weather conditions, battle damage expectations, and length of the operational day. Support factors include parameters such as maintenance availability; for example, three maintenance shifts per day at 8 hours per shift, phased maintenance intervals, and any additional assets available for battle damage repair. For unmanned air vehicles requiring a control station, factors such as control station manning and maintenance requirements must be considered.

REQUIREMENT LESSONS LEARNED (3.1.5.2.1)

To Be Prepared

4.1.5.2.1 Combat surge and sustained verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission a surge	Sortie rate	A,S	A,S	A,S		S,T
Mission a sustained	Sortie rate	A,S	A,S	A,S		S,T
Mission b surge	Sortie rate	A,S	A,S	A,S		S,T
Mission b sustained	Sortie rate	A,S	A,S	A,S		S,T
Mission … surge	Sortie rate	A,S	A,S	A,S		S,T
Mission … sustained	Sortie rate	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.2.1)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: Analysis indicates that system requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements provide the required sortie rates for the role(s) and mission(s) specified under the conditions stated in this requirement.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can achieve the specified sortie rates for the role(s) and mission(s) stated under the required conditions.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures, confirms that the system can achieve the specified sortie rates for the role(s) and mission(s) stated under the required conditions.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can achieve the specified sortie rates for the role(s) and mission(s) stated under the required conditions.

Sample Final Verification Criteria

Combat surge and sustained capability shall be verified through ___(1)___ analyses, and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified in 3.1.5.2.1 Combat surge and sustained.

Note: The type and scope of verification activities should be based on an established methodology for predicting sortie generation rate.

Blank 1. List the type and scope of analyses to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.2.1)

To Be Prepared

3.1.5.2.2 Air alert, loiter, surveillance

For the ___(1)___ missions, the system shall be capable of maintaining ___(2)___, ___(3)___ stations/routes for ___(4)___ days. Occupancy rates for the station/route shall be at least ___(5)___. ___(6)___ aircraft shall be maintained on the ground ready to launch on ___(7)___ notice to replace aircraft aborting the mission due to breaks. Conditions for the conduct of this mission are

a. Length of the operational day is ___(8)___.

b. Number of aircraft per flight is ___(9)___.

c. Number of flights per station/route is ___(10)___.

d. Size of the unit conducting the missions is ___(11)___.

e. In-flight refueling allowed? ___(12)___.

f. Flight abort rules are ___(13)___.

REQUIREMENT RATIONALE (3.1.5.2.2)

This requirement can be used in a wide variety of circumstances. It can pertain to maintaining air defense/air dominance over the battlefield to prevent hostile intrusion from air assets. It can be used for surveillance missions. It can be used as a means of forward deploying aircraft, such as close air support or unmanned reconnaissance assets to enable a more rapid response to ground actions. This requirement establishes a presence to react rapidly to hostile actions as far forward as deemed necessary.

REQUIREMENT GUIDANCE (3.1.5.2.2)

This requirement, as written, is scenario dependent. Replicate it, to the extent needed, to address the scenario dependencies. For example, operations in one scenario may dictate 4 air vehicles/flight others 2 air vehicles/flight. Some scenarios may include in-flight refueling, others may not. Frequently the intensity of air operations and the distances to the loiter location are the driving factors for the differences between scenarios.

Blank 1. Identify the missions to which this requirement applies. This should relate to, and cross-reference, a role and mission in 3.1.1 Roles and missions to provide the necessary situational and other data bearing on the requirement.

Blank 2. Identify the number of stations/routes to be maintained.

Blank 3. Identify the type of station/route. Examples are air alert, loiter and surveillance.

Blank 4. Identify the duration that this activity continues, for example, 1 week.

Blank 5. Identify the occupancy rate for the stations/routes. This allows for in-flight breaks (consistent with mission reliabilities specified elsewhere) and the launch readiness of replacement aircraft with some allowance for covering the distance between the base the station location.

Blank 6. Identify the number of aircraft maintained in launch readiness.

Blank 7. The amount of time from notification to launch until the air vehicle is in the air.

Blank 8. Identify the length of the operating day; for example, 24 hours.

Blank 9. Identify the number of aircraft in a flight. For a surveillance mission conducted by an AWACS this might be 1. For a combat air patrol mission, this might be two.

Blank 10. Identify the number of flights assigned to each station/route.

Blank 11. Identify the size of the unit conducting the mission, for example, a 24 aircraft squadron.

Blank 12. Identify whether or not aerial refueling is allowed.

Blank 13. Identify the flight abort rules. For example, for a flight size of two air vehicles, if one aborts due to a mission-critical failure, does the other aircraft abort the mission as well?

For unmanned air vehicles requiring a control station, the availability of the necessary operational control station(s) to meet the specified air alert, loiter, or surveillance capability cited herein should be considered.

REQUIREMENT LESSONS LEARNED (3.1.5.2.2)

To Be Prepared

4.1.5.2.2 Air alert, loiter, surveillance verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission a occupancy	(5)	A,S	A,S	A,S		S,T
Mission b occupancy	(5)	A,S	A,S	A,S		S,T
Mission … occupancy	(5)	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.2.2)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates system requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements achieve the required stations/routes occupancy rates for the conditions stated.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can achieve the required stations/routes occupancy rates within stated conditions.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures, confirm that the system can achieve the required stations/routes occupancy rates within stated conditions.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can achieve the required station/route occupancy rates within stated conditions.

Sample Final Verification Criteria

Air alert, loiter, surveillance capability shall be verified through ___(1)___ analyses and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified.

Note: The type and scope of verification activities should be based on an established methodology for predicting mission capable rate.

Blank 1. List the type and scope of analyses to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.2.2)

To Be Prepared

3.1.5.2.3 Mission execution from ground/deck basing

3.1.5.2.3.1 Non-lethal mission task initiation from ground/deck basing

The air system shall be capable of initiating mission tasks as specified and according to the conditions identified in table 3.1.5.2.3.1-I.

TABLE 3.1.5.2.3.1-I. Non-lethal mission task initiation from ground/deck basing.

Mission	Tasks	Number of aircraft	Type of target, objective, or friendly entity	Distance from alert location	Information sources	Mission sensors probability of detection

REQUIREMENT RATIONALE (3.1.5.2.3.1)

This requirement is intended to address non-lethal air system missions for which aircraft are launch ready and awaiting the occurrence of a specific event to initiate tasking. Such occurrences could be driven by notification of a high value, hostile asset requiring identification or surveillance, or a friendly entity requiring emergency support. The target or friendly entity can, in principle, be either airborne or ground/sea based. This mission stresses the ability of the air system to respond rapidly to emergent mission tasks. This is not strictly an availability requirement since it also involves air system task execution capabilities. The concept behind the requirement involves, for example, situations in which a small number of aircraft from a unit are in a ready state to provide time-critical command, control, communications, computers, intelligence, surveillance and reconnaissance (C^4ISR), emergency combat support, or emergency relief of a friendly entity that has lost mission capability due to damage or system failure. This requirement may apply to many mission roles, such as air-to-air, air-to-surface, reconnaissance/surveillance, command and control, forward air control, electronic warfare, search and rescue, etc. This requirement is presented in tabular form to accommodate multi-purpose and multi-mission air systems, or to modify existing air systems for expanding roles.

REQUIREMENT GUIDANCE (3.1.5.2.3.1)

Guidance for completing table 3.1.5.2.3.1-I follows:

Mission: Identify the missions to which this requirement applies. This should relate to, and cross reference, a role and mission in the 3.1.1 Roles and missions requirement to provide the necessary situational and other data bearing on the requirement.

Tasks: This requirement element lists the mission tasks to be performed. This could involve employing reconnaissance sensors and transmitting data, transfer of mission data and preparing to replace another combat support asset, airdrop, aerial refueling, etc.

Number of aircraft: Specify the size of the flight required to respond to accomplish each task.

Type of target, objective, or friendly entity: The type of target or objective requiring attention (surveillance, escort, ID, etc.), or the friendly entity being supported, rescued, refueled, etc. This may be a single or array of targets or friendly entities.

Distance from alert location: The relative location of the target, objective or friendly entity from the alert location at the time of task notification.

Information sources: Criteria should address the timeliness of the information to be provided and whether or not in-flight updates will be available. Reference to the C^4ISR portion of the 3.4 Interfaces section should be included.

Mission sensors probability of detection: Probability of detection of the target, objective or friendly entities identified above, at the distance identified above. This could include detection of transponders, RF/EO/IR signals, etc.

REQUIREMENT LESSONS LEARNED (3.1.5.2.3.1)

To Be Prepared

4.1.5.2.3.1 Non-lethal mission task initiation from ground/deck basing verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission a	Capable of initiating specified mission tasks according to conditions in table 3.1.5.2.3.1-I (pass/fail)	A,S	A,S	A,S		S,T
Mission b	Capable of initiating specified mission tasks according to conditions in table 3.1.5.2.3.1-I (pass/fail)	A,S	A,S	A,S		S,T
Mission …	Capable of initiating specified mission tasks according to conditions in table 3.1.5.2.3.1-I (pass/fail)	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.2.3.1)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements. The type and scope of verification activities should be based on an established methodology for predicting mission capable rate.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of the air system design concept(s) indicates system requirements have been decomposed to lower-tier requirements. Analysis and simulations of lower-tier requirements indicate that the system can initiate its mission functions under the conditions stated.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can initiate its mission functions under the stated conditions.

CDR: Analysis of detailed system design, and simulations using the most current predicted measures, confirm that the system can initiate its mission functions under the stated conditions.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can initiate its mission functions under the stated conditions.

Sample Final Verification Criteria

Non-lethal mission task initiation from ground/deck basing capability shall be verified through ___(1)___ analyses, and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.2.3.1)

To Be Prepared

3.1.5.2.3.2 Lethal engagement from ground/deck basing

For the ___(1) ___ mission, a ___(2)___ ship flight shall be capable of launching, entering a lethal engagement envelope (target acquired, weapons locked, weapon Pk greater than or equal to ___(3)___ percent of maximum weapon Pk) against ___(4)___ targets, detected by ___(5)___ source, at a distance of ___(6)___ from the alert location before the targets can enter their lethal engagement envelope of ___(7)___ against a friendly entity located at ___(8)___ relative to the alert location.

REQUIREMENT RATIONALE (3.1.5.2.3.2)

This requirement is intended to address missions for which aircraft are launch ready and awaiting the occurrence of a specific event to initiate potentially lethal engagement of a target. Such occurrences could be driven by notification of a high value, hostile asset being targeted. The target can, in principle, be either airborne or ground/sea based. This requirement stresses the ability of the aircraft to rapidly launch and engage. This is not strictly an availability requirement since it also involves aircraft engagement capabilities. The concept behind the requirement involves, for example, situations in which a small number of aircraft from an air combat unit are held back in a ready state to provide point defense. This could also apply to air-to-surface missions in which a small number of aircraft are held back in launch readiness with a predetermined ordnance load to be able to rapidly react to time-critical targets. In terms of availability, this requirement is more effective when the type of situation described is part of a set of situations that a larger unit (such as a squadron or a wing) is expected to be able to execute.

REQUIREMENT GUIDANCE (3.1.5.2.3.2)

Blank 1. Identify the missions to which this requirement applies. This should relate to, and cross reference, a role and mission in the 3.1.1 Roles and missions requirement to provide the necessary situational and other data bearing on the requirement.

Blank 2. Number of aircraft in the flight.

Blank 3. This requirement is intended to provide an envelope for weapon release.

Blank 4. The type of target being attacked. It may be a single target or a target array.

Blank 5. The source of the information. Criteria should address the timeliness of the information and whether or not in-flight updates will be available. Reference to the C^4ISR portion of the 3.4 Interfaces section should be included.

Blank 6. The relative location of the target from the alert location at the time of detection.

Blank 7. If the target is mobile and lethal, the intent is to engage the target prior to the target being able to release ordnance at a friendly entity.

Blank 8. The location of the friendly entity being protected.

Some high value targets are not lethal in themselves. Other targets are lethal, but the requirement may be to destroy the hostile target even after it releases weapons. In these circumstances, tailor the requirement statement to remove blanks 6 and 7.

REQUIREMENT LESSONS LEARNED (3.1.5.2.3.2)

To Be Prepared

4.1.5.2.3.2 Lethal engagement from ground/deck basing verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission a	Launch and enter lethal engagement envelope before target(s) can enter their lethal engagement envelope(s) against friendly entities as specified (pass/fail)	A,S	A,S	A,S		S,T

Mission b	Launch and enter lethal engagement envelope before target(s) can enter their lethal engagement envelope(s) against friendly entities as specified (pass/fail)	A,S	A,S	A,S		S,T
Mission …	Launch and enter lethal engagement envelope before target(s) can enter their lethal engagement envelope(s) against friendly entities as specified (pass/fail)	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.2.3.2)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements. The type and scope of verification activities should be based on an established methodology for predicting mission capable rate.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of the air system concept(s) indicates system requirements have been decomposed to lower-tier requirements. Analysis of simulations of lower-tier requirements indicate that the system can achieve target acquisition with the required Pk before the targets can enter their lethal envelope under the conditions stated.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can achieve the required Pk against the targets before the targets reach their lethal envelope under the stated conditions.

CDR: Analysis of detailed system designs, and system-level simulations using predicted measures, confirm that the system can achieve the required Pk against the targets before the targets reach their lethal envelope under the stated conditions.

FFR: No unique verification action occurs at this milestone.

SVR: System-level simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can achieve the required Pk against the targets before the targets reach their lethal envelope under the stated conditions.

Sample Final Verification Criteria

Engagement from ground/deck basing capability shall be verified through ___(1)___ analyses, and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.2.3)

To Be Prepared

3.1.5.2.4 Mission execution from loiter location

3.1.5.2.4.1 Non-lethal mission task initiation from loiter location

The air system shall be capable of exiting a loiter location, and initiating mission tasks as specified and according to the conditions identified in table 3.1.5.2.4.1-I.

TABLE 3.1.5.2.4.1-I. Non-lethal mission task initiation from loiter location.

Mission	Tasks	Number of aircraft	Type of target, objective, or friendly entity	Distance from alert location	Information sources	Mission sensors probability of detection

REQUIREMENT RATIONALE (3.1.5.2.4.1)

This requirement is intended to address non-lethal air system missions for which aircraft are airborne, frequently in a loiter location, and awaiting a specific event to initiate tasking. Such occurrences could be driven by notification of a high value, hostile asset requiring identification or surveillance, or a friendly entity requiring emergency support. The target or friendly entity can, in principle, be either airborne or ground/sea based. Missions may include identification or surveillance of an unknown platform, intercept of intelligence signals, or time-sensitive combat support of friendly forces from a forward loiter location. This mission stresses the ability of the air system to initiate mission tasks rapidly, or to transition to another mission task while already in the air. This is not strictly an availability requirement since it also involves air system task execution capabilities. The concept behind the requirement involves, for example, situations in which a number of aircraft from an air unit are already airborne and ready to provide time-critical C^4ISR, emergency combat support, or emergency relief of a friendly entity that has lost mission capability (damage or system failure). This requirement may apply to many mission roles where aircraft are maintained in a holding orbit to be able to react rapidly to time-critical tasking. In terms of stressing availability, this requirement is more effective when the type of situation described in the requirement is part of a set of situations that the air system is expected to be able to execute. This requirement is presented in tabular form to accommodate multi-purpose and multi-mission air systems, or to modify existing air systems for expanding roles.

REQUIREMENT GUIDANCE (3.1.5.2.4.1)

Guidance for completing table 3.1.5.2.4.1-I follows:

Mission: Identify the missions to which this requirement applies. This should relate to, and cross reference, a role and mission in the 3.1.1 Roles and missions requirement to provide the necessary situational and other data bearing on the requirement.

Tasks: This requirement element lists the mission tasks to be performed. This could involve employing reconnaissance sensors and transmitting data, transfer of mission data and being ready to replace another combat support asset, aerial refueling, SAR, etc.

Number of aircraft: Specify the size of the flight required to respond to accomplish each task.

Type of target, objective or friendly entity: The type of target or objective requiring attention (surveillance, escort, ID, etc.), or friendly entity being supported, rescued, refueled, etc. This may be individual or an array of targets or friendly entities.

Distance from alert location: The relative location of the target, objective, or friendly entity from the alert location at the time of task notification.

Information sources: Criteria should address the timeliness of the information to be provided and potential availability of in-flight updates. Reference to the C^4ISR portion of the 3.4 Interfaces section should be included.

Mission sensors probability of detection: Probability of detection of the target/objective or friendly entities identified above. This could include detection of transponders or RF/EO/IR signals.

REQUIREMENT LESSONS LEARNED (3.1.5.2.4.1)

To Be Prepared

4.1.5.2.4.1 Non-lethal mission task initiation from loiter location verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission a	Capable of initiating specified mission tasks according to conditions in table 3.1.5.2.4.1-I (pass/fail)	A,S	A,S	A,S		S,T
Mission b	Capable of initiating specified mission tasks according to conditions in table 3.1.5.2.4.1-I (pass/fail)	A,S	A,S	A,S		S,T
Mission …	Capable of initiating specified mission tasks according to conditions in table 3.1.5.2.4.1-I (pass/fail)	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.2.4.1)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements. The type and scope of verification activities should be based on an established methodology for predicting mission capable rate.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of the air system design concept(s) indicates system requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements can initiate the system mission functions under the conditions stated**Error! Reference source not found.**.

PDR: Analysis of preliminary system designs and simulations, using the most current analytically predicted measures of performance, indicates that the system can initiate its mission functions under the stated conditions.

CDR: Analysis of detailed system designs and use of simulations containing predicted measures confirm that the system can initiate its mission functions under the stated conditions.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can initiate its mission functions under the stated conditions.

Sample Final Verification Criteria

Non-lethal mission task initiation from loiter location capability shall be verified through ___(1)___ analyses, and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified**Error! Reference source not found.**.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.2.4.1)

To Be Prepared

3.1.5.2.4.2 Lethal engagement from loiter location

For the ___(1)___ mission, a ___(2)___ ship flight shall be capable of exiting a loiter location, entering a lethal engagement envelope (target acquired, weapons locked, weapon Pk greater than or equal to ___(3)___ percent of maximum weapon Pk) against ___(4)___ targets, detected by ___(5)___ source, at a distance of ___(6)___ from the loiter location. The flight shall be capable of accomplishing these maneuvers before the targets can enter their lethal engagement envelope of ___(7)___ against a friendly entity located at ___(8)___ relative to the alert location.

REQUIREMENT RATIONALE (3.1.5.2.4.2)

This requirement is intended to address missions for which aircraft are airborne, frequently in a loiter or combat air patrol location, and awaiting a specific event to occur to initiate potentially lethal engagement of a target. Such occurrences could be driven by notification of a high value, hostile asset being targeted. The target can, in principle, be either airborne or ground/sea based. Missions can include defense of an airborne platform by its escorts (for example, AWACS or E2C defense); intercept of incoming hostiles from a combat air patrol station; or ground attack of time-sensitive, hostile forces from a forward loiter location. This requirement stresses the ability of the aircraft to engage rapidly while already in the air. This is not strictly an availability requirement since it also involves aircraft engagement capabilities. The concept behind the requirement involves, for example, situations in which a number of aircraft from an air combat unit are already airborne and ready to provide point defense. This could also apply to air-to-surface missions where a number of aircraft are maintained in a holding orbit with a predetermined ordnance load to be able to react rapidly to time-critical targets. In terms of stressing availability, this requirement is more effective when the type of situation described in the requirement is part of a set of situations that a larger unit (such as a squadron or a wing) is expected to be able to execute.

REQUIREMENT GUIDANCE (3.1.5.2.4.2)

Blank 1. Identify the missions to which this requirement applies. This should relate to, and cross reference, a role and mission in 3.1.1 Roles and missions to provide the necessary situations and other data bearing on the requirement.

Blank 2. Number of aircraft in the flight.

Blank 3. This requirement is intended to provide an envelope for weapon release.

Blank 4. The type of target being attacked. It may be a single target or a target array.

Blank 5. The source of the information. Criteria should address the timeliness of the information and whether or not in-flight updates will be available. Reference to the C^4ISR portion of the 3.4 Interfaces section should be included.

Blank 6. The relative location of the target from the airborne location at the time of detection.

Blank 7. If the target is mobile and lethal, the intent is to engage the target prior to the target being able to release ordnance at a friendly entity.

Blank 8. The location of the friendly entity being protected.

Some high-value targets are not lethal in themselves. Other targets are, but the requirement may be to destroy the hostile target even after it releases weapons. In these circumstances, tailor the requirement statement to remove blanks 6 and 7.

REQUIREMENT LESSONS LEARNED (3.1.5.2.4.2)

To Be Prepared

4.1.5.2.4.2 Engagement from loiter location verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission a	Exit loiter location and enter lethal engagement envelope before target(s) can enter their lethal engagement envelope(s) against friendly entities as specified in 3.1.5.2.4.2 (pass/fail)	A,S	A,S	A,S		S,T
Mission b	Exit loiter location and enter lethal engagement envelope before target(s) can enter their lethal engagement envelope(s) against friendly entities as specified in 3.1.5.2.4.2 (pass/fail)	A,S	A,S	A,S		S,T
Mission …	Exit loiter location and enter lethal engagement envelope before target(s) can enter their lethal engagement envelope(s) against friendly entities as specified in 3.1.5.2.4.2 (pass/fail)	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.5.2.4.2)

This is a campaign-level requirement and is difficult to demonstrate short of actual use or full-scale exercises. In general, requirements at this level are verified through campaign-level analysis and simulation starting with specified performance values, progressing through predicted values, and finally using real performance data from actual testing of lower-level system elements. The type and scope of verification activities should be based on an established methodology for predicting mission capable rate.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of the air system design concept(s) indicates system requirements have been decomposed to lower-tier requirements. Analysis of simulations of lower-tier requirements indicate the design’s potential to achieve target acquisition with the required Pk before the target can enter their lethal envelope under the stated conditions.

PDR: Analysis of preliminary system designs and simulations, using analytically predicted measures of performance, indicates that the system can achieve the required Pk against the target before the targets reach their lethal envelope under the stated conditions.

CDR: Analysis of detailed system designs, and system-level simulations using predicted measures, confirms that the system can achieve the required Pk against the target before the targets reach their lethal envelope under the stated conditions.

FFR: No unique verification action occurs at this milestone.

SVR: System-level simulations, based on measured performance of lower-level system elements and, where applicable, specific system-level testing, confirm that the system can achieve the required Pk against the target before the targets reach their lethal envelope under the stated conditions.

Sample Final Verification Criteria

Engagement from ground/deck basing capability shall be verified through ___(1)___ analyses, and ___(2)___ simulations utilizing data obtained from performance testing of the lower-level system elements, and ___(3)___ system-level tests, for the conditions specified.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.5.2.4.2)

To Be Prepared

3.1.5.3 Availability

The system shall be able to conduct the missions in table 3.1.5.3-I within the availability, utilization, and conditions described therein.

TABLE 3.1.5.3-I. Mission availability, utilization, and conditions.

Mission	Utilization Rate	Availability	Conditions

REQUIREMENT RATIONALE (3.1.5.3)

Establish that the system is available to conduct the missions indicated. This requirement is particularly useful for those systems developed to conduct missions of long endurance and may or may not have a daily demand on a per air vehicle basis. This requirement can be used in characterizing cargo/transport, bomber, reconnaissance, or other long-endurance missions.

For some systems and missions, it is possible that a sortie rate or other requirement from sections 3.1.5.1 Peacetime operations and 3.1.5.2 Wartime operations could have been used as well for the same mission. Specification developers are encouraged not to pick two different sets of parameters for the same mission, scenario, and other conditions.

However, tailoring the requirements can lead to some useful characterizations. For example, assume a nonstressful or only moderately stressful sustained sortie rate. Artificially increasing the sortie rate beyond what is needed simply to capture the need to ensure some number of air vehicles is available on short notice places additional (and artificial) demands on the maintenance system. This results in excessive allocated requirements and more costly solutions. Thus, it may be appropriate to require a sortie rate (or some other utilization parameter) in addition to keeping some number of aircraft in a ready-to-launch status.

REQUIREMENT GUIDANCE (3.1.5.3)

The availability expected will vary with the utilization rate demanded. This will normally be a function of the expected state of readiness, which is contingent on conditions of peacetime, war, and conditions other than war. For some systems, there may be little, if any, difference. Where there are differences for the same mission, add lines in the table.

Guidance for completing table 3.1.5.3-I follows:

<u>Mission</u>: Identify the mission to be conducted. An explicit reference to 3.1.1 Roles and missions will be necessary to characterize the conditions.

<u>Utilization Rate</u>: For the mission and its associated operating conditions, identify the expected utilization rate. This is frequently expressed as flight hours/sorties expended or missions attempted per system during a specific interval of calendar time.

<u>Availability</u>: The scope of this parameter will vary depending on the system being developed. For example, some systems (for example, reconnaissance systems) may depend on a control station. That is, both the air vehicle and the control station should be functioning properly for the system to be available. Sometimes a control station will be developed in concert with the air vehicle and sometimes an existing control station will be utilized. The preferred approach would be to use the combined readiness of both the air vehicle and the control station if both are developed as part of the system. If an existing control station will be utilized, either the combined availability or just the air vehicle's availability can be used. The advantage of using the combined availability lies in ensuring that the air vehicle is available when the control station is available. In other words, it is a timing issue. Great care must be taken to ensure that, for an existing control station, the availability of the combined assets does not exceed that of the already developed control station.

Availability (Ao) is a measure of the degree to which an item is in the operable and committable state when the mission is called for at any random point in time. Availability is dependent on reliability, maintainability, and logistics supportability (the degree to which planned logistics support [including test, measurement, and diagnostics equipment; spares and repair parts; technical data; support facilities; transportation requirements; training; manpower; and software support] allow meeting system availability and wartime usage requirements). Frequently, the measure used for peacetime conditions is mission capable rate and for wartime, utilization rate. Since the intent of this requirement is to capture missions being conducted while maintaining a given level of capability, both parameters are needed.

Conditions: Fully describe the conditions and assumptions used in crafting the other requirements. Conditions include whether availability measures flight availability (Is the measure that of a single air vehicle or is it the measure of a flight of two or more air vehicles needed to perform a given mission?). Other conditions include whether control station availability is a factor in the availability described in those circumstances when a control station is essential for the conduct of a mission (for example, a ground control station for an unmanned air vehicle). If so, a description of the ground station will be necessary, as well as its critical operating characteristics (for example, its availability). Where an existing ground station is identified, a reference to the appropriate interfaces in section 3.4 Interfaces (such as C^4ISR) will be necessary.

REQUIREMENT LESSONS LEARNED (3.1.5.3)

To Be Prepared

4.1.5.3 Availability verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Availability	Table 3.1.5.3-I, column 3	A	A	A	A	A

VERIFICATION DISCUSSION (4.1.5.3)

Availability verification is the result of a series of efforts/tasks structured to provide increased insight into the attributes of the design, rather than the results of any single test or demonstration. Different elements composing the air system may have different phases or times associated with phases and functions. At the air system level, verification activities must encompass all of the air system's constituent items, to include, as appropriate, systems, subsystems, and equipment. Verification must also address air system operations and all levels of maintenance, from organizational through depot. The verification of this requirement is highly dependent upon the verifications conducted for mission reliability, integrated combat turn, diagnostics, and supply support.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Preliminary analysis indicates design concepts are compatible with the requirement based on systems design, mission reliability, maintenance and supply support concept, levels of redundancy, reconfigurability, resource sharing etc., and preliminary subsystem-level reliability and maintainability predictions (and subcontract requirements, where available). Measurement and growth management of availability requirements have been integrated into the program.

PDR: Analysis indicates preliminary design is compatible with the requirement based on systems design, mission reliability, levels of redundancy, reconfigurability, resource sharing, etc., and preliminary subsystem-level reliability and maintainability predictions (and subcontract requirements, where available). Initial availability math model is developed.

CDR: Analysis of the final design confirms compliance with the requirement. Predicted availability has been updated to include test results (where appropriate), as well as changes to the mission profiles, mix ratios, required functions, and maintenance concept.

FFR: No unique verification action occurs at this milestone.

SVR: Availability analysis/model and associated predictions updated and include changes based on test and demonstration results, as well as changes to the maintenance concept (changes to scheduled or on-demand maintenance, etc.). Analysis of all information confirms availability requirements for System Development and Demonstration (SDD) have been met. Projections/estimates for production have been updated and provide a high degree of confidence that produced systems will provide the specified levels of availability in field/deployed use.

Sample Final Verification Criteria

The availability requirement shall be satisfied when ___(1)___ analysis of test data generated during the ___(2)___ meets or exceeds the specified availability requirement.

Blank 1. Specify the scope and type of analysis to be performed utilizing the availability math model.

Blank 2. Specify the test period (ground and/or flight) during which the air system availability performance will be measured for compliance.

VERIFICATION LESSONS LEARNED (4.1.5.3)

To Be Prepared

3.1.5.4 Integrated combat turnaround (ICT) time

For the ___(1)___ mission, the elapsed time required to conduct an ICT starting with a mission-capable air vehicle shall not exceed ___(2)___ when the vehicle is equipped with the assets and quantities identified in table 3.1.5.4-I. These requirements shall be met under ___(3)___ conditions. Timing begins when ___(4)___ and ends at pilot/UAV controller acceptance. Integrated combat turnaround time ___(5)___ includes time needed for general servicing, replacement of mission data, and replacement/replenishment, as appropriate, of needed fluids, gases, and agents.

The system shall meet all the stated requirements during ___(6)___, using ___(7)___ power and ___(8)___ shelters.

The above requirements shall be met for ___(9)___ ICTs. The system shall be capable of ___(10)___ simultaneous ICTs.

TABLE 3.1.5.4-I. Items and quantities for integrated combat turnaround.

Item	Quantity at Start	Quantity at End	Remarks

REQUIREMENT RATIONALE (3.1.5.4)

The ability to return an air vehicle to mission readiness is a critical factor for combat air vehicles, especially fighter air vehicles. This requirement establishes the maximum time it will take the system to fully arm and ready a combat air vehicle for another mission immediately after it has returned to base from a previous mission.

Sortie rate requirements can be used to help determine a time allowed for turnaround of a combat air vehicle based on nominal conditions (average rates, squadron or larger size pool of air vehicles from which to draw, etc.). They do not, in themselves, assure that all critical system capabilities are achieved. Five-day, ten-day, or thirty-day average sortie rates do not communicate critical conditions that demand air power immediately, not in xx hours. For example, if a twelve-hour operating day and a 3-sortie-per-day requirement is set as the turnaround requirement, the required time would be 5 hours assuming a one-hour mission duration. Such a fallout capability may be unacceptable for some types of systems and operating conditions especially for lead elements deployed to counter “surprise” hostile actions and in high-intensity combat situations. At the same time, this requirement can be a significant design (and cost) driver. It should not be applied arbitrarily. The most operationally flexible time is near-instant turnaround, which is clearly unachievable and prohibitively expensive. The objectives in establishing this requirement should be to determine what is desired, to assess the design and cost impacts, and then to examine excursions that relax various portions of the requirement. Then, assess conditions to determine the costs and effectiveness of the alternatives, and select the most reasonable (satisfies the warfighter and is affordable) alternative requirement/ conditions.

REQUIREMENT GUIDANCE (3.1.5.4)

Blank 1. Enter the mission and organization. A reference to the pertinent content of paragraphs 3.1.1 Roles and missions and 3.1.2 Organization should also be included.

Blank 2. Enter the maximum allowable turn-around time. This time is usually expressed in minutes.

Blank 3. Enter the environmental factors, including chemical and biological, under which the performance is to be satisfied. Sometimes, different performance numbers are specified under different environmental conditions. A reference to program-specific source material can be used provided that material is intended for contractual application.

Blank 4. State the conditions under which the clock starts.

Blank 5. State whether general servicing and replacement of fluids, gases, agents, and mission data must be accomplished within the required time. Suggested approach is to delete blank 5 if the actions are to be part of the turnaround and must be completed within the time specified in blank 2. If such tasks are not included, enter “does not” in blank 5.

Blank 6. Clearly define the portion of the air system to which the ICT applies. It is also necessary to specify limitations on simultaneous actions. For example, is refueling with engine operating an allowed condition? Is turnaround maintenance or other interface between a UAV and its control station required?

Blank 7. State the requirements for an APU or external power source, if permitted.

Blank 8. State whether any or all actions are to take place within a shelter.

Blank 9. Indicate to what conditions the performance numbers apply. There are two different sets of conditions under which times may be specified. A hot ICT is one in which refueling is performed with air vehicle propulsion engine(s) operating (provides an instantaneous taxi capability). A cold ICT is one in which refueling is performed with the Auxiliary Power Unit (APU) and air vehicle propulsion engine(s) not operating. If both conditions are significant and the time (blank 1) is different for each condition, then this requirement will need the following adjustments:

Repeat the requirement if quantities, crews, or support equipment is different; or
Delete the last sentence (“The above requirements ....”), and use language such as “XX minutes for a hot ICT and YY minutes for a cold ICT” in blank 1 when the remaining conditions (blanks) have the same content for either ICT condition.

Blank 10. Define the number of simultaneous ICTs that the organization (identified in blank 1) is required to be capable of conducting.

Table 3.1.5.4-I can be used to specify the items and quantities which must be replenished during an integrated combat turnaround. The requirement must state all conditions under which the turn-around time is to be demonstrated. Table 3.1.5.4-I may be expanded to identify

different sets of equipment available for different turns. For example, Mark 84 bombs, laser guided bombs, ammunition, pallets, renewable sensors, etc. Nominally, table 3.1.5.4-I identifies an item to be replenished (fuel, 20-mm ammunition, sonobouys, etc.), the quantity of that item on-board the air vehicle at the start of the combat turn, and the quantity of that item on-board the air vehicle at the end of the combat turn. Note that for some items (for example, air-to-air missiles), it may be appropriate to specify a number. For other items (for example, fuel, 20-mm ammunition) it will probably be more appropriate to specify a percentage (for example, fuel quantity at start of 20 percent internal fuel or quantity at end of 100 percent internal fuel), since the absolute values are high depending on the actual design. In the remarks column, identify any restrictions or limitations on what equipment and people may be used, as well as other limiting conditions and factors.

REQUIREMENT LESSONS LEARNED (3.1.5.4)

To Be Prepared

4.1.5.4 Integrated combat turnaround (ICT) time verification

Requirements Element(s)	Measurand	SFR/ SRR	PDR	CDR	FFR	SVR
Time to complete a cold ICT	Minutes		A	A		A,D
Time to complete a hot ICT	Minutes		A	A		A,D
Simultaneous ICTs	Number		A	A		A,D

VERIFICATION DISCUSSION (4.1.5.4)

The integrated combat turn requirement stresses the ability to service the air vehicles (and where applicable, UAV control stations) and conduct corrective maintenance in a very short, defined time interval. Mission scenarios are usually defined that indicate the amount of fuel, types and quantities of weapons to be loaded, etc., during the ICT. Cold and hot ICTs are indicated in order to determine methods to be used to perform the servicing and maintenance. Simultaneous ICTs indicate the number of air vehicles that simultaneously undergo the ICT, which somewhat dictates the quantity of both support personnel and equipment required to service the air vehicles (and applicable UAV control stations). If multiple missions are to be verified, it is typically appropriate to evaluate the worst-case scenario that would drive ICT requirements.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: No unique verification action occurs at this milestone.

PDR: Analysis indicates that the various scenarios define the preliminary quantity and type of support equipment required, as well as the manpower requirements to achieve the ICT requirement.

CDR: Analysis of the updated design of the air system indicates that the ICT can be achieved.

FFR: No unique verification action occurs at this milestone.

SVR: Analyses of lower-level design and test/demonstration data, along with any system-level demonstrations performed, confirm the air system is capable of achieving the ICT requirement with the support equipment and personnel specified.

Sample Final Verification Criteria

The integrated combat turnaround (ICT) time requirement shall be satisfied when ___(1)___ analyses and ___(2)___ demonstrations confirm the ICT can be performed in the allotted timeframe and under the scenarios and conditions specified.

Blank 1. Identify the type and scope of analyses required to provide confidence that the requirement elements have been satisfied.

Blank 2. Identify the type and scope of demonstrations required to provide confidence that the requirement elements have been satisfied. Typically, demonstrations address the worst-case scenario(s) that would drive ICT requirements.

VERIFICATION LESSONS LEARNED (4.1.5.4)

To Be Prepared

3.1.6 System dependability

This is a paragraph header facilitating document organization.

3.1.6.1 Mission reliability

Mission reliability, the ability to conduct and complete mission tasks once committed to a mission, shall be as shown in table 3.1.6.1-I for the missions and scenarios identified.

TABLE 3.1.6.1-I. Mission reliability.

Scenario	Mission	Mission Reliability

REQUIREMENT RATIONALE (3.1.6.1)

Mission reliability (the ability of a system to complete its planned mission or function) is a critical factor in mission planning and accomplishment. It captures the ability of the system to maintain mission capability from commitment of the air vehicle to the mission until the completion of the mission tasks. Typically, completion of the mission tasks includes the delivery of weapons on assigned targets, completion of surveillance of assigned areas, delivery of cargo to intended locations, and maintaining offensive or defensive presence for a given duration or mission such as combat air patrol or air escort. Mission reliability is a direct input into mission planning systems to determine how many aircraft are needed to achieve a given level of destruction, or cargo delivery, or defense of airspace. For many air vehicle types, missions, and employment tactics, mission reliability of a single air vehicle may be a determining factor in whether the other flight elements continue the mission. In other words, if one aircraft aborts, others may be forced to abort depending employment conditions (such as single ship, two ship, multi-ship employment), tactics, and requirements for multi-air vehicle cooperation.

For some types of systems/missions, mission reliability is a measure of the air vehicle, air vehicle operations and other elements such as an unmanned air vehicle and its control station. For example, when the control station of a UAV is inoperative, the mission cannot be completed. This situation can be further complicated if there are multiple control stations, each with a given capacity that may be able to take over control of in-flight vehicles in the event that one of the control stations breaks. Other systems may depend on control stations for information processing and dissemination, and the cooperative capabilities of both may be mission essential.

Mission reliability drives equipment reliability at lower levels of the system architecture, including requirements for inherent reliability and redundancy.

REQUIREMENT GUIDANCE (3.1.6.1)

Guidance for completing table 3.1.6.1-I follows:

Scenarios and Missions

Since mission reliability captures the ability to maintain mission capability, identification of scenarios and missions becomes critical in ascertaining what air vehicle functions are essential. As development progresses, mission-essential subsystems will be identified. The development of the mission reliability requirement necessitates an understanding and definition of the employment and deployment conditions of the system, for all identified missions, at worldwide locations, in intended operating environments. Mission reliability is mission dependent. Thus, degradation of any subsystem below minimum acceptable performance results in a lack of mission reliability. Such an occurrence can be compensated for via subsystem redundancy and/or redundancy of critical items within the subsystem.

The scenarios and missions have been defined elsewhere in this system specification guide (3.1.1 Roles and missions). A reference to the scenario and mission information is sufficient in the “scenario” and “mission” columns. Use multiple rows for each scenario and mission combination. Ensure that the mission column (either explicitly or in the referenced paragraph) provides sufficient ground rules on air vehicle employment. Mission reliability is specified for the air vehicle or air vehicle and “other element” combination. Flight reliability should not be used. However, it must be evaluated in determining what the mission reliability should be. Thus, if we expect (in the case of a fighter aircraft) that both aircraft either operate together or abort together and the requirement is that the two aircraft will remain mission capable 98 percent of the time, then the mission reliability for a single air vehicle would be specified as “0.99.” Note, again, that parameters such as “mean time between mission-critical failures” are not recommended. Such duration-dependent parameters can be useful when specific mission durations are known. However, use of duration-independent parameters is preferred in the system specification to allow greater latitude in defining air vehicle requirements. Some knowledge of the mission duration will, however, be needed in defining the appropriate mission reliability to specify.

Specifying mission reliability for an air vehicle is preferred. Unmanned air vehicles are a special case. If the control station (either air, ground, or ship based) has already been developed, specifying the mission reliability for the UAV (that is, the air vehicle) is preferred. If the control station is being developed along with the UAV, there are options depending on the capability expected from the controlling station. For example, if there is one control station for each UAV, then specifying mission reliability for the combination of the control station and UAV would provide the greatest latitude in decomposing the mission reliability and allocating it to appropriate equipment. If the control station controls multiple UAVs or another control station can assume control of the UAV in the event of a control station failure, then specifying the mission reliability of both the control station and the UAV may be the preferred approach. If the mission reliability includes both the UAV and the control station, this fact must be noted in the mission column (along with the mission reliability expected) and sufficient information (such as employment ground rules, etc.) must be available in the description of the mission referenced.

Mission Reliability

There are three basic choices in the selection of a parameter to use for mission reliability.

Mean Time Between Critical Failures (MTBCF). The average time between failures, which prevents a system from performing its primary function. This is a useful parameter to characterize, but in the context of a system specification, it is not a good choice. In concept, specific mission durations will not be established until specific mission profiles are established. This includes a complete representation of the mission, including air vehicle-weapon combination impacts on target acquisition, target acquisition profile, delivery profile, speeds throughout all the profiles, and other related parameters. Such definition will not be available until the air vehicle specification, and possibly lower-tier specifications, are finalized including associated timelines. It is a good parameter for assessments, but not a good choice in setting a requirement. Additionally there are ambiguity problems in characterizing this parameter when mission-critical systems are redundant. For example, when two (or more) items capable of performing the same function are incorporated in the design and the air vehicle will not be committed to the mission unless both are operating and one fails in-bound to the target. The mission would not be aborted but the air vehicle will be considered to have a mission-critical failure.

Break Rate (BR). The percent of time an aircraft will return from an assigned mission (or where applicable, a UAV control station will complete a mission) with one or more previously working systems or subsystems on the mission-essential subsystems list (MESL) inoperable. While this is an important parameter, it is a poor choice for a system specification. Break rate impacts are already addressed by inclusion of sortie rate requirements. Break rate provides no insight as to when the break occurred (for example, in-bound versus out-bound) or whether the break occurred in a redundant system. It may be useful in assessments but is not an appropriate choice for a system specification requirement.

Operational System Reliability (OSR). The probability that a given system, initially in mission capable status, will successfully complete its designated mission or function. This is the parameter of choice for a system specification. The intent of this section is to define the system requirements impacting mission success. OSR feeds the mission planning system, avoids ambiguity in mission success determination, allows redundancy in mission-critical subsystems as a possible solution, and handles cooperative reliability conditions (such as air vehicles that rely on a successfully operating ground station).

While operational system reliability is the most appropriate choice for use in a system specification, this choice should not imply that the other parameters are unimportant. For example, preliminary assessments of break rates will be needed to set the sortie generation requirements and to confirm they can be feasibly achieved. Trade studies should be conducted both before and after the system specification is established on the costs of redundancy, maintainability, and reliability. The concern here is to capture the best parameter to satisfy the warfighter and to provide our contractors with sufficient latitude to define and design a solution. Of the three parameters, operational system reliability does this the best.

REQUIREMENT LESSONS LEARNED (3.1.6.1)

Mission reliability is a critical factor to ascertain the amount of resources required for a given job. Force sizes are decreasing. Achieving high productivity from the force is necessary. There have been circumstances when more aircraft are assigned to missions and operated than are actually needed to accomplish mission tasks simply to ensure that enough aircraft arrive in the combat area with the capability to conduct those tasks. Over-assigning aircraft to missions to compensate for low mission reliability must be avoided.

4.1.6.1 Mission reliability verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission Reliability	Table 3.1.6.1-I, column 3	A	A	A	A	A

VERIFICATION DISCUSSION (4.1.6.1)

Mission reliability verification is the result of a series of efforts/tasks structured to provide increased insight into the attributes of the design, rather than the results of any single test or demonstration. Different elements composing the air system may have different phases or times associated with phases and functions. At the air system level, verification activities must encompass all of the air system’s constituent items, to include, as appropriate, systems, subsystems, and equipment, and must address air system operations and all levels of maintenance, from organizational through depot.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analyses indicate the design concept is compatible with the requirement based on systems design, maintenance concept, levels of redundancy, reconfigurability, resource sharing etc., and preliminary subsystem-level reliability predictions (and subcontract requirements, where available). Mission profiles (and mission mix) associated with peacetime and wartime have been defined adequately to enable design refinement (design for life). Functions required for each mission have been defined. Estimated reliability values by function, or hardware (whichever is available) are applied to mission reliability model/analysis. Verification/validation of reliability levels (whether numerical or levels of detail) at program milestones are agreed to. Verification test methods, and acceptance criteria based on employment of agreed-to verification method(s), are incorporated into schedules, facilities requirements, manpower needs, and other programmatic imperatives. Measurement and growth management of mission reliability have been integrated into program management.

PDR: Analyses indicate the preliminary design is compatible with the requirement based on systems design, levels of redundancy, reconfigurability, resource sharing etc., and preliminary subsystem-level reliability predictions (and subcontract requirements where available). Functionally based mission essential subsystem list (MESL) provides links between functions required for missions, and maintenance checklists are developed and coordinated (preliminary MESLs developed for each part of the air system; that is, ground stations, aircraft, etc. required for complete functionality). Required functions have been associated with supporting hardware elements. Mission reliability analysis properly integrates integrity analysis (hardware durability and life estimates). Models and analysis have been updated based on changes in functionality, criticality, mission profile(s), mission mix and maintenance concept. Predicted mission reliability has been updated to include subcontractor information. Analysis/modeling correctly integrates mission reliability into higher-level requirements and analysis methods (effectiveness metrics, availability, etc.).

CDR: Failure modes effects and criticality analysis (FMECA), mission reliability, and reliability centered maintenance analyses are accomplished based on detailed design analysis. Predicted mission reliability has been updated to include test results (where appropriate) and usage of life-limited items. Functional MESL has been updated. Functions resolved into supporting hardware elements and supported by a FMECA (or acceptable like analysis) address interconnectivity between hardware and functions. FMECA addresses internal failures of the system as well as input failures to those same systems. Mission reliability analysis/modeling is updated as necessary to reflect changes to the mission profiles, mix ratios, required functions, and maintenance concept. Analysis/modeling correctly integrates mission reliability into higher-level requirements.

FFR: FMECA, mission reliability and reliability centered maintenance analyses are accomplished based on detailed design analysis. All scheduled or on-demand maintenance is planned and accounted for in reliability estimates. Mission reliability analysis/modeling and associated predictions are updated as necessary to reflect incorporation of test results and any changes to the mission profiles, mix ratios, required functions, and maintenance concept. This includes the effects of diagnostics/maintenance/inspection requirements required to identify the presence of any mission- or safety-critical malfunctions. A functional MESL has been agreed to for maintenance release-to-fly. FMECA is completed for all systems (at the hardware level) provided on flight test aircraft. FMECA addresses all interconnectivity of hardware and functions providing traceability of the failure propagation throughout and across subsystems. Effects of failures deemed to be critical via FMECA or subsystem safety hazard analysis (SSHA) are addressed in pilot and maintenance technical orders. Analysis/modeling correctly integrates mission reliability into higher-level requirements.

SVR: Agreed-to MESL accounts for any disparities or changes resulting from incorporation of test information. Adjustments for results of flight-test information (BIT codes, compensating provisions, etc.) and other testing results are incorporated into the FMECA. Mission reliability analysis/model and associated predictions are updated (must reflect design as described via FMECA) and include changes based on test and demonstration results, as well as changes to the maintenance concept (changes to scheduled or on-demand maintenance, etc.). Analysis of all information confirms mission reliability requirements for SDD have been met. Projections/ estimates for production have been updated; these give a high degree of confidence that produced systems will provide specified levels of mission reliability in field or deployed use. Analysis/modeling correctly integrates mission reliability into higher-level requirements.

Sample Final Verification Criteria

The mission reliability requirement shall be satisfied if analysis of test data generated during the ___(1)___ meets or exceeds the specified mission reliability requirement. Evaluation of demonstrated reliability performance of air system functions (phase of mission for which each function is required) is defined in the mission reliability math model. Failure relevancy shall be determined in accordance with the ___(2)___.

> Blank 1. Specify the test period (ground and/or flight) where the air system mission reliability performance will be measured for compliance.
>
> Blank 2. Include performance conditions that constitute a failure relevant to the mission reliability requirement. Also include the process by which the data are scored for relevancy.

VERIFICATION LESSONS LEARNED (4.1.6.1)

Mission reliability incremental verification does not occur through any one test or demonstration but rather through the results of efforts/tasks structured to provide increased insight into the attributes of the design. This is accomplished through a series of efforts and combined through analysis to ensure insight at the appropriate levels for management of the design refinement and acquisition process. Mature mission reliability is seldom achieved prior to SVR. Consequently, the metric to be demonstrated at this point in the program should be degraded and consistent with the logistics reliability requirement and systems design for this same period of measure.

Mission reliability is a performance parameter centered about the dependability of the air system. In this sense, dependability is a measure useful to command (mission planning and force size) as well as to pilots (ability to get through mission and compensating provisions in the event of a failure). There are a number of ways to verify the requirement. One method is an actual demonstration. If a demonstration is to be undertaken, then the number of sorties and aircraft (observing the number of aborted missions) must be determined so that an acceptable confidence level can be agreed on. Another method involves modeling based on estimates, achieved performance, and an acute understanding of the systems and interactions of subsystems (usually requiring a previously agreed-to mission reliability model and FMECA for an accurate understanding of subsystems interactions and allowing for pilot compensatory actions).

Mission reliability planning may be inherent/incorporated in master planning and scheduling delivered as contractual documents. However, these master planning documents generally do not describe interrelationships (unless CPM or PERT is used) critical to performing the defined roles and missions in a manner which provides sufficient insight into progress and results of activities/tasks. Therefore, unless CPM or PERT (or some like process/analysis) is used as a development tool for the master planning, it is suggested that additional planning documents be developed to describe these interrelationships for all stages/phases of the program. This also ensures sufficient insight is provided into actual vs. planned performance vs. schedule (milestones), and the resulting implications to effectiveness measures, cost (aborted missions and training), etc. have been integrated into management. Note: all areas impacted and the extent of impact by virtue of not meeting specification levels of mission reliability at the appropriate milestone within the program are inherent parts of program management.

The level of detail expected in design analysis varies with the milestone, phase of program, complexity of item/system, and the rate of change of technology. In this regard, one would expect a detailed landing gear design long before a detailed avionics design.

Design analysis, throughout the program, must show the design is compatible with the requirements based on systems design, levels of redundancy, reconfigurability, resource sharing, etc., subsystem-level reliability predictions (subcontract requirements, where available) and any modifications. If this is not true, immediate action must be taken to address the shortfall to determine acceptable alternatives, including the possible reduction in requirements (all other impacts of such changes must be well understood before making recommendations to reduce requirements, or requirement levels).

3.1.6.2 System survivability

This is a paragraph header facilitating document organization.

3.1.6.2.1 Mission and one-on-one survivability

The air system shall meet or exceed the probability of survival specified in table 3.1.6.2.1-I for the missions, scenarios, vignettes, mission phases, and conditions shown.

TABLE 3.1.6.2.1-I. Mission survivability.

Mission	Scenario	Vignette	Mission Phases	Probability of Mission Survival	Conditions

The one-on-one survivability of the air system shall meet or exceed the one-on-one probability of survival specified in table 3.1.6.2.1-II for the missions, scenarios, vignettes, mission phases, threats, and conditions shown.

TABLE 3.1.6.2.1-II. One-on-one survivability.

Mission	Scenario	Vignette	Mission Phases	Threat	Probability of One-on-one Survival	Conditions

REQUIREMENT RATIONALE (3.1.6.2.1)

The system must be survivable in threat environments. Lack of survivability erodes a force's capability to continue operations. Loss rates that may seem small for single missions become staggeringly large when viewed over time. For example, at three sorties per day for 10 days, less than 74 percent of the aircraft would be expected to remain at an average of one loss per hundred sorties and less than 55 percent at an average of two losses per hundred sorties. If the flight demand increases to four sorties per day, the remaining force is reduced to less than 67 percent at the end of 10 days, which is an average of one loss per hundred sorties. It is further reduced to less than 45 percent at the end of 10 days, for an average of two losses per hundred sorties. These loss rates are calculated using simple arithmetic (P_S^{Sr*t} where P_S is the single sortie probability of survival, S_r is the sortie rate and t is the number of days).

Over time, we would expect a force experiencing significant losses to take actions such as lethal suppression, tactical changes, and so forth to avoid such undesirable circumstances. At the same time, we do not necessarily expect a system to be self-survivable to the extent that it has no reliance on other systems. However, the actions a force can take are dependent on the inherent survivability of each system that composes that force.

Probability of survival is a useful measure that captures critical system requirements and also provides design flexibility. It allows trade-offs for and impacts specific characteristics such as mission planning systems (ability to avoid the threat); communications (ability to share threat information between air vehicles in a flight or with external systems); training; observables; vulnerability; maneuver; speed; altitude; countermeasures effectiveness (including expendables capacity); and balances between target acquisition and weapon delivery effectiveness versus survivability in a hostile environment. The associated parameter (see requirement guidance provided below) of probability of survivable damage provides critical criteria for lower-level trade-offs regarding hardening versus threat avoidance. Further, it is coupled with battle damage repair requirements to provide maintenance capability criteria.

Mission survivability is complex and often argumentative. This requirement is structured to preclude the need for campaign assessments (which should serve as the basis for establishing the requirement initially). Campaign assessments involve very complex interactions between force elements. While these necessary factors must be addressed, the complexity of those interactions often precludes direct, verifiable assessments. Frequently, the debate deals with the capabilities of supporting assets such as jammers, escorts, and other elements necessary to the successful application of air power, and the relative success of friendly forces in achieving air superiority or air dominance, also considering the rate at which that may (or may not) occur. While such factors are crucial, they have a tendency to “swamp” the characteristics of the system being developed. The purpose of this requirement is to isolate survivability characteristics to the system being developed.

This requirement is structured in two parts. The first part encompasses the mission. Mission survivability can be viewed as an integration of one-on-one situations into the one-on-few, one-on many, few-on-one, few-on-few, and many-on-many situations that comprise the execution of the mission from a survivability perspective. The second part encompasses the one-on-one survivability for a particular mission phase that can be directly related to testable system characteristics. (Note: This is not intended to imply that all characteristics be tested in all situations. Testing all possible conditions against all possible threats can be cost prohibitive.)

REQUIREMENT GUIDANCE (3.1.6.2.1)

These requirements and definitions should be structured to enable a build-up to mission survivability from the one-on-one survivability characteristics. In structuring and defining this requirement, the specification developer needs to consider what is to be achieved in terms of measurable characteristics to be developed. Top-level considerations include:

The specification developer needs data from trade-off studies in order to assess what features enable mission achievement. The survivability vignette highlights these features. Typical design trade-offs are between air system capability such as speed, maneuverability, mission altitude, observables, countermeasures, and mission planning. These design studies are conducted to guide the development of a survivability vignette, not necessarily to specify the individual features of the design.

The specification defines employment and operational requirements that enable an air vehicle designer to quantify the needed degree of observables, the degree of countermeasures, and so forth.

The specification defines interactions among common air vehicles and support jammers and escorts air vehicles (for example, cooperative tactics) that are required to achieve survivability.

For some air vehicle types, exposure to threat environments will be infrequent. Consider the nuclear bomber force. It has yet to be used to conduct its primary mission. Its value as a deterrent is a function of the bomber's survivability and capability.

Cargo/transport aircraft may not be frequently called upon to transport troops, supplies, and equipment into hostile territory. But if they do, what are the consequences of lack of survivability? Tanker aircraft have a similar exposure concern. For an unmanned air vehicle, the survivability of its control station may be an issue. The need for and degree of inherent survivability is driven by the consequences of failing to achieve required mission and force objectives and the costs involved in achieving that survivability.

Although this specification guide deals with the survivability of the system being developed, the inherent survivability required is dependent on the use (or lack of use) of other force elements that can contribute to survivability. In setting system-specific survivability requirements, those other force elements should be taken into account.

Requirement Guidance for table 3.1.6.2.1-I:

Mission and Scenario: Identify the mission being conducted and the scenario in which it is conducted. This should include a reference to 3.1.1 Roles and missions.

Vignette: A vignette (sometimes referred to as a mini-scenario) can be viewed as a single mission portion of a campaign. A vignette is a two-sided situation that encompasses system employment conditions. It describes starting and ending conditions, the number of systems involved, their tactics and operating conditions, the targets and their location, the relationships between systems, factors of the natural environment (including weather conditions and terrain), conditions of the operational environment (including dust and smoke), and any other operationally significant factors. The mini-scenario must be sufficiently broad to assess the interactions between like air vehicles in the flight and accommodate the interactions with systems external to the flight, such as a UAV control station. Each vignette needed to define the system should be incorporated into the descriptions and conditions defined in 3.1.1 Roles and missions. A vignette can also have a variety of conditions associated with it that describe specific characteristics of air vehicle operations to be conducted.

A vignette used to explore candidate system definitions at the start of product definition phase is substantively different from that used in a system specification. At the start of product definition/ risk reduction phase, the focus is on defining a system solution. The system specification represents that system solution. Thus, the vignettes used in the system specification reflect the air vehicle and operational concepts needed.

Some specific survivability conditions to reflect in the vignettes include the overall threat distribution and density. For example, assume that the mission involves a single air vehicle penetrating enemy airspace at low altitude. Further, assume that the air vehicle enters the engagement envelope of only 10 threat systems out of the 100 threat systems in the overall scenario. The vignette must be sufficiently encompassing to ensure that the air vehicle's threat detection capabilities are not limited to just the 10 threat systems engaging it, but also the other 90 in the scenario. That is, the air vehicle's survival capability may be strongly influenced by its ability to assess the entire environment and focus pertinent survival equipment and operating modes on the 10 percent that reflect the danger to this mission.

Mission Phases: Identify the mission phases and appropriate operating modes for the air vehicles in the vignette. Phases can include (but are not limited to) launch, cruise, initiate penetration altitude and speed, long-range target area acquisition, ingress to terminal area acquisition point, terminal area target acquisition, ingress to target area, target acquisition/weapon delivery, repeat target acquisition/weapon delivery as needed, proceed to next target, and target acquisition/weapon delivery and egress. Mission phases should lay out the mission from end to end to accommodate the tactics employed to accomplish the intended purpose of the mission successfully. The intent is not to specify mission survival for each mission phase, but to define the conditions that affect survivability. For example, there may not be an end-game survivability concern from launch to the cruise point; however, depending on threat capabilities and air vehicle characteristics, that phase of the mission may provide warning of in-bound activity that impacts threat readiness state.

Probability of Mission Survival: Define the survival probability required and the kill category. The probability of mission survival used depends on many factors, all of which must be properly integrated.

Kill Categories: In terms of affecting the overall system capability, there are three basic aircraft kill levels. An attrition kill (called "A Kill" or "5 Minutes Kill") indicates that the air vehicle is lost to the inventory. That is, either the air vehicle has been shot down or the damage is too expensive to repair. A mission abort kill (called "B Kill" or "30 Minutes Kill") indicates that the air vehicle is unable to complete its mission but is capable of being repaired. A mission availability kill indicates that an aircraft can complete its mission but requires repair before being usable for another mission. There are others as well. For example, there is a forced-landing kill normally used for helicopters that indicates that damage forces the helicopter to land and repair is required prior to resuming flight. The following table is a collection of kill levels from various sources. Prior specifications used the typical kill level description. This approach constrains trade space and uses nominal design points. The alternative “Warfighter Objectives” approach is oriented toward needed capability, hence is the preferred method.

Kill level description/objectives:

Kill Level	Typical Kill Levels Description	Warfighter Objectives
Catastrophic (KK)	Damage which results in the immediate disintegration and loss of the air vehicle from inventory	Immediate removal of air vehicle and loss of air crew
Catastrophic (K)	Damage which causes the air vehicle to lose control within 30 seconds after being hit, resulting in loss of the vehicle from inventory	Sufficient time for air crew assessment, ejection decision, and ejection
Attrition (A)	Damage which causes the air vehicle to lose control within 5 minutes after being hit	Sufficient capability for the air vehicle to return to friendly forces
B	Damage which causes the air vehicle to lose control within 30 minutes after being hit	Loss of the vehicle from inventory
E	Damage which causes the air vehicle to sustain additional levels of damage upon landing which makes it uneconomical to repair.	Loss of the vehicle from inventory
Mission Abort (MA)	Damage which prevents the air vehicle from completing the designated mission kill.	Loss of successful sortie
Forced Landing (FL)	Damage (to rotary-wing or VSTOL air vehicle) that forces the crew to execute a controlled landing	Potential loss of the vehicle from inventory – powered landing. Loss of the vehicle from inventory – unpowered landing.
Prevent Take-Off (PTO)	Damage to an air vehicle on the ground which prevents the vehicle from taking-off.	Loss of successful sortie
Landing/ Recovery	Fall out of manned control while landing/recovering	Sufficient capability for the air vehicle to return to base/carrier

For mission and one-on-one survivability requirement, kill level has somewhat of a different scope. An attrition kill category directly affects the future sustainability of the force. From a mission effectiveness perspective, a mission abort category defines high value, time-critical jobs that must be completed. The selection of the category to use is dependent on the mission to be accomplished and the capabilities expected from the system as a whole. It can even depend on the number of systems being procured (for example, there may be a need to ensure that key, high value/high cost assets that are only procured in limited quantities are more damage tolerant).

Acceptable attrition. A robust survivability/vulnerability and sortie generation analysis prior to selecting specification requirements cannot be understated. It is essential to know and understand what is important to the missions being conducted. Additionally, every parameter specified in this area potentially has significant design consequences. Ensure that all the critical requirements and conditions are specified, but it will not be prudent to specify every parameter and condition that could be specified.

Consider two alternatives to meeting an arbitrary probability of survival. One alternative achieves its attrition kill criteria by not being shot at, but it is soft (high vulnerability). The other meets the same criteria by being able to withstand a lot of damage (low vulnerability). Both lose the same number of aircraft per mission, but the low vulnerability air vehicle requires a lot of battle damage repair capability. Which alternative provides better combat effectiveness? Is the second alternative (low vulnerability) an acceptable solution? If it is, use of A or B kill criteria with the provision for XX percent survivable aircrew in the event of loss may be sufficient. If the second alternative is not acceptable, then criteria relating to damage tolerance will also be necessary.

Percent of aircrews that must survive. The survival of aircrews in peacetime and wartime operations remains a concern. In general, as air vehicle survival increases, the aircrew survival increases. However, the ability of the aircrew to eject or survive a crash over water does provide a significant reduction in pilot losses. For UAV systems, control station operator(s) may need to be considered.

Probability of survivable damage or damage tolerance. Damage tolerance requirements can be communicated by mission availability kill, an acceptable damage-to-loss rate, or a probability of survivable damage. Consider mission availability kill versus damage-to-loss rate as a candidate requirement to specify. For example, arbitrarily assume that an attrition kill criterion was selected with an acceptable probability of survival of 0.98. Suppose, at that level of survival, we would be willing to accept a 0.04 probability of a returning aircraft not being mission available due to damage. Is this the same as specifying a damage-to-loss rate of 2? On the surface it is. But what if the designer delivered an aircraft that yielded a 0.99 probability of survival? Would 0.04 probability of a returning aircraft not being mission available due to damage be acceptable (a damage-to-loss rate of 4)? Clearly, it wouldn't be if damage-to-loss rate was specified. The designer did a good job by beating the survivability requirement. If only a 0.04 probability of a returning aircraft not being mission available due to damage is needed, don't saddle the designer with a damage-to-loss rate. For UAV systems, probability of survival for the control station may need to be considered.

Damage tolerance criteria also has levels. An aircraft could be damaged and not fixable within days (or weeks). Thus, if mission availability kill is used, a time interval also needs to be specified (for example, 0.96 probability of aircraft being mission capable within XX hours). This poses another problem, what if it takes longer? Is it considered an attrition kill? That is, using mission availability kill criteria can introduce ambiguity. Consider using a probability of survivable damage as a factor and let the rate of fixing (or not fixing) the damage be controlled by the aircraft battle damage repair requirement. Another alternative is to let this be a fallout capability at the risk of having unlimited damage. That is, if the designer delivered 0.98 probability of survival against an attrition kill category, are we willing to accept a solution that allows damage to all the surviving aircraft?

<u>Conditions</u>: Define the operational conditions and approaches applicable to the mission phase such as: aircrew-to-air vehicle interface, UAV to control station interfaces, weapon delivery requirements, self-protection capabilities, tactics and training, and threat capabilities. Survivability is also a function of the air vehicle (and where applicable, UAV control station) features, such as countermeasures (ECM effectiveness, expendables effectiveness and

quantity), threat avoidance capabilities, observables, vulnerability reduction, maneuver, speed, altitude, etc.

Assess aircrew/air vehicle or UAV/control station interface. Threat environments impose both stress and workload factors that, historically, have been shown to significantly influence survivability. An example is a pilot's (or control station operator's) ability to assess and react to threat warning information effectively while conducting other mission tasks (such as navigation, target acquisition, and weapon delivery). Situational awareness is also a contributor to survivability, provided such information is presented to an aircrew in an effective manner. The importance of such factors can be driven by the threat environment. Combat environments pose stressing demands to process (by machine and by the human) and effectively utilize real-time information. This includes information from friendly sources (such as that shared between air vehicles in the flight, or received from external sources such as AWACS) as well as information obtained from threat sources (for example, acquisition and tracking radars).

Assess weapon delivery requirements. High-speed aircraft weapon delivery may be less accurate and may require an increased number of weapon delivery passes. Each pass increases an air vehicle's probability of being damaged by enemy fire. Slower aircraft get hit more often on the first pass. High-speed delivery may result in fratricide.

Assess the effectiveness of self-protection from lethal threats.

Assess tactics used, both autonomously and cooperatively. Assess effectiveness and fidelity of combat training.

Assess threat density, capability, and readiness states. Threat assumptions must be defined in detail suitable for modeling and analysis.

Thus, the requirement under mission probability of survival could be stated as:

"___(1)___ probability of survival using ___(2)___ kill criteria with ____(3)___ percent survivable aircrew in the event of loss and ____(4)____ probability of survivable damage.

Blank 1. Specify the acceptable attrition kill level.

Blank 2. Identify the attrition kill criteria (for example, A or B).

Blank 3. Specify the percent of aircrews that must survive the attrition kill.

Blank 4. Identify the probability of survivable damage.

<u>Class of air vehicle considerations:</u>

Fighter/Attack class air vehicle: Consider using A or B kill criteria with a provision for XX percent survivable aircrew in the event of a loss. We expect surviving aircraft to recover and fly another mission. Thus, repairable damage is also important.

Bomber: For tactical missions, criteria for fighter/attack class aircraft could be appropriate. For strategic missions, both A or B kill criteria and mission abort kill criteria would be significant.

Tanker: Is the tanker intended to go in harm's way or is the intent to protect the aircraft in specific circumstances? If there is a threat, and the concept of operations does not provide for back-up or alternative tanker capability, a mission abort kill can result in loss of the aircraft to be refueled.

Cargo/Transport: This class of air vehicles poses a significant problem in criteria and condition selection. For example, we would frequently expect some capability to operate in forward areas near the battle area. Additionally, these air vehicles also conduct air drop missions for troops, supplies, and equipment. They are relatively few in number and high cost. Is the survivability requirement just to protect the air vehicle? What about the cargo?

Requirement Guidance for table 3.1.6.2.1-II:

Mission, Scenario, Vignette: Identify the mission being conducted, the scenario in which it is conducted, and the vignette that describes aircraft employment and other conditions. These are used to provide traceability between the one-on-one requirements and the mission survivability. If the mission survivability portion of this requirement is not used, or specific one-on-one situations are being specified that are not encompassed within the mission survivability requirement, see the descriptions for table 3.1.6.2.1-I.

Mission Phases: Identify the mission phase to be used in the one-on-one assessment. Mission phases are frequently associated with specific portions of a mission profile. For example, the one-on-one probability of survival will likely be different for an air vehicle during terrain-following during ingress, while performing a pop-up maneuver for stand-off target acquisition, or when executing a low-level/pop-up and dive/stand-off weapon delivery.

Threat: Identify the threat system. Threats can include aircraft as well as ground or sea-based defenses.

Probability of One-on-one Survival: Define the one-on-one survival probability required and kill category. Guidance on kill categories is provided above in the guidance for table 3.1.6.2.1-I. The conditions and factors described for table 3.1.6.2.1-I generally apply here, except for damage tolerance. At the mission level, probability of survivable damage provides a maximum allowed frequency of occurrence and drives survival parameters that involve denying threats an effective weapon launch capability (do not compensate by specifying a minimum probability of survivable damage at the mission level). This may not be sufficient if the air vehicle must also be hard (that is, low vulnerability). One-on-one survivability deals with probability of survival given an engagement. Denial of an effective threat weapon launch capability may shrink engagement envelopes and does impact one-on-one survivability. However, what happens when an effective threat weapon launch occurs? Does the aircraft need to be able to survive damage? If not, then define the one-on-one probability of survival and appropriate kill level against each threat expected. But if the aircraft must survive some level of damage, then damage tolerance criteria must also be specified to provide a minimum acceptable level of damage tolerance. Thus, the requirement under one-on-one probability of survival against the threat identified could be stated as follows:

"___(1)___ probability of survival using ___(2)___ kill criteria with ____(3)___ percent survivable aircrew in the event of loss and ____(4)____ damage tolerance.

Blank 1. Specify the acceptable attrition kill level.

Blank 2. Identify the attrition kill criteria (for example, A or B).

Blank 3. Specify the percent of aircrews that must survive the attrition kill.

Blank 4. Insert an expression of the damage tolerance capability expected.

Conditions: The conditions and factors described for table 3.1.6.2.1-I generally apply here.

REQUIREMENT LESSONS LEARNED (3.1.6.2.1)

Combat aircraft take hits, which cause damage. Some damage results in aircraft losses. Survivable damage drives maintenance. We prefer aircraft to return from missions even if damaged. Avoiding threats is safest but is not always consistent with mission objectives.

Realistic and effective training is a critical yet often neglected factor in achieving a survivable system. Making the right decisions at the speed of combat is often the determiner of system survival; for example, timing of a maneuver to avoid a missile. This is not a trivial problem, especially when multiple threats are present. Additionally, aircrews must fully understand (and be confident in) air vehicle capabilities. For example, does a missile-dodging maneuver put the aircrew/air vehicle at greater risk than relying on and exploiting other capabilities of the air vehicle? This ability is not realized in peacetime flying conditions. Historical information indicates that pilots who have combat experience have better odds for survival than those without such experience. That is one of the purposes of the Red Flag exercises. However, operational exercises conducted by the warfighters must not be the rationale for lack of attention to training in development. Those exercises should be looked upon as further refinement of aircrew capabilities rather than the basis for those capabilities.

4.1.6.2.1 Mission and one-on-one survivability verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mission survivability	Probability of mission survivability	A	A, S	A, S		A
One-on-one survivability	Probability of one-on-one survivability	A	A, S	A, S		A

VERIFICATION DISCUSSION (4.1.6.2.1)

Mission and one-on-one survivability is used to establish the integrated capability of the system for one-on-one survival.

Probability of one-on-one survival requires test data to support the following modeling functions:

a. System's ability to evade the threat (data required includes speed, altitude, maneuver, threat warning).

b. System's threat avoidance ability (data required includes detection range)

c. System's threat suppression capability (data required includes missile fly out and burst point).

d. Air vehicle vulnerability posture (data required includes engagement probability of kill).

Mission and one-on-one survivability is used to establish the integrated capability of the system for mission survival.

Probability of mission survival requires test data to support the following modeling functions:

a. System's ability to evade the threat (data required includes mission planning with multiple air vehicles, threat warning).

b. System's ability to avoid multiple threats (data required includes air vehicle test).

c. System's ability to suppress multiple threats (data required includes air vehicle test).

It should be understood that there are error bounds associated with any model. The accuracy of the model is highly dependent on the fidelity of the associated databases. These must be considered when evaluating the results from the use of such modeling and simulation.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: Analysis indicates that requirements are understood and flowed down and that any available data has been integrated into the modeling and simulation process.

PDR: Modeling and simulation of the preliminary design indicates mission and one-on-one survivability requirements can be met considering the error bounds of the models. Analysis indicates that available data has been integrated into the modeling and simulation process.

CDR: Modeling and simulation of the final design confirms mission and one-on-one survivability requirements can be met considering the error bounds of the models. Analysis confirms available data has been integrated into the modeling and simulation process.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of modeling and simulation results confirms the mission and one-on-one survivability requirements have been met and the models incorporate lower-level test results.

Sample Final Verification Criteria

The mission and one-on-one survivability requirement shall be satisfied when ___(1)___ analyses confirm achievement of the specified performance requirements.

Blank 1. Identify the type and scope of analyses required to provide confidence that the requirement elements have been met. This will include analysis of modeling and simulation, and results from any lower-level tests.

VERIFICATION LESSONS LEARNED (4.1.6.2.1)

To Be Prepared

3.1.6.2.2 Parked aircraft and ground support survivability

System items shall satisfy the survivability criteria identified in table 3.1.6.2.2-I.

TABLE 3.1.6.2.2-I. Ground survivability.

Item	Criteria	Conditions

REQUIREMENT RATIONALE (3.1.6.2.2)

Losing an air vehicle at a basing location is just as significant as an in-flight loss. Losses of key support assets may have as big an impact on system productivity as air vehicle losses.

Often neglected, air vehicles or UAV control stations are vulnerable when based and have no capability to defend themselves, avoid the threat, or employ countermeasures. Their capability to survive is based on specific attention to basing survivability issues addressed during development, plus whatever elements of the basing infrastructure they can utilize.

Survivability of supporting assets is not frequently considered. However, preventing air vehicles from flying by damage or destruction of system specific support assets such as UAV control stations can degrade productivity more adversely than air vehicle break rates.

REQUIREMENT GUIDANCE (3.1.6.2.2)

A number of mechanisms can be used to improve parked aircraft and ground support survivability. Some of them may become infrastructure issues, such as having hardened shelters. Some may be a combination of infrastructure and system specific issues, such as camouflaging support equipment, not all of which will be system peculiar. Others are system specific but may require infrastructure support. For example, it may be necessary to have revetments for systems capable of operating from forward areas. Still others may be system unique such as decoys, camouflage, and so forth.

In general, survivability of assets on the ground can be improved from nominal conditions by a variety of techniques including redundancy of key support assets, deception such as decoys, avoidance such as camouflage, concealment, reconstitution (repair of damaged assets), dispersal, and hardening. Adequate levels of survivability are determined by analysis of threat operations and the capability of the threat.

There are a number of ways of specifying survivability of assets on the ground. First, a “weight of attack” and “frequency of attack” condition can be specified along with an acceptable level of degradation in sortie generation capacity and recovery time. This is generally a starting point to address the impacts to the system. However, resolution of these impacts may not solely be a system-specific problem. Resolution of the survivability problems may be an infrastructure and/or air base operations issue that does not fall under the scope of the system being developed. For example, more and better hardened air vehicle shelters or air bases that afford better dispersal characteristics may solve the problem. Such solutions are, however, not frequently within the program scope of the system being developed. There are, however, actions that can be taken and appropriate requirements specified. The following information represents some of the characteristics that can be specified for many types of air systems. The requirements selected for use are dependent on system expectations and scope of development.

Requirement Guidance for table 3.1.6.2.2-I:

Chemical/Biological Attack

Item: Air system

Criteria: Acceptable level of degradation of sortie generation capability due to chemical/biological attacks and a maximum recovery time (including decontamination) back to full sortie generation capability

Conditions: Description of the chemical/biological threat, weight of the attack and attack frequency. This should include a reference to Roles and missions (3.1.1) and Organization (3.1.2). The chemical/biological threat must be fully defined in the threat section (Roles and missions paragraph)

Conventional vulnerability

Item: Air vehicle (or support equipment)

Criteria: Survivable damage for blast fragmentation warheads detonating at distances in excess of XX meters

Conditions: Describe the threat ordnance (or provide a reference to the location of the description)

Conventional vulnerability

Item: Air vehicle (or support equipment)

Criteria: Survivable damage from small arms fire

Conditions: Specify the threat weapons

Conventional vulnerability

Item: Air vehicle (or support equipment)

Criteria: Survivable damage from indirect fire weapons (artillery, mortars, etc.; normally, survivability against direct fire weapons such as tanks is not used)

Conditions: Identify the weapons and payload (HE rounds, cluster munitions, etc.)

Deception (deny acquisition)

Item: Air vehicle (or support equipment)

Criteria: Decrease threat ability to acquire the item to XX

Conditions: Describe threat target acquisition capabilities and characteristics

Single Point Failures

Item: System support structure

Criteria: Damage or loss of any item of support shall result in ___ capability to generate sorties (note: this can be structured in a variety of ways including, “no degradation in” or a “percent acceptable degradation in” etc.)

Conditions: Specify pertinent conditions and constraints.

Runway denial

Item: Air vehicle

Criteria: The air system shall be capable of launching combat sorties within XX (specify a time interval) of attacks on air base surfaces given a critical field length (typically the maximum of the take-off and landing distance) of YY feet is available. (Note that repair of runways, taxiways, etc., is frequently a combined capability of both the system being developed and specialized, non-system-peculiar runway repair assets.)

Conditions: Specify conditions such as the nature of the attack, which can include anti-personnel munitions, and weight of the attack. Identify the non-system-peculiar assets available for air base recovery and their capabilities.

REQUIREMENT LESSONS LEARNED (3.1.6.2.2)

To Be Prepared

4.1.6.2.2 Parked aircraft and ground support survivability verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Item 1	Table 4.1.6.2.2-I criteria	A,S	A,S	A,S		A
Item 2	Table 4.1.6.2.2-I criteria	A,S	A,S	A,S		A
• •		A,S	A,S	A,S		A
Item n	Table 4.1.6.2.2-I criteria	A,S	A,S	A,S		A

VERIFICATION DISCUSSION (4.1.6.2.2)

As the required level of interaction increases, M&S become the only means of verifying these high-level design requirements. Each milestone should provide data to M&S tools to verify the tools. The M&S tool scope increases for each milestone, and the fidelity of the data used to support M&S should increase accordingly. Implementation of the M&S approach is critical to evaluate the system effectiveness. Updated test data should be used to ensure M&S results are credible at each level of modeling.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: Modeling and simulation of the preliminary design indicate parked aircraft and ground support survivability requirements can be met considering the error bounds of the models. Analysis of the preliminary design indicates requirements are understood and flowed down, and that any available data has been integrated into the modeling and simulation process.

PDR: Modeling and simulation of the preliminary design indicate parked aircraft and ground support survivability requirements can be met considering the error bounds of the models. Analysis indicates that requirements are understood and flowed down and that any available data has been integrated into the modeling and simulation process.

CDR: Modeling and simulation of the final design confirm parked aircraft and ground support survivability requirements can be met considering the error bounds of the models. Analysis confirms available data has been integrated into the modeling and simulation process.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of modeling and simulation results, supplemented with lower-level test results, confirms the parked aircraft and ground support survivability requirements have been met.

Sample Final Verification Criteria

The parked aircraft and ground support survivability requirement shall be satisfied when the __(1)__ analyses supported by lower-level test data confirm achievement of the specified performance requirements

> Blank 1. Identify the type and scope of analysis required to provide confidence that the requirement elements have been met. This will include analysis of modeling, simulation, live fire test results, and results from any lower-level tests.

VERIFICATION LESSONS LEARNED (4.1.6.2.2)

To Be Prepared

3.1.7 System capabilities

This is a paragraph header facilitating document organization.

3.1.7.1 Mission lethality

This is a paragraph header facilitating document organization.

3.1.7.1.1 Air-to-air lethality

The system shall achieve and sustain the air-to-air lethality as specified in table 3.1.7.1.1-I.

TABLE 3.1.7.1.1-I. Air-to-air lethality.

Mission	Scenario	Vignette	Mission Phase	Exchange Ratio	P(Kill)	Target Acquisition/ Cueing Condition	Config-uration	Conditions

REQUIREMENT RATIONALE (3.1.7.1.1)

This requirement establishes the lethality of the system in the air-to-air role and is a measure of the system's ability to execute its intended function. It integrates both the aircraft and weapon performance, thus addressing the aircraft's ability to achieve effective delivery conditions for the weapon. It also incorporates impacts for systems cued from external sources. Depending on the specific set of conditions specified, this requirement can be used to reflect options ranging from a single weapon to the entire payload. Note that, at the system level, this requirement integrates navigation, target acquisition (including detection, identification, classification, assessment, lock-on etc.) and weapon delivery capabilities. Defining this performance, and the conditions under which the system must perform, allows the prime contractor to allocate lower-tier performance requirements.

REQUIREMENT GUIDANCE (3.1.7.1.1)

Table 3.1.7.1.1-I will likely contain a number of entries to capture required system capabilities. For example, its scope should address one-on-one situations that enable verification of many of the capabilities needed to satisfy the requirement via high fidelity methods (for example, test or test "validated" methods. This then provides a link to few-on-few engagement situations.

Guidance for completing table 3.1.7.1.1-I follows:

<u>Mission, Scenario, and Vignette</u>: Identify the mission being conducted, the scenario in which it is conducted, and the vignette that establishes the conditions. This should include a reference to 3.1.1 Roles and missions.

For this requirement, a vignette could be as simple as the initial conditions for a one-on-one situation. A key point to remember is that, for an air combat aircraft, this requirement could be the "sizing" requirement on the capabilities expected from the system's target acquisition sensor(s).

<u>Mission Phases</u>: Identify the mission phases, and appropriate operating modes, for the air vehicles in the vignette. Phases can include (but are not limited to) launch, cruise, initiate penetration altitude and speed, long-range target area acquisition, ingress to terminal area acquisition point, terminal area target acquisition, ingress to target area, target acquisition/weapon delivery, repeat target acquisition/weapon delivery as needed, proceed to next target, target acquisition/weapon delivery, egress. Mission phases should lay out the mission from end-to-end to accommodate the tactics employed to successfully accomplish the intended purpose of the mission.

<u>Exchange Ratio</u>: Enter the minimum required exchange ratio against the threat aircraft for the stipulated conditions and P_K capability.

<u>P(Kill)</u>: The probability of kill (P_K). Specify in this entry the minimum required probability that a threat aircraft will be killed.

P_K refers not only to endgame effects but to probabilities of each of the following: detecting the target, acquiring the target, identifying the target, classifying the target (if necessary), locking on to the target, providing guidance to launched weapons, and finally, the endgame kill probability. Although the meaning of this measure seems apparent, it is not. Several different degrees of kill have been defined and accepted by DoD. Ambiguities in the meaning of the P_K parameter will likely lead to incorrect requirements during development of the lower-tier specifications. Therefore, carefully select and identify the appropriate kill criteria and ensure the P_K definition(s) are included in the definitions section of the system specification.

Target Acquisition/Cueing Condition: As a minimum, “Autonomous” should be selected as a condition. Other conditions can include “in-flight cooperative” and external systems. When external systems are identified, a reference to the C^4ISR interface requirements should also be identified. Identification requirements (or identification state) and their relationship to the rules of engagement should also be included. For example, few-on-few vignettes will not typically stress target identification. Target identification can be achieved autonomously, cooperatively among air vehicles in a flight, externally, or situationally. If external or situational criteria are used, any additional criteria to be applied prior to weapon release should be identified. Situational criteria is used to describe identification by observing where a potential target is (deep inside enemy territory), what it is doing (flying in formation with thousands of other unknowns and they are coming our way, shooting at the other aircraft in the flight, etc.), or other analogous conditions/situations.

Configuration: Identify the combat configuration of the air vehicle. If the decision on weapons carriage (type and numbers) has already been determined, identify the appropriate loadouts. If the developing contractor has latitude to define the carriage capability, use a generic description (for example, “full air combat weapons load”). Similarly, if other stores (such as expendables) have already been determined, these can be identified along with a reference to one of the paragraphs and entries under 3.3.7 Stores/weapons

Conditions: Enter those conditions under which the system must achieve the specified lethality (for example, "Night"). Ensure that the specification thoroughly defines the meaning of each condition stipulated. Also, since the lethality requirement can change significantly under different conditions, expect to make multiple entries for the same threat aircraft. For example, the exchange ratio requirement against a MiG-29 may be higher for night in poor weather conditions, than for daytime in clear conditions. For this situation, make two MiG-29 entries, because each entry affects the development of lower-tier specification requirements.

For systems on air-to-ground missions that require an air combat self-defense capability, identify whether external stores are allowed to be jettisoned or whether they must be retained. For air combat systems, identify whether external fuel tanks (if carried) are jettisoned prior to combat. Air combat conditions typically include rules of engagement. Additionally, limitations could be placed on the amount of ordnance to use (no gun firing, 50 percent of gun ammunition allowed, two air-to-air missile firings allowed, etc.)

In addition to light level or weather conditions, the entry in the conditions column should include any critical constraints, including engagement scenario, environment, weapons, or any other parameter necessary to establish the required anti-aircraft lethality of the system. Engagement scenarios (blue and red force sizes, tactics, command, control, communications, basing, support system, etc.) are particularly important considerations if the using command identifies them, either in the CDD or by other means, as critical constraints.

REQUIREMENT LESSONS LEARNED (3.1.7.1.1)

To Be Prepared

4.1.7.1.1 Air-to-air lethality verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Air-to-Air Lethality Mission Phase a	P_K	A,S	A,S	A,S		A,S
Air-to-Air Lethality Mission Phase b	P_K	A,S	A,S	A,S		A,S
Air-to-Air Lethality Mission Phase …	P_K	A,S	A,S	A,S		A,S

VERIFICATION DISCUSSION (4.1.7.1.1)

Air-to-air lethality verification is based on a product of air vehicle and missile performance, including number and type of selected weapons, their explosive yield, delivery accuracy, operational tactics, and target vulnerability. The system must be shown to support accurate and timely missile pre-launch, launch, and post-launch phases to include any multiple missile launches against multiple targets. During verification, ensure condition data defined in table 3.1.7.1.1-I is adequately defined and accurately incorporated/used in the analyses and simulations.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates that lethality requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements will provide the specified lethality and accuracy.

PDR: Analysis of preliminary system designs, and simulations using analytically predicted measures of delivery accuracy, indicate that the system contains the weapons, mission planning capability, and air vehicle performance to achieve the specified lethality.

CDR: Analysis of detailed system designs and use of simulations containing predicted measures of delivery accuracy confirm that the system contains the weapons, mission planning capability, and air vehicle performance to achieve the specified lethality. Analysis of delivery accuracy predictions includes, when available, lower-level test data such as weapon/sensor test data.

FFR: No unique verification action occurs at this milestone.

SVR: Analyses and simulations using actual performance measurements confirm that the air system provides the required accuracy and lethality for the conditions stated.

Sample Final Verification Criteria

The air system air-to-air lethality requirement shall be satisfied when ___(1)___ analyses and ___(2)___ simulations confirm that the air vehicle can be transitioned by the maintainer between the specified states.

Blank 1. Identify the type and scope of analyses to be performed.

Blank 2. Identify, using measured lower-level performance data, the type and scope of simulations to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.7.1.1)

To Be Prepared

3.1.7.1.2 Air-to-surface lethality

The system shall provide the lethality effectiveness index as specified in table 3.1.7.1.2-I.

TABLE 3.1.7.1.2-I. Air-to-surface lethality.

Mission	Scenario	Vignette	Mission Phase	Target	Effectiveness Index	Weapon Type & No.	Target Acquisition/ Cueing and Navigation Aids	Conditions

REQUIREMENT RATIONALE (3.1.7.1.2)

This requirement establishes the air-to-surface lethality of the system. Note that, at the system level, lethality includes target acquisition (including detection, identification, classification if appropriate, lock-on, etc.) and navigation capability. This requirement provides the fundamental reason why air-to-surface systems are developed and procured. Lethality is mission and scenario dependent due to terrain, basing, weather, and other factors. Air-to-surface systems are called upon to attack a wide variety of targets, both fixed and mobile, using a wide array of munitions. It will likely not be necessary to specify requirements for each and every target type an air-to-surface system may be called upon to attack with all the different choices of weapons available, but even a limited set can be large. The stressing conditions should be specified with sufficient coverage of other conditions to ensure that the system is designed with the needed flexibility. For example, only a few conditions may be necessary for “dumb bomb” attacks against fixed targets. Since point targets (air base hangar) stress different delivery capabilities than area targets (such as air base runways) some subset should be selected that ensures acceptable design criteria. Precision-guided-munitions attacks against fixed targets might also be limited to a small set of conditions. However, lethality is coupled with survivability in that optimal weapon delivery (and target acquisition) does not often directly equate with survivable conditions. Operational flexibility may be required. For example, ability to exploit a hole in the air defense coverage may drive certain weapon delivery capabilities to exploit a survival sanctuary. Additionally, some weapons that may be required have their own set of characteristics that drive delivery conditions. Mobile targets frequently provide more stressing situations than fixed targets, both in terms of target acquisition capability and due to their frequently vast numbers, small sizes, and differences in how they are arrayed. Defining this capability and the conditions under which the system must perform allows the prime contractor to allocate lower-tier performance requirements.

REQUIREMENT GUIDANCE (3.1.7.1.2)

Surface attack lethality requirements for an air system cannot be stipulated merely by identifying the target set. The lethality of a system against any target set is highly dependent on the type of weapon or weapons used, the number of weapons used during each attack, the system accuracy, and the conditions under which the weapon system attacks the target.
Table 3.1.7.1.2-I defines the system surface attack lethality performance. Accuracy is not included in the table. Although accuracy plays a large role in determining lethality, accuracy is best derived from the system lethality and other system requirements.

Guidance for completing table 3.1.7.1.2-I follows:

Mission, Scenario, Vignette: Identify the mission being conducted, the scenario in which it is conducted, and the vignette that sets the conditions. This should include a reference to 3.1.1 Roles and missions.

Mission Phases: Identify the mission phases and appropriate operating modes for the air vehicles in the vignette. Phases can include (but are not limited to) long-range target area acquisition, ingress to terminal area acquisition point, terminal area target acquisition, ingress to target area, target acquisition/weapon delivery, repeat target acquisition/weapon delivery as needed, proceed to next target, target acquisition/weapon delivery.

Target: If not included in the vignette, enter a precise description of the surface target(s), keeping in mind that any ambiguity will likely result in incorrect requirements in the lower-tier specifications. Some targets are single objects, such as a T-72 tank. Other targets are a combination of objects, such as a column of T-72 tanks. These "complex" targets usually require more information (for example, spacing). Other details, for instance, whether the target is stationary or hardened, are critical in defining the target with sufficient detail to allow proper flow-down to lower-tier performance requirements.

Effectiveness Index: Enter the appropriate effectiveness index. For point targets, enter the minimum required single pass (or single firing event) probability of kill for each expected target, weapon, and condition combination. For area targets, enter the minimum number of expected kills or minimum fractional kill criteria. Although the meaning of these measures may seem apparent, it is not. Several different degrees of kill are often available for each type of target. Therefore, it is important to carefully select and identify the appropriate kill criteria and ensure they are included in the definitions section (6.xx) of the system specification. Ambiguity in the meaning of the effectiveness index chosen will likely lead to incorrect requirements during development of the lower-tier specifications.

Weapon Type & No.: Enter the type and number of each weapon that will be used during a single pass or single firing event. For example, this entry may be 12 Mk-82 LDGP.

Target Acquisition/Cueing and Navigation Aids: Identify external, in-flight, cooperative and autonomous conditions for target acquisition. For external target acquisition/cueing systems, identify the location accuracy and in-flight update capability available from the external platform. For external navigation aids, identify the location accuracy available. When external systems are identified, a reference to the C^4ISR interface requirements should also be identified. Also included should be errors introduced (or passed on) by the mission planning capability/system.

Conditions: Enter all of the conditions under which the system must achieve the specified lethality. Carefully describe the conditions, such as light level, weather, or any other pertinent constraints. Also, since the lethality requirement can change significantly under different conditions, expect to make multiple entries for the same target. For example, the expected kills requirement for a column of T-72 tanks with 50 meter spacing traveling at 25 mph may be lower for night, in poor weather conditions, than for day, in clear conditions. For this situation, make two T-72 tank column entries, because each entry affects the development of lower-tier specification requirements. In addition to light level or weather conditions, the entry in the conditions column should include any critical constraints, including engagement scenario, environment, weapons, or any other parameter necessary to establish the required surface attack lethality of the system. Engagement scenarios (blue and red force sizes, tactics, command, control, communications, etc.) are particularly important considerations if the using command identifies them, either through the CDD or by other means, as critical constraints. Additional location information can be critical for attack of mobile targets. For example, sometimes air-to-surface attacks are cued from external sources. Mobile targets change location. Thus, factors such as “timely arrival” can have a significant bearing on the air-to-surface lethality. A recommended approach is to provide both conditions that include this factor and conditions that do not include this factor. When including this factor, the age of the information of the cued location and target location uncertainty should also be defined. Such factors can drive target acquisition capability requirements as well as other air vehicle performance requirements, such as speed.

Finally, the conditions should specifically relate to a mission phase in 3.1.6.2.1 Mission and one-on-one survivability and mission profile in 3.1.1 Roles and missions. Any additional conditions or constraints on weapon delivery profile should also be defined. This will help ensure that weapon delivery conditions, and resulting lethality, is consistent with the survivability requirements.

REQUIREMENT LESSONS LEARNED (3.1.7.1.2)

To Be Prepared

4.1.7.1.2 Air-to-surface lethality verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Lethality effectiveness index a	Effectiveness Index	A,S	A,S	A,S		A,S
Lethality effectiveness index b	Effectiveness Index	A,S	A,S	A,S		A,S
Lethality effectiveness index …	Effectiveness Index	A,S	A,S	A,S		A,S

VERIFICATION DISCUSSION (4.1.7.1.2)

Air-to-surface lethality, a measure of the effectiveness of the entire system, is a product of the number of selected weapons and their explosive yield, delivery accuracy, operational tactics, target vulnerability, and force size.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of the design concept indicates that lethality requirements have been decomposed to lower-tier requirements. Analysis and simulations indicate that lower-tier requirements will provide the required lethality.

PDR: Analysis of preliminary system designs, and simulations using analytically predicted measures of delivery accuracy, indicate that the system contains the weapons, mission planning capability, and air vehicle performance to achieve the specified lethality.

CDR: Analysis of detailed system designs, and use of simulations containing predicted measures of delivery accuracy, confirm that the system contains the weapons, mission planning capability, and air vehicle performance to achieve the specified lethality. Analysis confirms that delivery accuracy predictions incorporate actual test data.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations using actual performance measurements confirm that the air vehicle and other system elements provide the required lethality for the conditions stated.

Sample Final Verification Criteria

Air-to-surface lethality shall be verified through ___(1)___ analysis and ___(2)___ simulations, using measured performance data, for the conditions specified in 3.1.7.1.2 Air-to-surface lethality.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.7.1.2)

To Be Prepared

3.1.7.2 Transport

This is a paragraph header facilitating document organization.

3.1.7.2.1 Cargo Transport

The system shall provide cargo delivery capability as defined in table 3.1.7.2.1-I for the cargo types listed in table 3.1.7.2.1-II.

TABLE 3.1.7.2.1-I. Cargo delivery.

Mission/ Scenario	Air Vehicles	Cargo Quantity	Distance	Basing T/O Landing	Delivery Rate	Operations Period	Cargo Type(s)

TABLE 3.1.7.2.1-II. Cargo list.

Cargo Type	Cargo Description

REQUIREMENT RATIONALE (3.1.7.2.1)

This paragraph establishes the cargo delivery requirements for the system in terms of quantity and type. This requirement describes the installed performance characteristics that link ground/shipboard cargo handling (load and unload) capability with system availability, the "cube" requirements of the cargo to be delivered, and the rate at which cargo must be transported over a given distance for a specified operational period. This requirement is a critical design constraint and must be defined so that lower-tier requirements are properly derived.

REQUIREMENT GUIDANCE (3.1.7.2.1)

Use as many entries in table 3.1.7.2.1-I as needed to describe the critical delivery requirements for the system. The explicit linking of this portion of the requirement to the cargo interface requirement provides flexibility in specifying generic loadouts (this can be reduced to a "metric tons per kilometer" rate requirement) to specific loadouts. It is essential that explicit matches be defined between each line in this table to the cargo types requirements via the "Cargo Types" column in table 3.1.7.2.1-I. This process would allow the following requirement: "Not more than 24 aircraft shall be capable of delivering 1 unit of cargo 7000 kilometers per 10 days over a sustained operating period of 60 days," where 1 unit of cargo is defined in entry XYZ in table 3.1.7.2.1-II. This entry could be the cubic volume description of the personnel and equipment of an armored division. It would also allow the following requirement: "Aircraft numbering not greater than eight shall be capable of delivering 120 metric tons of cargo 7000 kilometers in 2 days for a sustained operating period of 30 days." This considers cargo as defined in table 3.1.7.2.1-II, which could be the cube description of some aggregate of generic form of supply.

Guidance for completing table 3.1.7.2.1-I follows:

Mission/Scenario: Identify the mission being conducted and the scenario in which it is conducted. This should include a reference to 3.1.1 Roles and missions.

Air Vehicles: Enter the number of aircraft available to achieve the cargo capability. This is the total pool of aircraft available and would (for example) include some fraction of the aircraft that are down for repair.

Cargo Quantity: Enter the number of units of cargo that the system must deliver (this is keyed to the corresponding cell in the "Cargo Types" column).

Distance: Enter the distance in kilometers that the system transports the cargo.

Basing: Identify the basing for Take-off (T/O) and Landing. Basing descriptions can include basing type (main operating base, forward operating base, unimproved area, ship/ship type etc.). Frequently, characteristics such as load capacity number or California Bearing Ratio and "runway" length should also be identified.

Delivery Rate: Specify the time (including load and unload time) in which the system must deliver the cargo specified.

Operations Period: Define the sustained operating period for which the system must deliver cargo at the amount and rate specified under columns for "Cargo Quantity," "Distance," "Delivery Rate," and "Cargo Types" within the number of available aircraft identified under "Air Vehicles." The time units should be either days, weeks, or months.

Cargo Types: Identify the specific cargo types from table 3.1.7.2.1-II that apply to this mission.

Guidance for completing table 3.1.7.2.1-II:

<u>Cargo List</u>: List all of the types of cargo that the system must deliver.

<u>Cargo Descriptions</u>: Provide the necessary descriptive detail to further identify the cargo types. This information can include pallet sizes, weights, volume, etc.

REQUIREMENT LESSONS LEARNED (3.1.7.2.1)

Rapid retasking of moving cargo on and off naval vessels at sea places unique constraints on cargo interface design.

4.1.7.2.1 Cargo transport verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Cargo delivery capability for mission a	Delivery rate 1	A	A	A,S		A, D, S
Cargo delivery capability for mission b	Delivery rate 2	A	A	A, S		A, D, S
Cargo delivery capability for mission …	Delivery rate …	A	A	A, S		A, D, S

VERIFICATION DISCUSSION (4.1.7.2.1)

A combination of analyses, simulations, demonstrations, and tests should be performed as necessary to verify the air vehicle can deliver the required cargo types within the specified timeframe.

Key Development Activities

Key development activities should include, but are not limited to, the following:

SRR/SFR: Analysis of the air system design concept indicates that the types of cargo and delivery rates can be achieved for the specified mission/scenarios.

PDR: Analysis of air system preliminary design indicates that the types of cargo and delivery rates can be achieved for the specified mission/scenarios.

CDR: Analysis of air system final design confirms that the types of cargo and delivery rates can be achieved for the specified mission/scenarios. Analysis and simulation or other visual tools confirms that the air vehicle will be able to load the required cargo items. Structural analysis of the forces involved in loading and flying each item are available and are within allowable limits.

FFR: No unique verification action occurs at this milestone.

SVR: Analyses and demonstrations confirm that the cargo transport missions can be readily accomplished by the air vehicle design and equipment installations. Cargo loading of all, and air transport of some items from the cargo list has been demonstrated. Worst-case scenarios have been demonstrated. The operational scenario for cargo handling has been successfully simulated.

Sample Final Verification Criteria

The cargo transport requirement will be considered to be satisfied when ___(1)___analysis, ___(2)___ demonstrations, and ___(3)___ simulations confirm specified delivery rate.

Blank 1. Specify the type and scope of analyses that will provide confidence that the requirement has been met.

Blank 2. Specify the type and scope of demonstrations that will provide confidence that the requirement has been met

Blank 3. Specify the type and scope of simulations that will provide confidence that the requirement has been met

VERIFICATION LESSONS LEARNED (4.1.7.2.1)

To Be Prepared

3.1.7.2.2 Personnel transport

The air system shall provide personnel transport capability as defined in table 3.1.7.2.2-I for the types of personnel listed in table 3.1.7.2.2-II.

TABLE 3.1.7.2.2-I. Personnel delivery.

Mission/ Scenario	Air Vehicles	# of Personnel	Distance	Basing T/O Landing	Delivery Rate	Operations Period	Type(s) of personnel

TABLE 3.1.7.2.2-II. Personnel list.

Type of Personnel	Personnel Description

REQUIREMENT RATIONALE (3.1.7.2.2)

This paragraph establishes the personnel delivery requirements for the system in terms of quantity and type. This requirement describes the installed performance characteristics that link the loading and unloading of personnel, system availability, the space, weight, and interface requirements of the personnel to be transported, and the rate at which personnel must be transported over a given distance for a specified operational period. This requirement is a critical design constraint and must be defined so that lower-tier requirements are properly derived.

REQUIREMENT GUIDANCE (3.1.7.2.2)

Use as many entries in table 3.1.7.2.2-I as needed to describe the critical personnel transport requirements for the system. The explicit linking of this portion of the requirement to the Human systems interface requirement provides flexibility in specifying generic personnel transport loadouts. It is essential that explicit matches be defined between each line in this table to the "Type of Personnel" column in table 3.1.7.2.2-II. This process would allow the following requirement: "Not more than 5 aircraft shall be capable of delivering 400 personnel (as defined in table 3.1.7.2.2-II) 7000 kilometers over a sustained operating period of 10 days."

Guidance for completing table 3.1.7.2.2-I follows:

<u>Mission/Scenario</u>: Identify the mission being conducted and the scenario in which it is conducted. This should include a reference to 3.1.1 Roles and missions

<u>Air Vehicles</u>: Enter the number of aircraft available to achieve the personnel transport. This is the total pool of aircraft available and would (for example) include some fraction of the aircraft that are down for repair.

<u># of Personnel</u>: Enter the number of personnel that the system must transport (this is keyed to the corresponding cell in the "Type(s) of Personnel" column).

<u>Distance</u>: Enter the distance in kilometers that the system is required to transport the personnel.

<u>Basing</u>: Identify the basing for Take-off (T/O) and Landing. Basing descriptions can include basing type (main operating base, forward operating base, unimproved area, ship/ship type etc.). Frequently, characteristics such as load capacity number or California Bearing Ratio and "runway" length should also be identified.

<u>Delivery Rate</u>: Specify the time (including load and unload time) in which the system must deliver the personnel specified.

<u>Operations Period</u>: Define the sustained operating period for which the system must deliver personnel at the amount and rate specified under columns for "# of Personnel," "Distance," "Delivery Rate," and "Type(s) of Personnel " within the number of available aircraft identified under "Air Vehicles." The time units should be either days, weeks, or months.

Type(s) of Personnel: Identify the specific types of personnel from table 3.1.7.2.2-II that apply to this mission. This might include entries such as combat troops, paratroopers, litter patients, civilian personnel, or special operations teams.

Guidance for completing table 3.1.7.2.2-II:

Types of Personnel: List all of the types of personnel that the system is required to deliver. These entries must directly correlate with the entries made in the “Types of Personnel” column in table 3.1.7.2.2-I

Personnel Description: Provide the necessary descriptive detail to identify the personnel types further. This information might include a description of the equipment carried, the weight of each fully-loaded individual, the space required, or the interface support required for each type of personnel.

REQUIREMENT LESSONS LEARNED (3.1.7.2.2)

Transporting personnel on and off naval vessels at sea places unique constraints on personnel interface design.

4.1.7.2.2 Personnel transport verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Personnel transport capability for mission a	Delivery rate 1	A	A	A,S		A, D, S
Personnel transport delivery capability for mission b	Delivery rate 2	A	A	A, S		A, D, S
Personnel transport capability for mission …	Delivery rate …	A	A	A, S		A, D, S

VERIFICATION DISCUSSION (4.1.7.2.2)

A combination of analyses, simulations, demonstrations, and tests should be performed as necessary to verify the air vehicle can transport the required personnel within the specified timeframe.

Key Development Activities

Key development activities should include, but are not limited to, the following:

SRR/SFR: Analysis of the air system design concept indicates that the types of personnel and delivery rates can be achieved for the specified mission/scenarios.

PDR: Analysis of air system preliminary design indicates that the types of personnel and delivery rates can be achieved for the specified mission/scenarios.

CDR: Analysis of air system final design confirms that the types of personnel and delivery rates can be achieved for the specified mission/scenarios. Analysis and simulation or other visual tools confirms that the air vehicle will be able to accommodate the required personnel. Structural analysis of the forces involved in loading and transporting each type of personnel is available and within allowable limits.

FFR: No unique verification action occurs at this milestone.

SVR: Analyses and demonstrations confirm that the personnel transport missions can be readily accomplished by the air vehicle design and equipment installations. Personnel loading of all, and air transport of some types of personnel have been demonstrated. Worst-case scenarios have been demonstrated. The operational scenario for personnel transport has been successfully simulated.

Sample Final Verification Criteria

The personnel transport requirement will be considered to be satisfied when ___(1)___analysis, ___(2)___ demonstrations, and ___(3)___ simulations confirm specified delivery rate.

Blank 1. Specify the type and scope of analyses that will provide confidence that the requirement has been met.

Blank 2. Specify the type and scope of demonstrations that will provide confidence that the requirement has been met

Blank 3. Specify the type and scope of simulations that will provide confidence that the requirement has been met

VERIFICATION LESSONS LEARNED (4.1.7.2.2)

To Be Prepared

3.1.7.3 Reconnaissance/surveillance

The system shall provide reconnaissance/surveillance capability as described in table 3.1.7.3-I for the conditions identified.

TABLE 3.1.7.3-I. Reconnaissance/surveillance capability.

Mission/ Scenario	Sensors	Coverage	Information Collection	Information Processing	Information Dissemination	Timeline	Conditions

REQUIREMENT RATIONALE (3.1.7.3)

Reconnaissance and surveillance are two functions that provide information for intelligence. Intelligence is

a. The product resulting from the collection, processing, integration, analysis, evaluation, and interpretation of available information concerning foreign countries or areas.

b. Information and knowledge about an adversary obtained through observation, investigation, analysis, or understanding.

Extracts from Air Force Doctrine Document 1:

> Intelligence, surveillance, and reconnaissance must operate together, enabling commanders to preserve forces, achieve economies, and accomplish campaign objectives. They are integral to gaining and maintaining information superiority. Intelligence provides clear, brief, relevant, and timely analysis on foreign capabilities and intentions for planning and conducting military operations. The overall objective of intelligence is to enable commanders and combat forces to “know the enemy” and operate smarter. It helps commanders across the range of military operations by collecting, analyzing, fusing, tailoring, and disseminating intelligence to the right place at the right time for key decision making. Intelligence provides indications of enemy intentions and guides decisions on how, when, and where to engage enemy forces to achieve the commander’s objectives. It assists in combat assessment through munitions effects assessment and bomb damage assessment.
>
> Surveillance is the function of systematically observing air, space, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means. Surveillance is a continuing process, not oriented to a specific “target.” In response to the requirements of military forces, surveillance must be designed to provide warning of enemy initiatives and threats and to detect changes in enemy activities. Air- and space-based surveillance assets exploit elevation to detect enemy initiatives at long range. Reconnaissance complements surveillance in obtaining, by visual observation or

other detection methods, specific information about the activities and resources of an enemy or potential enemy; or in securing data concerning the meteorological, hydrographic, or geographic characteristics of a particular area. Reconnaissance generally has a time constraint associated with the tasking. Collection capabilities, including airborne and space-based systems that are manned and unmanned, and their associated support systems, are tailored to provide the flexibility, responsiveness, versatility, and mobility required by the strenuous demands of fluid, global tasking. Intelligence critical to the prosecution of current combat operations is evaluated and transmitted in near real-time to those elements having a need for that information. Reconnaissance forces possess multiple and diverse capabilities. Because these capabilities are valuable across all levels of war, their specific employment at any one level should consider possible effects on other levels.

REQUIREMENT GUIDANCE (3.1.7.3)

The requirements imposed by this paragraph are intended for those missions whose primary function is reconnaissance/surveillance. In concept, the requirements could be adapted to missions that have a secondary or tertiary reconnaissance/surveillance function. Examples of missions with secondary or tertiary functions could be air-to-air or air-to-surface combat missions that require battle damage assessments (such as gun camera or bomb impact imagery) or a record of radar warning receiver information coupled with spatial location of the air vehicle. These requirements may be better communicated via 3.3.8 System usage information collection and retrieval.

An air system may be developed that provides just reconnaissance or just surveillance or a combination of reconnaissance and/or surveillance and intelligence. In establishing air system requirements for reconnaissance/surveillance and associated intelligence requirements (if any) it is necessary to examine the disciplines of intelligence.

Intelligence discipline. A well-defined area of intelligence collection, processing, exploitation, and reporting using a specific category of technical or human resources. There are five major disciplines: human intelligence, imagery intelligence, measurement and signature intelligence, signals intelligence (communications intelligence, electronic intelligence, and foreign instrumentation signals intelligence), and open-source intelligence.

Air systems can potentially contribute to three of these disciplines:

Imagery intelligence. Intelligence derived from the exploitation of collection by visual photography, infrared sensors, lasers, electro-optics, and radar sensors such as synthetic aperture radar wherein images of objects are reproduced optically or electronically on film, electronic display devices, or other media. Also called IMINT.

Measurement and signature intelligence. Scientific and technical intelligence obtained by quantitative and qualitative analysis of data (metric, angle, spatial, wavelength, time dependence, modulation, plasma, and hydromagnetic) derived from specific technical sensors for the purpose of identifying any distinctive features associated with the target. The detected feature may be either reflected or emitted. Also called MASINT.

Signals intelligence. 1. A category of intelligence comprising, either individually or in combination, all communications intelligence, electronics intelligence, and foreign instrumentation signals intelligence, however transmitted. 2. Intelligence derived from communications, electronics, and foreign instrumentation signals. Also called SIGINT.

An air system may need to be capable of information collection supporting IMINT, MASINT, or SIGINT, or some combination of the three. The air system may also be required to be capable of all three simultaneously. Alternatively, it may only need to be capable of performing one or two of these functions. Finally, it may need to have a modular capability that enables it to perform any one of the required capabilities with the collection capability changing from sortie to sortie. Thus, it is essential that the missions in 3.1.1 Roles and missions, be appropriately identified to allow correlation of other system requirements with the capabilities required here.

Guidance for filling in table 3.1.7.3-I follows:

Mission/Scenario: Identify the mission being conducted and the scenario in which it is conducted. This should include a reference to 3.1.1 Roles and missions. Mission designators that include descriptors identifying the type of information (IMINT, MASINT, and/or SIGINT) can be useful.

Sensors: Enter wording that describes whether the system will use onboard sensing devices, external or separate sensors, or a combination of both. Suggested wording for specifying the appropriate choice is "onboard" or "onboard and external." If external sensors are used, they must be identified and a reference to the appropriate section 3.4 Interfaces, Interfaces (particularly the C^4ISR interfaces) should be included. Additionally, if the system is required to use one or more existing sensors, identify the sensor and reference the appropriate sensor information in 3.3.7 Stores/weapons requirement. Be very clear in this paragraph so that the contractor can easily determine what capabilities they need to develop and what capabilities they need to integrate. It is possible that the system will use external sensors and one or more sensors identified 3.3.7 Stores/weapons and still need to develop one or more other sensors to provide the required information collection capability.

Coverage: Enter information describing coverage conditions. Coverage conditions include

a. Standoff characteristics: The air vehicle may over-fly or stand off from the area over which it is collecting information (enter “over-fly” or “stand off”). Also provide the altitude and maximum slant range to a detectable target/feature/event.

b. Conditions of coverage: The conditions and constraints necessary to establish each collection requirement. Entries may include day, night, weather conditions, speed, and time over area.

c. Frequency of coverage: The frequency with which the coverage area must be observed. Examples of valid entries are “Continuous” or “Twice a day.”

d. Sustainment period: The length of time that coverage must be sustained. An example of a valid entry is “1 month.”

e. Per Sortie Coverage Area: The number of square kilometers of area that must be observed for the conditions, frequency, and sustained period stipulated.

Information Collection: Enter information detailing the information collection requirements. Information collection requirements may include the following (Note: a system developed to conduct reconnaissance and/or surveillance may have significant avionics capability requirements at the system level. The system specification for such a system may reflect a tailored hybrid of the Air System JSSG and the Avionics JSSG with additional avionics detail at lower levels of the specification tree):

a. Detectable characteristic: Detectable characteristics depend on the type of information being collected (see above definitions for IMINT, MASINT, and SIGINT).

The detection characteristic and performance value for the conditions, coverage area, altitudes, and standoff ranges identified. These entries should describe the type of operational targets that must be detected and identified by the system. Examples would be "troops," "tank column," or "parked aircraft." If further descriptive information is pertinent, such as type, number, and spacing, provide these details as well.

Entries can also describe a generic size requirement if no target details are desired or available. In such a situation, an example of a valid entry would be "2 square meter object" or a minimum resolvable temperature. Additionally, the detectable characteristic may not be an object; a signal and a sensitivity measure may be more appropriate. Add range information if multiple sensitivity points need to be specified or if the operating slant range does not adequately describe the range (or is not pertinent) for detection (for example, resolve a delta temperature of X degrees at Y kilometers slant range).

Requirements for detection, identification, and classification (that is, a vehicle is present, the vehicle is a tank, and the tank is a T-62) may also be appropriate (or more appropriate to use for some types of systems than other type descriptions; for example, “the system must be capable of classifying tanks at 200 km").

Accuracy (or fidelity) of characteristic measurement: Define the accuracy (uncertainty) of the measurement device as it impacts the characteristic being measured.

Instantaneous coverage area: Describe the directional attributes and/or ground swath coverage.

Instantaneous capacity: How much information (of the type of information being collected) must the system be able to handle at the same time (for example, pulses/sec)? For some systems, this is not applicable (in photo-recon missions, for example, this may be the same as the instantaneous coverage area).

b. Storage capacity: How much information must be collected and stored.

Information Processing: Define the processed outputs (a complete list of final outputs includes all intermediate outputs for which a user of that information exists) in terms of the processing functions expected. For example, “correlation of emitter signals, with GPS and on-board air vehicle location information, and terrain maps to provide a current emitter bed down.” Include processing accuracy requirements, if any.

Information Dissemination: Define to whom the outputs go and how often those outputs are to be provided. Characteristics of dissemination can deal with many variables, such as "secure transmission of reconnaissance data to XX kilometers." Dissemination characteristics can include point-to-point, point-to-multiple point, or broadcast capabilities. This requirement can be quite complex if the platform also serves as a command and control platform (for example, an AWACS); dissemination would include segmenting information into meaningful portions and transmitting that information with tasking to other assets.

Dissemination characteristics may be as simple as "a roll of film extracted from the air vehicle at the end of a sortie." Dissemination requirements are also driven by who will be using the information. The system may require multiple dissemination capabilities to accommodate the needs of various end users of the information such as a pilot, a mission planner, a controller, or a force commander (at varying levels).

Timeline: Define all applicable timelines. Some systems may collect information and pass it on. Some systems may collect and process information and then pass it on. Some systems may collect information, pass it on, still perform processing, and then pass on the processed results. Timelines may be 1) real time (pertaining to the timeliness of data or information that has been delayed only by the time required for electronic communication -- this implies that there are no noticeable delays), 2) near real time (pertaining to the timeliness of data or information that has been delayed by the time required for electronic communication and automatic data processing -- this implies that there are no significant delays), or 3) delayed (defines the maximum allowed time delay).

REQUIREMENT LESSONS LEARNED (3.1.7.3)

To Be Prepared

4.1.7.3 Reconnaissance/surveillance verification

For each condition identified:

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Reconnaissance / surveillance capability for mission scenario a	1) coverage, 2) collection, 3) processing, 4) dissemination, and 5) timeliness	A,S	A,S	A,S		A,S, T
Reconnaissance / surveillance capability for mission scenario b	1) coverage, 2) collection, 3) processing, 4) dissemination, and 5) timeliness	A,S	A,S	A,S		S,T

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Reconnaissance / surveillance capability for mission scenario …	1) coverage, 2) collection, 3) processing, 4) dissemination, and 5) timeliness	A,S	A,S	A,S		S,T

VERIFICATION DISCUSSION (4.1.7.3)

Verification of the reconnaissance/surveillance function is a total system requirement that, while requiring some actual testing, should make maximum use of models, simulations, and analyses for validation of the requirements. These models, simulations, and analyses should start with specified performance values, progress through using predicted values, and ultimately should use actual lower-tier test data.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis and simulations indicate that lower-tier requirements provide the required reconnaissance/surveillance performance.

PDR: Analysis of preliminary air system designs and simulations, using analytically predicted measures of performance, indicates that the system can perform the specified reconnaissance/surveillance functions.

CDR: Analysis of detailed air system designs, and use of simulations containing predicted measures, confirms that the system can perform the stated reconnaissance/surveillance functions.

FFR: No unique verification action occurs at this milestone.

SVR: Analyses and simulations, based on measured performance of lower-level system elements and, where applicable, specific air system-level testing, confirm that the air system can achieve the reconnaissance/surveillance performance specified.

Sample Final Verification Criteria

Reconnaissance/surveillance shall be verified through ___(1)___ analyses, ___(2)___ simulations, and ___(3)___ system-level tests for the conditions specified utilizing data obtained from performance testing of the lower-level system elements.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.7.3)

To Be Prepared

3.1.7.4 Aerial refueling (tanker)

The system shall be capable of transferring fuel to other platforms as specified in table 3.1.7.4-I.

TABLE 3.1.7.4-I. Tanker refueling capability.

Mission	Receiver and Flight Size	# Simultaneous Receivers	Off-Load per Receiver	Refuel Process Duration	# Off-Load Occurrences/ Tanker Sortie	Conditions

REQUIREMENT RATIONALE (3.1.7.4)

Aerial refueling is valuable to air operations. It expands employment options available to commanders by increasing the range, payload, and flexibility of air forces. Air Force conventional aerial refueling assets are employed in five basic modes of operation:

a. Support of the nuclear, Single Integrated Operation Plan;
b. Support of long-range, conventional, strategic attack missions;
c. Deployment of air assets to a theater;
d. Support of an airlift line of communication or airbridge; and
e. Support of combat and combat support aircraft operating in theater.

When the air system includes an air vehicle that is to function as a tanker to refuel receiver air vehicles in-air, this role and the associated mission(s) should be identified. The tanker aerial refueling capability will impact the air vehicle and the aerial refueling subsystem design performance requirements. Accordingly, the targeted receiver fleet system capabilities and the specific operational conditions must be identified to determine the design requirements of the air vehicle and its tanker aerial refueling interface(s) in order to be compatible with the desired receiver(s).

REQUIREMENT GUIDENCE (3.1.7.4)

This requirement has been structured to identify the refueling capability for air vehicles not solely designed as tankers and will require tailoring to characterize this condition.

Guidance for completing table 3.1.7.4-I follows:

Mission/Scenario: Identify the mission being conducted and the scenario in which it is conducted. This should include a reference to 3.1.1 Roles and missions.

Receiver and Flight Size: Identify the receiver air vehicle and the number of air vehicles in the flight to be refueled. Reference the appropriate portion of section 3.4 Interfaces for each air vehicle identified. Identifying the specific air vehicle type is preferred over specifying a receptacle interface, since refueling compatibility (including airflows around air vehicles) must be established. If multiple air vehicle types will be refueled on the same mission, identify both types and add appropriate information in the conditions column. For a single mission, use a separate line for each air vehicle type to be refueled on that mission. Add pertinent information to the Conditions column, such as a requirement to refuel, on the same mission, two different aircraft types that require different fuel types.

Simultaneous Receivers: When the refueling capability requires multiple simultaneous hook-ups to receivers, identify the number. If not, the receiver number will be computed based on the time allowed for refueling, and off-load per receiver and number of air vehicles to be refueled.

Off-load Per Receiver: Specify the amount of fuel that must be off-loaded to each receiver aircraft.

Refuel Process Duration: Specify the amount of time allowed for the refueling process for the entire flight. Identify both the starting and ending conditions.

Off-Load Occurrences per Tanker Sortie: Specify the number of times per tanker sortie that this refueling condition occurs. In conjunction with off-load per receiver and number of air vehicles per flight, this will size the total off-load capacity per tanker. Note: this is total off-load capacity per mission (an installed performance requirement).

Conditions: Special conditions include natural environmental factors (lighting, turbulence, wind, etc.), air speed and altitude ranges (if necessary), conditions for multiple fuel types, angle-of-attack maximums and minimums. Also include other factors necessary to fully communicate the condition of performance (such as interface clearances, separation distances, receiver flight envelope/fuel pressure/flow rate, and the tanker boom/drogue system(s).

REQUIREMENT LESSONS LEARNED (3.1.7.4)

If the air vehicle has a tanker mission, identification of the targeted receiver air vehicle should be based on inputs from the CDD, and possibly the mission(s) of the air vehicle and its aero-performance capabilities. If the air vehicle has a general support tanker mission, there is an existing MOU between the U.S. Navy and the USAF (10 Jul 81) which states that all general support tankers will be equipped with both tanker aerial refueling subsystems, that is, boom and drogue subsystem. The MOU further states that each tanker aerial refueling subsystem will operate independently from the other tanker aerial refueling subsystem(s) and will be capable of refueling the targeted receiver air vehicles throughout the receiver's normal aerial refueling envelope. The MOU also specifies that specialized mission tankers (for example, carrier-based tankers and helicopter-dedicated tankers) need only be compatible with their planned receiver air vehicle.

The identified receiver fleet dictates many of the design requirements for the air vehicle as a tanker. For example, the targeted receiver fleet will determine the type of tanker aerial refueling subsystem(s) installed on the air vehicle; that is, boom versus drogue subsystem. In addition, it determines the number of tanker aerial refueling subsystems installed; that is, single subsystem versus dual subsystem. It also determines the configuration of each tanker aerial refueling subsystem installed; that is, single point versus multipoint/redundant points. The identified receiver fleet will also dictate the aerial refueling envelope within which the air vehicle and its tanker aerial refueling subsystem(s) will have to operate to be compatible with each targeted receiver aerial refueling subsystem. The identified receiver fleet can also dictate the aerial refueling procedures that must be used, which can impact the air vehicle and its tanker aerial refueling subsystem(s) design. The physical size of each targeted receiver platform can dictate the number and location of each tanker aerial refueling subsystem installed on the air vehicle. The targeted receiver fleet will also dictate what type of fuel(s) the air vehicle must be able to carry and off-load as a tanker to the receiver(s). The targeted receiver mission(s) can dictate the allowed aerial refueling process duration for a receiver or a cell of receivers. As such, predetermined aerial refueling time requirements within the receiver mission(s) can impact the air vehicle tanker design with regard to number and location of each tanker aerial refueling subsystem and the fuel off-load rate for each tanker aerial refueling subsystem.

As the aerial refueling subsystem performance capabilities can vary drastically from each type of receiver air vehicle, the identification of the targeted receivers should be specific to aircraft model, series, and country/service to account for differences among receiver air vehicles. For example, different series within a given model can have a different location for the aerial refueling subsystem(s) that could impact tanker/receiver clearances during the aerial refueling process. In addition, different design features can be incorporated into a model series' aerial refueling subsystem(s), for example, probe strength, which could dictate different performance requirements for the air vehicle's tanker aerial refueling subsystem(s).

Ensure all targeted receiver air vehicles are identified by using an CDD that has been coordinated by the user command(s) for the air vehicle and the respective receiver command(s) that the air vehicle will operate with when aerial refueling. In addition, examine any MOUs/MOAs that may exist between the DoD services and/or with other allied countries regarding tanker support.

The U.S. Government has agreed to comply with NATO STANAG 3971, without reservation or exception. As such, all new tanker air vehicles with an aerial refueling subsystem, must be able to conduct aerial refueling operations per NATO STANAG 3971 procedures.

New tanker air vehicles and their tanker subsystems should be able to aerially refuel fielded receiver air vehicles using procedures consistent with the receiver air vehicle’s existing aerial refueling procedures. The USAF has defined aerial refueling procedures with each receiver air vehicle. These procedures are contained within a series of TOs numbered 1-1C-1-XX (XX designates a unique number for each receiver air vehicle, for example, 1-1C-1-35 is for the C-17). Aerial refueling procedures for the U.S. Navy/USMC receivers are provided in individual aircraft NATOPS manuals and NAVAIR NATOPS 00-80T-110 Air-to-Air Refueling Manual.

The NATO STANAG 3971 (ATP 56) document contains a list of points of contact (POC) for current allied receivers. When aerial refueling support is to be provided to, or obtained from, allied air vehicles; these POC's should be contacted to determine if any unique changes/exceptions to the aerial refueling procedures in the document are required to be compatible with their air vehicles. An allied country may have agreed to the STANAG with reservations and/or concurred with the document for *future* air vehicles but took exception for existing air vehicles at the time of coordination.

For tanker drogue aerial refueling subsystems, it is important that the aerial refueling procedure(s) identify the limitations and restrictions associated with the receiver's closure rate (relative to the tanker). This information is required to achieve a successful engagement of the probe nozzle with the drogue coupling and the receiver's maneuvering rate (relative to the tanker) once engaged.

When identifying the induced environmental conditions, ensure that during the aerial refueling operation (particularly when the tanker and receiver(s) are engaged) electromagnetic compatibility of the equipment onboard each air vehicle is maintained and that there are no unintentional electromagnetic interactions on any air vehicle caused by the flight operations of another air vehicle in the aerial refueling process. Transmissions on HF communication are a particular concern during aerial refueling operations because the wavelength involved can cause resonant interaction between the air vehicles participating in the aerial refueling process. Electromagnetic compatibility on any air vehicle may be compromised, and arcing is possible across poor electrical bonds.

The airspeed/altitude envelope within which existing receiver aerial refueling subsystems are able to operate varies from subsystem to subsystem. Each receiver has its unique airspeed/altitude envelope within which it can operate its aerial refueling subsystem(s). As such, the airspeed/altitude envelope for each new tanker aerial refueling subsystem being developed should be made as broad as possible to maximize operational utility of the subsystem and mission flexibility for the air vehicle.

Tanker stability varies from platform to platform. Similarly, the stability of a tanker aerial refueling subsystem interface varies from platform to platform and from subsystem to subsystem. Each receiver has its own inherent stability characteristics that can be altered when placed behind a tanker. Receiver stability behind a tanker will differ from tanker platform to tanker platform and from tanker subsystem to tanker subsystem. Thus, the minimum separation distance(s) must be specified for each particular aerial refueling subsystem on each particular tanker platform, taking into account these various stability parameters.

Separation distances have been specified as definite lengths (feet) and have been defined in relative proportion of receiver air vehicle wingspans. For example, the minimum separation distance between adjacent receiver air vehicles in simultaneous, multipoint refueling operations has been specified to equal at least one quarter of the wing span of the largest winged receiver air vehicle that can be in the simultaneous, multipoint refueling operation when the receiver air vehicles are in any position within the fuel transfer range for the tanker aerial refueling systems.

For tanker drogue subsystems, it is critical to address this requirement, particularly when the target receiver air vehicle(s) include(s) rotary-wing (helicopter) receivers. For such receivers, it is important that there is adequate clearance between the trailing aerial refueling hose and the rotary blade(s) of the helicopter receiver such that the rotary blade does not strike the aerial refueling hose during the aerial refueling process. Particular concern for adequate clearance should be upon the approach to contact, initial contact, and fuel transfer positions associated with drogue aerial refueling subsystem. One critical design parameter that can affect the clearance between the trailing aerial refueling hose and the rotary blade(s) of a helicopter receiver is the hose trail angle (catenary curve) for the given airspeed/altitude conditions. Another critical design parameter is the hose response capability (hose reel drogue subsystems) at initial receiver contact and when an engaged receiver maneuvers about within the operating envelope for the given drogue aerial refueling subsystem.

Obstructions can cause the tanker subsystem interface to hang-up and prevent it from mating with the receiver subsystem interface. Obstructions can also cause damage to either aerial refueling subsystem interface, which can make mating not possible or can cause uncontrollable fuel leakage. In addition, obstructions in and around the aerial refueling subsystem interface areas can be damaged and/or break off. This could result in a loss of capability to other air vehicle subsystems and/or could be a source of FOD to the receiver air vehicle. Obstructions identified in previous air vehicles include external air data sensors, external temperature sensors, raised structural fasteners, and antennae.

The U.S. Government has agreed to comply with NATO STANAG 3447 without reservation or exception. As such, all new aerial refueling subsystems must meet NATO STANAG 3447 with regard to clearance around the interface(s).

The tanker boom subsystem interface (boom nozzle) must comply with the dimensional requirements of MS27604 in order to be physically compatible with existing receiver receptacle subsystem interfaces. The tanker drogue subsystem interface (drogue/coupling) must comply with the dimensional requirements of NATO STANAG 3447 in order to be physically compatible with the existing receiver probe subsystem interfaces. The U.S. Government has agreed to comply with NATO STANAG 3447, without reservation or exception. As such, all new drogue subsystem interfaces must meet NATO STANAG 3447. Ensure an adequate target area is provided in the receiver receptacle and tanker drogue interfaces to facilitate engagement with the boom nozzle and probe nozzle, respectively.

Following any type of disconnect, it must be possible for the tanker and receiver to effect another contact, if required, to successfully meet mission requirements. The shorter the time duration, the faster the cycle time between successive contacts of the tanker subsystem with the receiver subsystem will be. From a fuel pressure standpoint, a time of three seconds has been required for the fuel pressure to relieve back down to head pressure after the tanker's coupling disconnects from the receiver's probe. For tanker drogue subsystems, the specified time must account for the hose extension time to its full trail position following an inadvertent disconnect of the receiver probe from the coupling from the innermost position within the fuel transfer envelope for the subsystem.

When a boom subsystem is to be compatible with existing receptacle subsystems, the boom subsystem must be designed to withstand an ultimate tension (pullout) load of 14,000 pounds divided by cosine A, where angle A may vary within a 30 degree cone measured about the receptacle bore centerline with the load applied at the boom nozzle ball joint. The boom subsystem must also withstand an ultimate compression load of 20,000 pounds applied at the boom nozzle ball joint, with the ball joint angle anywhere within a 34 degree cone measured about the receptacle bore centerline. The boom subsystem should also be designed for limit tension and compression loads of 9000 pounds divided by cosine C, where the load is applied at the boom nozzle ball joint and the angle C may vary for 0 to 17 degrees. In addition, the boom subsystem should also be designed to withstand ultimate impact loads of 2000 pounds laterally and 5000 pounds vertically. If it is a drogue subsystem, the drogue subsystem must be able to withstand the design limit disconnect loads. In the past, drogue subsystems were designed to withstand 115 percent of the design limit disconnect load. The limit disconnect load was calculated by the following formula:

$$\text{Load} = [(D + 1500)^2 + (W - L)^2]^{1/2}$$

D = Aerodynamic drag of the hose/drogue when at the full-trail position and at the airspeed/altitude for maximum dynamic pressure.

W = Weight of the hose when full of fuel plus the weight of the drogue/coupling.

L = Aerodynamic lift of the hose at full trail.

The limit disconnect load was applied along the centerline and the extremities of a $\pm 20^{\circ}$ cone centered about the normal lay of the hose when at the full trail position during flight. Also, in the past, a hose load of 2770 pounds had been specified for a 40° cone taken about the normal hose trail axis for the drogue subsystem within its specified operating airspeed/altitude envelope.

In addition, the drogue subsystem should be capable of withstanding impact loads produced by the receiver's probe nozzle contacting all positions of the drogue/coupling up to an angular position of 15° off-center of the drogue/coupling centerline and at probe velocities up to 10 feet per second. The impact loads should be based on the drogue drag at the maximum airspeed within the aerial refueling envelope for that particular drogue aerial refueling subsystem.

The above loads are in addition to any aerodynamic/gust loads that may be imparted on the structure of the air vehicle, its aerial refueling subsystem and the aerial refueling interface while in flight. Also, when the resultant incremental load is additive, the additional load conditions created by the presence (or lack of) cabin pressure and the presence (or lack of) fuel pressure in the fuel lines of the subsystem/interface must be considered. All loading conditions must be applied to the support structure to which the aerial refueling subsystem/interface attaches.

Drogue aerial refueling subsystems have used markings on the fuselage, wing, engine nacelles, and external stores to provide formation references for the receiver air vehicle(s) during the aerial refueling process. The hose of a drogue aerial refueling subsystem typically contains markings to assist the receiver crew(s) in 1) determining that the drogue aerial refueling system is properly functioning, 2) determining the receiver's position relative to the tanker air vehicle once engaged with the drogue, 3) determining where to position the receiver in order to receive fuel from the drogue aerial refueling subsystem.

Centerline boom aerial refueling subsystems have provided position markings on the boom's shaft. These markings have been provided to assist the boom operator in 1) determining the air vehicle's position relative to the tanker air vehicle once engaged with the boom and 2) determining where to position the air vehicle in order to receive fuel from the boom aerial refueling subsystem.

Some tanker boom and receiver receptacle aerial refueling subsystems permit a secure voice communication capability once the tanker's boom nozzle is properly engaged within the receiver's receptacle. This design approach only allows communication to one receiver air vehicle during the contact/fuel transfer phase of the aerial refueling process.

One form of required data communication between tanker and receivers is identification of the receiver by tail number for the tanker's fuel accounting/billing requirements. In boom/receptacle aerial refueling operations, one method used to communicate such data has been to identify the receiver's tail number near/around the receptacle so that it is clearly visible to the boom operator. However, for probe-equipped receivers using a tanker's centerline drogue aerial refueling subsystem, the tail number may have to be verbally communicated to the tanker by the receiver. Other possible required data communication may include the specific amount of fuel accepted by each receiver.

There may be mission requirements where voice/data communication is required throughout the entire aerial refueling sequence (from rendezvous, formation, pre-contact, contact/fuel transfer, reformation). There also may be mission requirements where simultaneous voice/data communication is required between the tanker and multiple receivers throughout the aerial refueling process. Voice/data communication system(s) must be electromagnetically compatible with flight operation of the air vehicles involved in the aerial refueling operation.

When the air vehicle is a tanker, the type(s) of fuel that its aerial refueling subsystem(s) is capable of delivering must be selected based upon the designated primary fuel(s) of the targeted receiver air vehicles. The type(s) of fuel to be delivered by each tanker aerial refueling subsystem may vary from subsystem to subsystem. When the air vehicle is a receiver, the primary fuel(s) for the air vehicle must be identical to the fuel(s) capable of being delivered by the tanker aerial refueling subsystem(s) of the targeted tanker(s). If the air vehicle's primary fuel is different than the primary fuel of the target tanker(s), special modifications will be required on the tanker(s) to support the air vehicle. See the Air Vehicle JSSG-2001 section titled "Fuel designation."

The fuel specifications identify what the requirements are for the fuel at procurement. Once the fuel has been handled through the fuel delivery system (pipeline, storage tanks, hydrant tanks, refuel trucks, etc.), certain properties of the fuel can change prior to the introduction into the air vehicle. Once inside an air vehicle, the fuel properties can change again such that the fuel may no longer meet all of its original specification requirements. This feature must be recognized when transferring fuel from a tanker air vehicle to a receiver air vehicle. The receiver air vehicle may be accepting fuel that no longer meets its procurement specification requirements and may have different properties than that same fuel originally delivered on the ground.

If a tanker air vehicle uses its fuel for thermal management, and that fuel can be transferred to a receiver, the delivered fuel temperature from the tanker to the receiver may be incompatible for use in the receiver's aerial refueling/fuel subsystem, particularly if the receiver also uses its fuel for its own air vehicle thermal management.

Receiver aerial refueling subsystems are designed assuming a predetermined fuel delivery pressure at the aerial refueling interface from the tanker. If the fuel delivery pressure from the tanker is significantly lower than that for which the receiver's aerial refueling subsystem was designed, the fill rate into the receiver will be slower than what is expected for the receiver. In addition, a significantly lower delivery pressure could affect the fill sequence into the receiver, which could impact the center of gravity of the receiver as it aerially refuels. If the fuel delivery pressure from the tanker is significantly higher than that for which the receiver's aerial refueling subsystem was designed, the receiving aircraft can experience higher surge pressures within its aerial refueling subsystem than what is expected. These higher surge pressures might exceed the proof pressure of the receiver's aerial refueling subsystem, which could lead to fuel leaks and/or component damage within the receiver's aerial refueling subsystem.

The maximum fuel delivery rate and delivery pressure possible must be taken into consideration for the tanker/receiver combination, regardless of whether the constraint for delivery rate/pressure is attributable to the tanker subsystem or the receiver subsystem.

Fuel surge pressures include, but are not limited to, those generated by pump start-up, tanker/receiver valve closures, and tanker/receiver disconnects (normal operational disengagement and inadvertent, fuel-flowing disengagement). These types of transient pressures are typical during the aerial refueling process; that is, they are not expected to cause subsystem failures within either the tanker or any receiver aerial refueling subsystem.

Proof pressure limitations must include positive and negative pressures.

In multi-point aerial refueling operations (a tanker having more than one aerial refueling subsystem that has at least two receivers simultaneously refueling), it is important to consider pressure transients generated by the refueling process to one receiver, which can affect pressures in the refueling of another receiver. Where tanker subsystem designs permit such an occurrence, the resultant cumulative fuel surge pressures experienced within the engaged receiver aerial refueling subsystem can be higher than during single-receiver refueling.

When applicable, consider those fuel surge pressures generated during reverse aerial refueling procedures.

Single failures of fuel pressure regulation mechanisms within the air vehicle’s aerial refueling subsystem include any pressure regulator, whether it is installed in a component (for example, coupling), is part of a subassembly (for example, pod), or is installed within the air vehicle’s basic fuel/aerial refueling subsystem. Single failures of surge alleviation mechanisms include surge boots, surge accumulators, surge dampeners, etc.

The total fuel off-load capacity for a tanker must not compromise the air vehicle’s ability to meet other performance requirements within its mission(s); for example, range, loiter, etc.

4.1.7.4 Aerial refueling (tanker) verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Capability to transfer fuel per table 3.1.7.4-I for mission a	Pass/fail	A,S	A,S	A,S		A,S,D
Capability to transfer fuel per table 3.1.7.4-I for mission b	Pass/fail	A,S	A,S	A,S		A,S,D
Capability to transfer fuel per table 3.1.7.4-I for mission …	Pass/fail	A,S	A,S	A,S		A,S,D

VERIFICATION DISCUSSION (4.1.7.4)

Verification of the aerial refueling system requirements is based on identifying the characteristics of the air vehicle receiver(s) the aerial refueling system must accommodate. Then, verification of the aerial refueling system compatibility requires the evaluation of each of the mission and interface requirements between the air vehicle receivers that the aerial refueling system must accommodate. The verifications will be accomplished by integrating a series of analyses followed by simulations, tests, and demonstrations to evaluate each of the interface requirements.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis and simulation of receiver to aerial refueling system interface physical, functional, and procedural characteristics (for example, mandatory STANAGs requirements and mandatory joint service characteristics) between the known receivers and the aerial refueling system indicate that the aerial refueling interfaces are defined and understood. Analysis of the aerial refueling system mission is performed, including fuel capacity, offload rate, pressure regulation capability, and refueling envelope. The totality of these analyses indicates that the requirements have considered all features related to each of the characteristics that are driven by the receivers and by the aerial refueling system mission(s) of the CDD.

PDR: Analysis and simulation of the aerial refueling system missions and interfaces with the targeted receiver aircraft have been completed. Analyses of planned simulations of aerodynamic characteristics of the aerial refueling system and the resulting impact on the receivers have been considered and evaluated relative to aerial equipment mounting locations. Lower-level structural analyses of the loads transferred from the aerial refueling system to the receiver have been evaluated and are within required limits. All moderate-to-high risk items have been identified and mitigation approaches are in place. Interface control documents, if any, have been determined and are in preparation.

CDR: Analysis of the lower-level completed design provisions, simulations, and analysis of lower-level testing of the aerial refueling system design confirms compatibility with the specified requirements for achieving the aerial refueling system requirements. Any area of incompatibility has been thoroughly researched and additional testing of areas of concern has been completed. Interface control documents, if any, have been completed and provided.

FFR: No unique verification action occurs at this milestone.

SVR: Simulations, demonstrations, and analyses of lower-level testing confirm that the aerial refueling interfaces have been achieved.

Sample Final Verification Criteria

The aerial refueling system requirements shall be satisfied when ___(1)___ analyses, ___(2)___ simulations and ___(3)___demonstrations confirm the capability to transfer fuel as specified.

Blank 1. Identify the type and scope of analyses required to confirm the aerial refueling system has met all of the requirements and is capable of transferring fuel as specified.

Analysis should include lower-level air vehicle and subsystem simulations, demonstrations, and testing results.

Blank 2. Identify the type and scope of aerial refueling system simulations required to confirm the aerial refueling system has met all of the requirements and is capable of transferring fuel as specified.

Blank 3. Identify the type and scope of aerial refueling system ground and flight demonstrations required to confirm the aerial refueling system is capable of transferring fuel as specified.

VERIFICATION LESSONS LEARNED (4.1.7.4)

To Be Prepared

3.1.7.5 System reach

The system shall provide the reach indicated in table 3.1.7.5-I for the mission and altitude regime stipulated.

TABLE 3.1.7.5-I. Reach.

Mission, Scenario, Vignette	Reach	System reach reliability	Remarks

REQUIREMENT RATIONALE (3.1.7.5)

System reach characterizes the distance/time for which the system must maintain flight worthiness and mission reliability while deploying to an operating location or conducting a given mission. Normally, it is derived from target base coverage requirements, departure and arrival locations, operational presence requirements, and other factors which demand that air vehicles (supported or unsupported by external assets such as tankers) have endurance measured in terms of distance and/or time. Note that this requirement may result in lower-tier requirements to provide crew rest and provisioning capabilities for missions that are of particularly long duration.

REQUIREMENT GUIDANCE (3.1.7.5)

Guidance for completing table 3.1.7.5-I follows:

Mission, scenario, vignette: List all missions, scenarios, and vignette, (see 3.1.1 Roles and missions), including training missions, as required, to satisfy the CDD. Do not reference the CDD.

Reach: Enter the required distance for the various missions and the type of distance (radius, unrefueled range, etc.). It may be necessary to describe a combination of missions executed in sequence (for example, a refueled range and an unrefueled range or a multiple refueled ferry range and an unrefueled mission radius from a deployment base location). The mission profiles in 3.1.1 Roles and missions should identify aerial refueling points.

For some systems or missions, this may be better described as time duration or a combination of distance and combat loiter duration. For example, the distance between an AWACS base and its orbit location is an important factor, although the critical specification factor is not the distance it travels while in orbit, but it is the required time on orbit.

For some systems, such as cargo/transport systems, additional information may be necessary. Some types of transport missions involve multiple take-offs and landings similar to a commercial bus. These circumstances should be defined, as well as if and what type of servicing is permitted at each stop. The following are a few examples for this situation:

a. Total distance of 6000 km with 5 stops, no servicing; or
b. Total distance of 8000 km with 5 stops, no servicing except refueling; or
c. Total distance of 8000 km with 5 stops, general servicing and refueling allowed.

System reach reliability: Define the mission reliability, consistent with the method of definition chosen in paragraph 3.1.6.1 Mission reliability, for the deployment scenario and vignette.

Remarks: Provide any necessary clarification, such as operational presence, external support requirements, mission weapon loads, deployment equipment loads, etc.

REQUIREMENT LESSONS LEARNED (3.1.7.5)

To Be Prepared

4.1.7.5 System reach verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Required air system reach for each mission and altitude regime stipulated.	Reach and reliability column of table 3.1.7.5-I	A,I	A,S	A		A, D,S, T

VERIFICATION DISCUSSION (4.1.7.5)

Preflight verification for the system reach should be performed with a combination of analysis of design, analysis and inspection of modeling/simulation results, and analysis of wind tunnel testing results. Wind tunnel testing should be used to determine the air vehicle's lift and drag characteristics and engine installation losses to be applied to the uninstalled engine performance models. These air vehicle and engine characteristics and models should be used to predict the air vehicle's range, radius, and loiter, and subsequently the system reach capability.

Final verification for the system reach capability should be performed with a combination of analysis of design, analysis and inspection of modeling/simulation results, analysis of wind tunnel testing results, flight demonstration, and flight-testing using standard flight test techniques. In-flight net propulsive forces and moments should be calculated from in-flight engine measurements, wind tunnel engine thrust calibrations, inlet pressure recovery determined from flight test measurements, and predicted inlet and nozzle power dependent forces and moments from wind tunnel model test data. Airplane drag should be determined from net propulsive forces and moments and air vehicle flight test acceleration/deceleration, rate of climb/descent. The resulting flight test drag polars should be in accordance with a thrust drag accounting system. All configurations such as clean, doors open, external stores, and ferry should be tested. Final verification for the system reach compliance with this requirement should be calculated using flight test drag polars, production air vehicle weight and fuel quantities, and engine uninstalled performance corrected for flight test inlet pressure recovery, bleed and horsepower extraction, and inlet/nozzle power setting effects. The inlet/nozzle power setting effects used will be identical to those used to derive the flight test drag polars.

System reach (mission) reliability verification is the result of a series of efforts/tasks structured to provide increased insight into the attributes of the design, rather than the results of any single test or demonstration. Different elements composing the air system may have different phases or times associated with phases and functions. At the air system level, verification activities must encompass all of the air system's constituent items, to include, as appropriate, systems, subsystems, and equipment, and must address air system operations and all levels of maintenance, from organizational through depot.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Inspect program documentation to ensure that the specified system reach requirements and related mission requirements are addressed. Analysis indicates requirements have properly been allocated to all subsystem requirements. Analyses indicate the design concept is compatible with the requirement based on systems design, maintenance concept, levels of redundancy, reconfigurability, resource sharing, etc., and preliminary subsystem-level reliability predictions (and subcontract requirements, where available). Analysis indicates functions required for each mission have been defined, and that estimated reliability values by function, or hardware (whichever is available) are applied to mission reliability model/analysis. Analysis indicates that verification/validation of reliability levels (whether numerical or levels of detail) at program milestones are agreed to.

PDR: Analysis of the preliminary (total) system design and lower-tier specifications ensures the derivation of appropriate lower-tier requirements. Analysis of the design and flight simulation/modeling indicates the air system can achieve system reach performance. This analysis, simulation, and modeling will be performed on an iterative basis as the contractor modifies the design. Analysis indicates that functionally based mission essential subsystem list (MESL) provides links between functions required for missions, and maintenance checklists are developed and coordinated (preliminary MESLs developed for each part of the air system; that is, ground stations, aircraft, etc. required for complete functionality). Analysis indicates that required functions have been associated with supporting hardware elements, and that predicted mission reliability has been updated to include subcontractor information. Analysis/modeling correctly integrates mission reliability into higher-level requirements and analysis methods (effectiveness metrics, availability, etc.).

CDR: Analysis of system design information, lower-level test/demonstration data, simulation and modeling results, and wind tunnel test results confirms the ability of the air system to achieve all system reach requirements. Failure modes effects and criticality analysis (FMECA), mission reliability, and reliability centered maintenance analyses are accomplished based on detailed design analysis. Predicted mission reliability has been updated to include test results (where appropriate) and usage of life-limited items. Functional MESL has been updated. Functions resolved into supporting hardware elements and supported by a FMECA (or acceptable like analysis) address interconnectivity between hardware and functions. FMECA addresses internal failures of the system as well as input failures to those same systems. Analysis/modeling correctly integrates mission reliability into higher-level requirements.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis, of lower-level test and demonstration data, flight simulation and modeling, wind tunnel tests and ground/flight demonstrations and tests confirms the air system can achieve system reach requirements. Analysis confirms that agreed-to MESL accounts for any disparities or changes resulting from incorporation of test information. Analysis confirms that adjustments for results of flight-test information (BIT codes, compensating provisions, etc.) and other testing results are incorporated into the FMECA. Mission reliability analysis/model and associated predictions are updated (must reflect design as described via FMECA) and include changes based on test and demonstration results. Analysis of all information confirms mission reliability requirements for SDD have been met.

Sample Final Verification Criteria

The system reach requirement shall be satisfied when the ___(1)___ analyses, ___(2)___ demonstrations, ___(3)___ simulations, and___(4)___tests confirm achievement of specified system reach requirements.

Blank 1. Identify the type and scope of analyses required to provide confidence that the requirement elements have been met.

Blank 2. Identify the type and scope of demonstrations required to provide confidence that the requirement elements have been met.

Blank 3. Identify the type and scope of simulations required to provide confidence that the requirement elements have been met.

Blank 4. Identify the type and scope of tests required to confirm that the requirement elements have been met.

VERIFICATION LESSONS LEARNED (4.1.7.5)

To Be Prepared

3.1.7.6 Electronic support jamming

The air system shall provide support jamming or effective electronic countermeasure protection for increased survivability of friendly aircraft against enemy radar systems specified in table 3.1.7.6-I. The air system shall be capable of autonomous, automatic surveillance, intercept, analysis, and identification of the threat/mode of the radars identified in table 3.1.7.6-I. It shall be capable of this operation when the threats are operating individually or when operating in the multiple threat environments defined in table 3.1.7.6-II. Additional capabilities shall include___(1)___. The air systems shall support the electronic jamming mission phases as described in table 3.1.7.6-III.

TABLE 3.1.7.6-I. Threat systems.

Threat System	Characteristics	Definition Source

TABLE 3.1.7.6-II. Multiple threat environments.

Multiple Threat Environment _____ (2)____					
Threat System	Geolocation	Signal Characteristics	Friendly Signals	Geolocation	Signal Characteristics
Multiple Threat Environment _____ (2)____					
Threat System	Geolocation	Signal Characteristics	Friendly Signals	Geolocation	Signal Characteristics

TABLE 3.1.7.6-III. Electronic support jamming mission phase descriptions.

Mission	Scenario	Vignette	Mission Phase	Threat or Threat Environment ID	Jamming Mission-Phase Environment ID

REQUIREMENT RATIONALE (3.1.7.6)

This requirement establishes the electronic support jamming capability of the air system and is a measure of the system's ability to execute its intended function. Defining this capability allows allocation of lower-tier performance requirements.

REQUIREMENT GUIDANCE (3.1.7.6)

Blank 1. Add one or more of the following basic jamming mission descriptions as applicable:

"The air system shall support stand off jamming (SOJ) missions to disrupt the enemy's ability to control the air space in and near the battle area. This shall be accomplished when flying on the friendly side of the forward edge of the battle area (FEBA)."

"The air system shall support close in jamming (CIJ) missions to deny the enemy acquisition inputs to associated terminal threat subsystems."

"The air system shall support missions to provide direct support jamming (DSJ) for friendly aircraft operating near or over enemy territory. DSJ missions shall include escorting friendly aircraft near the FEBA and protecting friendly aircraft during penetration into enemy territory."

Blank 2. Enter a description ID number for each multiple radar threat environment to be referenced in table 3.1.7.6-III.

Complete table 3.1.7.6-I as follows: It is imperative that an adequate threat definition be provided since this information constitutes a major part of the problem statement that the contractor is attempting to solve. Table 3.1.7.6-I should define as clearly as possible what the threats are, their characteristics, and the source of the definition. Types of enemy systems considered for jamming are long and short-range early warning (EW), ground control intercept (GCI), search, track and terminal guidance radars. If the sample tables are not adequate for providing the necessary information, consider using multiple tables to define the necessary parameters, or reference stand-alone documents or appendices with in-depth descriptions.

Complete table 3.1.7.6-II as follows: Along with table 3.1.7.6-I, the threat scenarios define the problem statement. The information in table 3.1.7.6-II defines the geo-location of each of the threats as well as any friendly radar signals in the laydown. This information is instrumental in defining the signal density, frequency distribution, and amplitude distribution that will be processed. This laydown will help to define subsystem bandwidth, dynamic range, timing, and scanning strategy requirements.

This section defines the mission and the environment, and links the functional requirements which follow with the environment under which the system must operate. Table 3.1.7.6-I should define the threat radar systems to be jammed. Table 3.1.7.6-II should define all threat scenarios, emitter laydown, and signal environment in which the system must operate. Together, these tables should define the total signal environment (enemy radars as well as friendly emitters, background signals, wingman emissions, etc.) that must be processed. The threat definition should not be limited to threat parameters only, but should include descriptions of the threat operator's performance/reactions and the overall integrated air defense system (IADS) characteristics and performance. It is especially important in determining system effectiveness that the system will be evaluated against the total IADS, rather than a single radar. While it is a goal to be able to jam every threat on the threat system list simultaneously, it is impractical to design a system to do so. Prioritization of the threat list will enable the contractor to make the informed decisions on the trades that will be required during the design process. An ID number should be assigned for each multiple threat environment description sub-table.

Table 3.1.7.6-III is intended to provide additional guidance to the designer in the area of the mission description. This table will provide valuable insight into the requirement and the

problems associated with existing subsystems. The CDD can be used to help define this area of the specification. Details of this table must reference the altitude, profiles, and operating characteristics of the support jamming aircraft as well as identify the corresponding information for the associated friendly aircraft that are to be protected. Much of this information is included in the mission, scenario, and vignette descriptions in 3.1.1 Roles and missions. The better this area of the specification can be defined, the better the resulting system will be able to meet the requirements.

Complete table 3.1.7.6-III as follows:

Mission, Scenario, Vignette: Identify the mission being conducted, the scenario in which it is conducted, and the vignette that sets the conditions. This should include a reference to 3.1.1 Roles and missions.

Mission Phases: Identify the mission phases, and appropriate operating modes, for the air vehicles in the vignette. Phases can include (but are not limited to) launch, cruise, initiate penetration altitude and speed, long-range target area acquisition, ingress to terminal area acquisition point, terminal area target acquisition, ingress to target area, target acquisition/weapon delivery, proceed to next target, next target acquisition/weapon delivery, egress. Mission phases should lay out the mission from end-to-end or segment-to-segment for each radar threat environment within the mission.

Threat or threat environment ID: Specify threat system from table 3.1.7.6-I or multiple threat system environment ID from table 3.1.7.6-II.

Jamming mission-phase environment ID: Specify an ID number for each mission line for reference in 3.1.7.6.1 Support jamming effectiveness requirements.

REQUIREMENT LESSONS LEARNED (3.1.7.6)

To Be Prepared

4.1.7.6 Electronic support jamming verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Electronic jamming and/or countermeasure capabilities	Provide capabilities against systems in table 3.1.7.6-I (pass/fail for each system)	A,S	A,S	A,S		A,S, T
Electronic jamming and countermeasure systems operation capabilities	- Autonomous, automatic surveillance, intercept, analysis, and identification of threat/mode of radars in table 3.1.7.6-I (pass/fail) - Capability against	A,S	A,S	A,S		A,S, T

	threats individually or when operating together as defined in table 3.1.7.6-II (pass/fail)					
Basic electronic jamming and countermeasure mission scenarios	Blank (1) (pass/fail)	A,S	A,S	A,S		A.S, T
Specific electronic jamming and countermeasure mission phases	Provide capabilities within environments in table 3.1.7.6-III (pass/fail)	A,S	A,S	A,S		A,S, T

VERIFICATION DISCUSSION (4.1.7.6)

Verification of the electronic support jamming function is a total system requirement that, while requiring some actual testing, should make maximum use of models, simulations, and analyses for validation of the requirements. These models, simulations, and analyses should start with specified performance values, progress through using predicted values, and ultimately should use actual lower-tier test data.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis and simulations indicate that lower-tier requirements will provide the required electronic jamming performance.

PDR: Analysis of preliminary air system designs and simulations, using analytically predicted measures of performance, indicates that the system will be capable of performing the specified electronic jamming functions.

CDR: Analysis of detailed air system designs, and use of simulations containing predicted measures, confirms that the system will perform the stated electronic jamming functions.

FFR: No unique verification action occurs at this milestone.

SVR: Analyses and simulations, based on measured performance of lower-level system elements and, where applicable, specific air system-level testing, confirm that the air system can achieve the electronic jamming performance specified.

Sample Final Verification Criteria

Electronic jamming shall be verified through ___(1)___ analyses, ___(2)___ simulations, and ___(3)___ system-level tests for the conditions specified utilizing data obtained from performance testing of the lower-level system elements.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the system-level testing to be used in verifying the requirement.

VERIFICATION LESSONS LEARNED (4.1.7.6)

To Be Prepared

3.1.7.6.1 Electronic support jamming effectiveness

The air system shall provide support jamming capable of denying threat EW/GCI search/acquisition radars identified in table 3.1.7.6-I and in the IADS radar environments specified in table 3.1.7.6-II. The air system shall have the ability to detect and acquire associated friendly aircraft in the mission phase environments specified in table 3.1.7.6-III to within the ranges identified in table 3.1.7.6.1-I, or be capable of deceiving the EW/GCI search/acquisition radars such that acquisition of the correct target is delayed for the time period identified in table 3.1.7.6.1-I. The air system shall also be capable of degrading threat tracking radars identified in table 3.1.7.6-I, in the IADS radar environments specified in table 3.1.7.6-II, the ability to track associated aircraft in the mission phase environments specified in table 3.1.7.6-III, to within the ranges identified in table 3.1.7.6.1-I. For lethal engagements of friendly aircraft, the support jammer shall provide a reduction in lethality (R_L) of each threat identified in table 3.1.7.6.1-I. (Reduction in lethality is defined as the reduction of the percentage of missile or projectile hits versus shots when the subsystem is operating compared to when the subsystem is not operating.) This shall apply when friendly aircraft are within the ___(1)___ dB beam-width of the threat radar and the support jammer is within ___(2)___degrees of the threat mainstream.

Alternately, this requirement might be written as follows:

The air system shall provide support jamming to enhance the Probability of Survival (P_S) of the associated friendly aircraft in the mission phase environments specified in table 3.1.7.6-III, by denying threat search/acquisition radars identified in table 3.1.7.6-I, in the IADS radar environments specified in table 3.1.7.6-II, the ability to detect and acquire. The air system shall reduce the aggregate average Probability of Kill (P_K) of the associated friendly aircraft in each mission phase environment specified in table 3.1.7.6-III, by a minimum of ___(3)___ compared to an identical set of missions without the support jamming capability. The air system shall achieve a minimum percentage Net Reduction in Lethality specified in table 3.1.7.6.1-I of the associated friendly aircraft in each mission phase environment specified in table 3.1.7.6-III, as compared to an identical set of missions without the support jamming capability.

TABLE 3.1.7.6.1-I. Support jamming system effectiveness.

Jamming Mission-Phase ID	Threat EW/GCI Radar Maximum Detection and Acquisition Range	Threat EW/GCI Radar Minimum Target Acquisition Time Delay	Threat Radar Minimum Degraded Tracking Range	Reduction in Lethality (R_L)	Increased Probability of Survival (Ps)	Minimum % Reduction in Aggregate Average Probability of Kill (Pk)	Minimum % NRL

REQUIREMENT RATIONALE (3.1.7.6.1)

This paragraph defines the single most important aspect of the air system's support jammer capability, that of the effectiveness against the threat. Specifying the effectiveness forces the performance of the analyses, modeling, and tests required to ensure the performance of the support jamming capability. The threat weapon systems and their vulnerabilities need to be identified. It is important in determining system effectiveness that the system will be evaluated against the total IADS, rather than a single radar system. The threat definition should not be limited to threat parameters only, but should include descriptions of the threat operator's performance/reactions and the overall Integrated Air Defense System (IADS) characteristics and performance. This must be coupled with detailed knowledge of the operational aspects of the support jamming mission.

REQUIREMENT GUIDANCE (3.1.7.6.1)

The choice of which of the two requirement options to use in the program specification may be driven by the requirement stated in the CDD.

Blank 1. Specify value according to threat assessment.

Blank 2. Specify value according to assessment of operational integrated employment of friendly weapons systems and support jammer.

Blank 3. Specify percentage value for all conditions or state "specified values in table 3.1.7.6.1-I".

Table 3.1.7.6.1-I defines the detailed effectiveness required of the subsystem. The specific threats and their corresponding modes must be analyzed for potential vulnerability to both onboard and off-board countermeasures. The effectiveness requirements must be accomplished on a per threat basis and placed in table 3.1.7.6.1-I. This should be accomplished both on a single threat basis and for each threat when placed in the table 3.1.7.6-II scenarios. Definition of the requirement should consider the geometry of the engagement--i.e. the relative positions of the threat, the friendly aircraft and the host aircraft/jammer. The requirement for mainbeam vs. sidelobe jamming should also be include in the threat analysis. During a typical

mission, it will be difficult to maintain the friendly aircraft within the beamwidths of both the support jammer and the threat radar.

Table 3.1.7.6.1-I should also include the anticipated screening range required for each of the friendly aircraft identified as associated aircraft above. table 3.1.7.6.1-I should also identify the anticipated time delays that will be evident from the deceptive countermeasures techniques, the required time delay associated with preventing the radar from transitioning from one mode to the next, and the Reduction in Lethality (R_L) that will be evident against terminal threat radars.

In using this equation, the term 'Hit' must be defined. This is often stated as the closest approach of a threat missile or projectile to the aircraft compared to the weapon lethal range. Weapon lethal range is normally defined in the available threat documentation or in the MCM 3-1 Manual. The term "Wet" and "Dry" refer to a jamming and no jamming condition, respectively.

For non lethal countermeasures, metrics that are not related to weapon shots are needed. For these types of deception countermeasures, required time delay associated with preventing the weapon system from transitioning from one mode to the next can be used. Examples are reduction in radar track time, percentage of the threat track envelope denied, confusion caused by false targets, etc.

Complete the support jamming mission effectiveness table (table 3.1.7.6.1-I) as follows:

Jamming mission-phase ID: Specify the applicable mission-phase ID number from table 3.1.7.6-III. Applies to all parameters in table 3.1.7.6.1-I.

Threat EW/GCI radar maximum detection and acquisition range (search & acquisition radars): Specify maximum range for denial of friendly aircraft detection and acquisition by threat radar. This measurand parameter applies to the first requirement option.

Threat EW/GCI radar minimum target acquisition time delay (search & acquisition radars): Specify minimum delay time for correct target acquisition by threat radar. This measurand parameter applies to the first requirement option.

Threat radar minimum degraded tracking range (tracking radars): Specify minimum range for threat radar beyond which it has degraded ability to track friendly aircraft. This measurand parameter applies to the first requirement option.

Reduction in lethality (R_L): Specify minimum positive value. This measurand parameter applies to the first requirement option. For lethal modes, the R_L should be defined using the following equation:

$$R_I = \left(\frac{\left(\frac{\quad}{\#SHOTS_{DR}} \right) - \left(\frac{\quad}{\#SHOTS_{WE}} \right)}{\left(\frac{\quad}{\#SHOTS_{DRY}} \right)} \right) X\ 100\%$$

$$R_I = \left(\frac{\left(\frac{\quad}{\#SHOTS_{DR}} \right) - \left(\frac{\quad}{\#SHOTS_{WE}} \right)}{\left(\frac{\quad}{\#SHOTS_{DRY}} \right)} \right) X\ 100\%$$

<u>Increased probability of survival (Ps):</u> This measurand parameter applies to the second requirement option.

<u>Minimum % reduction in aggregate average probability of kill (Pk):</u> This measurand parameter applies to the second requirement option.

<u>Minimum % net reduction in lethality (NRL):</u> This measurand parameter applies to the second requirement option. NRL is defined using the equation below, where P_K is the probability of Kill, for the non-jamming case (Dry), and for the jamming case (Wet). This equation is similar to that of the Reduction in Lethality (R_L) in that the basis is in the comparison of the non-jamming case (Dry) with the jamming case (Wet). Whereas the R_L depends on only two factors (miss distance and weapon lethal radius), the NRL adds to this other factors including missile fusing characteristics, aircraft fuse signature, warhead characteristics and blast pattern, specific missile orientation and position at time of detonation, fragment size/fly-out, aircraft vulnerability, etc.

$$NRL = \left(\frac{P_{K\ DRY} - P_{K\ WET}}{P_{K\ DRY}} \right) X$$

$$NRL = \left(\frac{P_{K\ DRY} - P_{K\ WET}}{P_{K\ DRY}} \right) X$$

REQUIREMENT LESSONS LEARNED (3.1.7.6.1)

In the past, electronic countermeasures programs have concentrated on defining and measuring characteristics of the subsystem such as ERP, antenna coverage etc. without defining the 'real' requirement which is to provide effective protection to the aircraft of interest. Simply defining the parameters of a weapon system does not ensure the system performance. Specifying the performance at a system level will result in a more well-defined set of subsystem requirements.

4.1.7.6.1 Verification of support jammer effectiveness.

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Denial or deception of threat EW/GCI search/acquisition radars	- Maximum detection and acquisition range (for each mission phase environment ID in table 3.1.7.6.1-I) - Minimum target acquisition delay time (for each mission phase environment ID in table 3.1.7.6.1-I)	A,S	A,S	A,S		A,S, T
Degrading threat tracking radars	Minimum degraded tracking range (for each mission phase environment ID in table 3.1.7.6.1-I)	A,S	A,S	A,S		A,S, T

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Jamming effectiveness against threat radars in lethal engagements of friendly aircraft when: - Friendly aircraft within (1) dB threat radar beam-width - Support jammer within (2) degrees of threat mainstream	Reduction in lethality (R_L) (for each mission phase environment ID in table 3.1.7.6.1-I)	A,S	A,S	A,S		A.S, T
Deny threat search/acquisition radars ability to detect and acquire friendly aircraft	Increased Probability of Survival (Ps) (for each mission phase environment ID in table 3.1.7.6.1-I)	A,S	A,S	A,S		A,S, T
Degrading radars of IADS	- Minimum of __(3)__% reduction in aggregate average Probability of Kill (Pk) - Minimum % NRL (for each mission phase environment ID in table 3.1.7.6.1-I)	A,S	A,S	A,S		A,S, T

VERIFICATION DISCUSSION (4.1.7.6.1)

Verification of the air system's support jammer effectiveness is normally done through a combination of analysis, modeling and testing. Analysis should include the verification of key subsystem parameters such as ERP, antenna coverage, detection range etc. Modeling should be accomplished at various levels of the subsystem. Modeling of the various functions such as the receiver/processor and transmitters will provide insight into whether the subsystem architecture will support operation against the threats defined in table 3.1.7.6-I and in the defined scenarios of table 3.1.7.6-II. Modeling of the countermeasures techniques and their associated interaction with the threats will provide insight into the expected effectiveness of the subsystem. The effectiveness of the support jammer can be modeled at a campaign or mission level to assess the overall improvement of the Ps of the friendly aircraft when the support jammer is employed. Finally, the air system must be tested to verify that the actual support jammer performance meets the expected performance as shown in the subsystem modeling and analysis.

Testing may be accomplished at various levels of the subsystem. The test program may include testing of the subsystem's functions such as the receiver processor and transmitter, and effectiveness testing of the ECM techniques. These tests may be accomplished at the contractor's facility where threat emitter wave forms may be generated in a single and multiple threat environment. Additionally, various Government facilities such as the IDAL, RADC, REDCAP, the AFEWES and the BAF are available to test various aspects of the support jammer. Flight testing would then be accomplished as a final check of the operation of the support jammer. As the testing requirements are defined, the available facilities must be evaluated for their ability to test a given requirement adequately. It is common for a given requirement to be verified in multiple ways. For example, verification of the ability to detect, identify, prioritize, etc. would normally be verified initially via paper analysis followed by in-plant testing and then testing at one or more Government ground test facilities. The final verification of the requirement would then be done in flight test.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis and simulations indicate that lower-tier requirements will provide the required electronic jamming performance. Rationale which demonstrates that the verification of electronic jamming support aircraft system performance effectiveness requirements is accomplished by combining results of the verifications partitioned to subordinate paragraphs.

PDR: Analysis of preliminary air system designs and simulations, using analytically predicted measures of performance, indicates that the system will perform the specified electronic jamming functions. Analyses of preliminary designs indicate that threat environment and system capabilities are being considered in identification of system concept of operation for single and multiple threat scenarios.

CDR: Analysis of detailed air system designs, and use of simulations containing predicted measures, confirms that the system will perform the stated electronic jamming functions. Estimate of countermeasures effectiveness and its impact on host aircraft and associate aircraft survivability.

FFR: No unique verification action occurs at this milestone.

SVR: Analyses and simulations, based on measured performance of lower-level system elements and, where applicable, specific air system-level testing, confirm that the air system can achieve the electronic jamming performance specified. Results of analysis, simulation, test, and other development tools support effectiveness of countermeasures assessments against each of the threats.

Sample Final Verification Criteria

Electronic jamming effectiveness shall be verified through ___(1)___ analyses, ___(2)___ simulations, and ___(3)___ system-level tests for the conditions specified utilizing data obtained from performance testing of the lower-level system elements.

Blank 1. List the type and scope of analysis to be performed.

Blank 2. List the type and scope of the simulations to be used in verifying the requirement.

Blank 3. List the type and scope of the testing to be used in verifying the requirement.

Verification lessons learned (4.1.7.6.1)

The verification plan/procedure should be agreed to very early in the program, preferably before contract award.

3.1.7.7 Search and rescue

The air system shall provide search and rescue (SAR) capabilities as defined in table 3.1.7.7-I. The system shall provide ___(1)___ level of medical assistance to retrieved personnel.

TABLE 3.1.7.7-I. Search and rescue capability.

Mission, Scenario, Vignette	Conditions	Personnel Retrieved at End of On-Station Loiter

REQUIREMENT RATIONALE (3.1.7.7)

This requirement establishes the capability to perform SAR missions as a primary requirement of the system and is a measure of the system's ability to execute its intended function. Defining this performance allows the developer to allocate lower-tier performance requirements.

REQUIREMENT GUIDANCE (3.1.7.7)

Blank 1. The type and level of medical assistance to be provided during SAR operations must be stipulated as this will drive onboard equipment, crew station, and crew size and composition requirements.

Complete table 3.1.7.7-I as follows:
Mission, scenario, vignette: Enter the type of search and rescue missions that the air system must be capable of performing. Examples of valid entries include "Combat," "Maritime," and "Mountain". Reference mission profile, scenario, vignette from section 3.1.1 Roles and missions.

Conditions: Enter the conditions in which the system must be able to perform SAR missions. Examples of valid entries include "all weather day\night," wind strength (Beaufort scale, or wind force number, etc.) at on-station loiter/rescue location, sea-state at on-station loiter/rescue location if applicable, type of rescue mission equipment load, etc.

Personnel retrieved at end of on-station loiter: Enter the maximum number of personnel that the air system must be capable of retrieving in a single mission.

REQUIREMENT LESSONS LEARNED (3.1.7.7)

To Be Prepared

4.1.7.7 Search and rescue verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Search and rescue capabilities identified in table 3.1.7.7-I	Mission (a) capabilities: (pass/fail) Mission (b) capabilities: (pass/fail) Mission (. . .) capabilities: (pass/fail)	A	A	A,S		A, D, S,T
Medical assistance capability	___(1)___ level of medical assistance	A	A	A, S		A, D, S,T

VERIFICATION DISCUSSION (4.1.7.7)

A combination of analyses, inspections, demonstrations, and tests should be performed as necessary to verify the air vehicle can perform the desired SAR mission.

Key Development Activities

Key development activities should include, but are not limited to, the following:

SRR/SFR: Analysis of the air system design concept indicates that SAR mission capabilities are being considered and are allocated to lower level requirements.

PDR: Analysis of the preliminary air system design indicates that the SAR mission capabilities are included and are being flowed down to lower level requirements.

CDR: Analysis and simulation of the air system design confirms that the SAR mission can be performed. Analysis and simulation confirms that the air system will be able to retrieve the required number of personnel. Analysis of lower level structural analyses confirms that the forces involved in loading and flying each person are available and are within allowable limits.

FFR: No unique verification action occurs at this milestone.

SVR: Analyses, demonstrations, and test confirm that the SAR mission can be accomplished. System level simulation confirms that the operational scenario for search and rescue can be achieved. System level demonstrations confirm that worst-case scenarios can be performed.

Sample Final Verification Criteria

The SAR mission requirement will be considered to be satisfied when ___(1)___analyses, ___(2)___simulations, ___(3)___ demonstrations and ___(4)___ tests confirm specified delivery rate.

Blank 1. Specify the type and scope of analyses that will provide confidence that the requirement has been met.

Blank 2. Specify the type and scope of system-level simulations that will provide confidence that the requirement has been met

Blank 3. Specify the type and scope of system-level demonstrations that will provide confidence that the requirement has been met

Blank 4. Specify the type and scope of system-level tests that will provide confidence that the requirement has been met

VERIFICATION LESSONS LEARNED (4.1.7.7)

To Be Prepared

3.1.8 Reserve modes

The system shall be capable of providing wartime reserve modes as indicated in table 3.1.8-I.

TABLE 3.1.8-I. Wartime reserve modes.

Function/Characteristic	Capability

REQUIREMENT RATIONALE (3.1.8)

Wartime reserve modes are characteristics and operating procedures of sensor, communications, navigation aids, threat recognition, weapons, and countermeasures systems that will contribute to military effectiveness if unknown to, or misunderstood by, opposing commanders before they are used but could be exploited or neutralized if known in advance.

Wartime reserve modes are deliberately held in reserve for wartime or emergency use and seldom, if ever, applied or intercepted prior to such use.

REQUIREMENT GUIDANCE (3.1.8)

Wartime reserve modes are determined via three primary sources:

a. Directed, for example, in the operational requirements document or program direction;

b. Interface driven (either directed or derived); or

c. Translating operational (or other) requirements into system specific capabilities. That is, during concept exploration and program definition phases, capabilities are identified that are consistent with, and that support achievement of, warfighter requirements but should be held in reserve for wartime use to prevent exploitation by an adversary.

Guidance for completing table 3.1.8-I follows:

Function/Characteristic: Identify the function or characteristic for which a wartime reserve mode capability is required.

When a function is identified, be as explicit as possible to provide limiting guidance to the extent required. For example, consider the difference between “communication” and “intra-flight communication.” The first would require that all communications throughout the system (including communications in training and support) be afforded the capability defined. The second would limit the capability to just communications between the air vehicles in a flight. Rather than specifying all communication, identify each type to the extent required by using separate entries in the table (for example, “intra-flight communication” could be one entry, “communication with AWACS” could be another, and so forth).

When a characteristic is identified, specificity is also important. One dilemma with characteristics is they tend to be associated with specific solutions. This may be unavoidable where characteristics are associated with specific parameters the warfighter has deemed important and with characteristics/capabilities associated with an interfacing item. Characteristics should be tied to a specific requirement in the system specification or, if appropriate, an attachment to it.

Capability: Describe the capability required. For example, if multiple reserve modes for intra-flight communication are needed, define what is expected. For example, “3 channels” and cite the characteristics of those channels such as whether or not they need to be secure and what constitutes “secure” such as encryption or other mechanism. It will likely be necessary to describe capabilities for characteristics in more specific terms than is necessary for a function. For example, the capability for secure, intra-flight communication could be expressed in terms of denial of reception of an emission, interpretation of the content, etc. To the extent practicable, provide functional descriptions and performance requirements and avoid the use of specific solutions.

REQUIREMENT LESSONS LEARNED (3.1.8)

To Be Prepared

4.1.8 Reserve modes verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Function a	Capability measurement parameter	TBD	TBD	TBD	TBD	TBD
Function b	Capability measurement parameter	TBD	TBD	TBD	TBD	TBD
Function …	Capability measurement parameter	TBD	TBD	TBD	TBD	TBD

VERIFICATION DISCUSSION (4.1.8)

The above table, as well as the incremental and final verification paragraphs below, are placeholders and are dependent upon what the actual reserved modes are. Some modes can be tested or demonstrated at the system or subsystem level, while others, because of security considerations, may only be evaluated through analysis or simulation at the system or subsystem level. No further guidance can be given on this section.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Unique to program.

PDR: Unique to program.

CDR: Unique to program.

FFR: Unique to program.

SVR: Unique to program.

Sample Final Verification Criteria

Unique to program.

VERIFICATION LESSONS LEARNED (4.1.8)

To Be Prepared

3.1.9 Lower-tier mandated requirements

The air system lower-tier mandated requirements shall be as specified in the following: __(1)__.

REQUIREMENT RATIONALE (3.1.9)

This paragraph accommodates those circumstances in which system technical characteristics have been deemed essential by the operational requirements proponent and incorporated into the CDD. Requirements included in this section are typically derived from system specification requirements and included in lower-tier specifications, but these have been identified as crucial system characteristics. Sources of such requirements include the CDD, the program management directive (PMD), and the acquisition decision memorandum (ADM) to name a few. Including these requirements in the system specification is necessary to ensure that all lower-tier requirements can be traced to controlling requirements contained in the system specification.

REQUIREMENT GUIDANCE (3.1.9)

This requirement is typically completed by the Government program office, sometimes in concert with potential contractors. Include any performance requirements mandated by the sources listed in the rationale paragraph, but do not include interface requirements. Provide a paragraph number for each separate requirement.

REQUIREMENT LESSONS LEARNED (3.1.9)

To Be Prepared

4.1.9 Lower-tier mandated requirements verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Mandated Requirement a	Capability measurement parameter	TBD	TBD	TBD	TBD	TBD
Mandated Requirement b	Capability measurement parameter	TBD	TBD	TBD	TBD	TBD
Mandated Requirement …	Capability measurement parameter	TBD	TBD	TBD	TBD	TBD

VERIFICATION DISCUSSION (4.1.9)

Completion of the above table, as well as the incremental and final verification paragraphs below, is dependent upon what the actual, mandated requirements are. In general, the final verification of these requirements will be by test or demonstration at a lower level and will be evaluated at this level by review of verification documentation.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Unique to program.

PDR: Unique to program.

CDR: Unique to program.

FFR: Unique to program.

SVR: Unique to program.

Sample Final Verification Criteria

Unique to program.

VERIFICATION LESSONS LEARNED (4.1.9)

To Be Prepared

3.2 Environment

The system shall provide full, specified performance during and after experiencing the cumulative effects of the combination(s) of environments the system is expected to experience over its lifetime.

a. Natural Environment. The system shall satisfy the requirements specified herein throughout its service life during and after operation in, and exposure to, the following worldwide conditions: ___(1)___.

b. Induced Environment. The system shall satisfy the requirements specified herein throughout its service life during and after operation in, and exposure to, its intended functional environment. Specifically, the man-made (non threat), induced environmental conditions in which the system and its components must function are ___(2)___. Man-made threat environments are addressed as part of the vulnerability and susceptibility requirements.

c. Limiting Environmental Conditions. The system shall satisfy the requirements specified herein throughout its service life, during and after operation in, and exposure to, the conditions in table 3.2-I, with exceptions as noted therein.

TABLE 3.2-I. Environmental conditions.

Absolute Environment Condition	Frequency	Duration	Requirement Exceptions During Operation	Remarks

REQUIREMENT RATIONALE (3.2)

The environments in which the system must perform can affect the overall performance (for example, the effect of weather on sensor range). The internal and external environmental conditions to which the system is exposed, both while operating and not operating, impose stresses on the system that lead to failure. These environments, along with the design usage data established in section 3.1.1 Roles and missions, and its associated subparagraphs, are used to establish the specific design duty cycles for each element of the system. This requirement provides the environmental boundaries in which the system is expected to meet full specified system performance and provides the necessary information when combined with the usage data of 3.1, and its associated subparagraphs, for designing integrity into the system at all levels.

REQUIREMENT GUIDANCE (3.2)

Typically, the platform or host vehicle environmental data are documented in environmental control documents (ECDs) or similar technical documentation. If the program requires the system equipment to be installed or used on more than one host system, requirements from each system should be included. The service life of the system is defined in 3.3.1.2 System service life.

The technical documentation discussed above, which defines the environmental conditions for the system, should not be put under formal Government control until after completion of the SVR, or later. This allows the contractor to refine the environmental conditions throughout the design as more details are obtained, and to make the necessary changes to the system design without requesting Government approval and specification changes. This technical documentation, under formal Government control at the completion of the program, is used as the initial environmental definition documentation for future system updates.

Constraints on the combination of environments must meet the test of reasonableness. That is, the combination must be one that may be encountered during actual employment and not a contrived combination. For example, requiring an immersion test while simultaneously freezing the test article (for example, an electronic jammer) and then requiring it to perform satisfactorily would not normally be considered reasonable, would be inconsistent with intended usage, and is too detailed for a system specification. On the other hand, expecting an aircraft to perform its mission after exposure to deicing chemicals while parked in a freezing rain would be reasonable.

Blank 1. The prime contractor for a system item is usually responsible for the specific environmental data for the item. It is reasonable to expect that the prime contractor will work with subcontractors to determine or estimate the expected natural and induced environmental conditions as those conditions are propagated within the system. The Government defines the required set of environmental conditions for system operation. In the system specification, the natural environment (blank 1) can be handled by identification/description of geographic areas and seasons. For example, winter carrier operations in the North Atlantic, or summer basing in Southwest Asia deserts (Saudi Arabia), or year-round operations from any CONUS air base.

Blank 2. The functional environment of the system is further subject to induced environmental effects, such as the man-made phenomena of vibration, shock, electromagnetic interference (EMI), adjacent heating and cooling, acidic/corrosive atmosphere (for example, acid rain), chemicals, and other contaminants (blank 2). Of particular interest is the achievement of electromagnetic compatibility (EMC) among subsystems and equipment during all functional operating modes, and while individually or collectively operated, as well as with like platforms, other systems, and the external electromagnetic environment. Attention to expected operating environments is essential, such as shipboard conditions associated with electromagnetic emissions, and power-on testing of mission systems (such as radar). In addition to the air vehicle, the support and training equipment operated in their respective functional environments also shall be electromagnetically compatible.

The induced environments should be characterized for both steady-state and transient conditions for each critical point in the life cycle environmental profile and/or flight envelope. Particular attention should be directed at transient conditions, power cycling, vibration, and thermal stresses that occur on start-up, dwell, cycling, and shutdown. Similarly, identify the environments associated with manufacturing, training, maintenance (at all levels), transportation, and handling, since they all can impact the life and reliability of the system.

Guidance for completing table 3.2-I follows:

There are some environmental conditions not adequately characterized by seasonal information (natural, induced, and combinations) that the system will experience and must be capable of withstanding while sustaining full (or some minimum level of) performance. These limiting environmental conditions should be identified in table 3.2-I. Examples of such limiting environmental conditions include full performance at -65°F; safe launch, recovery, and on-deck maneuvering in sea state 3; ability to withstand XX MPH winds while parked in an exposed state at an air base; and other such factors impact the system design. Also, identify the frequency (for example, occurrences per year) and duration (for example, minutes or hours for high winds, days/weeks/months for temperature extremes) of such limiting conditions. Some of these conditions may reasonably be expected to degrade the system's ability to meet requirements during exposure. If so, enter the minimum expectations as an exception during operation. If exceptions are permitted, care should be taken to ensure that reasonable impacts are identified, and the exception is only for the duration of the condition. The reason this requirement is framed in this manner may be illustrated by a simple example. Suppose that the system must be capable of operating in exceptionally cold temperature. It may be reasonable to allow some relaxation in the integrated combat turnaround time. However, it may not be reasonable to allow a relaxation after the limiting environmental condition has terminated, nor would it likely be reasonable to allow a decreased lethality while the condition is occurring. The remarks column can be used to communicate special considerations. Additionally, it can identify a condition simply as a withstand condition. For example, in the case of high winds, the requirement could simply be to withstand the wind with no expectations that sorties will be generated.

REQUIREMENT LESSONS LEARNED (3.2)

Many of the environments are based on the missions, scenarios, mission mix, and mission profiles established in 3.1.1 Roles and missions. Any changes to these may result in changes to the environments. Understanding the design environment early in the development phase will help eliminate excessive redesign and the potential program delays.

4.2 Environment verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Natural environment	(1)	A	A	A	A	A
Induced environment	(2)	A	A	A	A	A
Limiting Conditions	Table 3.2-I Requirement Exceptions	A	A	A	A	A,T, D

VERIFICATION DISCUSSION (4.2)

This requirement provides condition information that must be considered in developing all air system performance requirements and verifications. In the event that conditions of the natural environment are defined or modified in other specific air system performance requirements, the text of said specific requirement should take precedence over this requirement for that particular performance. Therefore, the verification approach defined below assumes that the air system performance in specific environments will be verified via the specific performance requirements.

Natural Environment

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Natural environment conditions are defined and analyzed for the specified operations, missions, and service life usage profile. Analysis should define the life cycle model which reflects natural environments, including any combinations expected to occur.

PDR: Natural environmental conditions/data are finalized. Initial design requirements incorporate natural environment considerations.

CDR: Design requirements incorporate considerations concerning the natural environment.

FFR: Conditions of the natural environment have been appropriately and consistently applied to the system and system element verifications.

SVR: Conditions of the natural environment have been appropriately and consistently applied to the system and system element verifications.

Sample Final Verification Criteria

Analysis of verification criteria for each air system performance requirement specified herein confirms that the natural environment has been applied in defining the specific environmental requirements/conditions for each air system performance requirement.

<u>Induced Environment</u>

This requirement provides condition information that must be considered in developing all air system performance requirements and verifications. In the event that induced environmental conditions are defined or modified in other specific air system performance requirements, the text of said specific requirement should take precedence over this requirement for that particular performance. Therefore, the verification approach defined below assumes that the air system performance in specific environments will be verified via the specific performance requirements.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Conditions of the induced environment are defined and analyzed for the specified operations, missions, and service life usage profile. Analysis should define the life cycle model which reflects induced environments, including any combinations expected to occur.

PDR: Induced environmental conditions/data are finalized. Initial design requirements incorporate induced environment considerations.

CDR: Design requirements incorporate considerations concerning the induced environment.

FFR: Considerations concerning conditions of the induced environment have been appropriately and consistently applied to the system and system element verifications.

SVR: Considerations concerning conditions of the induced environment have been appropriately and consistently applied to the system and system element verifications.

Sample Final Verification Criteria

Analysis of verification criteria for each air system performance requirement specified herein confirms that the induced environment has been applied in defining the specific environmental requirements/conditions for each air system performance requirement.

Limiting Environmental Conditions

Limiting environmental condition requirements may be defined in other air system requirements. In those instances, verification of compliance with the limiting environmental conditions should be defined in the corresponding verification requirements. When limiting environmental conditions are specified in 3.2C, verification should be as defined below.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Limiting environmental conditions/requirements are defined and analyzed for the specified operations, missions, and service life usage profile. Analysis should define the life cycle model which reflects limiting environments, including any combinations expected to occur.

PDR: Limiting environmental conditions/data are finalized. Initial design requirements incorporate limiting environment considerations.

CDR: Design requirements incorporate limiting environmental considerations.

FFR: Limiting environmental conditions have been applied to the system and system element verifications.

SVR: Limiting environmental conditions have been applied to the system and system element verifications are complete. Method of verification is dependent on the specific limiting conditions.

Sample Final Verification Criteria

The ___(1)___ requirement exception shall be verified by ___(2)___ for the ___(3)___ environmental conditions.

Blank 1. Identify the requirement that incurs a reduced level of performance while stressed by an adverse environment. For example, time to conduct an ICT in extremely cold weather might be expanded from 5 minutes to 25 minutes.

Blank 2. Specify the verification method and scope/confidence level/fidelity. For example, three ICT demonstrations achieving the exception time requirement. In developing this verification, the specification developer should refer to the verification associated with the requirement prior to exception (for example, ICT requirement).

Blank 3. Identify the limiting environmental conditions from table 3.2-I.

VERIFICATION LESSONS LEARNED (4.2)

To Be Prepared

3.3 System characteristics

This is a paragraph header facilitating document organization.

3.3.1 Force life cycle management

This is a paragraph header facilitating document organization.

3.3.1.1 System architecture

This is a paragraph header facilitating document organization.

3.3.1.1.1 Growth

The air system shall have the growth capability as defined in table 3.3.1.1.1-I.

TABLE 3.3.1.1.1-I. Growth provisions.

Type of Provision	Capability	Growth Value	Conditions

REQUIREMENT RATIONALE (3.3.1.1.1)

Historically, military air systems have incurred numerous changes, upgrades, and modifications over their service life. System modifications are required for many reasons (correction of deficiencies, performance upgrades, technology insertion, parts obsolescence, etc.). The scope of changes can vary from basic software modifications to complete redesigns. This requirement is intended to incorporate growth provisions in the system's design that would enable the system to accommodate some level of modification without continually requiring major, expensive redesigns.

When a known, parallel development program or a preplanned product improvement has been scheduled for out year integration into the air system, growth provisions are established during initial system design to facilitate the planned integration.

> Growth: The inclusion of physical and/or functional characteristics/provisions that enable expansion or extension of the system's capability with minimum disruption of the system design.

REQUIREMENT GUIDANCE (3.3.1.1.1)

Provisions for growth beyond original design criteria can be a significant cost driver and should be carefully considered and controlled.

Include this requirement to ensure the system has flexibility and growth provisions to accommodate required changes. Although the specific or exact changes or modifications that will be incurred by the system over its life cannot be defined at the time of the system's initial development, historical precedence indicates that system changes are inevitable. Design approaches should be taken to define the system architecture in a way that provides growth capacity to make undefined, future changes easier and less costly to implement. Recognizing that some changes, upgrades, and modifications may require major redesigns, the requirement should be defined consistent with a portion of the system's service life. The requirement is stated in general terms, describing the overall characteristics desired to achieve the intended purpose or end result. If more specific characteristics or features are known, or can be defined, (that is, the percent of growth capacity, amount of growth memory, number of spare pins, etc.), provide the more definitive requirement.

Computer resources and software are particularly sensitive to growth capacity to promote supportability and mitigate impacts of change over the system's life. Computer processing capability is advancing at a high rate, enabling dramatic improvements in system functionality. System designs should plan for and accommodate such technological evolution. Software, by nature, is continually modified and expanded. In fact, history shows that there is typically a significant growth in the software even during a system's development phase. However, these growth requirements focus on "post-development" changes. That is, the baseline design should incorporate the capacities needed during development plus the required growth provisions. The system computer resources design needs to incorporate the necessary additional memory, processing capability and input/output capacity to improve or extend the specified system or system component operations and/or performance without major modifications to the system.

Defining growth provisions necessitates anticipation of both planned and unplanned requirements. Planned requirements typically address preplanned product improvement (P^3I) and evolutionary acquisition approaches.

> Preplanned Product Improvement. The conscious, considered strategy that involves deferring the development of necessary performance capabilities associated with elements having significant risks or delays so that the system can be fielded while the deferred element is developed in a parallel or subsequent effort. Provisions, interfaces, and accessibility are integrated into the system design so that the deferred element can be incorporated in a cost-effective manner when available. The concept also applies to process improvements.

> Evolutionary Acquisition. An adaptive and incremental strategy applicable to high technology and software intensive systems when requirements beyond a core capability can generally, but not specifically, be defined.

Unplanned requirements can be borne out of examining historical information on mission growth potential or analyzing historical use of the class of air vehicle being developed. For example, air combat fighters are frequently reroled as air-to-surface air vehicles. Redesigning/redeveloping structure and adding "hard points" can be prohibitively expensive but can be realized at modest costs and penalties during the original development. Another way to accommodate for growth is incorporating just-in-case provisions that are inexpensive to implement in design and construction but expensive to implement in already built articles (for example, adding additional wire(s) for power or information transfer during initial construction, or providing additional capacity for power and cooling). Also, by examining the potential impact of promising, mission-relevant technologies that are not yet ready for transition, growth considerations can be planned for future integration.

Regardless of why growth capability may be needed, a well-thought-out plan should be constructed that identifies reasonable estimates of the costs, benefits, and penalties.

Complete table 3.3.1.1.1-I as follows:

Type of Provision: Identify the type of provision required. This may include terms such as “Group A Provisions,” “Group B Provisions,” “Complete Provisions for,” ”Power Provisions,” “Space Provisions,” “Weight Provisions,” etc. A complete list of applicable terms and their definitions can be found in 6.3.7.1 Provisions, contractor (expressions).

Capability: Define the capability for which a growth design allowance is needed. To the extent possible, describe the capability functionally. For example, unused volume, additional capabilities or functionality (for example, air-to-surface), provisions for weight growth, power distribution, etc.

Growth Value: Define the magnitude or growth required. Identify whether the growth provisions are to extend the functional capability or whether the growth potential is for incorporation of new functionality. For example, avionics cooling of XXXX BTUs, growth volume of 5 cubic feet, hard points for air-to-surface ordnance, unused power cable to “growth” equipment bays, etc. The growth value should be stated as uninstalled growth, installed growth, or both.

Conditions: Define any conditions necessary for the envisioned application of the requirement. For example, if the requirement were for 5 cubic feet of volume, it would be desirable to identify the minimum contiguous volumes necessary (such as 1 cubic foot). If allowances are being provided for pre-planned improvements, identifying a location may also be necessary, such as 2 cubic feet at the forward, bottom portion of the fuselage.

REQUIREMENT LESSONS LEARNED (3.3.1.1.1)

To Be Prepared

4.3.1.1.1 Growth verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Growth Capability	Table 3.3.1.1.1-I, Growth Value	A	A/I	A/I		A

VERIFICATION DISCUSSION (4.3.1.1.1)

Growth capability verification is based on positive determination through progressive analysis and inspection that the required air system growth requirement is addressed in the design and is attained in the production system.

Verification of growth should thoroughly address not only the satisfaction of the growth requirements, but should also verify adequate provisioning by subsystems and total compatibility with other systems/subsystems that will be affected by future growth (cooling, power, etc.). These air system provisions should individually be verified with representative configurations.

Key Development Activities

Key development activities include, but are not limited to the following:

SRR/SFR: Analysis of the design concept indicates that air system growth requirements are properly allocated.

PDR: Analysis and inspection of preliminary design indicates that air system growth requirements are allocated and are ready for detailed design.

CDR: Analysis and inspection of final design documentation confirm that air system growth provisions and capabilities are incorporated and will satisfy the requirements.

FFR: No specific verification actions required.

SVR: Analysis of lower-level air system tests and demonstrations confirm that the growth requirements have been allocated and attained. In some cases, results from air-system-level demonstrations may need to be analyzed to confirm compliance with the growth requirement.

Sample Final Verification Criteria

The growth requirement shall be satisfied when ___(1)___ analyses confirm the availability of the required growth value.

> Blank 1. Identify the specific types and scope of analysis required to provide confidence that the requirement has been satisfied. Analysis should include examination of the results of lower-level tests and demonstrations.

VERIFICATION LESSONS LEARNED (4.3.1.1.1)

To Be Prepared

3.3.1.1.2 Interchangeability

Parts, subassemblies, assemblies, and software having the same identification, independent of source of supply or manufacturer, shall be functionally and physically interchangeable.

REQUIREMENT RATIONALE (3.3.1.1.2)

It is essential that parts, subassemblies, assemblies, and software with the same identification be interchangeable, maintaining the key product characteristics and associated tolerances of the original item. This reduces logistic support requirements, minimizes maintenance/repair problems, minimizes assembly problems during production, and assures that performance and operability are not compromised.

REQUIREMENT GUIDANCE (3.3.1.1.2)

This requirement generally applies to all situations and should be included in the system specification. The requirement may be tailored to address specific items if deemed necessary.

REQUIREMENT LESSONS LEARNED (3.3.1.1.2)

To Be Prepared

4.3.1.1.2 Interchangeability verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Parts, subassemblies, assemblies and software, with same identification, are functionally and physically interchangeable	Functional and physical interchangeability (form, fit, function, interface)	I	I	I	I	I

VERIFICATION DISCUSSION (4.3.1.1.2)

During assembly, developmental test, and remove-and-replace activities, substantial data is obtained that could be used to verify this requirement. Use of this type of data should be maximized to avoid the cost and schedule impacts of a formal demonstration.

Parts, subassemblies, assemblies and software bearing the same identification are functionally and physically interchangeable

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Inspection of the design concept indicates a configuration management approach to identify and control parts, subassemblies, assemblies and software has been established.

PDR: Inspection of the preliminary design indicates parts, subassemblies, assemblies and software that are currently planned to be interchangeable, regardless of source of supply, have been identified. All instances of nonconformance to the requirement discovered during the review of product definition have a corrective action plan.

CDR: Inspection of the final system design confirms design requirements are established that permit parts, subassemblies, assemblies and software to be used in the parent assembly without regard to the source of supply or manufacturer. All instances of nonconformance to the requirement discovered during the review of product definition have a corrective action plan.

FFR: No unique verification action occurs at this milestone.

SVR: Inspection of available data from assembly, developmental test, and remove-and-replace actions confirms that hardware/software bearing the same identification is functionally and physically interchangeable.

Sample Final Verification Criteria

The interchangeability requirement shall be satisfied when inspection of available data confirms that any requirement nonconformance has been corrected by product definition change.

VERIFICATIONS LESSON LEARNED (4.3.1.1.2)

To Be Prepared

3.3.1.2 System service life

The air system shall provide the performance specified herein for __(1)__ years, given the system usage defined in section 3.1.5 System usage and the following table.

TABLE 3.3.1.2-I. Usage and conditions for determining service life.

Usage	Rate/Conditions
Wartime operations	(# or % / type of operations)
Peacetime operations	(# or % / type of operations)
Basing	(# or % ground operations/checkouts)
Testing/checkouts	(# or %)
Assembly/disassembly	(# /abnormal conditions – exposure)
Transportation	(# shipments/abnormal conditions – exposure)
Storage	(# shipments/abnormal conditions – exposure)
Realistic training (for example, red flag, on-equipment training)	(# of occurrences and training conditions)

REQUIREMENT RATIONALE (3.3.1.2)

Service life. The period spanning from an asset's introduction into the inventory for operational use until it is consumed or disposed of. The service life of a system typically exceeds the service lives of the assets that compose it.

Ongoing assessments of current and projected threats against defense capabilities result in a definition of mission needs that includes operational life. The system service life requirement is directly determined by these mission needs and defines how long the system is projected to be needed. Since exact system utilization and service life is not known at the time of initial development, this requirement provides a reasonable design point or definition based on the best estimate or projection of the system's service life and utilization. The requirement is allocated to system elements to ensure that all elements provide the necessary utility for the required duration. This information forms the basis for design loads/stress criteria and the integrity program. While the system may last for the specified duration, the parts of the system may be upgraded, repaired or replaced. The objective is to establish an overall requirement for the system and then to allocate, to the individual assets, appropriate criteria for their serviceable life.

The serviceable life for individual assets should be based on life cycle trade-offs, including technology cycle time, reliability, reparability, durability, and so forth. It may be more cost-effective to replace a part, component, assembly, etc. than to design each item to match the system service life requirement. Each type of equipment typically has a different critical parameter that best characterizes its service life. For example, structural lifetime is typically expressed in hours, engines in cycles, and so forth. Table 3.3.1.2-I illustrates some of the critical parameters the may be used to characterize lower-level parameters.

REQUIREMENT GUIDANCE (3.3.1.2)

System service life defines how long a system is intended to be in service based on the manner in which the system is expected to be used. It establishes a reasonable design point since the precise or exact length of service and utilization for the system is not known that far into the future. It is, however, an important parameter for the designer and can drive specific design parameters like structural strength, parts/component selection, reliability, maintenance/ sustainability concepts, manufacturing techniques, etc. Blank 1 should define the specific service life or the desired duration the system is to be in operation and is likely expressed in number of years. Table 3.3.1.2-I should provide an estimated life cycle profile describing the anticipated number and mix of operations/missions already defined in 3.1.5 System usage, in addition to any other factors that would impact the system over its life. Operations for both peacetime and wartime might be expressed in terms of the number or percentage each mission type described in section 3.1.5 System usage would be flown over the system’s life. Basing should include ground operations such as taxiing, alert stationing, number of power-up cycles, etc. Assembly/disassembly may be especially pertinent for unmanned air vehicles and their control stations, particularly for those systems which are frequently set-up and disassembled in forward-deployed situations. Transportation should include the number of anticipated trips; storage should include the time or percentage spent in storage over the system’s life; and for both, any abnormal environment and exposure conditions should be defined. Realistic training should reflect planned/anticipated frequencies, conditions, and environments. For example, the number of “Red Flag” operations for each unit of the force. Note that realistic combat and other on-equipment training (see 3.7.3 On-equipment training) has been observed to “consume” significant amounts of the defined service life of the assets involved. If the system is envisioned to be used in any manner other than what is defined in section 3.1.5 System usage, like dedicated testing (flight or ground), then define those system utilization(s) as well. These parameters will typically be established by the using service and included in the basic program directives. If no guidance is provided, a requirements allocation process using mission needs, threat projections, and/or historical data from previous systems may be used. For the USAF, *AFI 63-1001* assigns the operational command the responsibility to establish the service life for all aircraft systems. For the Navy, service life policy and responsibilities are addressed in NAVAIRINST 13120.1 for fixed wing air vehicles, and in NAVAIRINST 13130.1 for rotary wing air vehicles.

REQUIREMENT LESSONS LEARNED (3.3.1.2)

The service life specified in the contract is, in all likelihood, not the actual service life the system will experience. Changes over time in usage, threat driven upgrades, technology evolution, etc. will have significant impact on a system's actual service life. However, as previously stated, this requirement is important since it serves as a reasonable target design point for the designer. Every attempt should be made to define the desired length of service the user wants from the system and to think through all of the conditions that would impact that length of service.

An aircraft initially designed for high altitude operation may require life-extending structural modifications if the mission is changed to include high speed, low altitude penetration in response to changing threats.

A particular fighter aircraft required structural modification to maintain specified service life when it was learned the actual operational usage was more severe than the planned design spectrum. Additional modifications were also required to compensate for manufacturing-induced flaws.

While a design usage spectrum for a rotorcraft vehicle may define a design durability service life of the airframe of 10,000 hours, a minimum depot inspection interval of 3000 flight hours, and a safe life of all dynamic components of at least 4500 flight hours, these service intervals may need to be altered based on actual air vehicle usage.

4.3.1.2 System service life verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Service Life	(1)	A	A	A	A	A

VERIFICATION DISCUSSION (4.3.1.2)

Service life design based on air system usage data will be incrementally verified using analysis. This requirement identifies conditions that must be considered in developing all system performance requirements and verifications. Therefore, the verification of compliance with the air system usage information defined within this requirement should be accomplished within the other performance requirement verifications. The information below is provided to ensure that the air system verification program is properly defined and applied in terms of the overall system usage information.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis using service life methodologies indicates that the air system service life requirements are properly allocated to each tier of the system. Air system usage requirements are defined and complete for the specified operations, missions, and service life.

PDR: Initial analysis indicates that the lower-level service life allocations were based on life cycle trade-offs that addressed technology cycle time, reliability, reparability, durability, etc. Analysis using service life methodologies indicates that the service life requirements are allocated to each tier of the air system and are ready for detailed design. Air system usage data are finalized and allocated to applicable air system elements. Initial design requirements incorporate air system usage considerations.

CDR: Analysis of lower-level development test results and inspection of final design documentation using service life methodologies confirm that the requirements are incorporated and satisfy the allocated requirements and that the detail design is ready for manufacture. Analysis confirms that the updated lower-level service life allocations were based on life cycle trade-offs that addressed technology cycle time, reliability, reparability, durability, etc. Design requirements incorporate air system usage considerations.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of lower-tier verifications confirms that the air system service life requirement has been achieved, given the system usage and life cycle profile as specified.

Sample Final Verification Criteria

This requirement shall be satisfied when the analysis of lower-tier verifications substantiates the required air system service life, given the specified system usage and life cycle profile.

VERIFICATION LESSONS LEARNED (4.3.1.2)

To Be Prepared

3.3.1.3 Manpower and personnel

The system shall be operated, maintained, and supported by not more than the numbers and classifications of personnel, exclusive of the manning as shown in table 3.3.1.3-I through table 3.3.1.3-V for the following force/operational structure conditions:

a. Number of flying organizational units is ___(1)___ with ___(2)___ air vehicles per unit;

b. Number of flying training units is ___(3)___ with ___(4)___ air vehicles per unit;

c. Number of off-base support locations is ___(5)___;

d. Other force/operational structure conditions include ___(6)___; and

e. The maintenance concept as defined in ___(7)___ of this specification.

TABLE 3.3.1.3-I. Manning (military officer).

Military Personnel (Officer)				
	Job Type (optional)	Skill Level (optional)	Numbers	Conditions
Operators				
Maintainers				
Support				
Training				

TABLE 3.3.1.3-II. Manning (warrant officer).

Military Personnel (Warrant Officer)				
	Job Type (optional)	Skill Level (optional)	Numbers	Conditions
Operators				
Maintainers				
Support				
Training				

TABLE 3.3.1.3-III. Manning (enlisted).

Military Personnel (Enlisted)				
	Job Type (optional)	Skill Level (optional)	Numbers	Conditions
Operators				
Maintainers				
Support				
Training				

TABLE 3.3.1.3-IV. Manning (civilian).

Civilian Personnel				
	Job Type (optional)	Skill Level (optional)	Numbers	Conditions
Operators				
Maintainers				
Support				
Training				

TABLE 3.3.1.3-V. Manning (contractor).

Contract Personnel				
	Job Type (optional)	Skill Level (optional)	Numbers	Conditions
Operators				
Maintainers				
Support				
Training				

REQUIREMENT RATIONALE (3.3.1.3)

This requirement defines the maximum quantities and quality of personnel required to operate, maintain, support and provide training for the system upon full operational deployment. Manpower refers to the numbers of military and civilian (including contract personnel) and the Air Force Specialty Codes (AFSCs) needed to operate, maintain, and support the functional requirements and mission of the system. “Personnel” refers to the type of individual (that is, job type) and the degree of skill required to operate, maintain, and support the functional requirements and mission of the system.

There are three external “agents” driving this requirement. The first is a congressional reporting requirement (Title 10, United States Code, Section 2434, Independent cost estimates; operational manpower requirements). This simply states that the Secretary of Defense shall prescribe regulations that require that the manpower estimate, include an estimate of the total number of personnel required to operate, maintain, and support the program upon full operational deployment and to train personnel to carry out those activities.

The second is implementation of this requirement by DoD 5000.2-R, paragraph 3.5:

The manpower estimate shall report the total number of personnel needed to operate, maintain, support, and provide training for the program upon full operational deployment. It shall report the number of military (officer, warrant officer, and enlisted), DoD civilian, and contract manpower requirements for each fiscal year of the program beginning with initial fielding and ending with full operational deployment. A separate estimate shall be provided for each Component (for joint programs) and separately for the Active, Reserve, and National Guard forces.” (Note the difference between a specification requirement, “full operational deployment,” and a programming requirement “for each fiscal year of the program beginning with initial fielding and ending with full operational deployment.”)

The third is implementation of the DoD regulation by service. For example, the Air Force estimate categorizes the maintenance grouping into organizational and intermediate maintenance; and it categorizes the support grouping into depot maintenance, central logistics support, program office, and associated base operating system manpower for each element. The current service regulations should be reviewed and assessed prior to establishing the manpower requirements in the system specification. These should be carefully examined to determine the actual (and appropriate) requirements to specify versus the reporting/planning factors used to apportion manpower.

When establishing a manpower requirement, an examination must be conducted to ascertain the basis for the requirement. The driving factor may be monetary, it may be driven by personnel constraints of the broader force structure, or it may be driven by a need to manage military skills populations. Where possible, the developing contractor should be given the maximum latitude to describe the specific skills needed subject to the constraints established by this requirement.

Manpower and personnel (M&P) requirements must be identified for an acquisition program to proceed beyond program initiation and are necessary to determine affordability in terms of military end-strength and civilian work-years (see DoD 5000.2-R, paragraph 3.5.2). M&P requirements must specify the limitations the work force imposes on the system and conversely, any limitations the system imposes on the work force. This is especially critical when new personnel skill mixes are required to operate, maintain, and support systems employing new technologies with increased operational complexity.

As of the date of this document, a query has been submitted to DoD to ascertain the rationale behind the expected content of table 3.3.1.3-V Contract Personnel. In circumstances where contract personnel are used to supplement the organic workforce, basically in a person-for-person sense, or when there is a need for constant/continual access to various capabilities only available via contract, the rationale for this part of the requirement is clear. However, when support or training is procured as a service (for example, contracted logistics support) the rationale for such a requirement is not evident. However, reporting of contractor manpower in the Manpower Estimate Report (MER) is required by public law (Title 10, United States Code, Section 2434). This item should be clarified in later revisions to this specification guide. Until that time, program offices should request clarification of this particular item if they need to establish a manpower requirement for their program (typically prior to the Milestone II decision) and elect to employ this requirement in a contract system specification.

REQUIREMENT GUIDANCE (3.3.1.3)

When a manpower requirement is established, the conditions for that requirement are critical. Blanks 1 through 6 describe some (but likely not all) of the conditions that impact the requirement. Ideally, the manpower requirement would scale with the actual number of air vehicles fielded. This is not strictly achievable for a variety of reasons, including the following:

Manning is integer based. That is, it is based upon a defined number of crews consisting of fixed numbers of people. Changing the size of the organizational unit will not necessarily change the numbers of maintenance crews needed or the size of a crew. Additionally, each organizational unit has a staff to manage the maintenance activity.

Centralized intermediate repair facilities are sometimes used to consolidate maintenance efforts in a region. Changing the number of air vehicles (organizational units) served by such a facility may affect the number of crews needed simultaneously (and thus impact manning), but there is still a need for a staff to manage the maintenance activity. Such facilities (similar to depots) offer economy-of-scale manpower savings (for example, if a crew is needed to fix broken engines, but insufficient breaks occur to keep the crew busy, consolidating engine repair at an intermediate facility enables more efficient workload-to-manpower management).

Maintenance and training may be accomplished by a) only the Government; b) only contract personnel; or c) some mix of the two.

Blank 1. Describe the number of operational units of a size identified in blank 2. It may be necessary to replicate this entry for each different size unit to be fielded. For example, squadron size may vary and the number of squadrons per wing may vary. This will affect the number of crews available to a squadron or wing (based on the maintenance concept) and the number and sizes of the maintenance staff at the organizational level. For an unmanned air vehicle organization, the number of required control stations may be identified if known.

Blanks 3 and 4. Characterize information similar to operational units; however, the staffing of a dedicated training unit is frequently different from an operational unit.

Blank 5. Identify the number of off-base maintenance locations. These normally fall into two categories: centralized intermediate repair facilities and depots. Centralized intermediate repair facilities may not apply to every program. If such facilities are needed, they should be identified in the support concept. Both entries incur certain manpower requirements that are part of the total manpower required. It is important to remember that every organizational entity consumes manpower just to perform necessary functions (security, safety, etc.) that go beyond the fundamental mission of the organization (that is, to fix broken items). Note that this is a limiting condition. The objective is to minimize the number of such locations to realize manpower savings.

Blank 6. Define any other critical conditions that are factors in the manpower requirement.

Blank 7. Identify the paragraph detailing the maintenance concept for the system. In this specification guide, it is 3.6 System dependability.

Guidance for completing tables 3.3.1.3-I through 3.3.1.3-V follows:

Maintenance and training may be accomplished by only the Government, only contract personnel, or some mix of the two. Prior to establishing the content of the tables,

a. Analyze and conduct trade-offs on the ramifications of alternative sources of manning;

Work with the operational user to ensure that a mutual understanding exists between trading military and DoD civilian workforce with contracted workforce;

Establish the costs and benefits of each alternative approach;

Determine where there is latitude in specifying the manpower breakout.

Fill in the columns of each applicable table as follows:

Job Type: List the job type only when absolutely essential. Consider eliminating this column to give the developer latitude to optimize manpower allocations. Job types can include all specialties associated with the system, are not limited to the aircrew and maintenance crew members, and may or may not correspond to an existing AFSC. Examples of job titles include aircraft commander, maintenance engine run technician, simulator technician, computer analyst, etc. If necessary to list, limit the number of entries as much as possible. In some cases, it may not be necessary to have a job type category. It is more critical to list job types when specific job types are being managed in a force structure sense and when there is a requirement to consolidate jobs.

Skill Level: Enter the highest level of proficiency or ranking required to satisfy job performance requirements. For aircrew members (operators of the system), this may be a knowledge and skill-coded proficiency level (4b, 2a, etc.). For maintenance crewmembers, this may be a technical status (level 3, level 5, etc.). For support members, such as a computer analyst, it may be a "trade designation" (novice, journeyman, senior, etc.). The need for this category will be driven by two factors. The first factor deals with the degree to which skill levels (as well as job types) are managed in a force structure sense. The second factor addresses "ceilings" to preclude unrealistic expectations on force composition/maintainer capability (basically, it is unrealistic to expect that the system will be maintained by "all-PhD" crews). It is preferable to establish some basic constraints to preclude unreasonable demands on personnel proficiency and provide the developer with the maximum latitude to determine appropriate skill levels, stating specifics only when it is essential to do so.

Numbers: Enter the maximum number of personnel allowed. If job types and skill levels are included, enter the number of personnel for each job type, for each skill level.

Conditions: Define any conditions bearing on the requirement. For example, it may not be necessary to specify numbers by job type and skill level. It may be sufficient to define a set of jobs with some reasonable maximum numbers on various skill levels and let the contractor determine the proper allocation. Additional conditions could include factors such as whether new/unique job types/skill codes are allowed, constraints on the selection of job types and skill levels, etc.

REQUIREMENT LESSONS LEARNED (3.3.1.3)

To Be Prepared

4.3.1.3 Manpower and personnel verification

Requirement Elements	Measurand	SFR/ SRR	PDR	CDR	FFR	SVR
System Manpower for skill level a	Number of Personnel		A	A	A	A
System Manpower for skill level b	Number of Personnel		A	A	A	A
System Manpower for skill level …	Number of Personnel		A	A	A	A

VERIFICATION DISCUSSION (4.3.1.3)

The quantity and mix of personnel, as well as the skill levels required to operate, maintain, and support the system, along with the training requirements performed on the system are generally specified in the manning document provided as part of the system requirements. The required number, type, and skill level of personnel is dependent upon the complexity of the system and the maintenance philosophy chosen.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: No unique verification action occurs at this milestone.

PDR: Analysis of specified manning levels and skills, compared to the preliminary support concept, establishes that the system can satisfy requirements at the required manning level.

CDR: Analysis of specified manning levels and skills, compared to the final support concept, confirms that the system can satisfy requirements at the required manning level.

FFR: Analysis of lower-level tests and demonstrations conducted prior to FFR and at FFR confirms that the system can satisfy system manning requirements for first flight. Any noncompliance to the specification should be analyzed for the long-term effect on the operation and maintenance of the system.

SVR: Analysis of lower-level and other system-level tests and demonstrations confirms compliance with the quantity, types, and skill levels of personnel required to operate and maintain the system.

Sample Final Verification Criteria

The manpower and personnel requirement shall be satisfied when ___(1)___ analyses and ___(2)___ demonstrations confirm that the air system can be operated, maintained, and supported with the quantity, type, and skill level of personnel specified.

> Blanks 1 and 2. Identify the type and scope of analyses and demonstrations required to provide confidence that the manpower and personnel requirement elements have been satisfied.

VERIFICATION LESSONS LEARNED (4.3.1.3)

To Be Prepared

3.3.1.4 Asset identification

System assets that are repairable, replaceable, salvageable, or consumable shall be permanently identified by a method that is observable and recognizable throughout the life of the asset and that does not adversely affect the life and utility of the asset. The identification shall include ___(1)___.

REQUIREMENT RATIONALE (3.3.1.4)

Identification markings are necessary on any system item (hardware, software, etc.), component, and part designated for replacement, repair, and/or salvage. Identification markings should not be required on items, components, or parts that would not be replaced, repaired, and/or salvaged. For example, resistors on a board would not be required to have identification markings if replacement, repair, and/or salvage were at the board level only. Identification markings also facilitate maintenance, modification, spares procurement, logistic supply systems, deficiency reporting, and configuration management. Marking system items, components, and parts by serial number (or other identifiers) enables rapid identification of specific items and provides pertinent information to the personnel required to support the system.

Emerging efforts in the field of unique identification (UID) have placed requirements on all new solicitations as of 1 January 2004. These requirements are contained in the DFARS interim rule as outlined in DFARS Case 2003-D081. Additional new UID requirements including radio frequency identification (RFID) are being considered for use within DOD.

REQUIREMENT GUIDANCE (3.3.1.4)

In the blank, include required identification method or information content such as national stock number (NSN), serial number, CAGE code, manufacturer's part number, etc. For example, it may be required to include as part of the markings a notice that an item, component, or part is subject to warranty and state the period or conditions of that warranty. MIL-STD-130, Identification Marking of U.S. Military Property, can be consulted for additional guidance on this requirement. Identification can be implemented by any method that meets the requirement for the given asset. Such methods could include electronic, bar code, etching/engraving, etc.

Information on the interim DFARS rule and emerging UID requirements may be found at http://www.acq.osd.mil/uid. Information on RFID policy and initiatives may be found at http://www.dodait.com/references.htm.

REQUIREMENT LESSONS LEARNED (3.3.1.4)

To Be Prepared

4.3.1.4 Asset identification verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Assets identification	Presence of identification Durability of identification (1)	A	I	I		I

VERIFICATION DISCUSSION (4.3.1.4)

Asset identification is used for accountability. It begins with design, progresses through development testing, continues for production procurement, and is used throughout deployment until disposal of each asset.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates the establishment of a configuration management approach to identify parts, subassemblies, assemblies, and software. Analysis indicates that UID and RFID requirements are being considered.

PDR: Inspection of air system preliminary design documentation confirms assets which are repairable, replaceable, salvageable, or consumable have identification provisions, and the intended marking is sufficiently durable for the anticipated environment and contains all necessary information. Analysis indicates that UID and RFID requirements are being refined.

CDR: Inspection of design documentation indicates assets which are repairable, replaceable, salvageable, or consumable have identification provisions, and the intended marking is sufficiently durable for the anticipated environment and contains all necessary information. Inspection confirms that UID and RFID requirements are being implemented.

FFR: No unique verification action occurs at this milestone.

SVR: Inspections of available data from assembly, development test, and remove-and-replace actions confirm that hardware and software have been identified in accordance with their respective identification requirement(s). Inspection confirms UID and RFID requirements are being met.

Sample Final Verification Criteria

The asset identification requirement shall be satisfied when inspections of available data confirm that any requirement nonconformance has been corrected by product definition change.

VERIFICATION LESSON LEARNED (4.3.1.4)

During one development program, iterative changes were made to one or more parts in the process of attempting to reconcile a repetitive flight test defect. Initially, no attempt was made to identify the changing software; therefore, when the problem was resolved it was uncertain which changes had resulted in the successful resolution of the problem. Accordingly, unnecessary additional testing was required to determine which assets resulted in the corrective action. When problems occur, nameplates can provide the capability to locate and isolate the lot(s) with the defective items.

3.3.2 Diagnostics

The system shall detect, isolate, and report loss or degradation of system functions. The system shall detect safety- and mission-critical failures, functionally isolate those failures, and, where practicable, provide the information needed (to the crew or other equipment) in time to preclude further uncontrolled degradation to safety, mission accomplishment, and survivability. The system shall detect and isolate failures to allow maintenance personnel to perform necessary maintenance to meet mission, logistics, and availability requirements. The system shall incorporate a hierarchy of diagnostic data and tolerancing across indentures of design to assure compatibility of tested parameters, test tolerances, ranges, sequences, interfaces, and techniques. The system shall further ___(1)___.

REQUIREMENT RATIONALE (3.3.2)

Diagnostic information regarding the status of a system is needed for a variety of reasons. There are safety, mission, and maintenance decisions which must be made, all of which require timely and accurate knowledge of the system condition. Further, it is necessary to ensure that information tested/reported at one level of the system's architecture is consistent with information reported at lower levels (for example, on-board diagnostics results are consistent with results reported by off-board test equipment).

REQUIREMENT GUIDANCE (3.3.2)

Blank 1. List applicable diagnostic methods that are available for use in meeting diagnostic requirements at this and the following design levels. This could include a variety of embedded test methods, portable diagnostic aids, manual troubleshooting, or an automatic test system (ATS). This allows the contractor complete flexibility to study a variety of combinations of the available diagnostic methods and arrive at an optimum mix.

Blank 1 should also contain any additional limitations, restrictions, or requirements for the diagnostic system. These may include, but are not limited to, the following:

a. Any mandated requirement, such as the use of a particular automatic test system (ATS).

b. The need to support rapid reconfiguration of mission software to enable graceful degradation when mission hardware failures occur.

c. Compatibility with the appropriate service maintenance data system (for example, REMIS, 3M, IMDS, etc.).

REQUIREMENT LESSONS LEARNED (3.3.2)

To Be Prepared

4.3.2 Diagnostics verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Diagnostics	- Diagnostic Functionality - Fault Detection - Fault Isolation - Fault Reporting	A	A	A	A	A

VERIFICATION DISCUSSION (4.3.2)

Verification of air system diagnostics should be accomplished by analysis of lower-level diagnostic analyses, tests, and demonstrations. Verification of diagnostics performance requires an iterative process to verify, at each step of the development process, the adequacy of air system diagnostic performance.

Key Development Activities

Key development activities should include, but are not limited to, the following:

SRR/SFR: Preliminary analysis indicates the integrated diagnostics design is compatible with the requirement based on systems design and maintenance concept and preliminary subsystem-level built-in test (BIT) predictions (plus subcontract requirements where available). The maintenance concept (including on-board and off-board diagnostic tools) associated with peacetime and wartime has been defined to enable air system integrated diagnostics design refinement. General architecture of the integrated diagnostics design should be established during this phase with emphasis on the type of diagnostic information and means by which this information will be presented to the aircrew and maintainer. Verification/validation of diagnostic maturity (whether numerical or levels of detail) at program milestones are established. Verification test/demonstration methods and acceptance criteria based on the agreed-to verification method employed are incorporated into schedules, facilities requirements, manpower needs, and other programmatic imperatives. Measurement and maturity management of air system diagnostics has been integrated into the overall management of the program.

PDR: Preliminary analysis indicates that the air system integrated diagnostics design and preliminary system fault detection and isolation predictions are consistent. Integrated diagnostic design architecture should define the types and means by which diagnostic information (warning/caution/advisory, exceedances, etc.) will be presented to the aircrew and maintainer consistent with the maintenance concept. Preliminary failure modes effects and criticality analyses (FMECA), testability analyses and fault detection and isolation predictions are updated to include subcontractor information. Diagnostic analysis/modeling is integrated into higher-level requirements and analyses (maintainability, availability etc.).

CDR: Assessment of air system diagnostic functionality has been accomplished based on detailed design analyses. FMECA (or acceptable like analysis) addresses diagnostic capability (BIT coverage) to detect and isolate both internal failures of system as well as input failures to those same systems. All diagnostic information presented is substantiated through engineering and diagnostic analyses. The maintenance concept of air system integrated diagnostics has been updated to reflect changes in diagnostics design.

FFR: FMECA (or acceptable like analysis) has been completed and addresses diagnostic capability to detect and isolate all failures. This includes the effects of diagnostics/ maintenance/ inspection requirements to identify the presence of any mission- or safety-critical malfunctions. Diagnostics indications of failures deemed by FMECA or subsystem safety hazard analysis (SSHA) to be safety-critical are addressed in flight crew and maintenance technical orders. Fault detection, isolation predictions, and associated models are updated, as necessary, to reflect incorporation of subsystem diagnostic test/demonstration results. Diagnostic analysis/modeling integrated into higher-level requirements and analyses (maintainability, availability etc.).

SVR: The integrated diagnostics maintenance concept has been updated to reflect test results. Adjustments for results of flight-test information (BIT codes, compensating provisions etc.) and other diagnostics tests/demonstration results have been incorporated in the FMECA. Analysis and flight test results of all diagnostics information confirms air system diagnostics requirements have been met. Diagnostic analysis/modeling has been integrated into higher-level requirements and analyses (maintainability, availability etc.).

Sample Final Verification Criteria

The integrated diagnostic requirement shall be satisfied if analyses of test data generated during the ___(1)___, meets or exceeds the specified diagnostic requirements. Diagnostic relevancy criteria will be determined in accordance with the ___(2)___.

> Blank 1. Specify test period in which the air system will be measured for compliance. For example, if the data collection period will run from first flight through a specific flight test milestone, specify that in Blank 1.
>
> Blank 2. Include reference that describes the process by which diagnostics will be evaluated. For example, the joint reliability maintainability evaluation team charter.

VERIFICATION LESSONS LEARNED (4.3.2)

To Be Prepared

3.3.3 Nuclear surety

The air system shall employ the nuclear weapons listed in table 3.3.7-I. The air system shall interface with nuclear weapons, in accordance with table 3.3.7-I, to prevent such weapons from producing unintended nuclear yield. The air system shall comply with the __(1)__ nuclear weapon interface requirements.

REQUIREMENT RATIONALE (3.3.3)

Air vehicles with a mission to employ nuclear stores must be capable of meeting certification requirements for nuclear store deployment. Inherent within the certification process is the ability to safely employ nuclear weapons without inadvertent or unauthorized activation.

REQUIREMENT GUIDANCE (3.3.3)

Blank 1. To complete, obtain assistance from Headquarters, USAF/SE, AAC/WNE, and the Directorate of Nuclear Surety, Headquarters Air Force Safety Agency (HQ AFSA).

Navy air vehicle nuclear capability planning and subsequent implementation of this requirement must be coordinated with the Office of the Chief of Naval Operations to obtain current policy and direction.

REQUIREMENT LESSONS LEARNED (3.3.3)

To Be Prepared

4.3.3 Nuclear surety verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Nuclear surety	(1)	TBD	TBD	TBD	TBD	TBD

VERIFICATION DISCUSSION (4.3.3)

Complete the verification based upon unique program requirements. Obtain assistance from Headquarters USAF/SE, AAC/WNE, and the Directorate of Nuclear Surety, Headquarters Air Force Safety Agency (HQ AFSA). In light of this, verification activities of this requirement will be developed in concert with this group.

Nuclear certification is a continuous process whereby the agencies identified in this document determine if the weapons system is safe and secure, if the nuclear weapon is compatible with the air vehicle, and if any operational restrictions are needed to assure its safety, security, and compatibility.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Unique to program.

PDR: Unique to program.

CDR: Unique to program.

FFR: Unique to program.

SVR: Unique to program.

Sample Final Verification Criteria

Unique to program.

VERIFICATION LESSONS LEARNED (4.3.3)

To Be Prepared

3.3.4 Electromagnetic environmental effects (E^3)

The system shall comply with the requirements of ___(1)___ to achieve system electromagnetic compatibility (EMC) among all subsystems and equipment within the system and with environments resulting from electromagnetic effects external to the system.

REQUIREMENT RATIONALE (3.3.4)

Imposition of E^3 requirements is necessary to ensure the system is electromagnetically compatible with itself and other systems with which it is intended to work. Subsystems and equipment in the system must work with each other within the internal electromagnetic environment which both the system equipment itself and external environments (such as lightning, radio frequency (RF) fields, and electromagnetic pulse (EMP)) may create. A flow down of the external environment stresses to the lower-tier specifications using transfer functions is necessary to allow tailoring of the subsystems and equipment requirements. Structural designs and materials affect electrical bonding, grounding techniques, electrostatic charging, and the electromagnetic interference (EMI) requirements that will be imposed on all subsystems and equipment. High levels of electromagnetic radiation can pose hazards to personnel, fuels, and electroexplosive devices and should be addressed with safety, design, and mission impact in mind. All of these requirements need to consider life cycle aspects of maintaining the E^3 protection.

REQUIREMENT GUIDANCE (3.3.4)

Blank 1. Enter the current version of MIL-STD-464 or an alternative source of E^3 requirements. Requirement areas to address are margins, intra-system EMC, inter-system EMC, lightning, EMP, subsystem and equipment EMI, electrostatic charge control, electromagnetic radiation hazards to personnel, fuel, and ordnance, life cycle, E^3 hardness, electrical bonding, external grounds, TEMPEST, and emission control (EMCON).. Depending on the approach selected, the information in the blank should be expanded to include tailoring of MIL-STD-464 (such as appropriate external, inter-system environments and service-unique requirements) or the alternative source for the particular system. Whichever approach is used, MIL-STD-464 should be consulted to ensure that requirements are adequately addressed and for the extensive rationale, guidance, and lessons learned contained in the standard. Mission success depends on the ability of all subsystems and equipment intended to operate concurrently within the system to do so successfully and on the ability of the subsystems and equipment to operate with the external environments.

REQUIREMENT LESSONS LEARNED (3.3.4)

Emphasis on systems engineering aspects of E^3 system design is important. In the past, the electromagnetic effects area was often viewed as a test-and-fix effort; little attention was given to E^3 design at the system level. Today, with the proper performance of electronics playing a more important role for safety and mission completion and the extensive use of composite materials in the system structure, it is essential that the response of the system to electromagnetic stresses be analyzed and understood. MIL-STD-464 contains detailed lessons learned.

Antenna-to-antenna compatibility problems have been common on aircraft. Receivers have been degraded from radiation from other antennas due to common operating frequencies, harmonics of transmit frequencies, amplified thermal noise, and spurious outputs. Achieving RF compatibility requires careful strategic planning of the placement of antennas and operation of RF subsystems. Involved personnel require detailed technical knowledge of the operating characteristics of subsystems. An RF compatibility effort needs to be established early in the program. Early analysis should be accomplished to estimate antenna-to-antenna isolation.

EMI requirements at subsystem and equipment level (radar, support equipment, etc.) are an important key to successful design and need to include controls on 1) emission levels, that is, interference conducted or radiated from the equipment on electrical interfaces and 2) resistance to susceptibility, that is, undesirable responses from external fields and conducted interference. Subsystems and equipment are generally designed to the requirements of MIL-STD-461. These requirements are tailored based on the transfer functions from the external environments to the internal stresses.

The types of requirements, placement of limits, and applicable frequency ranges in MIL-STD-461 are based on lessons learned from past programs. MIL-STD-461 includes an appendix to explain the rationale for the requirements and to provide guidance in tailoring the requirements. There had been a great deal of misunderstanding and confusion in the past regarding MIL-STD-461 requirements. The DoD issued the current version of MIL-STD-461 after extensive revision effort by a tri-service working group. The document is coordinated and approved for use by all the services. MIL-STD-461 contains default baseline levels for requirements suitable for many applications. Tailoring is encouraged.

Electrical bonding is often one of the first areas reviewed for adequacy when an electromagnetic compatibility problem develops at the aircraft level. Some problems have been fixed simply by improving the bonding. The actual need for a certain level of bonding is dependent on a number of issues, including shielding topology, type of circuit interfaces, and ground referencing of circuits to the avionics and equipment enclosures.

4.3.4 Electromagnetic environmental effects (E^3) verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Electromagnetic Environmental Effects	(1)	A	A,S	A,S	A,I,D ,T	A,I,D ,T

VERIFICATION DISCUSSION (4.3.4)

The wide use of military and commercial radio frequency (RF) transmitters, sensitive receivers, other sensors, and electronic data processors creates a potential for interference problems within the air system, as well as opportunity to cause hazards to personnel, fuels, and ordnance. Accordingly, verification should include analysis, testing, demonstration, and inspections to show that the air system is compatible with all environments and that potential hazards related to the electromagnetic effects are controlled. Verification methods must, to the greatest extent practicable, assess the full range of subsystem/equipment operation during exposure to the most demanding external electromagnetic environment anticipated during air system missions. It is necessary to verify that the internally generated and external electromagnetic environments will not impair the mission of the air system via disruption or damage to its subsystems or equipment.

The selection of test, analysis, demonstration, or inspection, or some combination, to demonstrate a particular requirement is generally dependent on the degree of confidence in the results of the particular method, technical appropriateness, associated costs, and availability of assets. For example, subsystem and equipment-level testing must be accomplished, because analysis tools are not available which will produce credible results.

Analysis and testing often supplement each other. Prior to the availability of hardware, analysis will often be the primary tool being used to ensure that the design incorporates adequate provisions. Testing may then be oriented toward validating the accuracy and appropriateness of the models used. If model confidence is high, testing may then be limited. For example, design of an aircraft for protection against electromagnetic pulse (EMP) or the indirect effects of lightning must rely heavily on analysis.

Key Development Activities

Key development activities should include but are not limited to the following:

SRR/SFR: Analysis indicates that required events have been defined, tailored requirements for sub elements of the air system based on the overall design concept have been established, documentation trail for verification (such as electromagnetic effects control procedures) has been developed. Analysis indicates that the process of allocating requirements to lower-level elements of the air system has been initiated and addresses issues such as electromagnetic interference (EMI) requirements for subsystems, electrical bonding and grounding provisions throughout the air system, wiring harness design constraints, and potential shielding of volumes.

PDR: Analyses and simulations indicate that issues such as transfer functions relating external environments to induced currents on cables, electromagnetic coupling between various antennas on the air system, electromagnetic hardening trade-offs, presence and mitigation of any hazards, adequacy of subsystem design controls (such as EMI requirements, bonding, and grounding), and ability of subsystems and equipment to function together without unacceptable levels of internally generated disruption have been satisfactorily addressed. Analysis indicates that requirements allocated to lower-level elements of the air system have been updated based on the latest design information, and that design risks and appropriate courses of action have been identified.

CDR: Analysis confirms that refined simulations and analyses as listed for the PDR are available. Analysis of lower-tier, limited testing (such as determinations of cable shield transfer functions, direct-effects lightning tests of structural coupons, and characterization of material properties) to reduce risk and validate analyses should be completed.

FFR: EMI qualification testing of equipment and subsystems should be complete. At the air system level, a safety-of-flight intra-system electromagnetic compatibility evaluation must be completed and the air system must be cleared for lightning and external RF environments, or appropriate flight restrictions should be imposed. Testing, analysis, demonstrations, and inspections to verify control of any potential electromagnetic hazards should be complete.

SVR: The overall verification process consisting of an accumulated audit trail of analyses, tests, demonstrations, and inspections that establish compliance with requirements for all subsystems and equipment installed must be completed.

Sample Final Verification Criteria

Operation within the electromagnetic environment shall be verified during SDD when ___(1)___ indicate acceptable performance within the external electromagnetic environment; when ___(2)___ indicate safety-critical functions are electromagnetically compatible within the system, including compatibility among all internal subsystems; and, when ___(3)___ indicate freedom from electromagnetic hazards.

> Blanks 1 - 3. Insert the type and scope of tests, analyses, simulations, demonstrations, or inspections, or combinations thereof, as appropriate, for the requirement/requirement element in accordance with the current version of MIL-STD-464.

The selection of test, analysis, simulation, demonstration, or inspection, or some combination, to verify a particular requirement or requirement element, is generally dependent on the degree of confidence in the results of the particular method, technical appropriateness, associated costs, and availability of assets. For example, subsystem and equipment-level testing must be accomplished, because analysis tools are not available which will produce credible results.

VERIFICATION LESSONS LEARNED (4.3.4)

Without specific design and verification requirements, problems caused by the external electromagnetic environment are not discovered until the air system becomes operational. By that time, the air system can be well into production, and changes will be expensive. In the past, onboard RF subsystems of the air system produced the controlling electromagnetic environment; however, with external transmitter power levels increasing, external transmitters can drive the overall system environment. The nonmetallic (composite) skins used on most aircraft provide relatively less shielding than metallic skins against electromagnetic fields at frequencies below approximately 100 MHz, and against lightning. These effects have become important due to the increased use of electrically and electronically controlled flight and engine systems. The use of nonmetallic materials for parts such as fuel tanks and aircraft wings also introduces the need for specific tests for lightning-induced sparking and arcing in these members. Most aircraft lost to lightning have been lost as a result of fuel tank arcing and explosion.

The limits specified in MIL-STD-461 are empirically derived levels that cover most configurations and environments; they may not, however, be sufficient to guarantee system compatibility. Tailoring should be considered for the peculiarities of the intended installation. When appropriate controls are implemented (such as hardening, EMI requirements on subsystems and equipment, and good grounding and bonding practices), there are relatively few intra-system EMC problems found.

It has been firmly established that sufficiently high electromagnetic fields can harm personnel, ignite fuel, and fire electrically initiated devices. Multiple emitters may be present. Even when overall field strength is below hazardous levels, resonance and reflections may create "hot spots." In addition, ignition of ordnance and fuel vapors, injury to personnel, and damage to electronics have all occurred from static discharges. The physical arrangement of structural components and the design of electrical systems may have interrelated effects that may not be seen until tested in their final configuration.

Historically, failure to verify system performance adequately in an operational EME has resulted in costly delays during system development, mission aborts, and reduced system and equipment operational effectiveness. It is important that assets required for verification of E^3 requirements be identified early in the program to ensure their availability when needed.

3.3.5 System security

The system shall deny access to sensitive assets, capabilities, and information by unauthorized parties or functions. The threat to the system's security is ___(1)___.

REQUIREMENT RATIONALE (3.3.5)

This system security requirement is directed at negating the security threats to the completed, deployed air system while that system is in an operational environment. The objective is to preclude compromise, exploitation, sabotage, and intentional damage and destruction. The premise of this requirement is that these objectives can be achieved by denying access. Paragraph 3.3.7.1 of DoD 5000.2R requires that acquisition programs identify elements of the program design for protection of critical program information (CPI).

REQUIREMENT GUIDANCE (3.3.5)

Blank 1. Define or identify the source document of the multidiscipline, counter-intelligence threat supplied by the appropriate DoD component counterintelligence analysis center.

The security requirement can be expanded, given sufficient attention, prior to putting the system specification on contract. For example, acquisition systems protection is the overall concept of protecting the program's essential program information, technologies, and/or systems (EPITS) from compromise and inadvertent loss from the establishment of the MNS to demilitarization. By establishing basic criteria on the EPITS, system vulnerabilities, and countermeasures, design features can be devised and incorporated into the system to reduce the costs and burdens of security operations after deployment.

If the EPITS are sufficiently defined prior to development of the program system specification, the following can be used to expand this requirement.

The EPITS, security vulnerabilities, and functional countermeasures are identified in the example table below.

Example EPITS, security vulnerabilities, and functional countermeasures table.

EPITS	Security Vulnerability

Essential Program Information, Technologies, and/or Systems (EPITS). The critical elements of the system that make it unique and valuable to U.S. defense forces. Those items that, if compromised, would cause a degradation of combat effectiveness, would decrease the combat-effective lifetime, or would allow a foreign activity to clone, kill, or neutralize the U.S. system. Pieces of information or technology that provide the essential capability to be protected.

Security Vulnerability. The susceptibility of the system to the security threats in a given environment. Vulnerabilities possessed by the system's EPITS are based on

a. How the EPITS are stored, maintained, or transmitted (for example, electronic media, blueprints, training materials, facsimile, or modem).

b. How the EPITS are used (for example, bench testing or field testing).

c. What emanations, exploitable signals, or signatures (electronic or acoustic) are generated by the EPITS or reveal them (for example, telemetry, acoustic, or radiant energy).

d. Where the EPITS are located (program office, test site, developer, or vendor).

e. What types of OPSEC indicators or observables are generated by program or system functions, actions, and operations involving EPITS.

At the system level, the EPITS could be expressed by identifying the functions needing protection and the sensitivity of the information or technology to be protected. Some functions that may be included are mission-critical functions and classified components and data. There may be other functions unique to the system that should also be included. Generally, physical, electronic, and software threats are applicable. Within each of these broad threat groups are subgroups, such as sabotage, espionage, and so forth. In a system program office, the collocated Acquisition Security representative or the Acquisition Security home office can assist in the identification process. Other organizations will have a comparable group that can provide assistance.

Significant threats exist when individuals have the opportunity to place or design a vulnerability into the system that could create an operational deficiency. As an example, during a system's development, disgruntled employees could install software programs that sabotage the firing system.

Operational physical protection requirements of the system are usually defined by the warfighter (in the case of aircraft, by priority A, B, and C or other protective measures). This affords a certain level of security, but there may be subsystems or components that require a level of security beyond that provided for the system. As an example, consider classified unit identification data that is stored in computer software. An attack aircraft that runs a high risk of being captured in enemy territory represents one level of threat. A command and control aircraft that never leaves friendly airspace but whose crew requires access to the data to perform its mission represents a different level of threat. The disgruntled airman doing maintenance work on the flight line represents another.

All mission-critical functions will be identified and ranked through the life cycle of the air system, including the system/subsystem/ components, ground support equipment, system support, depot support/facilities, personnel, training, information, computer, communications, and operational security requirements, as applicable, at the various locations to include manufacturing and test sites. The most realistic threats and associated air system vulnerabilities will be identified.

It may also be appropriate to identify specific countermeasures that represent the solutions to correct design deficiencies. While this may be vital, it is still important to describe them generically, if possible, to provide the developer latitude in the final design solution. Countermeasures are the culmination of the risk management process. That is, once the threats and vulnerabilities are identified, the risk is analyzed and if considered significant, countermeasures are applied. There is a myriad of approaches to this: from accepting the risk and applying no countermeasures to spending a significant amount of money and time on one or several countermeasures. This is all decided in the analysis/trade-off process, always keeping in mind the importance of what is being protected and how critical it actually is.

Security measures (hardware, firmware, software, procedures, etc.) must be accredited and certified by appropriate risk acceptance authority (RAA) and designated approval authority (DAA) prior to its use. Each service has an agency to help with certification and accreditation, such as AFWIC. Often, the phrase certification official is used in place of RAA and DAA.

Usually, system security engineering requirements are accredited and certified, but the DAA or RAA will indicate what requirements need to be specified.

REQUIREMENT LESSONS LEARNED (3.3.5)

The reprogramming flight line capability on the air vehicle enhances operational readiness but brings security more vividly into the picture. A previously unclassified function may now need to include security procedures and techniques in the overall function design. An example is digital flight controls. Although the control laws may be unclassified, the effects of sabotage or inadvertently altered programs could have a catastrophic effect on the air vehicle. Thus, trusted software bases and accountability procedures may be warranted.

4.3.5 System security verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Air System Function a Threat #1	Security provisions for accreditation / certification at required level	A	A,I	A,I	A,D,I	A,D,I, T
Air System Function a Threat #2 ... etc	Security provisions for accreditation / certification at required level	A	A,I	A,I	A,D,I	A,D,I, T
Air System Function b Threat #1	Security provisions for accreditation / certification at required level	A	A,I	A,I	A,D,I	A,D,I, T
Air System Function b Threat #2 …etc	Security provisions for accreditation / certification at required level	A	A,I	A,I	A,D,I	A,D,I, T
Air System Function … Threat #1	Security provisions for accreditation / certification at required level	A	A,I	A,I	A,D,I	A,D,I, T
Air System Function … Threat #2 …etc	Security provisions for accreditation / certification at required level	A	A,I	A,I	A,D,I	A,D,I, T

VERIFICATION DISCUSSION (4.3.5)

Final accreditation/certification for the air system is attained by the end user since part of the accreditation is personnel training and other issues, such as proper operating procedures.

Security verification should, therefore, focus on the features under developer control, and should be accomplished incrementally with a combination of analysis, modeling, simulation, inspection, demonstration and test. For each threat to each air system function, a level of security accreditation/certification should be described by the Government, and developer's features in support of that accreditation/certification should be verified. Threats should be addressed individually and in combinations that are expected to occur in the design and development, manufacturing, field operations, training, maintenance, transportation, handling and demilitarization. MIL-HDBK-1785, *System Security Engineering Program Management Requirements* should be consulted for further guidance

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: Analysis of the air system design concept indicates that security provisions are integrated into the systems engineering process and that requirements have been properly allocated to air system/subsystems.

PDR: Analysis and inspections of the preliminary air system design and lower-tier specifications indicate the derivation of appropriate lower-tier security requirements for the development, manufacturing, and operational life of the air system. Analysis of the preliminary design indicates appropriate security provisions for the aircrew and maintainer to operate and maintain the air system and achieve successful mission performance under all specified security threats. This analysis will be done on an iterative basis as the developer modifies the design. Security vulnerability analysis identifies any system-level security requirements that require consideration.

CDR: Analysis and inspections of the air system design information, and updated analysis of lower-level test/demonstration data confirms an ability to achieve secure development, manufacturing, and operational aircrew and maintainer mission performance under specified threat conditions. Analysis of the design confirms the presence of security functions for lifecycle information protection, for secure operation of the air system, and for aircrew situational awareness under threat conditions encountered during the mission, fully supportive of government accreditation/certification requirements.

FFR: Analysis, demonstration, and inspection of the security design and provisions confirm security functions and operations are implemented for conducting first flight.

SVR: Analysis of lower-level test and demonstration data, demonstrations, inspection, and test of the total air system security provisions confirm that for each air system function, security requirements are in place to protect information throughout the lifecycle of the air system. Additionally, the ability of the aircrew and maintainer to conduct all required mission operations securely under specified security threat conditions is confirmed.

Sample Final Verification Criteria

The security requirements shall be satisfied when ___(1)___ analyses, ___(2)___ inspections, ___(3)___ demonstrations, and ___(4)___ tests confirm that the air system security provisions required to attain government accreditation/certification throughout the lifecycle of the air system, for all air system functions, are in place and operational.

Blank 1. Identify the type and scope of analysis required to provide confidence that the requirement elements have been met.

Blank 2. Identify the type and scope of inspection required to provide confidence that the requirement elements have been met.

Blank 3. Identify the type and scope of demonstrations required to provide confidence that the requirement elements have been met.

Blank 4. Identify the type and scope of tests required to provide confidence that the requirement elements have been met.

VERIFICATION LESSONS LEARNED (4.3.5)

To Be Prepared

3.3.6 System safety

The air system, when performing the prescribed missions within the environments specified herein, shall have a cumulative risk hazard index (RHI)* not greater than __(1)__for all identified hazards with individual risk hazard index values greater than __(2)__. The identified hazards, each of which is comprised of the expected frequency of the hazard occurrence and the consequent loss of said occurrence, do not include those attributable to acts of war, combat, civil unrest and disorder. Nor do they include acts of nature except as specifically identified in the environments and missions delineated herein. The cumulative risk hazard index shall be the sum of the risk hazard indices associated with the frequency of occurrence and the consequence for each hazard where such value for the risk hazard index shall be as defined in table 3.3.6-I.

*****Note: Risk hazard index (RHI) is equivalent to mishap risk assessment (MRA).

TABLE 3.3.6-I. Individual risk hazard indices.

	Hazard Frequency					
Hazard Consequence	__(F1)__	__(F2)__	__(F3)__	__(F4)__	__(F5)__	__(F6)__
___(C1)___						
___(C2)___						
___(C3)___						
___(C4)___						
___(C5)___						

Hazard Consequence. The following consequence definitions shall be used to quantify identified hazards:

C1: ____(C1D)____
C2: ____(C2D)____
C3: ____(C3D)____

C4: ____(C4D)____
C5: ____(C5D)____

Hazard Frequency. The following hazard frequency definitions shall be used to quantify identified hazards:

F1: ____(F1D)____
F2: ____(F2D)____
F3: ____(F3D)____
F4: ____(F4D)____
F5: ____(F5D)____
F6: ____(F6D)____

REQUIREMENT RATIONALE (3.3.6)

This requirement establishes the overall requirement for air system safety. Specifying an allowed maximum for hazards provides a performance basis for the requirement as well as providing the developing agent with a trade space for cost-effective safety decisions. The requirement has been crafted to encompass the material, human, and environmental aspects of safety. Too often, safety has been addressed procedurally or with prescribed solutions that have, at times, necessitated intense government oversight to ensure compliance. While such approaches have provided some degree of success, it is not evident that resulting designs have realized the degree of success or system optimization that could be effected via use of performance requirements that enable innovative solutions.

There are circumstances in which additional safety-related system requirements become necessary. For example, air vehicle noncombat loss is one of the factors used in determining the buy quantity, and such a requirement is included in this document.

REQUIREMENT GUIDANCE (3.3.6)

This requirement has been structured to control hazards within a region of risk hazard indices. The developing agent is required to ensure that the cumulative risk hazard index, for every hazard above a given level, is not exceeded. That is, every hazard in the system is characterized in terms of its consequences of occurrence and its frequency of occurrence. Each hazard is then assigned a risk hazard index based on its frequency of occurrence and its consequence of occurrence. For all hazards with a risk hazard index greater than the threshold value established (the value specified in blank 2 of the requirement), the risk hazard index is summed. The cumulative value computed must not exceed the allowed cumulative value specified in blank 1 of the requirement.

For example, assume individual risk hazard indices are as shown in table 3.3.6-II and that the cumulative value for all hazards specified in blank 1 was 1000 and that the threshold value specified in blank 2 was 6. Hazards with risk hazard indices less than or equal to 6 (the light blue cells) are not counted against the summed RHIs. The developing agent is still responsible for identifying and characterizing all the hazards. However, those hazards with RHI’s less then the threshold (the light blue cells) will not be subject to the same level of management attention as the other hazards. When the joint government and industry team devised this requirement, there was a strong emphasis to provide an enabling mechanism to eliminate excessive design and management efforts for factors having negligible payoffs. As this requirement is formulated, the specifying agency can choose wherein that threshold lies for the specific program. For example, the threshold could be lowered to “1” (in blank 2) and all hazards would be subject to a similar level of technical and management scrutiny. Specification of higher values for the threshold, which result in some categories (and as a consequence, some hazards) to not be addressed as part of the “cumulative” requirement controlled by blank 1, does not mean they are ignored. As part of the verification of the requirement, specific criteria should address the degree of confirmation necessary to establish the existence of safety hazards and their associated consequences and frequencies. The developing agent will need to confirm that reasonable attention has been given to the identification of all safety hazards and that the characteristics of each hazard have been adequately characterized.

Continuing the example, the cells in green identify the hazards that must not exceed the cumulative requirement. Suppose that there were 100 hazards identified in the initial system design with an RHI greater than 6. Clearly, if 33 of those hazards were categorized as both “catastrophic” and “frequent,” the requirement would not be met. The developing agent would be redesigning the system to drive the risk hazard indices lower. The trade space enabled by the requirement expands the options available to the designer to include increasing the frequency of occurrence of one hazard if, for example, its design implementation decreased the consequences of others.

Individual hazard risk indices - filled-in example.

	Hazard Frequency					
Hazard Consequence	*Frequent*	*Probable*	*Occasional*	*Unlikely*	*Remote*	*Improbable*
Catastrophic	30	25	20	15	10	5
Critical	24	20	16	12	8	4
Significant	18	15	12	9	6	3
Marginal	12	10	8	6	4	2
Negligible	6	5	4	3	2	1

It is also possible to include a “forbidden zone” in the matrix. That is, precluding a given set of hazard characteristics and forcing a condition that requires remedy by the developing agent. This can be accomplished by setting the RHI value for the appropriate frequency and consequence greater than the cumulative value allowed. For instance, extending the above example to preclude “frequent” and “probable,” “catastrophic” and “critical” hazards can be accomplished by entering “1001” in the cells, as highlighted in red in the example filled-in table below.

Individual hazard risk indices - filled-in example.

	Hazard Frequency					
Hazard Consequence	*Frequent*	*Probable*	*Occasional*	*Unlikely*	*Remote*	*Improbable*
Catastrophic	1001	1001	20	15	10	5
Critical	1001	1001	16	12	8	4
Significant	18	15	12	9	6	3
Marginal	12	10	8	6	4	2
Negligible	6	5	4	3	2	1

Establishing hazard consequence and frequency criteria:

Define the consequence and frequency criteria specified in table 3.3.6-I to be appropriate to the extent and nature of the air system. Completion of blanks 1 and 2 will require determination of the acceptable loss by assessment of the cost of consequent losses resulting from hazards involved in the peacetime operation of the air system that can be tolerated. Such loss must be considered in the context of the effectiveness of the air system with respect to countering the threat to which the system responds. Given this assessment, the total acceptable loss, less a subjective, semi-quantitative margin to account for all of the hazards (identified and not identified) that belong to the set of hazards of lesser consequence and frequency set in the value of blank 2 of 3.3.6, becomes the value of blank 1.

Constructing table 3.3.6-I:

Table 3.3.6-I is a derivative of the content of similar tables in MIL-STD-882, System Safety. Both the hazard consequences and hazard frequencies can be tailored as needed for a given program.

Hazard Consequence:

For each row under the “Hazard Consequence” heading, identify a consequence criteria identifier. Suggested identifiers are

Blank C1: Catastrophic
Blank C2: Critical
Blank C3: Significant
Blank C4: Marginal
Blank C5: Negligible

Define each of these identifiers. Definitions should include dollar criteria (financial consequence of a hazard occurrence), a human criteria (human consequence of a hazard occurrence, and environmental criteria (environmental consequence of hazard occurrence). Suggested criteria are the following:

C1. Catastrophic:

a. Dollar: loss of a capital asset or damage thereto and resources in excess of one million dollars (production acquisition value).

b. Human: injury to the public or the operator resulting in death or permanent disability.

c. Environmental: irreversible severe environmental damage that violates law or regulation.

d. Combined (blank C1D): consequences include any event that leads to loss of a capital asset or damage thereto and resources in excess of one million dollars (production acquisition value) or injury to the public or the operator resulting in death or permanent disability or irreversible severe environmental damage that violates law or regulation.

C2. Critical:

a. Dollar: capital equipment or resource loss or damage of less than one million dollars but more than $250,000.

b. Human: one or more injuries that result in partial disability.

c. Environmental: reversible environmental damage causing a violation of law or regulation.

d. Combined (blank C2D): consequences include those that result in capital equipment or resource loss or damage of less than one million dollars but more than $250,000 and/or resulting in one or more injuries that result in partial disability or reversible environmental damage causing a violation of law or regulation.

C3. Significant:

a. Dollar: capital equipment and resource loss or damage of less than $250,000 and more than $100,000.

b. Human: personal injury, or injuries, resulting in temporary partial or complete disability of greater than fifteen (15) days.

c. Environmental: mitigable environmental damage causing a violation of law or regulation.

d. Combined (blank C3D): consequences include those that result in capital equipment and resource loss or damage of less than $250,000 and more than $100,000 or personal injury, or injuries, resulting in temporary partial or complete disability of greater than fifteen (15) days or mitigable environmental damage causing a violation of law or regulation.

C4. Marginal:

a. Dollar: capital equipment and resource loss or damage of less than $100,000 and more than $10,000.

b. Human: personal injury, or injuries, resulting in temporary disability of less than fifteen (15) days and more than one (1) lost day.

c. Environmental: mitigable environmental damage without violation of law or regulation where restoration activities can be accomplished.

d. Combined (blank C4D): consequences include those that result in capital equipment and resource loss or damage of less than $100,000 and more than $10,000 or personal injury, or injuries, resulting in temporary disability of less than fifteen (15) days and more than one (1) lost day or mitigable environmental damage without violation of law or regulation where restoration activities can be accomplished.

C5. Negligible:

a. Dollar: capital equipment and resource loss or damage of less than $10,000.

b. Human: personal injury, or injuries, resulting in first aid requirements and one (1) or less days lost to disability.

c. Environmental: minimal environmental damage not violating law or regulation.

d. Combined (Blank C5D): consequences include those that result in capital equipment and resource loss or damage of less than $10,000 and personal injury, or injuries, resulting in first aid requirements and one (1) or less days lost to disability or minimal environmental damage not violating law or regulation.

Hazard Frequency

There are two options for hazard frequency, either a probability of occurrence or rate is used. The safety community normally uses a probability of occurrence. If an absolute rate is used (for example, in the context of X occurrences per year), then include an operating fleet size condition in the requirement such as, "For the purposes of this requirement, the operating fleet size shall be assumed to be ____(3)___."

Suggested identifiers for the row beneath "Hazard Frequency" are

Blank F1: Frequent
Blank F2: Probable
Blank F3: Occasional
Blank F4: Unlikely
Blank F5: Remote
Blank F6: Improbable

Define each of these identifiers. An understanding of individual events and likely impacts across the fleet will be needed. Further, these can be directly applied to the service life (see 3.3.1.2) of the items.

F1. Frequent:

Blank F1D includes all hazards likely to occur often in the life of an item, with a probability of occurrence greater than 0.1 in that life for an air system operated in accordance with the operational scenarios and missions as defined herein.

F2. Probable:

Blank F2D includes all hazards that will occur several times in the life of an item, with a probability of occurrence less that 0.1 but greater than 0.01 in that life for an air system operated in accordance with the operational scenarios and missions as defined herein.

F3. Occasional:

Blank F3D includes all hazards likely to occur at some time in the life of an item, with a probability of occurrence less than 0.01 but greater than 0.001 in that life for an air system operated in accordance with the operational scenarios and missions defined herein.

F4. Unlikely:

Blank F4D includes all hazards unlikely but possible to occur in the life of an item, with a probability of occurrence less than 0.001 but greater than 0.0001 for an air system operated in accordance with the operational scenarios and missions defined herein.

F5. Remote:

Blank F5D includes all hazards unlikely but possible to occur in the life of an item, with a probability of occurrence less than 0.0001 but greater than 0.000001 for an air system operated in accordance with the operational scenarios and missions defined herein.

F6. Improbable:

Blank F6D: includes all hazards so unlikely it can be assumed they may not occur, with a probability of occurrence less than 0.000001 in that life for an air system operated in accordance with the operational scenarios and missions defined herein.

Establishing Risk Hazard Indices

To fill out the risk hazard index table, weights are often established for each consequence and frequency category with the product of the category weights for each cell used as the risk hazard index. See an example of assigned weights in the table below.

Individual hazard risk indices – example weights assigned.

	Hazard Frequency					
Hazard Consequence (Weight)	*Frequent (6)*	*Probable (5)*	*Occasional (4)*	*Unlikely (3)*	*Remote (2)*	*Improbable (1)*
Catastrophic (5)	6 X 5 =30					
Critical (4)						
Significant (3)						
Marginal (2)						
Negligible (1)						

This guidance on using the weights to establish RHIs should not be taken as limiting. It could be argued that weights, if used, should represent the seriousness of the increase from category to category. For example, there is typically an order of magnitude difference in frequency from category to category. In consequence, the dollar values typically associated with the categories vary by a factor of 2.5-10 on a category-to-category basis. The implication being that a frequent, catastrophic" hazard be considered in excess of one million times more serious than a negligible, improbable hazard in terms of relative RHI. Such distinctions may not matter as much when procedural requirements with intense oversight by the government are used. However, a performance-based requirement that allows a trade-space will require more care when building the table to ensure that the more serious and frequently occurring hazards are appropriately dealt with during development.

The values to use for Blanks 1 and 2 (the cumulative value of RHIs that must not be exceed and the lower threshold for counting RHIs) could initially be derived based on historical data for a given air system. However, the expectation would be that the historical information may be useful to enter PDRR phase, but the exit from PDRR should be based on actual design work accomplished as tempered by historical data and warfighter requirements to better target effective requirements. A starting point for selecting the threshold value could be examining the point at which the costs associated with in-depth management and oversight of the requirement to reduce or preclude the consequences or frequency of the hazard versus the cost of the consequences expected over the life of the system. For example, it may not be cost effective to try to manage, preclude or reduce the consequences of remote or improbable hazards evaluated as having negligible consequences.

A filled-in example of the table and definitions follows:

Individual hazard risk indices - filled-in example.

	Hazard Frequency					
Hazard Consequence	*Frequent (32)*	*Probable (16)*	*Occasional (8)*	*Unlikely (4)*	*Remote (2)*	*Improbable (1)*
Catastrophic (16)	512	256	128	64	32	16
Critical (8)	256	128	64	32	16	8
Significant (4)	128	64	32	16	8	4
Marginal (2)	64	32	16	8	4	2
Negligible (1)	32	16	8	4	2	1

Hazard Consequence. The following consequence definitions will be used to quantify identified hazards:

a. Catastrophic consequences include any event that leads to loss of a capital asset or damage thereto and resources in excess of one million dollars (production acquisition value) or injury to the public or the operator resulting in death or permanent disability or irreversible, severe environmental damage that violates law or regulation.

b. Critical consequences include those that result in capital equipment or resource loss or damage of less than one million dollars but more than $250,000 and/or resulting in one or more injuries that result in partial disability or reversible environmental damage causing a violation of law or regulation.

c. Significant consequences include those that result in capital equipment and resource loss or damage of less than $250,000 and more than $100,000, or personal injury or injuries resulting in temporary, partial, or complete disability of greater than fifteen (15) days, or mitigable environmental damage causing a violation of law or regulation.

d. Marginal consequences include those that result in capital equipment and resource loss or damage of less than $100,000 and more than $10,000, or personal injury or injuries resulting in temporary disability of less than fifteen (15) days and more than one (1) lost day, or mitigable environmental damage without violation of law or regulation where restoration activities can be accomplished.

e. Negligible consequences include those that result in capital equipment and resource loss or damage of less than $10,000, and personal injury or injuries resulting in first aid requirements and one (1) or less days lost to disability, or minimal environmental damage not violating law or regulation.

Hazard Frequency. The following frequency of hazard definitions will be used to quantify identified hazards:

a. Frequent includes all hazards likely to occur often in the operational life of an item, the probability of occurrence being greater than 0.1 for an air system operated in accordance with the scenarios and missions defined herein.

Probable includes all hazards that will occur several times in the operational life of an item, the probability of occurrence being less that 0.1 but greater than 0.01 for an air system operated in accordance with the scenarios and missions defined herein.

Occasional includes all hazards likely to occur some time in the operational life of an item with a probability of occurrence less than 0.01 but greater than 0.001 for an air system operated in accordance with the scenarios and missions defined herein.

Unlikely includes all hazards unlikely but possible to occur in the operational life of an item with a probability of occurrence less than 0.001 but greater than 0.0001 for an air system operated in accordance with the scenarios and missions defined herein.

Remote includes all hazards unlikely but possible to occur during the operational life of an item, the probability of occurrence being less than 0.0001 but greater than 0.000001 for an air system operated in accordance with the scenarios and missions defined herein.

Improbable includes all hazards so unlikely it can be assumed they may not occur during the operational life of an item, the probability of occurrence being less than 0.000001 for an air system operated in accordance with the scenarios and missions defined herein.

For example, using the example table 3.3.6-I as a basis, all hazards with a risk hazard index greater than 12, arbitrarily set as the value of blank 2 in this example, would be accumulated and established as the value of blank 1. This value (for blank 1) may be established as 100 hazards of average risk hazard index of 20 resulting in a specification value of 2000 in blank 1 for the air system.

Controlling air vehicle losses:

An air vehicle loss is a catastrophic event (capital asset in excess of $1M). The acceptable level of risk is generally measured in terms of losses per hundred thousand flying hours. Using an arbitrary planning factor of 5/100,000 hrs (the warfighters or force planners would make the estimate for the particular system), an average mission duration of 1 hour, a peacetime flying hour program of 20 missions/month, a service life of 20 years, and an operating fleet size of 500 air vehicles, “planned” losses would have approximately 0.21 probability of occurrence. This meets the criteria for “frequent” with a resulting risk hazard index of 30. A potential problem is that, regardless of how high the acceptable risk factor, the hazard score never exceeds 30 for any given hazard. It may be prudent to also specify an acceptable loss rate for air vehicles.

REQUIREMENT LESSONS LEARNED (3.3.6)

Operators and maintainers of air systems must be capable of performing their job effectively in exceedingly challenging (stressful) environments. It is the developer’s responsibility to provide those operators and maintainers with equipment that is inherently safe and not rely on warnings, indicators, or additional training to achieve acceptably safe operating states. While this may not always be practicable, equipment operator intervention should be minimized, if not eliminated. To affect this, the system design practice(s) to preclude hazards should be in accordance with the following order of precedence:

a. Eliminate hazards through design.

If a hazard cannot be eliminated, reduce mishap risk through the use of protective safety features or devices.

Incorporate detection and warning capability to alert personnel of the hazard.

Incorporate special procedures, including personnel protective equipment and training.

4.3.6 System safety verification

Requirement Elements	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
System safety	(1) Cumulative RHI* (or MRA)	A	A	A	A	I,A,T

*****Note: Risk hazard index (RHI) is equivalent to mishap risk assessment (MRA).

VERIFICATION DISCUSSION (4.3.6)

The system safety verification is accomplished to predict the occurrence of mishaps due to design attributes and shortcomings. At the air system level, verification activities must encompass all of the air system’s constituent items, to include the systems, subsystems, and equipment, and must address air system operations and maintenance. There are other system-level verifications conducted that provide information to be analyzed in determining compliance with this requirement. For example, test and demonstrations to confirm compliance with the ICT requirement may expose safety issues with air system equipment and operating procedures.

Key Development Activities

Key activities include, but are not limited to, the following:

SRR/SFR: A preliminary hazard analysis (PHA) of the system design concept indicates the system will be able to meet the established RHI limits. Analysis of the design concept indicates a reasonable degree of assurance that all the consequence levels are exposed and proffers an understanding of how they interrelate. Tools such as fault trees and FMEA/FMECA are often used. Typically, the system safety program plan (SSPP) is provided for review and comment. Analysis of the design concept indicates the system safety program plan has been implemented to mitigate known risk. This plan will address the approach used to accomplish the system safety management and engineering activities and will consider how hazards are identified, analyzed, and corrected. This plan needs to demonstrate capability and understanding of the tasks required to ensure a safe design.

PDR: Subsystem safety hazard analyses (SSHA) of the system preliminary design indicates the system will be able to meet the established RHI limits. These analyses indicate a reasonable degree of assurance that all hazards (including consequence, frequency, and interrelationships) impacting the requirement have been identified, quantified, and mitigated to the extent necessary to meet the requirement. Preliminary risk assessments should be accomplished early in the system development prior to the detailed design process. The assessments should identify critical system and subsystem hazards and an approach to resolve these hazards to a lower level of risk through design changes. Tools such as fault trees and FMEA/FMECA are often used.

CDR: A system hazard analysis (SHA) of the system detailed design, to include the system's configuration items and their interfaces, indicates the system will be able to meet the established RHI limits. These analyses indicate a reasonable degree of assurance that all hazards (including consequence, frequency, and interrelationships) impacting the requirement have been identified, quantified, and mitigated to the extent necessary to meet the requirement. Analysis confirms there are no unaddressed safety issues. The detailed design incorporates operational and support equipment and procedures. Tools such as fault trees and FMEA/FMECA are often used.

FFR: Analysis of the flight-ready equipment and procedures, lower-level testing, and analysis of ground testing confirms that previously unidentified hazards have been quantified and mitigated or accepted. Analysis of the final safety reports identifies the hazards affecting first flight and the controls employed to control or prevent their occurrence. These reports should address all facets of the system to include hardware, software, operations, training, and support equipment and procedures. A safety assessment report (SAR) and operational and support hazard analysis (O&SHA) is normally provided for review and comment.

SVR: System-level test and analysis of lower-level tests confirm the system satisfies the established RHI limits. Inspection confirms all design changes since CDR have been verified and reflected in the system documentation.

Sample Final Verification Criteria

The system safety requirement shall be satisfied when ___(1)___ inspections, ___(2)___ analyses, and ___(3)___ tests confirm the system will be able to meet the established RHI limits.

Blank 1. Identify the type and scope of inspections required to provide confidence that the requirement elements have been met.

Blank 2. Identify the type and scope of analyses required to provide confidence that the requirement elements have been met.

Blank 3. Identify the type and scope of tests required to provide confidence that the requirement elements have been met.

VERIFICATION LESSONS LEARNED (4.3.6)

To Be Prepared

3.3.7 Stores/weapons

The system shall be capable of employing and deploying the stores/weapons listed in table 3.3.7-I.

TABLE 3.3.7-I. Stores/weapons list.

Store/Weapon Nomenclature	Variant Descriptors	Minimum Required Modes

REQUIREMENT RATIONALE (3.3.7)

This paragraph is used to identify the stores/weapons that are part of the system. Stores/weapons include items such as internal/external weapons, external fuel tanks, sensor pods, cargo pods, suspension and release equipment, and expendable countermeasures. Employment involves the integration of the store and the weapon system to ensure effective and efficient completion of the mission.

REQUIREMENT GUIDANCE (3.3.7)

Complete the columns of the table as follows:

Stores/Weapon Nomenclature. List by nomenclature all of the stores/weapons that the system must employ and provide a description of the mission required to be performed with the store/weapon.

Variant Descriptor. Include any pertinent, variant-specific information.

Minimum Required Modes. Enter the weapon modes that must be employed by the system. If all available weapon modes must be employed, indicate by entering “All.”

REQUIREMENT LESSONS LEARNED (3.3.7)

Differences can exist between stores/weapons, even within a family of stores/weapons, so it is essential to be specific. For example, specifying AIM-120 is not sufficient; include the specific variant, for example, AIM-120C-5. Note that the design attributes required for an AIM-120B can be different than for the AIM-120C-5. Attaching the associated mission to the store/weapon will allow the system to be designed to accomplish the mission. For example, an offensive, counter-air mission with an AIM-120C-5 will drive requirements different from those for an escort mission with the same weapon.

4.3.7 Stores/weapons verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Stores/weapons employment and deployment	Stores/weapons list (table 3.3.7-I)	A	A	A		A

VERIFICATION DISCUSSION (4.3.7)

Verification of the stores/weapons employment and deployment requirement should be accomplished through analysis of lower-level inspections, analyses, demonstrations, and tests of the stores/weapons listed in table 3.3.7-I.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of system function and requirements documents indicates proper flow down of store/weapon driven functions and requirements. This flow down should include, but is not limited to, mission planning system, training system, support system, and air vehicle.

PDR: Analysis of the preliminary weapon system design indicates that successful employment and deployment of the required store/weapons can be achieved.

CDR: Analysis of the weapon system design confirms that successful employment and deployment of the required store/weapons can be achieved. Analyses typically increase in fidelity.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of lower-level analyses, demonstrations, and tests confirms that the system can employ/deploy the stores/weapons listed in table 3.3.7-I.

Sample Final Verification Criteria

The stores/weapons employment/deployment requirements shall be verified by ___(1)___ analyses.

Blank 1. Identify the type and scope of the analyses required to provide confidence that the requirement has been satisfied.

VERIFICATION LESSONS LEARNED (4.3.7)

To Be Prepared

3.3.8 System usage information collection and retrieval

The system shall be capable of collecting, storing, and using real-time information resulting from the use of the system and the conditions it experiences. For the item(s) identified, the following shall be as specified in table 3.3.8-I: the functionality to be provided for operational, support, and other uses (such as accident investigations); the minimum information characteristics required; and the performance characteristics of that information. Additionally, special security provisions for the information/equipment, information/equipment retrieval performance/characteristics (including compatibility requirements with infrastructure equipment and information processing systems) and any other relevant conditions shall be as specified in table 3.3.8-I.

TABLE 3.3.8-I. System usage information collection and retrieval.

Item	Functionality (Purpose)	Information Characteristics	Performance Characteristics	Security	Retrieval Performance/ Characteristics	Conditions

REQUIREMENT RATIONALE (3.3.8)

System usage information can be used for a wide variety of operational, support, and other purposes. These may include

a. Information collected to support air operations such as battle damage assessment (for example, “gun camera” or bomb impact video) and threats encountered to support planning of future missions.

b. Information collected to provide accurate data on environments experienced by the system to assist in redressing aging, stress, strain, thermal, and other impacts that affect the reliability/durability of the item. Usage information can also provide maintainers with sufficient information to ascertain the cause of equipment degradation and the operability of items, in order to enable rapid maintenance actions and minimize equipment downtime.

c. Information collected on flight conditions and flight-critical equipment operating states to enable identification of accident sources during mishap investigations. Sufficient information to ascertain the cause of the problem may enable corrective actions to preclude future flight mishaps.

Application of this requirement might lead to incorporation of a flight data recorder (or other such mechanism), a gun camera, a fatigue monitoring system, etc.

REQUIREMENT GUIDANCE (3.3.8)

Guidance for completing table 3.3.8-I follows:

(Note: most of the guidance relates to air vehicles since they provide easy examples; however, if there is a requirement to generate and store usage history information, application to equipment such as flight simulators, UAV control stations, and other high value, specialized, or complex support equipment can be included as well.)

Item: Identify the item that must have the capability to collect and store usage information. Typically, this will be the air vehicle; however, other complex, costly, and/or safety-critical items may be included as well (for example, a flight simulator or UAV control station). Enter the item as many times as needed to fully capture the information needed and its purpose. For example, "Air Vehicle" may be entered a number of times including for mishap investigations and for durability of big ticket, critical items such as aircraft structures.

Functionality (purpose): Define the functionality to be obtained. This may also be expressed as the purpose (or reason why) the information is to be collected. It can be simply stated and is intended to provide a scope for the information needed. Examples could be "Battle damage assessment," "monitor mission-critical subsystem performance," "identify threat locations for mission planning," "support accident cause determination."

Information characteristics: This parameter is optional. Use it to specify the minimum information characteristics needed. If used, it should either be complete or include a statement such as "and other relevant information." Sometimes, our historical experience provides considerable knowledge on what is important to accomplish various functions (such as accident investigations). Other times, it is preferable to rely on the functionality and performance characteristics. Care is needed. Information characteristics coupled with the functionality and performance characteristics can lead to additional capabilities (and expense) that may not be needed. For example, is it essential that threat location be established to a given accuracy or do we just want the information collected by a radar warning receiver at accuracies necessary for the system to meet its other requirements. Specify the type of information needed. For example, "operating state of flight-critical equipment and flight operating conditions" may be needed to ascertain the cause of a mishap. Observed performance (such as "g-force" history) may be necessary for continuous assessment of system integrity. Encountered threat characteristics can be stored for future mission planning use.

Performance characteristics: Performance characteristics should address the capacity of the information to be stored, the frequency at which it is stored, the volatility of the information (see below), and other information such as accuracy. The performance characteristics can introduce additional capabilities, such as sensors, into the system. For example, "full weapon flight tracking from launch to flight termination plus 5 seconds on permanent media capable of 10 X enlargement without apparent image degradation" may communicate to some that a motion picture camera with high resolution film is necessary.

Volatility characteristics: Describes the storage performance for the information and how long it needs to be retained. It may be necessary to subcategorize the information parameter and express the volatility for each subcategory. Further, it may be necessary to break out conditions for volatility. For example, if the information is "flight conditions and operating status and states of flight-critical items" with a functionality of "ascertain cause of mishap" for an air vehicle, cockpit voice information may only be needed for the last XX minutes of flight. But the operating states and status of flight-critical equipment may be needed for the last YY minutes of flight. It may be required to retain all the information for a given set of information for the duration of the entire mission. Another condition to consider is where the event occurs. For example, if the mishap were to occur over threat territory, the volatility parameter can include a condition that this recorded information be erased on operator command. This can be used, in general, to protect sensitive information.

Security: Identify any special security requirements for information storage and retrieval for each condition of storage and retrieval experienced. Normally, the security requirements will be dictated by the information (and may be covered elsewhere in the specification). Other times, due to the type of performance required, additional equipment/capabilities will be necessary. For example, suppose it is desirable to generate and store the characteristics of encountered threats. There may need to be one set of security requirements for the information storage device itself, another for how the information is used in-flight, and still another if the information is to be passed to other air vehicles or equipment during the mission.

Retrieval performance/characteristics: This parameter covers a wide range of possibilities. For example, if the operating performance of on-board equipment were being collected to ascertain the experienced equipment performance (for system integrity purposes), the retrieval characteristics may include maintenance data collection systems. If the information is related to mishap analyses, there may be multiple entries that address retrieval of a crash survivable storage device (visual, aural, and/or electromagnetic signals, beacons) as well as the retrieval of the information itself (which may include data formats and/or equipment interfaces). If information is to be passed from the air vehicle to an external receiver, identify the receiver and appropriate characteristics of the physical and functional interface. Where possible, use performance terminology ("crash survivable and locatable") and/or identify the interface ("compatible with the XXX maintenance data collection system") with a reference to the appropriate interface in section 3.4 Interfaces)

Conditions: Identify any conditions impacting the requirement. For example, collecting and storing information comes at a cost. Some types of information may not be needed from every item built and cost can be avoided by not instrumenting every item. For example, if stress profiles are needed from every air vehicle, enter "every vehicle." If they are needed from a fraction of the aircraft to be built (such as from every other air vehicle) enter that fraction. Use whichever numeric designation makes the most sense.

REQUIREMENT LESSONS LEARNED (3.3.8)

To Be Prepared

4.3.8 System usage information collection and retrieval verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Functionality provided	Column 2 of table 3.3.8-I	A	A	A	A	A,D
Information recorded	Column 3 of table 3.3.8-I	A	A	A	A	A,D
Performance characteristics recorded	Column 4 of table 3.3.8-I	A	A	A	A	A,D
Security of recorded information	Column 5 of table 3.3.8-I	A	A	A	A	A,D
Retrieval of recorded information	Column 6 of table 3.3.8-I	A	A	A	A	A,D

VERIFICATION DISCUSSION (4.3.8)

Verification activity needs to address the three key design areas. These are

a. The information collection methods;

b. The information recording methods; and

c. The in-flight or post-flight information retrieval methods.

However, due to commonality of requirement elements, verification approach, and methodology, these design areas are addressed as a unit. Initial verification should consist of analysis activities and final verification should include both analyses and tests or demonstrations. Integration with other recording functions should also be considered as possible information sources. Verification of this requirement would typically be accomplished as part of other air system verification tests. Use of this type of data should avoid the cost and schedule impacts of formal "stand alone" demonstrations.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: Analysis indicates the conceptual design, including information collection, recording, and retrieval, satisfies the basic mission need. Analysis identifies mission parameters to be collected. Functional analysis indicates logical allocations to hardware and software elements.

PDR: Analysis of design trade study results and of preliminary designs for the various components of the information collection function indicates the individual elements have been functionally integrated within the air system. Analysis of required parameters, sources, data rates, and data compression algorithms, if used, indicates readiness for detailed design.

CDR: Analysis of the design, including lower-level development testing, the information collection function integration into the air system, and the integration with all applicable air system subsystems and functions, including support systems, confirms a “ready for build” status. Analysis confirms that information parameters to be recorded include all data necessary for evaluation of the mission. Analysis of lower-level verifications (for example, hardware and software tests, hardware in the loop (HITL) integrated systems tests) and overall air system integration, confirms the system can achieve specified requirements.

FFR: Analysis of functionality (for example, crash recording) required for first flight confirms acceptable performance.

SVR: Air system demonstrations and analysis of lower-level demonstrations and tests confirm that collection, storage, and retrieval requirements have been achieved. Analysis and demonstrations confirm that the requirements of table 3.3.8-I have been met.

Sample Final Verification Criteria

The system usage information requirement shall be satisfied when ___(1)___analyses and ___(2)___ demonstrations confirm that the air system information collection capability provides for retaining required information at the required security level from the specified sources in a retrievable form.

> Blank 1. List the type and scope of analysis required to provide confidence that the requirement has been achieved.
>
> Blank 2. List the type and scope of demonstrations required to provide confidence that the requirement has been achieved.

VERIFICATION LESSONS LEARNED (4.3.8)

To Be Prepared

3.3.9 Human systems

The air system shall be capable of meeting the requirements specified herein when operated by ___(1)___ and maintained by ___(2)___ in the environments specified in ___(3)___.

REQUIREMENT RATIONALE (3.3.9)

The populations (including population characteristics) and operating environments/conditions for crews operating and maintaining the system must both be established to enable the definition and design of a system that can perform its intended functions. This affects the placement of components (size ranges), the weight of components (strength range of population), the education level to which technical manuals are written, endurance capabilities, crew accommodations, and so forth, that must be designed into system products and services.

REQUIREMENT GUIDANCE (3.3.9)

Blanks 1 and 2. Define the anticipated operator and maintainer populations. Population characteristics include anthropometrics with special attention to requirements, limitations, or allowances for physical attributes not normally characterized (for example, unusual expectations for human endurance, strength, etc.) as well as capabilities/attributes that can be characterized and selected from an allowed population that will limit/expand design options. Other pertinent population requirements/characteristics may include educational level.

Blank 3. Define the anticipated environments in which the air system will be operated and maintained. These include the threat environments (see 3.1.1 Roles and missions), the natural and induced environments (see 3.2 Environment) that can be handled by reference. Additional human operating environments should be specified here including, for example, acceptable crew environment requirements such as “shirt sleeve” environments and self-contained crew rest/accommodation environments.

Human engineering performance requirements are necessary to achieve mission success through integration of the human into the system, subsystem, equipment, and facility as well as to achieve effectiveness, simplicity, efficiency, reliability, and safety of system operation, training, and maintenance. These areas shall include environment, anthropometry, maintainability, and operability. Environment considers life support and emergency escape/egress for the operator as well as protection of both the operator and maintainer. Anthropometry includes body size ranging for both operator and maintainer. Maintainability covers the ability of the maintainer to work effectively and efficiently to provide an operable system. Operability includes controls and displays and their interaction to enable the operator to perform the intended mission.

REQUIREMENT LESSONS LEARNED (3.3.9)

To Be Prepared

4.3.9 Human systems verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Air system performance with specified operational and maintenance personnel	Capability for (1) and (2) personnel to operate and maintain the system	A	A	A		A,D, S

VERIFICATION DISCUSSION (4.3.9)

The human systems evaluation will require a number of subjects in order to represent the required population (normally 20 or more). It is best to have at least two different subjects to represent each model to get an accurate assessment of the accommodation. This is necessary due to differences in torso, limb thickness, flexibility, etc. Lower-level demonstration and test results and computer simulations should be used, whenever possible, to verify this requirement at the air system level.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of the design concept indicates that human system requirements for the interface between air system elements and the operator and maintainer are defined and understood. Analysis indicates that the system design approach is considering all specified human interactions (for example, anthropometry, clothing and equipment, control design, cautions and advisories). Analysis indicates that the personnel population is fully described.

PDR: Analysis of lower-level preliminary design indicates the system can be operated and maintained by the specified population. For example, crew station, maintenance bay, and stores station designs, as well as other design aspects, are integrated with anthropometric models and incorporated into a computer model. An anthropometric evaluation analyzed electronically further substantiates acceptable system design.

CDR: Analysis of lower-level final design confirms the system can be operated and maintained by the specified population. Analysis of lower-level demonstrations in high fidelity mock-ups and/or computer simulations confirms acceptable accommodation. Subjects are evaluated while wearing the full complement of equipment and possible variations (over water vs. over land, cold weather, chemical/biological, etc.).

FFR: No unique verification action occurs at this milestone.

SVR: Demonstrations and/or analysis of lower-level demonstrations confirm the system can be operated and maintained by the specified population. Subjects are evaluated while wearing the full complement of equipment and possible variations (over water vs. over land, cold weather, chemical/biological, etc.). Analysis, demonstrations, and simulations confirm that all pre-flight, in-flight, and post-flight personnel operations can be successfully performed by personnel within the full range of parameters defined.

Sample Final Verification Criteria

The operator and maintainer human systems requirements shall be satisfied when___(1)___analyses, ___(2)___ demonstrations and ___(3)___simulations confirm the system can be operated and maintained by the specified personnel.

Blank 1. Identify the type and scope of analyses required to provide confidence that the requirement has been satisfied.

Blank 2. Identify the type and scope of demonstrations required to provide confidence that the requirement has been satisfied. Demonstration is the surest method of ensuring that the required population is accommodated. Subjects participating in the evaluation should wear life support gear. All LSS connections and crew restraints should be connected.

Blank 3. Identify the type and scope of simulations required to provide confidence that the requirement has been satisfied.

VERIFICATION LESSONS LEARNED (4.3.9)

To Be Prepared

3.3.10 Basic modes of operation

The air system shall be capable of, but not limited to, executing the basic modes of operation shown in table 3.3.10-I.

TABLE 3.3.10-I. Basic modes of operation.

Mission system	Mode	Mode requirement

REQUIREMENT RATIONALE (3.3.10)

In this section of the specification, the air system basic modes of operation are defined. Three basic modes of operation are suggested to cover most conceivable mission situations, but others may be required. The Off mode will account for pre-mission operations and maintenance functions when prime power is not required. Examples of this are when the mission systems OFP software, mission planning data, and threat/countermeasure data base tables are up/down loaded. In this case, Memory Loader Verifier (MLV) equipment will generally power the necessary circuits in the subsystem. Some countermeasures or surveillance subsystems will typically have a Standby Mode that the subsystem enters upon power up. The Operate mode is the normal mode of operation in which all subsystem functions are engaged and the mission system(s) are ready to be employed.

REQUIREMENT GUIDANCE (3.3.10)

Mission system: Identify the air system mission system component(s) or functions which are required to have the defined basic mode of operation. Enter the mission system component/function as many times as needed to fully capture the information needed. Enter “all mission systems” if all apply.

Mode: Specify name of mode.

Mode requirement: The modes identified describe the basic modes of operation on the mission system component(s)/function(s). These modes may be supplemented with additional modes or sub-modes that are application specific. If multiple mission systems have the same basic mode, the name of the mode is sufficient and the definition requirement need not be repeated on subsequent mission systems. Three basic mode definitions are suggested:

a. Off Modes. The air system shall be capable of executing an off mode. In this mode, operating power is not applied, but the mission system shall be capable of being accessed by ground support equipment/personnel to complete preflight and postflight tasks such as uploading/downloading mission and operational flight program (OFP) software.

b. Standby Mode. The air system shall be capable of executing a standby mode when operating power is applied. In this mode, 1) the mission systems shall be capable of receiving and processing information such as navigation data, threat signals, or off-board target designations; 2) mission systems shall be powered-on, but inhibited from transmitting, on-board target designation, or weapon employment; and 3) the mission systems shall be capable of executing diagnostics (self-test) and other sub-modes such as internal calibrations and uploading/downloading of mission and OFP software.

c. Operate Mode. The air system shall be capable of executing an operate mode when operating power is applied. In this mode, the air system shall be capable of performing all operational tasks and functions as specified elsewhere in this document.

d. Stored Mode. A stored mode may be applicable for systems such as UAVs which are placed in storage for long times between operating periods.

REQUIREMENT LESSONS LEARNED (3.3.10)

To Be Prepared

4.3.10 Verification of mission systems basic modes of operation

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Capable of executing basic modes of operation	Mission system mode list (table 3.3.10-I) {Pass/fail}	A	A	A	A	A

This requirement must be verified to ensure that the air system is capable of sequencing through the defined mission system modes of operation. Verification of the air system basic modes of operation requirement should be accomplished through analysis of lower-level inspections, analyses, demonstrations, and tests of the mission system modes listed in table 3.3.10-I.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of air system function and requirements documents indicates proper flow down of basic mission system driven functions and requirements. This flow down should include, but is not limited to, mission planning system, training system, support system, and air vehicle.

PDR: Analysis of the preliminary air system design indicates that successful execution of each required mission system basic mode of operation can be achieved.

CDR: Analysis of the air system design confirms that successful execution of each required mission system basic mode of operation can be achieved.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of the final air system design and inspection of the pilot-vehicle interface confirms that successful execution of each required mission system basic mode of operation can be achieved. Analysis of lower-level analyses, demonstrations, subsystem testing in a systems integration laboratory (SIL), and lower level flight tests confirms that the air system can execute the basic modes of operations for mission systems listed in table 3.3.10-I. Analysis of the results from lower level testing confirms that other avionics that are not part of the specific mission system tested do not interfere with its proper operation. During this testing, each mode should be extensively tested over the range of its control to assure that subsystem control problems are eliminated.

Sample Final Verification Criteria

The air system basic mode of operation requirements shall be verified by ___(1)___ analyses, ___(2)___ inspections, ___(3)___ demonstrations, and ___(4)___ tests.

Blank 1. Identify the type and scope of the analyses required to provide confidence that the requirement has been satisfied.

Blank 2. Identify the type and scope of inspection required to provide confidence that the requirement elements have been met.

Blank 3. Identify the type and scope of demonstrations required to provide confidence that the requirement elements have been met.

Blank 4. Identify the type and scope of tests required to provide confidence that the requirement elements have been met.

VERIFICATION LESSONS LEARNED (4.3.10)

To Be Prepared

3.4 Interfaces

The system shall operate as a self-contained unit or in concert with same service forces, multi-national military forces, other service forces, and/or national assets as identified in the table below. The system shall meet the interface requirements identified in table 3.4-I.

TABLE 3.4-I. Interface requirement matrix.

Country, Organization, Service, Agency	Operational	Support	Training	C^4ISR	Inter-operability*	Trans-portation	Mapping, Charting, and Geodesy

*Specification developers shall refer to the most recent version of JTA, Aviation Domain, for mandated interoperability requirements.

REQUIREMENT RATIONALE (3.4)

Air systems may operate in concert with same-service forces, multi-national military forces, other service forces, and/or national assets. In such situations it is crucial that the system operate successfully with the respective operational systems, support equipment, training systems, C^4ISR assets, mission planning systems and data, encryption information/codes and other assets or services required to deploy and operate.

REQUIREMENT GUIDANCE (3.4)

A system's interfaces include assets and processes that the system must operate with in order to achieve its requirements. For example, in supporting a system there are interfaces not only to "common" support equipment that are selected for use and deployed with the unit but also to the support process(es) that may include transportation of malfunctioning items to and from the depot or other location/agency responsible for the repair/refurbishment of the items. While we may expect a system to operate successfully in combat for some period of time, utilizing resources from the spares kit deployed with the unit, sustaining operations beyond that point requires infrastructure, or other, support and transportation assets to maintain the flow of parts, consumables, and expendables. The developing contractor may not be responsible for services provided by the military infrastructure; such services may impose additional constraints on successful operations. For example, consider a situation in which spares can be transported within constraints imposed by operational deployment requirements, but planned transportation assets beyond the initial deployment are limited. Inability to move broken items between an operating location and a designated repair location may be a driving factor in the reliability and maintainability of the system. That is, the design solution may be different for a system assumed to have an unlimited source of supply than for one whose supply pipeline is limited. In order to impact the solution effectively, the interface requirements and constraints must be defined. Where (and how) the system being developed directly fits within the overall architecture of the force defines the boundary conditions (interfaces) needed for successful operations, support, training, and so forth. While the developing contractor may not be responsible for the other assets and services, these may impose requirements and constraints that impact the solution.

The meaning of each column header follows:

Operational: Include requirements to use, or integrate with, other operational assets. Examples would include the type of ship for carrier operations and other systems that designate/guide weapons launched from an air vehicle (such as one helicopter guiding a weapon launched from another) or vice versa. Reference the interface requirements documentation, as appropriate.

Support: Include any requirement to use support equipment other than that developed as part of the system. This includes support equipment from other services, NATO, or other nations. The specific requirement should identify the level of use of these other support systems. For instance, a system may be required to use existing NATO refueling and weapon loading equipment. Reference the interface requirements documentation, as appropriate.

Training: This area refers to any requirement to use training systems; however, if interface requirements for training assets are not included in the Training Section of this document, those requirements should be identified here. Valid training interface requirements include identifying foreign pilots/operators that must be trained, as well as other service or another nation's training that must be used. Reference the interface requirements documentation, as appropriate.

C^4ISR: Refers to command, control, communications, computers, intelligence, surveillance, and reconnaissance requirements. This area refers to a large interface area and will likely include a large number of specific requirements. The system specification includes a system description, employment concept (including targeting, battle damage assessment, and bomb impact assessment requirements), operational support requirements (including C^4ISR, testing, and training), interoperability and connectivity characteristics, management, and scheduling concerns. Reference the interface requirements documentation, as appropriate.

Interoperability: Refers to the ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together and to the condition achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. Examples of achieving some degree of interoperability would include the ability of US air combat fighters to employ allied weapons, or ability to use fuels and lubricants that allied forces use at their bases. Reference the interface requirements documentation, as appropriate.

The DoD Joint Technical Architecture (JTA) is a key piece of DoD's overall strategy to achieve a seamless flow of information quickly among DoD's sensors, processing and command centers, and shooters. System specification developers evaluate JTA standards and guidelines and establish program-specific information interface requirements to achieve the interoperability needed for quick, seamless information flow across the DoD warfighter battlespace.

Transportation: This requirement should define the methods intended for use in transportation of various elements of the air system. Reference the interface requirements documentation, as appropriate.

Mapping, Charting, and Geodesy Support: Refers to cartographic materials, digital topographic data, and geodetic data needed for system employment. Where possible, Defense Mapping Agency standard military data should be used. Reference the interface requirements documentation, as appropriate.

The table format is intended to provide a single reference point from which interface areas can be identified and correlated to specific requirements. In the “Country, Organization, Service, Agency” column of the table, enter the appropriate countries, organizations, services or agencies for which interface requirements exist. Examples of valid entries are “NATO,” “Mexico,” “CIA,” and “Israel.”

In the proper table cell, enter a letter or some other designator to identify a specific requirement. It is possible that a cell may have more than one designator, and may have several.

Example interface requirement matrix table.

Country, Organization, Service, Agency	Operational	Support	Training	C^4ISR	Inter-operability*	Trans-portation	Mapping, Charting, and Geodesy
NATO		a		b, c			

Below the table, list the specific requirement associated with the identifier. Examples are provided below:

a. The system shall be capable of exploiting existing support equipment and facilities at all NATO member main operating bases as available and necessary to accomplish its roles and missions.

The system shall include communication modes and frequencies as necessary to operate with the forces of Mexico.

The system shall be capable of communicating with all US Navy aircraft, ships, and installations in both secure and nonsecure modes.

The column headers identify typical areas of interface, but may not include all interface areas. If an interface area is identified that is not included in the table, include as many additional columns as necessary to capture all interface needs.

It may be preferable to express the interface requirements differently; for example, break out individual paragraphs for each class of interface (that is, a support paragraph, a C^4ISR paragraph) or break out individual paragraphs for each interfacing item or service. Item-by-item paragraphs are useful when the interface deals with a limited, but specific, set of operating modes/conditions. The choice of format for the program-specific system specification should be driven by the need to communicate the requirements completely and to ensure that all the elements of the interface are appropriately verified.

REQUIREMENT LESSONS LEARNED (3.4)

To Be Prepared

4.4 Interfaces verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Capability to interface with country, organization, service, agency a	Table 3.4-I	A	A	A	A	A,D
Capability to interface with country, organization, service, agency b	Table 3.4-I	A	A	A	A	A,D
Capability to interface with country, organization, service, agency …	Table 3.4-I	A	A	A	A	A,D

VERIFICATION DISCUSSION (4.4)

Verification of the country(s), organization(s), service(s) and agency(s) interface requirements should be accomplished by integrating analysis with demonstrations of the air system interfaces with the country(s), organization(s), service(s) and agency(s) specified. During other air system developmental activities, substantial data is typically obtained that could be used to verify this requirement. Use of this type of data should be maximized to avoid the cost and schedule impacts of a formal demonstration.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates that requirements for the interface between the air system and the country(s), organization(s), service(s) and agency(s) are defined and understood. Analysis indicates that the preliminary design approach considers interface to the country(s), organization(s), service(s) and agency(s) listed.

PDR: Analysis of the air system preliminary design indicates compatibility with the country(s), organization(s), service(s) and agency(s) interface(s) specified.

CDR: Analysis of the air system design confirms compatibility with the country(s), organization(s), service(s) and agency(s) interface requirements.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis and demonstration confirm air system interfaces are compatible with the country(s), organization(s), service(s) and agency(s) specified.

Sample Final Verification Criteria

The air system interface requirements for country(s), organization(s), service(s) and agency(s) shall be verified by ___(1)___ analyses and ___(2)___ demonstrations of the interface between the air system and the country(s), organization(s), service(s) and agency(s) specified.

Blank 1. Identify the type and scope of analysis required to confirm air system interface compatibility with country(s), organization(s), service(s) and agency(s).

Blank 2. Identify the type and scope of demonstrations required to confirm air system interface compatibility with country(s), organization(s), service(s) and agency(s).

VERIFICATION LESSONS LEARNED (4.4)

To Be Prepared

3.4.1 Supply support

The system shall be compatible with the ___(1)___ supply support infrastructure.

REQUIREMENT RATIONALE (3.4.1)

The supply support function addresses all management actions, procedures, and techniques used to determine requirements to acquire, catalog, receive, store, transfer, issue, and dispose of secondary items, including provisioning for initial support as well as replenishment supply support. This includes identification of the functional and physical interfaces between the air system and all support system elements. The clear determination and execution of system supply support requirements is required for affordable system sustainment, because the proliferation of unique supply items increases life cycle costs and puts unacceptable, additional demands upon the supply system.

REQUIREMENT GUIDANCE (3.4.1)

Supply support requirements include any requirements imposed to make the air system compatible with the existing supply system in order to minimize the costs of operations and maintenance. The increase in use of commercial items and services in DoD systems is making the supply support infrastructure more complex. All interfaces between the air system and the support system must be identified. Detailed quantitative interfaces are described in lower-tier specifications and interface control documents (ICDs). Supply support requirements should identify interface requirements between the air system and the total support system. Items to address include:

Design to minimize demands on the supply system (that is, reduce life cycle cost) by use of modular designs, on-condition repair concepts, reduction of secondary failures, and an appropriate balance between on- and off-equipment maintenance.

Introduction of a new item into the supply system and method of supply/resupply of all items should not require development of additional supply systems or reporting procedures.

Blank 1. Describe the supply support infrastructure. Suggested wording includes “organic,” “contracted,” “commercial,” or “combination of ...” with appropriate clarifying information.

REQUIREMENT LESSONS LEARNED (3.4.1)

To Be Prepared

4.4.1 Supply support verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Supply support Interface	Supply support interfaces	A	A	A	A	A,D

VERIFICATION DISCUSSION (4.4.1)

Verification of the supply support interface requirements should be accomplished by integrating analysis and demonstrations of the air system interfaces with the supply support systems specified. During air system developmental activities, substantial data is typically obtained that could be used to verify this requirement. Use of this type of data should be maximized to avoid the cost and schedule impacts of a formal demonstration. Verification of the supply support requirements should be accomplished by analyzing the procedures and techniques used to acquire, catalog, receive, stock, transfer, issue, and dispose of items to support the supply infrastructure.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis of the preliminary system design indicates that requirements for the interface between the air system and the supply support system are defined and understood. Analysis indicates that the preliminary design approach considers interface to the supply support system(s) listed.

PDR: Analysis of the air system preliminary design indicates compatibility with the supply support interface(s) specified and indicates that preliminary lists of unique, commercial and national stock listed items are available.

CDR: Analysis of the air system design confirms compatibility with the supply support interface requirements. Any area of incompatibility has been thoroughly researched, and trade-offs identified.

FFR: Analysis confirms supply support interfaces that impact first flight are compatible.

SVR: Analysis and demonstration confirm air system interfaces are compatible with the supply support system(s) specified.

Sample Final Verification Criteria

The air system supply support interface requirements shall be verified by ___(1)___ analyses and demonstrations of the interface between the air system and the supply support system(s) specified to confirm that the interface requirements defined by ___(2)___ have been met.

Blank 1. Identify the type and scope of analyses and demonstrations required to confirm air system interface compatibility with the supply support requirement.

Blank 2. Identify the interface control document requirements that must be met during the demonstration.

VERIFICATION LESSONS LEARNED (4.4.1)

To Be Prepared

3.4.2 Facility interfaces

The system shall be capable of interfacing with the facilities identified in table 3.4.2-I.

TABLE 3.4.2-I. System/facility interfaces.

Facility	Functional Capability	Status	Facility Description (Compatibility Requirements)

REQUIREMENT RATIONALE (3.4.2)

Facilities include all permanent or semi-permanent real property assets required to support the air system consistent with the operational and support concept. Facilities include a structure, building, utility system, or pavement and underlying ground at a testing, training, operating, or support location. This requirement also includes interfaces to shipboard applications.

Facilities can be system specific, in which case their requirements are typically defined in the support system segment (or lower); or, they can be part of the infrastructure with which that the system must be compatible. In the case of infrastructure, facilities can represent existing assets or they can be planned/in-development assets. For example, if a new air vehicle needs to be housed in a hangar, an existing hangar (for example, a TAB-V) might be suitable; or, if the air vehicle is unusually large or demanding of a special environment, a new type of hangar might be defined, designed, and built. Typically, permanent structures are not part of an air vehicle development program, even if they are deemed necessary for proper maintenance, training, and use. Permanent structures are normally handled as military construction items and become part of the infrastructure. In the case of existing structures (for example, the TAB-V shelter), a requirement to house an air vehicle imposes strict dimensional (and other) restrictions on the design of the air vehicle. If a new type of shelter were to be needed, the air vehicle developer would be required to work with the shelter developer to ensure that interface compatibility is achieved.

REQUIREMENT GUIDANCE (3.4.2)

Guidance for completing table 3.4.2-I follows:

Facility: Identify the facility, preferably using its appropriate nomenclature.

Functional Capability: Identify the functionality realized by the system when using the facility (for example, if the facility was an air vehicle shelter, the functionality could include protection of the air vehicle and crews from the natural and threat environments).

Status: Identify whether this is an "existing" facility with fixed interface requirements or a "planned" facility for which interface compatibility must be defined.

Facility Description: Where possible, reference to an interface description or other documentation that appropriately characterizes the facility should be used. In cases of a planned facility, it may be necessary to provide the characteristics here. For example:

a. Size/dimensions
b. Type
c. Environmental control (for example, humidity, temp)
d. Environmental impact
e. Life expectancy
f. Access (for example, size of hangar door)
g. Interface requirements with installed equipment (for example, power supply, hazardous materials, capture, and disposal)
h. Demilitarization/disposal
i. Special access required/classified material capability

REQUIREMENT LESSONS LEARNED (3.4.2)

To Be Prepared

4.4.2 Facility interfaces verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Facility Interfaces	Interface to each facility (table 3.4.2-I)	A	A	A	A	A,D

VERIFICATION DISCUSSION (4.4.2)

Verification of the facility interfaces requirements should be accomplished by integrating analysis with demonstrations of the air system interfaces with the facilities listed in table 3.4.2-I. During air system developmental activities, substantial data is typically obtained that could be used to verify this requirement. Exploiting this data can help avoid the cost and schedule impacts of a formal demonstration.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates that requirements for the interface between the air system and each required facility are defined and understood. Analysis indicates the preliminary design approach considers interface to the facilities listed.

PDR: Analysis of the air system preliminary design indicates compatibility with the facility interfaces listed.

CDR: Analysis of the air system design confirms compatibility with the facility interface requirements. Any area of incompatibility has been thoroughly researched, and trade-offs identified.

FFR: Analysis confirms facility interfaces that impact first flight are compatible.

SVR: Analysis and demonstration confirms air system interfaces are compatible with all required facilities.

Sample Final Verification Criteria

The air system facility interface requirements shall be verified by ___(1)___ analyses and demonstrations of the interface between the air system and each facility listed in table 3.4.2-I to confirm that the interface requirements defined by ___(2)___ have been met.

Blank 1. Identify the type and scope of analysis and demonstrations required to confirm compatibility between air system interfaces and the listed facilities.

Blank 2. Identify the interface requirement documents used during the demonstration.

VERIFICATION LESSONS LEARNED (4.4.2)

To Be Prepared

3.4.3 Common support equipment

The system shall be capable of interfacing with the common support equipment identified in table 3.4.3-I.

TABLE 3.4.3-I. System/common support equipment interfaces.

Common Support Equipment	Functional Capability	Status	Common Support Equipment Description (Compatibility Requirements)

REQUIREMENT RATIONALE (3.4.3)

The SE requirement maximizes system support while minimizing costs. This is accomplished by making the right SE available at the right time with a complete support structure. Common support equipment further mitigates costs by enabling multiple air vehicle systems to use the same item. This is particularly valuable when space is constrained (for example, on an aircraft carrier) or when multiple types of air vehicles are bedded down at the same location.

REQUIREMENT GUIDANCE (3.4.3)

Guidance for completing table 3.4.3-I follows:

Common Support Equipment: Identify the common support equipment, preferably with its appropriate nomenclature.

Functional Capability: Identify the functionality realized by the system when using the common support equipment (for example, refueling or weapons loader).

Status: Identify whether this is existing common support equipment with fixed interface requirements or planned common support equipment for which interface compatibility must be defined.

Common Support Equipment Description: Where possible, reference to an interface description or other documentation that appropriately characterizes the common support equipment should be used. In cases of planned common support equipment, it may be necessary to provide the characteristics here. For example:

a. Deployability of SE
b. Calibration
c. Reliability, Maintainability, & Availability of SE
d. Physical Characteristics (weight, size, etc.)
e. Environmental Operating Conditions
f. Logistics Support of SE
g. Interoperability

REQUIREMENT LESSONS LEARNED (3.4.3)

To Be Prepared

4.4.3 Common support equipment verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Common Support Equipment Interface	Interface to Common Support Equipment (table 3.4.3, column 4)	A	A	A	A,D	A,D

VERIFICATION DISCUSSION (4.4.3)

Verification of the common support equipment requirement should be accomplished by integrating analysis with demonstrations of the support equipment listed with the air system. During system developmental activities, substantial data are typically obtained that could be used to verify this requirement. Use of this type of data should be maximized to avoid the cost and schedule impacts of a formal demonstration.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Preliminary analysis focuses on the mission profiles, maintenance concept, and any unique requirements of the air system that would tend to inhibit use of the required common support equipment. Requirements for the interface between the air system and common support equipment are defined and understood. Preliminary analysis indicates the design approach is considering interface to common support equipment.

PDR: Preliminary analysis of the air system indicates the design is compatible with the support equipment interface requirements based on the system's design. A preliminary maintenance plan is available for review and comment.

CDR: Analysis of the air system confirms the design is compatible with the support equipment interface requirements based on the system's design. Analysis of the air system has defined all areas (equipment and interfaces) of known commonality, and areas where unique design is required have been thoroughly researched with trade-offs, if any, presented to the customer for review.

FFR: All common support equipment identified is available, and analyses and demonstrations, as appropriate, have been completed. Preflight, post-flight, and all maintenance check lists are available and have been reviewed for accuracy and completeness to utilize the common support equipment. Review system functional testing results for proper interfacing.

SVR: The system will be considered compliant when all appropriate common support equipment listed has been analyzed/demonstrated to be compatible with the air system. Review system-level verification testing results to include full support hardware and software demonstrations not previously performed.

Sample Final Verification Criteria

The common support equipment requirements shall be verified by analysis and/or demonstration. ___(1)___demonstrations of the interface between ___(2)___ and the air system confirm that the interface requirements defined by ___(3)___ have been met.

(Note: The sample final verification criteria statement would be completed for each common support equipment item listed in table 3.4.3-I.)

> Blank 1. Identify the type and scope of demonstrations required to provide confidence that the requirement has been satisfied.
>
> Blank 2. Identify the common support equipment item.
>
> Blank 3. Identify the interface requirements document that must be met during the demonstration. This should be the same document that is listed in the column 4 of table 3.4.3-I.

VERIFICATION LESSONS LEARNED (4.4.3)

Support equipment can be a significant cost to a program, not only in the acquisition phase but also in the sustainment phase. While most common support equipment selected for a new program can save the program time and money, it is important that all the equipment selected be analyzed and demonstrated as appropriate for its intended purpose. Challenge those items on the common support equipment list that do not make sense. It is important to verify each and every item on the list since many items will be put on the list without a lot of investigation. Items have made the list because they have been used on a previous program but they were failures on that program and the specification writer was not aware of the problems.

3.5 Manufacturing

All manufactured elements of the system shall be repeatably, reliably, and economically manufacturable at the expected production rate.

REQUIREMENT RATIONALE (3.5)

Producibility is a significant design constraint. In the past, the goal of developing and deploying economically producible and supportable weapon systems capable of meeting all performance requirements has proven difficult to achieve. Historically, weapon system acquisition programs have experienced cost overruns, performance shortfalls, and schedule delays, especially as they transition from development to production. Many of these problems are driven by 1) not understanding the linkage between performance requirements, key design attributes, and the manufacturing processes needed to support them; and 2) the failure to recognize manufacturing process capability limitations in the design phase.

This requirement encourages the consideration of manufacturing capabilities during the initial design. Specifically, the design should be producible in accordance with the overall program's schedule requirements, anticipated production rate, and affordability goals.

REQUIREMENT GUIDANCE (3.5)

This requirement may be tailored to include a specific measure of producibility.

REQUIREMENT LESSONS LEARNED (3.5)

The *Manufacturing Development Guide* contains tools for achieving these requirements. These include design trade studies, manufacturing process capability assessments, production cost modeling, key characteristics, variability reduction, and virtual manufacturing. The guide is available to ".mil" customers at https://www.en.wpafb.af.mil/mdg/mdg.pdf. Others may request a copy of the document from engineering.standards@wpafb.af.mil.

Early involvement of the manufacturing community in the design process is critical. The best opportunities for influencing the design and for reducing overall life-cycle costs are in the beginning of the program. Production issues should be analyzed in conjunction with design issues and manufacturing risks must be identified as soon as possible while there is time to develop design alternatives and investigate trade-offs. Key suppliers must also be involved early in the design team.

4.5 Manufacturing verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Repeatably & reliably manufacturable	Pass/Fail	A	A	A		A,I,T
Economically manufacturable	Pass/Fail	A	A	A		A

VERIFICATION DISCUSSION (4.5)

Repeatably & Reliably Manufacturable

To the maximum extent possible, final verification should rely on the analysis of quantifiable results as opposed to merely demonstrating that best practices have been employed. The tools and processes described in the *Manufacturing Development Guide* are excellent ways to achieve the requirements, but their use does not guarantee that the requirements have been achieved. Useful manufacturing data may be difficult to obtain early in the program so the verification activities at early milestones revolve around planning for and "doing the right things'" but move more towards relying on data later in the program. For final verifications, objective results from process capability studies and quality metrics are desired, as well as evidence that design and process changes were made if producibility risks were identified. Manufacturing simulation's role in developing and verifying producible designs and repeatable production processes has grown significantly along with new, more powerful simulation software tools. The use of appropriate simulation and analysis may reduce the need for other objective product and process verification data.

Key Development Activities

Key activities include, but are not limited to, the following:

SRR/SFR: Analysis of the design concept indicates that

a. Manufacturing risks have been identified for processes that may not be capable or for immature manufacturing technologies.

b. Producibility studies are considering key characteristics.

c. Simulation tools are being developed to demonstrate production concepts.

d. Key manufacturing processes are being identified.

e. Measures of manufacturing quality are being developed.

PDR: Analysis of the preliminary design indicates that

a. Risk mitigation plans have been developed for manufacturing risks.

b. Producibility studies identify key characteristics.

c. Manufacturing simulations demonstrate production concepts are repeatable and reliable.

d. Key process capabilities are characterized and integrated with design requirements.

e. Initial process control plans are developed.

f. Measures of manufacturing quality are identified.

CDR: Analysis of the detailed design confirms that

a. Risk mitigation plans are being implemented.

b. Producibility studies have been completed and recommendations are incorporated in the product design.

c. Manufacturing simulations verify production planning.

d. Design requirements match process capabilities.

e. Process control plans have been implemented.

f. Measures of manufacturing quality are being implemented and corrective action plans are developed to correct areas of concern.

FFR: No specific verification action occurs at this milestone.

SVR: Inspection and/or test of first article air system, and its applicable subsystems, confirms the manufacturing processes produce a conforming product. Analysis confirms that

a. Manufacturing risk mitigation actions are complete or risk is determined to be acceptable.

b. Manufacturing simulations incorporate actual experience and verify manufacturing planning.

c. Process control plans yield products that consistently conform to design requirements.

d. Quality metrics demonstrate that conforming product is being delivered.

Sample Final Verification Criteria

The reliable and repeatable manufacturing element shall be satisfied when ___(1)___analyses and __(2)__ inspections and/or tests confirm that the air system meets all specified performance requirements.

Blank 1. Identify the type and scope of analysis required to provide confidence that the reliable and repeatable manufacturing element has been met. Consider the following analyses:

a. Manufacturing risk mitigation

b. Producibility studies

c. Manufacturing simulations

d. Process controls

Blank 2. Identify the type and scope of inspections and/or tests required to provide confidence that the reliable and repeatable manufacturing element has been met. Consider first production article inspections and quality metrics.

VERIFICATION LESSONS LEARNED (4.5)

The systematic development of robust design and manufacturing processes is more important than ever, due to recent fluctuations in program production quantities. For example, recent programs have entered SDD planning for production runs of several hundred aircraft only to be cut by a factor of ten. Their production strategy would have been significantly different if the final quantity were known when the production facility was laid out and suppliers were brought on board. While it will never be possible to develop a strategy that is optimal at any possible quantity, consideration of the risks up front will influence the design trade-offs by changing how producibility will affect unit cost. Lean manufacturing techniques provide some independence from production quantity constraints, and manufacturing simulation is a useful tool for exploring many options over a short period.

Economically Manufacturable

While the requirement for economical manufacture does not quantify a specific cost goal, the intent is to be able to demonstrate that the air vehicle can be produced within the given cost constraints of the program. Production cost estimates should reflect impacts of alternate design approaches as well as data from the most current actual manufacturing experience in building the air vehicle.

Key Development Activities

Key activities include, but are not limited to, the following:

SRR/SFR: Analysis of the design concept indicates that the air system is manufacturable within initial program cost goals.

PDR: Analysis of the preliminary design indicates that

a. Production cost models reflect the current design approach.
b. Production cost estimates demonstrate cost objectives are achievable.
c. Cost risk mitigation actions are identified, as needed.

CDR: Analysis of the detailed design confirms that

a. Production cost models reflect the current design approach.
a. Production cost estimates demonstrate cost objectives are achievable.
b. Cost risk mitigation actions are identified, as needed.

FFR: No specific verification action occurs at this milestone.

SVR: Analysis confirms that

a. Manufacturing cost mitigation actions are complete.

b. Production cost estimates reflect actual manufacturing data and demonstrate cost goals have been met.

Sample Final Verification Criteria

The economical manufacture element shall be satisfied when ___(1)___analyses confirm that the air system meets all specified performance requirements within the cost goals of the program.

Blank 1. Identify the type and scope of analysis required to provide confidence that the economical manufacture element has been met.

VERIFICATION LESSONS LEARNED (4.5)

As with the lessons learned above, variations in quantities dramatically affect the ability to produce a weapon system economically. However, the lean aerospace initiative, led by MIT and a consortium of industry, government, labor, and academia, may provide some solutions. One of the over-arching principles of lean is the ability to be responsive to change. The lean principles and practices are designed to enable a company to be less sensitive to changes in production rate. Aggressive implementation of this initiative may therefore result in a more stable and reliable production cost estimate.

3.6 System dependability

The system shall provide the resources and peculiar infrastructure, as required, to restore and sustain the delivered performance of the air system elements when the system is operated and deployed as specified herein for the operational service life specified herein (see 3.3.1.2 System service life).

REQUIREMENT RATIONALE (3.6)

This paragraph provides a top-level support requirement. It addresses the two key elements of the support function: to fix what is broken and to maintain the originally delivered performance of the air system.

REQUIREMENT GUIDANCE (3.6)

Based on the amount of work done prior to application of the system specification on contract, additional elaboration may be appropriate on topics such as source of support (organic, contracted, combined), and so forth.

REQUIREMENT LESSONS LEARNED (3.6)

To Be Prepared

4.6 System dependability verification

Verification of system dependability is contained in the verification for the following subparagraphs.

3.6.1 Maintenance concept

The levels of maintenance for the air system shall be ___(1)___.

REQUIREMENT RATIONALE (3.6.1)

This paragraph provides a minimum top-level requirement for the system's maintenance concept. Based on the amount of work done prior to application of the system specification on contract, additional elaboration may be appropriate on topics such as maintenance-phasing, depot and regional repair centers, and so forth.

REQUIREMENT GUIDANCE (3.6.1)

Blank 1. Identify the levels of maintenance allowed. Descriptions such as "2-level" or "3-level" can be ambiguous. Phrases such as "on-aircraft," "base-level off-aircraft," "regional repair," and "depot repair" should be used in appropriate combinations to communicate the needed concept. This information can be further clarified by identifying the source (organic, contracted, etc.) for the maintenance. Additionally, this information can be communicated in a table format since the maintenance concept for the air vehicle may be different from the maintenance concepts for training systems or support equipment. For example:

Example maintenance table.

Equipment	Maintenance Concept	Remarks
Air Vehicle	On-Aircraft Depot Repair	Two depots (one in ___ that services engines from ___ and one in ___ that services engines from ___)
Training Systems	Contracted, On-simulator repair OEM "depot" repair	
Etc.		

Based on the amount of work done prior to application of the system specification on contract, elaboration may be appropriate on topics such as maintenance-phasing, depot and regional repair centers, use of preventive, time directed, and run-to-failure maintenance and so forth.

For example, preventive and time-directed maintenance concepts, supplemented as necessary with functionality tracking/assessment and periodic inspections, shall be the basis for sustaining the delivered performance characteristics of mission- and safety-critical elements.

Examples of preventive maintenance are lubrication, or removing parts to perform some action, such as removing deposits, and then reinstalling the same part.

Time-directed maintenance is the removal of functioning equipment and installing a new unit; for example, aircraft engines are removed and replaced based on number of cycles, operating hours, etc., prior to a failure occurrence.

Functionality tracking (from an on-vehicle health monitoring system, for example) is useful for those items that provide a performance response that can be recorded during actual use of the item (for example, power from a power supply). Inspections are necessary for those items that do not provide such a response (for example, structure).

Run-to-failure maintenance is efficient when failures will not cause human hazard or additional equipment damage and maintenance costs are relatively high

The system maintenance planning process develops and implements the maintenance concept to satisfy the desired user system operational employment and deployment requirements and defines the related system or equipment maintenance technical requirements and design parameters. The developed maintenance plan also prescribes maintenance actions, intervals, and locations (including levels of repair and organizational responsibility for maintenance activities). The system's maintenance planning addresses technical data, equipment, facilities, spares, and repair parts for each significant item of the system, as well as personnel numbers and skills (see 3.3.1.3 Manpower and personnel). The maintenance planning process must address the flexible sustainment approach to effective system support. This includes key system quantitative reliability and maintainability attributes, the life/application cycle of the technology, relative cost values, total life cycle cost, and system life cycle management.

REQUIREMENT LESSONS LEARNED (3.6.1)

To Be Prepared

4.6.1 Maintenance concept verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Levels of maintenance	(1)		A	A		A

VERIFICATION DISCUSSION (4.6.1)

Analysis of the air system maintenance concept requirements should be accomplished by analyzing the air system compatibility with the specified support concept ensuring the optimum combinations of built-in test, diagnostics, on/off aircraft maintenance, etc. Typically, during assembly, developmental test, and remove-and-replace activities, substantial data is obtained that could be used to verify this requirement. Use of this type of data should be maximized to avoid cost and schedule impacts of a formal demonstration.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: No unique verification action occurs at this milestone.

PDR: Analysis indicates the preliminary system design is compatible with the specified maintenance concept.

CDR: Analysis indicates the system design is compatible with the specified maintenance concept.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of maintenance performed during development activities and test confirm compliance to the requirement.

Sample Final Verification Criteria

The maintenance concept requirement shall be satisfied when ___(1)___ analyses and ___(2)___ lower-level demonstrations confirm that the system meets the maintenance level specified.

> Blanks 1 and 2. Identify the type and scope of analyses and lower-level demonstrations required to provide confidence that the requirement elements have been satisfied.

VERIFICATION LESSSONS LEARNED (4.6.1)

To Be Prepared

3.6.2 System capability and procedure information

The system shall provide operators, maintainers, and trainers with relevant information regarding the capabilities and limitations of applicable portions of the system (equipment, procedures, and use). The information shall be provided in a form that enables realization of the full capabilities of the system in the environments and conditions of use of the equipment, procedures, and uses.

REQUIREMENT RATIONALE (3.6.2)

System capability and procedure information, normally provided in technical orders/technical manuals (TOs/TMs), supports operation and maintenance of the system (air vehicle, associated ground stations, and support equipment) by trained personnel. The instructions (whether contained on electronic or paper media) must be appropriate for each intended level of operation or maintenance. The operations and maintenance instructions must be compatible with all interfacing prime mission and support equipment (SE) hardware and software. System capability and procedure information is normally developed and delivered in a digital format that is compatible with the integrated digital environment (IDE) and the digital data format selected for on- and off-equipment diagnostic data capture and recording. For system life cycle management, supportability/sustainment analyses, and spare support, the proposed maintenance data collection system must be interoperable with the digital format of operation and maintenance system capability and procedure information.

REQUIREMENT GUIDANCE (3.6.2)

Operation and maintenance instructions must be compatible with all interfacing systems and support equipment as well as the IDE. System capability and procedure information development includes

a. Definition of the level at which they will be used (field, intermediate or depot);

b. Interfaces with other systems and equipment at each defined level;

c. Description of the digital data formats for creation and maintenance, delivery, presentation, and archiving; and

d. Maintenance data collection system interface for each defined level.

The resulting TOs/TMs are the only approved method for disseminating operation and maintenance information for centrally procured and managed air systems or equipment for use by organic personnel. The use of TO/TM instructions is mandatory. TO/TM format and content requirements are imposed by technical manual specifications and standards (TMSS) to make the air system interoperable with existing military or commercial TOs/TMs and support equipment to minimize operation, maintenance, and sustainment costs. All interfaces between the air system and the TOs/TMs must be identified. Detailed qualitative and quantitative interfaces should be described in lower-tier specifications and interface control documents (ICDs).

REQUIREMENT LESSON LEARNED (3.6.2)

System capability and procedure information is verified against production assets and delivered concurrently with fielding of the system to support organic operation, troubleshooting, repair, and maintenance of the system to meet the mission requirements. The resulting TOs/TMs are some of the most costly products purchased for support of the air system or equipment. While this is recognized at some point in every program, planning for development, verification and delivery of TO/TM products is often poorly scheduled or integrated with system development and operational evaluation tasks. As a result, accuracy of TO/TM data may be poor and interface data may be improperly defined, requiring extensive correction and reverification. These factors increase the risk of successful program execution and will prevent operational safety, suitability, and effectiveness (OSS&E) certification. Early development and use of TOs/TMs can assist in successful development of acceptance test procedures (ATPs) and support equipment hardware and software. These (and the system integrated diagnostics philosophy and capability) should all be developed concurrently. Past experience with serial development has led to operation and maintenance errors, incompatible software, rejection of good equipment, unacceptable rates of serviceable unit removal (retest OK – RTOK), and costly redesign. The ongoing transition from paper TOs/TMs to electronic maintenance aids and data systems must be carefully addressed in TO/TM and sustainment planning. Electronic formats for prime system equipment, maintenance data collection and analysis systems, and SE must be interoperable. Finally, when procuring commercial technical data/manuals, compatibility with all of the above issues must be considered.

4.6.2 System capability and procedure information verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Relevant information regarding capabilities and limitations	Quantity and quality of information		A	A	A	A,D
Usable form of the information	Presentable form of the information		A	A	A	A

VERIFICATION DISCUSSION (4.6.2)

Verification of the system capability and procedure information should be accomplished by analyzing the air system to ensure that all relevant information regarding air system equipment, procedures, and usage data have been incorporated in a usable form of TOs/TMs. These TOs/TMs must have enough information to enable the operator and/or the maintainer to safely and properly operate or maintain the air system. The information may be presented in either paper or electronic format, as long as it is adequate to accomplish the task under the conditions specified. Analysis of all testing accomplished where the TOs/TMs are utilized should constitute the majority of the verification. Demonstrations will be performed only in those areas not adequately covered during the normal course of system testing. Validation and verification of the TOs/TMs may be concurrent.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: No unique verification action occurs at this milestone.

PDR: Analysis indicates the preliminary system design takes into consideration the capabilities and limitations of the system and system information will be presented in an acceptable format.

CDR: Analysis of the air system design has yielded the information regarding the capabilities and limitations of the applicable portions of the system (equipment, procedures, and use) and that information will be presented in an acceptable format.

FFR: Analysis of the events leading up to and including first flight indicates the information was adequate, easily understood, and presented in an acceptable format.

SVR: Analysis of the maintenance procedures and operations during the development activities and tests confirms compliance to the requirement. Demonstrations will be accomplished only for those procedures for which insufficient analysis exists.

Sample Final Verification Criteria

The system capability and procedure information requirement shall be satisfied when ___(1)___ analyses and ___(2)___ lower-level demonstrations confirm that the system provides information regarding the capabilities and limitations of applicable portions of the system (equipment, procedures, and use) in sufficient quantity and quality, and in a presentable format.

Blank 1. Identify the type and scope of analyses required to provide confidence that the requirement elements have been satisfied.

Blank 2. Identify the type and scope of lower-level demonstrations required to provide confidence that the requirement elements have been satisfied.

VERIFICATION LESSONS LEARNED (4.6.2)

To Be Prepared

3.6.3 Protective structures

The system shall provide protection of assets from the conditions to which they are exposed as described in table 3.6.3-I.

TABLE 3.6.3-I. Protection of assets.

Asset	Condition	Capabilities

REQUIREMENT RATIONALE (3.6.3)

Many types of high value assets (people, for example) have a low tolerance to continued exposure to adverse conditions (such as low temperatures or chemical/biological environment). Protective structures can mitigate the impacts of adverse conditions and improve overall combat effectiveness.

REQUIREMENT GUIDANCE (3.6.3)

Guidance for completing table 3.6.3-I follows:

Asset: Identify the asset to be protected. For example, people, high explosives, consumables, air vehicles, control station, etc.

Condition: Identify the condition that is the source of adverse effects. For example, “Arctic temperatures (^{o}C) and high winds (km/hr),” “chemical/biological environment (agent/density/duration)," "sand storm (wind speed and particulate density)," etc. The environments are based on the content specified in section 3.2 Environment.

Capabilities: Define the required capabilities of the structure. For example, "environmentally controlled crew rest and mess capability," or "isolated decontamination and environmentally controlled crew rest capability," or "environmentally controlled air vehicle maintenance area," or "deployable air vehicle shelter."

REQUIREMENT LESSON LEARNED (3.6.3)

To Be Prepared

4.6.3 Protective structures verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Asset Protection	Level of Protection		A	A		A,T

VERIFICATION DISCUSSION (4.6.3)

Verification of the protective structures requirement should be accomplished by a combination of analyses and tests. The testing should be reserved for those protective structures for which analyses are inconclusive or, due to the high dollar value or criticality of the asset (crewmembers), dictate testing to ensure adherence to the requirement.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: No unique verification action occurs at this milestone.

PDR: Analysis indicates that the protective structure concepts are identified and can achieve the required protection level.

CDR: Analysis confirms the protective structures are identified and can achieve the required protection level.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis and tests confirm protective structures are sufficient to meet the requirement.

Sample Final Verification Criteria

The protective structures requirement shall be satisfied when ___(1)___ analyses and ___(2)___ tests verify that the protective structures identified are capable of meeting the asset protection requirements under the conditions specified.

Blank 1. Identify the type and scope of analyses required to provide confidence that the requirement elements have been satisfied.

Blank 2. Identify the type and scope of demonstrations required to provide confidence that the requirement elements have been satisfied.

VERIFICATION LESSONS LEARNED (4.6.3)

To Be Prepared

3.6.4 Packaging, handling, storage, and transportation (PHS&T)

System items shall be transportable by ___(1)___ modes of transportation in compliance with ___(2)___ for all assemblies, subassemblies, equipment, components, and end items, including training and support equipment, except ___(3)___. System items shall be capable of being packaged and shall be able to withstand ___(4)___ of storage of all assemblies, subassemblies, equipment, components, and end items for worldwide shipments in accordance with ___(5)___.

REQUIREMENT RATIONALE (3.6.4)

This is required to minimize the cost of operation and maintenance and ensure supportability. The system packaging requirements shall be any desired aggregate of the constituent products, and may or may not apply at the air system level.

REQUIREMENT GUIDANCE (3.6.4)

The PHS&T concept is developed during the design of deliverable equipment and included in follow-on contracts. Design requirements are based on existing PHS&T capabilities and equipment, anticipated availability of handling and transportation equipment, anticipated storage conditions, and any other pertinent factors. Special considerations such as packaging and transportation of hazardous materials, electrostatic discharge items, and any item requiring special containers or special handling and transportation equipment shall be minimized. Availability of existing specialized containers or designs is determined through the DOD container design retrieval system prior to designing new containers. If a transportability problem item as defined in MIL-STD-1366 is identified, the material developer submits a transportability report in compliance with the applicable data item.

Blank 1. Identify the modes of transportation (rail, air transport, truck, etc.).

Blank 2. Incorporate the tailored provisions of MIL-STD-1366, Transportability Criteria. If the entire document is to be applied, simply cite the document.

Blank 3. Identify known exceptions.

Blank 4. Identify the duration of storage; for example, 5 years. This entry must be consistent with information specified on storage in 3.3.1.2 System service life.

Blank 5. Incorporate the tailored provisions of MIL-STD-2073-1, DoD Standard Practice for Military Packaging. If the entire document is to be applied, simply cite the document.

REQUIREMENT LESSONS LEARNED (3.6.4)

The existing lessons learned (see DoD Defense Acquisition Deskbook) are a source to help the procuring activities to make decisions about PHS&T concept application for a given program.

4.6.4 Packaging, handling, storage, and transportation (PHS&T) verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Transportability by mode a	(2)	A	A	A		A
Storage life a	(5)	A	A	A		A
Transportability by mode b	(2)	A	A	A		A
Storage life b	(5)	A	A	A		A
Transportability by mode…	(2)	A	A	A		A
Storage life …	(5)	A	A	A		A

VERIFICATION DISCUSSION (4.6.4)

Verification of the PHS&T requirement should be accomplished by analyzing the physical features of the system items that require packaging, storage, and transportation and applying the tailored provision of the appropriate MIL-STD. The CDD normally specifies the modes of transportation to be utilized and any long-term storage requirements.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Analysis indicates that modes of transportation, packaging, and storage requirements are identified.

PDR: Analysis indicates the general physical limitations for the desired modes of transportation have been compared to the system design concept. Also, any limitations or special conditions associated with the long-term storage requirements have been defined. (For example, a missile may require a new battery installed prior to launch following long-term storage.)

CDR: Analysis, updated to include any refinements to the information presented at the PDR, confirms that the design can achieve the PHS&T requirement.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of the system confirms that the final design can achieve the specified requirements. Analysis is updated to include data from any shipments and tests of lower-level assemblies, subassemblies, equipment, components, and end items, including training and support equipment.

Sample Final Verification Criteria

The packaging, handling, storage, and transportation (PHS&T) requirement shall be satisfied when ___(1)___analyses confirm that the system items can be transported by the modes specified and ___(2)___ analyses confirm that all assemblies, subassemblies, equipment, components and end items are able to withstand the PHS&T requirements specified.

> Blanks 1 and 2. Indicate the type and scope of analysis required to provide confidence that the requirements have been satisfied.

VERIFICATION LESSONS LEARNED (4.6.4)

Refer to the DoD Defense Acquisition Deskbook.

3.7 Training

3.7.1 Training capability

The system shall provide the training necessary to ensure the personnel identified in tables 3.3.1.3-I, II, III, IV, & V have the knowledge, skills, and abilities to perform their operational, maintenance, support, training, and ___(1)___ roles. Training rates shall support the demands for skilled people to accomplish unit start-up, personnel rotations, reassignment, attrition, and other factors that affect the availability of skilled people to perform system tasks to exploit fully the performance of the system.

REQUIREMENT RATIONALE (3.7.1)

Trained personnel are critical to the successful employment of the air system. This introductory paragraph ties the manpower requirements identified within the specification to the performance expectations of the system, thus providing the basis for partitioning and establishing more specific training system requirements.

REQUIREMENT GUIDANCE (3.7.1)

Blank 1. Identify any additional system roles that require trained personnel. Most air system specifications include some mention of training requirements; however, many times such requirements are allocated directly to a trainer development specification with little thought given to how the entire air system can be employed to maximize training. When a need arises for support equipment, mission planning systems, or aircraft systems to provide some function to the training system, through an interface or in support of a curriculum, it is usually fulfilled in a coincidental manner rather than through systematic analysis and consideration of the entire air system. This paragraph, along with its subordinate paragraphs, is the launching point for allocating training system requirements to all tier 2 specifications (or segments) including training system, support system, and air vehicle.

Therefore, ensure the personnel identified in the tables of 3.3.1.3 Manpower and personnel are complete to meet the performance defined in the specification and that they adequately support the genesis of a sufficient training program. Should there be no manpower or personnel requirements defined elsewhere in the specification, this paragraph should specify the number and, if appropriate, roles of officer, enlisted and civilian specialties to be assigned to the air system.

REQUIREMENT LESSONS LEARNED (3.7.1)

To Be Prepared

4.7.1 Training capability verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Training content	Job performance standards (skills, knowledge, abilities)	A	A,I	A		A,D
Training rates	Student throughput	A	A	A		A,D

VERIFICATION DISCUSSION (4.7.1)

Verification of the training capability of the training system over its development cycle should begin with a training system requirements analysis (TSRA) and end with the demonstration and test of the training system (and its components). The verification should focus on three areas:

a. The correct allocation of training and training system requirements and the allocation process;

b. A viable implementation of these requirements via the proposed design configuration(s) of the training system; and

c. An overall assessment/rating of the system's ability to provide the numbers and types of personnel to each qualification skill level (KSAs).

A key consideration in verification strategy for acquisition by personnel of the required skills, knowledge, and abilities is a viable method to ensure traceability of the training requirements from job tasks, to training task, to training objective and final curriculum structure.

A key consideration in verification strategy that the proposed training system will support the student throughput is a viable method to ensure that operational surge requirements can also be met.

Key Development Activities

Key activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR: Preliminary analysis indicates the suitability of the TSRA methodology to provide adequate and accurate data products (analytical reports) for verification of the specified training capability. Analysis indicates that training capability requirements have been correctly allocated to all draft tier 2 specifications, including training system, support system and air vehicle and verify that requirements traceability has been implemented. Analysis indicates that allocated requirements for the specified training capability are complete and consistent with all other functional /performance requirements for the air system, and that the process of requirements allocation for the specified training capability to lower-tiered specifications is complete and integrates both the systems engineering and instructional systems development (ISD) processes. Inspection of all lower-level draft specifications indicates that the student throughput (training rates) requirements are achievable and will satisfy the training requirements in the CDD. Analysis indicates the adequacy of the conceptual design configuration for the training system, support system and air vehicle to provide the required training (skills, knowledge, & abilities) and to meet the overall training capability.

PDR: Preliminary analysis indicates the training capability requirements, as defined by the data products from the TSRA, are consistent with the overall preliminary air system design and, in particular, the preliminary training system design. Analysis indicates that allocation of all lower-tier training capability requirements is complete and that requirements traceability has been properly implemented. Analysis validates source data requirements for the training system to ensure the preliminary design of the training system remains concurrent with the preliminary design of the air system. Analysis indicates the use of new and emerging advances in training concepts, methods, techniques, and technologies to satisfy the training capability requirements and preliminary design of the training system. Inspection of the preliminary System Training Plan provides scheduling and resource requirements for future training.

CDR: Analysis confirms the allocated training capability requirements are compatible and consistent with the detailed design of the air vehicle, training system and support system. Analysis of detailed training system, including numbers and types of training devices/media indicates job performance capability (knowledge, skills, & abilities) and student throughput are attainable. Analysis of lower-level demonstration results validates the use of any new and emerging advances in training concepts, methods, techniques and technologies to satisfy allocated training requirements.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of lower-level demonstration and test results associated with final training specific hardware, software and courseware for the air vehicle, training system and support system confirm that all allocated job performance capability (skills, knowledge, abilities) and student throughput (training rate) requirements have been met. Periodic demonstrations confirm that the overall air system has met the job performance capability (skills, knowledge, abilities) that trained personnel have met their respective evaluation standards to satisfy job performance requirements to the skill levels as specified in tables 3.3.1.3, I, II, II, IV and V.

Sample Final Verification Criteria

The training capability requirement shall be satisfied via two methods: For student throughput (training rates), by analysis of___(1)___ demonstrations and ___(2)___ test results of the air vehicle, training system and support system performance to meet tier 2 training requirements. For job performance capability (skills knowledge, abilities), by ___(3)___ demonstrations that trained personnel have met or exceeded evaluation standards for job performance.

Blank 1. Identify the type and scope of demonstration results requiring analysis to produce confidence that training rates have been satisfied.

Blank 2. Identify the type and scope of test results requiring analysis to produce confidence that training rates have been satisfied.

Blank 3. Identify the type and scope of demonstrations required to produce confidence that trained personnel have met or exceeded evaluation standards for job performance.

VERIFICATION LESSONS LEARNED (4.7.1)

To Be Prepared

3.7.2 Training types

The system shall be capable of providing the following training: ___(1)___.

REQUIREMENT RATIONALE (3.7.2)

The scope of the training program is established through the type of system-specific training defined here. System specific training requirements, at a top-level, serve to structure overall training expectations, providing a departure point for establishing more detailed training curricula and equipment.

REQUIREMENT GUIDANCE (3.7.2)

Blank 1. Identify the types of training to be used, such as

a. Initial Qualification: The training necessary to provide personnel the capability to safely operate, maintain, and support the system.

b. Qualification: Training necessary to prepare personnel for deploying the system in the operational environment.

c. Continuation: Training to maintain the skills obtained during initial and unit training.

d. Mission Rehearsal: Training to practice specific operational plans.

e. Train the Trainer: The training necessary to qualify an initial cadre of personnel to provide training to the system operators, maintainers, and supporters.

REQUIREMENT LESSONS LEARNED (3.7.2)

To Be Prepared

4.7.2 Training types verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
System training types	Curriculum structure, training system configuration, and training integration for (1)	A	A	A		A

VERIFICATION DISCUSSION (4.7.2)

Verification of training types is accomplished by analysis of both the lower-level training requirements and training system requirements generated by the training system requirements analysis (TSRA). Lower-level requirements determine the curriculum structure and the training system configuration. Verification begins with confirming by analysis that the operational training concept has the appropriate breakout of training types that will satisfy the specified overall training capability as defined in 3.7.1 Training capability. Verification ends with confirming by analysis that the final curriculum structure and training system configuration will support the breakout of training types and any integration (that is, commonality) of training across training types.

A key consideration in developing a verification strategy is developing a method to ensure training integration across training types. Integrating training across types can result in common training requirements, common courseware, and a more efficient verification of curriculum structure.

Key Development Activities

Key activities include, but are not limited to, the following:

SRR/SFR: Preliminary analysis indicates the detailed training requirements and preliminary curriculum structure, as defined by the data products from the TSRA, are complete and consistent with the breakout of training types in this requirement. Preliminary analysis indicates the conceptual design configuration(s) and training system requirements will support the types of training.

PDR: Analysis indicates the preliminary design approach of the air system, and in particular the training system, will satisfy the detailed training requirements that support development of the training types. Analysis indicates preliminary design of the curriculum structure and training system components (devices, media, etc.) will satisfy all lower-level training requirements for each type of training. Analysis indicates that allocation of all training objectives to specific training components and course syllabi are complete and will support each type of training. Analysis indicates that areas of commonality in courseware for each type of training have been identified.

CDR: Analysis indicates the final design approach of the air system, and in particular the training system will meet the detailed training requirements that support types of training. Analysis indicates final design of curriculum structure and training system components meets all lower-level training requirements for each type of training. Analysis indicates that final courseware design incorporates integration of common training requirements across types of training.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis of results from lower-level demonstrations and tests of the final curriculum and training system components confirm that all training requirements for each type of training have been met. Analysis of results of lower-level demonstrations and tests of courseware confirm areas of commonality between types of training have been verified and integration is complete.

Sample Final Verification Criteria

Types of training shall be verified by ___(1)___ analysis results of demonstrations, and tests of the performance of the air vehicle, training system and support system to meet tier 2 specification training requirements. Commonality and integration of training between types of training shall be verified by ___(2)___ analysis of results from demonstrations and tests of the courseware.

> Blank 1. Identify the type and scope of training system demonstrations and tests to produce confidence that training requirements for each training type have been satisfied.
>
> Blank 2. Identify the type and scope of analysis required to produce confidence that commonality between training types has occurred and is effectively integrated.

VERIFICATION LESSONS LEARNED (4.7.2)

To Be Prepared

3.7.3 On-equipment training

The system shall accommodate ___(1)___ on-equipment training capabilities. On-equipment training includes utilization of the system assets solely, utilizing the system assets in combination with dedicated training assets, and/or incorporating embedded training features into system assets to accomplish the necessary system training.

System assets shall be available for on-equipment training subject to the constraints in table 3.7.3-I.

TABLE 3.7.3-I. On-equipment training.

Equipment	Purpose of Training	Maximum Utilization

On-equipment training shall neither interfere with nor be detrimental to the availability of equipment and people necessary to support system availability, sortie generation, and other system utilization requirements, nor to the safe operation of the equipment.

Note: On-equipment training capabilities and use must be consistent with 3.3.1.2 System service life.

REQUIREMENT RATIONALE (3.7.3)

On-equipment training capabilities can enhance operations and support training and accommodate concurrency of training devices, which, in turn, facilitates the accomplishment of specific training objectives. If all training were to be allocated to the tier 2 training system specification only, then it would be unnecessary to specify training requirements at the system level in this specification. However, it is typically advantageous to allocate training requirements throughout the entire system, since both air vehicles and support systems may present opportunities for efficient, effective, and affordable training for both aircrews and maintenance personnel. This paragraph addresses requirements for including specific capabilities into operational, support, and training equipment. For example, a requirement that the air vehicle also serve as a simulator for maintenance training. A requirement for an air vehicle to have embedded capabilities for instrumented air combat training (ACMI).

This paragraph also identifies specific limitations on the time available for on-equipment training.

REQUIREMENT GUIDANCE (3.7.3)

Using system assets for on-equipment training purposes necessitates careful consideration of the costs, penalties, and benefits incurred by such use. For example, using an operational air vehicle for maintenance training makes it unavailable for missions, consumes service life (for example, wear and tear on fasteners and connectors as well as use of on-board power systems), and can result in induced failures requiring maintenance. At the same time, maintenance crews would have more time working on the real articles with increased proficiencies (for example, reduced time to diagnose and rectify failures) an expected result. These types of trade-offs are conducted prior to establishing the system specification for an SDD contract to arrive at a cost-effective set of system requirements for on-equipment training.

Blank 1. Specify the level of on-equipment training that is allowable in the system. There are nominally three conditions in which an asset can be used for on-equipment training.

a. The equipment could be made available just for practice. For example, use of an air vehicle to enable crews to “practice” removal and replacement of subsystems. The equipment itself would include no specific training features.

b. Some features to assist training could be incorporated. For example, an air vehicle could be “programmed” to simulate a given type of failure to enable a maintenance crew to train in both diagnosis and rectification of a given problem.

c. A training capability could be incorporated into system assets. For example, it may be deemed appropriate to embed mission rehearsal training within the air vehicle.

A wide range of specifics is possible; for example:

a. Specify any known, mandated, on-equipment and/or embedded training features here. For example, if engine reliability were high enough to preclude maintenance crews from staying current on removal/replacement of engines, then a requirement for on-equipment training (removal/replacement of good engines) may be appropriate. Also, a possible requirement for the air vehicle is to be able to simulate a failure for maintenance training purposes. While specific training requirements may not be known up front, it should be possible to define some basic and vital embedded features necessary to incorporate in the system requirements; for example, OFP hooks/portability to simulators, support equipment training modes, and mission planning system compatibility with simulator database generation systems. Also, constraints to embedded training features can be included in this paragraph. If there are multiple on-equipment training requirements, a table format may be better suited.

b. If no specific on-equipment training features are known but they are allowable or encouraged, due to life cycle economics, then incorporate a generic or general statement. For example, “The system shall accommodate life cycle economic on-equipment training features…”

c. If there are cases where no on-equipment or embedded training features are allowable, then so state here and delete the remainder of the requirement.

Table 3.7.3-I can be used to constrain the amount of time system equipment can be used for training purposes.

Equipment: Enter the type of equipment such as “air vehicle,” “system peculiar support equipment,” “training devices,” etc.

Purpose of Training: Define the types of embedded training being constrained. For example, if the type of equipment is “air vehicle,” it may be prudent to constrain its use as a training device for “maintenance training.”

Maximum Utilization: Define the maximum percent of time that the equipment can be used for that training. The sum of the values for any given type of equipment would be the maximum allowed use of that item for on-equipment training purposes. An example could be as follows:

Example on-equipment training table.

Equipment	Purpose of Training	Maximum Utilization
Air Vehicle	Maintenance Training	25%
Air Vehicle	Mission Rehearsal	10%
System-Peculiar Support Equipment	Failure Simulation	30%
Training Devices	Train the Trainer	50%

This requirement should drive specific allocations in the tier 2 air vehicle, support system, and/or training system specifications. Also, if on-equipment and/or embedded training features are utilized, their impact on sortie generation, utilization, reliability, maintenance, and service life would need to be accommodated in the overall system design.

REQUIREMENT LESSONS LEARNED (3.7.3)

There are examples of training features embedded in air systems. Some are used interactively while in an operative mode, such as simulated threats that are connected into the avionics of the MH-53J IDAS/MATT and activated during flying training. Others are no more than "hooks" programmed into operational flight programs (OFPs) that allow use of the OFP in-flight simulators; this is the case for the F-15 and the B-1B. A training-specific computer program transformed the electronic system test set for ALCMs & SRAMs into a training system for avionics technicians.

4.7.3 On-equipment training verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
On-equipment Training Capability	Level/Types of Training, On-equipment utilization	A	A	A		A

VERIFICATION DISCUSSION (4.7.3)

Verification of the levels/types of on-equipment training (that is, just for practice, diagnosis, mission rehearsal) is accomplished by analysis of lower-level training analyses (for example, TSRA), demonstrations, and tests that verify tier 2 air vehicle, training system, and support system specification performance of both training and system requirements. On-equipment training utilization, expressed as a percentage or unit of time available for use, is viewed as a constraint that is determined by analysis along with other air system utilization requirements. Verification of on-equipment training utilization is accomplished by confirming, through analysis of tier-2 specification performance, that this requirement is allocated to the air vehicle, training system, and support system.

Key Development Activities

Key development activities include, but are not limited to, the following:

SRR/SFR: Preliminary analysis indicates the detailed training requirements and preliminary curriculum structure (course syllabi), as defined by the data products from the TSRA, are complete and support the proposed levels of on-equipment training defined in blank 1. Preliminary analysis indicates that the conceptual design configuration(s) will support the proposed levels of on-equipment training and will not interfere with, nor be detrimental to, the availability of equipment and people, nor to the safe operation of the equipment. Preliminary analysis of maximum utilization requirements (including those in tier 2 specifications) indicates that sortie generation, utilization, reliability, maintenance, and service life of equipment will not be adversely impacted.

PDR: Analysis indicates the preliminary design approach for on-equipment training will satisfy the allocated training objectives for the levels of training defined in blank 1. Analysis indicates preliminary design of the curriculum structure and design features for on-equipment training satisfy all lower-level training requirements allocated to tier 2 specifications. Analysis indicates that preliminary design of on-equipment training features satisfies maximum utilization requirements and the overall system design accommodates any impacts on sortie generation, utilization, reliability, maintenance, and service life of the equipment.

CDR: Analysis indicates the final design of the air system and the on-equipment training design features will meet the allocated tier-2 detailed training requirements and support the levels of training defined in blank 1. Analysis of developmental test results of on-equipment training features on the air vehicle, training system and support system indicates that equipment is safe to operate and verifies overall air system safety requirements. Analysis indicates that final design of on-equipment training features will satisfy maximum utilization requirements and that overall system design accommodates any impacts on sortie generation, utilization, reliability, maintenance, and service life of the equipment.

FFR: For on-equipment training features designed into the air vehicle, analysis of preflight test results confirms that functionality of the equipment in the training mode meets safety requirements.

SVR: Analysis of results from lower-level (that is, tier 2) demonstrations and tests of the final on-equipment training features confirm all training requirements for each level of training have been met. Analysis of results of lower-level demonstrations and tests verify that maximum utilization requirements for on-equipment training are not exceeded.

Sample Final Verification Criteria

On-equipment training capability shall be verified by ___(1)___ analysis results of demonstrations and tests of the performance of the air vehicle, training system and support system to meet tier 2 specification on-equipment training requirements. Maximum utilization requirements (see table 3.7.3-I) shall be verified by ___(2)___ analysis of results from demonstrations and tests of the air system

> Blank 1. Identify the type and scope of on-equipment training demonstrations and test results requiring analysis to produce confidence that training requirements for each training level have been satisfied.
>
> Blank 2. Identify the type and scope of analysis, of results from demonstrations and tests of the air system, which produce confidence that maximum utilization requirements have been satisfied (Note: If on-equipment maximum utilization requirements have been satisfied, it is assumed that impacts on sortie generation, utilization, reliability, maintenance, and service life have been accommodated in the overall system design.)

VERIFICATION LESSONS LEARNED (4.7.3)

To Be Prepared

3.8 Disposal

The air system and any portions of the air system (components, parts, materials, etc.) shall provide for being permanently stored, salvaged, cannibalized, recovered, reused, recycled, demilitarized, and disposed of. The air system shall provide for the identification, isolation, and control of hazardous and radiological material to ensure personnel safety and environmental protection.

REQUIREMENT RATIONALE (3.8)

This requirement is to ensure the air system, or portions and/or components of the air system, can be withdrawn from service, reutilized, or disposed of in an economical, safe, and environmentally responsible manner. Although disposal is often thought of as occurring at the end of a system's useful life, disposition of excess, residual, obsolete, and condemned items begins during development, occurs during acquisition, and continues throughout the life of the system.

Certain portions of the air system (normally either weapons [guns, energetics, etc.] or classified material) require demilitarization prior to resale or disposal. Other portions of the air system require special handling to protect the environment or personnel safety. From some portions, strategic or precious materials can be recovered. Some portions can be recovered or salvaged for reuse. The objective of this requirement is to provide the basis for economical withdrawing from service and reutilization, or disposal, of air system assets.

REQUIREMENT GUIDANCE (3.8)

The degree to which the disposal aspects of the air system should be “designed in” is dependent on costs, benefits, and risks. The cost-benefit of ensuring that precious metals can be recovered from integrated circuit leads may be questionable, but the manpower and equipment costs to remove and dispose of hazardous and radiological materials can be mitigated by smart design choices. Similarly, the risks involved in simply “throwing away” explosive and related materials outweigh the alternatives.

This requirement may be amplified in a number of ways. For example, a table identifying specific materials to be precluded from use in the air system’s design or criteria to be used in defining quantities and thresholds for recovery of precious and strategic materials.

Consideration needs to be given to federal, state, and local laws and regulations applicable to manufacture, operation, and disposal of the air system. Consider also the cost of reutilization or disposal in dollars as related to the total operating cost. This includes the cost of occupational health considerations/risks such as employee personal protective costs, health monitoring costs, cleanup and/or decontamination costs, etc., during reutilization or disposal, and total costs of mishaps during reutilization or disposal. In addition, consider the number of mishaps involving damage to equipment or personnel (injured/killed) during reutilization or disposal and the number of environmental violations during reutilization or disposal.

REQUIREMENT LESSONS LEARNED (3.8)

A program was known to spend more than a year working with EPA officials to get approval to use a government-specified process before checking with the government for a waiver.

4.8 Disposal verification

Requirement Element(s)	Measurand	SRR/ SFR	PDR	CDR	FFR	SVR
Provide for permanent storage, salvage, cannibalization, recovery, reuse, recycle, demilitarization, and disposal	Disposal provisions are present	A	A	A/I		A/I
Provide for the identification, isolation, and control of hazardous and radiological material	Personnel safety and environment protection are present	A	A	A/I		A/I

VERIFICATION DISCUSSION (4.8)

Verification of the requirement to withdraw from service, reutilize, or dispose, in an economical, safe, and environmentally responsible manner should be accomplished by integrating analysis and inspections of the air system and its components. During air system developmental activities, substantial data is typically obtained that could be used to verify this requirement. Use of this type of data should be maximized to avoid the cost and schedule impacts of a formal demonstration.

Key Development Activities

Key development activities include, but are not limited to, the following:
(Note: The key development activities identified below apply to all of the requirement elements.)

SRR/SFR: Analysis of the air system concept indicates that requirements for withdrawing from service, reutilizing, or disposing of the air system and its components in an economical, safe, and environmentally responsible manner are defined and understood.

PDR: Analysis of the air system preliminary design indicates the air system and its components can be withdrawn from service, reutilized, or disposed of in an economical, safe, and environmentally responsible manner. Tradeoff analyses have been initiated, which may include but are not limited to occupational health considerations/risks such as employee personal protective costs, health monitoring costs, cleanup and/or decontamination costs during reutilization or disposal; total costs of mishaps during reutilization or disposal; number of mishaps involving damage to equipment or personnel (injured/killed) during reutilization or disposal; and number of environmental violations during reutilization or disposal.

CDR: Analysis of the air system final design and inspection of components shows the air system and its components can be withdrawn from service, reutilized, or disposed of in an economical, safe, and environmentally responsible manner. Analyses confirm that any problem areas have been thoroughly researched, and trade-offs are implemented.

FFR: No unique verification action occurs at this milestone.

SVR: Analysis and inspection of the final design of the air system and its components confirm they can be withdrawn from service, reutilized, or disposed of in an economical, safe, and environmentally responsible manner. Analyses of program documentation confirm that the disposal processes are in place and correct, and all known instances of noncompliance have been identified and design solutions presented.

Sample Final Verification Criteria

The disposal requirement shall be satisfied when ___(1)___ analyses and ___(2)___ inspections, confirm that the air system and its components can be withdrawn from service, reutilized, or disposed of in the manner specified.

Blank 1. Identify the type and scope of analyses required to provide confidence that the requirements have been met. Analyses include identification of item and category; determination of proper procedures and required actions for the category; and evaluation of the safety, and environmental impact of following the proper procedures and taking the required actions.

Blank 2. Identify the type and scope of inspections required to provide confidence that the requirements have been met. Inspections include looking at the air system and its portions and components, as they are built, and determining the safety and environmental impact of following the proper procedures and taking the required actions.

VERIFICATION LESSONS LEARNED (4.8)

To Be Prepared

5. Packaging requirements

5.1 Packaging

For acquisition purposes, the packaging requirements shall be as specified in the contract or rder (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful but is not mandatory.)

6.1 Intended use

This Joint Service Specification Guide is intended to be tailored for the development of first-tier, program-unique performance specifications for DoD air systems.

6.2 Acquisition requirements

Acquisition documents must specify the following:

a. Title, number, and date of the specification.

b. Packaging requirements (see section 5).

6.3 Definitions

6.3.1 Asset

Any item, service, or process, whether developmental, nondevelopmental, possessed, or procured. Frequently used interchangeably with “item.”

6.3.2 Availability (Ao)

A measure of the degree to which an item is in the operable and committable state when the mission is called for at any random point in time. Availability is dependent on reliability, maintainability, and logistics supportability.

6.3.3 Battle damage assessment

The timely and accurate estimate of damage resulting from the application of military force, either lethal or nonlethal, against a predetermined objective. Battle damage assessment can be applied to the employment of all types of weapon systems (air, ground, naval, and special forces weapon systems) throughout the range of military operations. Battle damage assessment is primarily an intelligence responsibility with required inputs and coordination from the operators. Battle damage assessment is composed of physical damage assessment, functional damage assessment, and target system assessment. Also called BDA. *(Joint Pub 1-02, 15 Apr 98)*

6.3.4 Computer resources

System computer hardware, system computer software/firmware, and computer resources support subsystems.

6.3.5 Evolutionary acquisition

An adaptive and incremental strategy applicable to high technology and software intensive systems when requirements beyond a core capability can generally, but not specifically, be defined.

6.3.6 Full mission capable

Material condition of an aircraft or training device indicating that it can perform all of its missions. Also called FMC. See also mission capable; partial mission capable; partial mission capable, maintenance; partial mission capable, supply. *(Joint Pub 1-02, 15 Apr 98)*

6.3.7 Growth

The inclusion of physical and/or functional characteristics/provisions which enable expansion or extension of the system's capability with minimum disruption of the system design.

6.3.7.1 Provisions, contractor (expressions)

Complete provision for (expression)	"Complete provision for" or "provision should be made for" means that all supports, brackets, tubes, fittings, electrical wiring, hydraulic lines, etc., have been installed and adequate weight and space allowed in order that the equipment can be installed without alteration to the specified equipment or the air vehicle. No additional parts are required for installation, other than the item itself. Standard stock items such as nuts, bolts, cotter pins, etc., need not be furnished. The weight of the item is to be included in weight empty and in all design gross weights for the air vehicle including structural design gross weights. Power for the item should be provided as specified in "Power provision for" below. Cooling for the item shall be provided based on equipment specification.
Group A provisions	Group A provisions accommodate future installations of equipment, specifically space, weight, power and cooling. Space and weight provisions are based on the volume of generic classes of equipment which would allow for future installation of equipment without changes to existing structure, mounting location, or other compartment features. Included in the provisions are space and weight for shock mounts, connectors, cooling ducts, etc., as might be required. Weight for these items should be included in the specification weights, and location should be such that vehicle balance and inertia are unaffected whether the item(s) are installed or not. Power provisions require the allocation of generator and/or battery capacity such that the future capability can be added without changing the electrical system configuration or capacity. Cooling provisions require allocation of cooling capacity such that the future capability can be added without changing the environmental control system configuration or capacity. Access doors, if needed, shall be incorporated into the basic design. For computers, this would include card slots.
Group B provisions	Group B provisions accommodate future installation of known equipment. In addition to group A provisions, installation features such as supports, brackets, tubing, wiring, fittings, ducting, etc. should be provided such that no additional parts are required for installation other than the item itself.
Power provision for (expression)	"Power provision for" means that the primary electrical, hydraulic and pneumatic power and distribution systems should be of sufficient capacity to allow later incorporation of the specific equipment without modification to the primary power and distribution systems. This capacity is in addition to the excess capacity provided for growth in

	the load demand. "Power provision for" does not include electrical wiring, hydraulic or pneumatic lines, brackets, bolt holes, etc.
Space provision for (expression)	"Space provision for" means that space only should be allocated for the installation, and that brackets, bolt holes, electrical wiring, hydraulic lines, etc., are not required. "Space provision for" does not imply that adequate attaching structure is provided, unless otherwise specified.
Weight provision for (expression)	"Weight provision for" means that suitable weight allowance to simulate later incorporation of the item or complete installation should be included in weight empty and all design gross weights and structural design conditions.
Shall be installed (expression)	The expression "shall be installed" means that the item or equipment is to be furnished by the Government and installed by the contractor.
Shall be provided (expression)	The expression "shall be provided" means that the item or equipment is to be furnished and installed by the contractor.

6.3.8 Imagery intelligence

Intelligence derived from the exploitation of collection by visual photography, infrared sensors, lasers, electro-optics, and radar sensors such as synthetic aperture radar wherein images of objects are reproduced optically or electronically on film, electronic display devices, or other media. Also called IMINT. *(Joint Pub 1-02, 15 Apr 98)*

6.3.9 Intelligence

The product resulting from the collection, processing, integration, analysis, evaluation, and interpretation of available information concerning foreign countries or areas.

Information and knowledge about an adversary obtained through observation, investigation, analysis, or understanding. *(Joint Pub 1-02, 15 Apr 98)*

6.3.10 Intelligence discipline

A well defined area of intelligence collection, processing, exploitation, and reporting using a specific category of technical or human resources. There are five major disciplines: human intelligence, imagery intelligence, measurement and signature intelligence, signals intelligence (communications intelligence, electronic intelligence, and foreign instrumentation signals intelligence), and open-source intelligence. *(Joint Pub 1-02, 15 Apr 98)*

6.3.11 Interoperability

(1) The ability of systems, units or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. (DoD)

The condition achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. The degree of interoperability should be defined when referring to specific cases. *(Joint Pub 1-02, 15 Apr 98)*

6.3.12 Logistics supportability

The degree to which planned logistics support [including test, measurement, and diagnostics equipment; spares and repair parts; technical data; support facilities; transportation requirements; training; manpower; and software support] allow meeting system availability and wartime usage requirements.

6.3.13 Measurand

A parameter that is measured in order to verify a required system/end-item feature or characteristic.

6.3.14 Measurement and signature intelligence

Scientific and technical intelligence obtained by quantitative and qualitative analysis of data (metric, angle, spatial, wavelength, time dependence, modulation, plasma, and hydromagnetic) derived from specific technical sensors for the purpose of identifying any distinctive features associated with the target. The detected feature may be either reflected or emitted. Also called MASINT. *(Joint Pub 1-02, 15 Apr 98)*

6.3.15 Mission capable

Material condition of an aircraft indicating it can perform at least one and potentially all of its designated missions. Also called MC. See also full mission capable; partial mission capable; partial mission capable, maintenance; partial mission capable, supply. *(Joint Pub 1-02, 15 Apr 98)*

6.3.16 Modularity

A system composed of discrete elements, each of which is defined in sufficient completeness and detail such that selected element(s) can be replaced and/or modified in a competitive environment with minimal or no modifications to other system elements while maintaining equal or improved system performance and capability.

6.3.17 Near real time

Pertaining to the timeliness of data or information which has been delayed by the time required for electronic communication and automatic data processing. This implies that there are no significant delays. *(Joint Pub 1-02, 15 Apr 98)*

6.3.18 Objective

The goal or desired value (see Technical objectives).

6.3.19 Partial mission capable

Material condition of an aircraft or training device indicating that it can perform at least one but not all of its missions. Also called PMC. See also full mission capable; mission capable; partial mission capable, maintenance; partial mission capable, supply. *(Joint Pub 1-02, 15 Apr 98)*

6.3.20 Partial mission capable, maintenance

Material condition of an aircraft or training device indicating that it can perform at least one but not all of its missions because of maintenance requirements existing on the inoperable subsystem(s). Also called PMCM. See also full mission capable; mission capable; partial mission capable; partial mission capable, supply. *(Joint Pub 1-02, 15 Apr 98)*

6.3.21 Partial mission capable, supply

Material condition of an aircraft or training device indicating it can perform at least one but not all of its missions because maintenance required to clear the discrepancy cannot continue due to a supply shortage. Also called PMCS. See also full mission capable; mission capable; partial mission capable; partial mission capable, maintenance. *(Joint Pub 1-02, 15 Apr 98)*

6.3.22 Preplanned product improvement

The conscious, considered strategy which involves deferring the development of necessary performance capabilities associated with elements having significant risks or delays so that the system can be fielded while the deferred element is developed in a parallel or subsequent effort. Provisions, interfaces, and accessibility are integrated into the system design so that the deferred element can be incorporated in a cost effective manner when available. The concept also applies to process improvements.

6.3.23 Real time

Pertaining to the timeliness of data or information which has been delayed only by the time required for electronic communication. This implies that there are no noticeable delays. *(Joint Pub 1-02, 15 Apr 98)*

6.3.24 Reconnaissance

A mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area. *(Joint Pub 1-02, 15 Apr 98)*

6.3.25 SEEK EAGLE (SE)

The Air Force certification program for determining safe carriage, employment and jettison limits, safe escape, and ballistics accuracy, when applicable, for all stores in specified loading configurations on United States Air Force and Foreign Military Sales (FMS) aircraft. SE includes compatibility analyses for fit, function, electromagnetic interface, flutter, loads, stability and control, and separation; stores loading procedures; ground and wind tunnel tests; and flight tests. The end product is source data for flight, delivery, loading manuals, and the weapon ballistics portion of the aircraft operational flight program. (*AFI 63-104*).

6.3.26 Service life

The period spanning from an asset's introduction into the inventory for operational use until it is consumed or disposed. The service life of a system typically exceeds the service lives of the assets that compose it.

6.3.27 Signals intelligence

1) A category of intelligence comprising, either individually or in combination, all communications intelligence, electronics intelligence, and foreign instrumentation signals intelligence, however transmitted. 2) Intelligence derived from communications, electronics, and foreign instrumentation signals. Also called SIGINT. *(Joint Pub 1-02, 15 Apr 98)*

6.3.28 Specification

A description of the essential technical requirements for items, materials, and services that includes the verification criteria for determining whether these requirements are met. A specification supports the acquisition and life cycle management of the item, material, and service described.

6.3.29 Surveillance

The systematic observation of aerospace, surface or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means. *(Joint Pub 1-02, 15 Apr 98)*

6.3.30 Technical performance measurement (TPM)

The continuing verification of the degree of anticipated and actual achievement for technical parameters. Confirms progress and identifies deficiencies that might jeopardize meeting a system requirement. Assessed values falling outside established tolerances indicate a need for evaluation and corrective action (see figure 6.3.30-I).

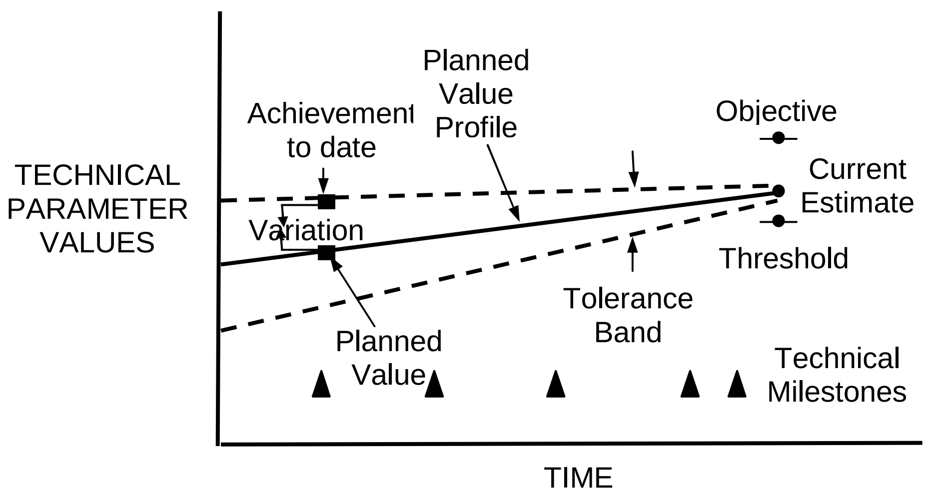


FIGURE 6.3.30-I. Example technical performance measurement profile.

6.3.30.1 Achievement-to-date

Present assessed value of the technical parameter.

6.3.30.2 Current estimate

The technical parameter value predicted to be achieved by the end of the contract with remaining resources (including schedule and budget).

6.3.30.3 Objective

The goal or desired value (see Technical objectives).

6.3.30.4 Planned value

Technical parameter value based on the planned value profile.

6.3.30.5 Planned value profile

Projected time-phased achievement of a technical parameter.

6.3.30.6 Technical milestone

A point where a TPM evaluation is accomplished or reported.

6.3.30.7 Threshold

The limiting acceptable value of a technical parameter.

6.3.30.8 Tolerance band

Alert envelope around the planned value profile indicating allowed variation and projected estimating error.

6.3.30.9 Variation

Difference between the planned value and the achievement-to-date value.

6.3.31 Verification definitions

The verification methods are defined as follows.

6.3.31.1 Inspection/evaluation (I)

Examination of equipment, drawings, or documentation.

6.3.31.2 Analysis (A)

A method of verification that utilizes established technical or mathematical algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures.

6.3.31.3 Simulation/modeling (S)

The process of conducting experiments with a model. Simulation may include the use of analog or digital devices, laboratory models, or “testbed” sites.

6.3.31.4 Demonstration (D)

A method that generally utilizes, under specific scenarios, the actual operation, adjustment, or reconfiguration of items.

6.3.31.5 Test (T)

A method of verification that generally determines, quantitatively, the properties or elements of items, including functional operation, and involves the application of established scientific principles and procedures.

6.3.32 Wartime reserve modes

Characteristics and operating procedures of sensor, communications, navigation aids, threat recognition, weapons, and countermeasures systems that will contribute to military effectiveness if unknown to or misunderstood by opposing commanders before they are used, but could be exploited or neutralized if known in advance. Wartime reserve modes are deliberately held in reserve for wartime or emergency use and seldom, if ever, applied or intercepted prior to such use. *(Joint Pub 1-02, 15 Apr 98)*

6.4 Verification by milestones

The incremental verification approach is intended to accomplish several important objectives, ensuring that

a. System-level performance requirement is consistent with the requirement allocations made and implemented in lower-tier specifications/product definition documentation;

b. Product design decisions support the allocated performance requirements; and

c. The system-level performance requirements are met.

To ensure that product design decisions support and properly allocate performance requirements, verification should be accomplished in iterations at appropriate program milestones. Ideally, iterative verifications, while accomplishing the same basic objective each time, are done with greater and greater fidelity and accuracy as designs mature and more detailed information becomes available. Some verifications may progress in method from inspection to analysis to simulation to test through successive milestones. Other verifications may call for using the same method (i.e., analysis) through each program milestone but requiring successively more insight into and fidelity in data and assumptions.

Requirements should be verified prior to each major system milestone to provide the greatest assurance that verification criteria are achieved. The milestones for a specific program may differ or be called by a different name. There may be more milestones or fewer. Milestone objectives may be different. These are all program choices. In all cases, program milestones must be defined. However, the verification criteria must be matched to the milestones selected and the milestone objectives.

The following are typical milestones intended for use in the JSSGs:

a. System Requirements Review (SRR)/System Function Review (SFR) or equivalent

b. Preliminary Design Review (PDR) or equivalent

c. Critical Design Review (CDR) or equivalent

d. First Flight Review (FFR) or equivalent

e. System Verification Review (SVR) or equivalent

The key objectives of each milestone, applicable to specifications, are summarized below:

a. <u>System Requirements Review (SRR)/System Functional Review (SFR) or equivalent</u>. Confirm convergence on and achievability of system requirements and readiness to initiate preliminary design by confirming :

(1) System functional and performance requirements have converged and characterize a system for which one or more design approaches exist that satisfy established customer needs and requirements;

(2) The system's draft physical architecture and draft lower-level product performance requirements definition establish an initial assessment of, the adequacy, completeness, and achievability of functional and performance requirements, and quantification of cost, schedule, and risk;

(3) Critical technologies for people, product, and process solutions have been verified at an acceptable level of risk for availability, achievability, needed performance, and readiness for transition;

(4) Life cycle requirements for people, products and processes have been defined, within acceptable limits of certainty, that provide the encompassing essential functionality, capability, interfaces, and other requirements/ constraints; and

(5) Preplanned product and process improvement and evolutionary acquisition requirements planning have been defined as required.

b. Preliminary Design Review (PDR) or equivalent. Confirm that the detailed design approach satisfies system requirements and the total system is ready for detailed design. PDR confirms that the process completely defines system requirements for design including:

(1) The system physical architecture is an integrated detailed design approach for people, products, and processes to satisfy requirements, including interoperability and interfaces;

(2) An audit trail from SRR is established with changes substantiated;

(3) Available developmental test results support the system design approach;

(4) The product performance requirements are defined;

(5) Sufficient detailed design has been accomplished to verify the completeness and achievability of defined requirements, and quantification of cost, schedule, and risk; and

(6) Preplanned product and process improvement and evolutionary acquisition requirements planning have been refined.

c. Critical Design Review (CDR) or equivalent. Confirm that the total system detailed design is complete, meets requirements, and that the total system is ready for manufacturing. CDR confirms that the process completely defines system design requirements including:

(1) The system physical architecture is an integrated detailed design for people, products, and processes to satisfy requirements, including interoperability and interfaces;

(2) The system design compatibility with external interfaces has been established;

(3) Developmental test results are consistent with system design and interface requirements and design constraints;

(4) Critical system design and interface requirements and design constraints are supported by developmental test results;

(5) Preplanned product and process improvement and evolutionary acquisition requirements planning has been defined; and

(6) Fabrication and support definition for the system is provided.

d. First Flight Review (FFR) or equivalent. Confirm that, prior to testing, system items, individually or in combination, demonstrate:

(1) The safety inherent in the test article(s) and the procedures and plans for its use have been evaluated as being safe;

Personnel involved in the testing are trained in both the objectives of the test(s) and the jobs they are responsible for accomplishing;

The configuration control process necessary to support flight testing is established;

Planning for testing is complete, evaluated for adequacy and available to all applicable personnel;

Hazardous materials and procedures are defined and documented, and handling equipment, instructions, and special actions are defined and provided to affected personnel with warnings, instructions, and special training as appropriate;

Resources (people, equipment, and materials) needed to accomplish the testing are available and ready for the testing;

The test article(s), equipment, facilities, and ranges (if applicable) are evaluated as ready for test; and

Documentation of evaluations, assessments, plans, procedures, training and other factors applicable to the tests is available, correlated, and complete.

e. System Verification Review (SVR) or equivalent. Confirm that the total system is verified. SVR confirms the completion of all incremental accomplishments for system verification (for example, Test Readiness Reviews, System Functional Configuration Audits) and confirms, within acceptable limits of certainty, that ;

(1) System verification procedures are complete and accurate (including verification by test and demonstration of critical parameters as well as key assumptions and methods used in verifications by analytic models and simulations);

The system is confirmed to be ready for verification;

Verifications have been conducted in accordance with established procedures and are completed for people, products, and processes; and system processes are current, executable, and meet the need;

An audit trail from CDR is established with changes substantiated and the system verified;

The interface compatibility has been achieved;

Plans and procedures for downstream processes (production, training, support/sustainment, deployment/fielding, operations, and disposal) evaluated for adequacy; discrepancies resolved; and documentation and results incorporated in the system data base; and

Preplanned product and process improvement and evolutionary acquisition requirements and plans have been refined.

6.5 Specification tree

The following list identifies the documents that comprise the top level of the specification tree for the air system.

Example

Level	Document
1	Air System Specification
2	Air Vehicle Specification
2	Control Station Specification
2	(Other Tier 2 Specification(s))

This section identifies the top three tiers of the specification tree. The complete tree of requirements documentation is normally the developing contractor's responsibility to develop. See the Integrated Performance Based Business Environment Guide and the Performance Based Product Definition Guide for additional information.

A specification tree is a program-unique construct to organize the requirements flow-down into documentation that describes requirements for segments of the system and items that comprise the system. An air system specification is normally the top-tier document in the specification tree for system development. This is not intended to preclude the use of another document as the top-tier specification on a modification program such as using a tailored avionics specification for a radar upgrade. As always, significant insight and planning is necessary when constructing a set of requirements for the program. For example, how much of that radar upgrade needs to be verified in its installed environment (air vehicle) or how much of that requirements set is dependent on system environments, interfaces, and other factors such as impacts on support and training.

This Air System Joint Service Specification Guide (JSSG) has been developed in concert with other JSSGs. Plans for future JSSG publications include developing a Control Station JSSG (for use in those circumstances when the air vehicle being developed is an unmanned air vehicle) and an Air Vehicle/Ship Integration JSSG (for those air vehicles which will operate in a shipboard environment). The nominal JSSG hierarchy depicted on figure 6.5-1 should not be construed as a program specification tree. While the JSSGs shown at tier 2 may represent program-unique specifications to be developed, those specification guides shown under the Air Vehicle at tier 3 may or may not have a resemblance to a program-specific specification architecture. These tier 3 JSSGs nominally communicate performance expectations for areas of air vehicle functionality. While they could exist in a program-specific form, some (or some portions) of these documents express functionality that would frequently be expressed as part of the functionality of the air vehicle. That is, in developing a program-specific air vehicle specification, portions of the tier 3 documents may be appropriately tailored and incorporated in an air vehicle specification. Additionally, the choices on how best to organize requirements are frequently driven by the organization of the program, risk, and complexity among other factors. For example, the use of integrated product teams may make it desirable to consolidate all requirements for avionics into a single specification even though some of the performance expectations are tier 2 (i.e., air vehicle requirements) and some tier 3 (for example, radar requirements). This would enable making a single team accountable for the development and implementation of a given area of requirements. The organization of the Joint Service Specification Guide specification tree is intended to assist the program office in constructing appropriate sets of requirements, not in hindering factors such as teamwork, team accountability, or other mechanism used to organize requirements.

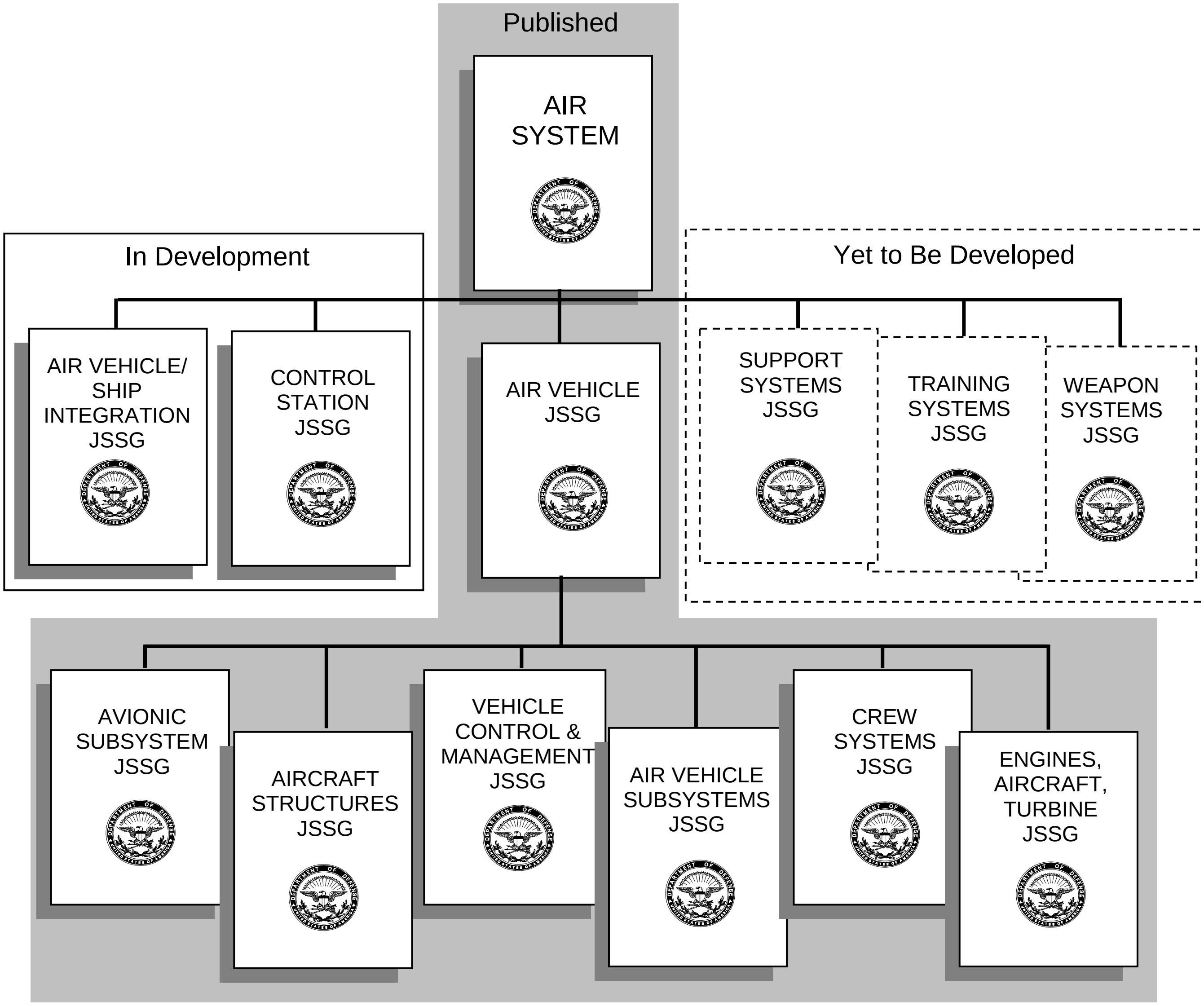


FIGURE 6.5-1. Joint Service Specification Guide specification tree.

6.6 Key word list

acquisition requirements
aerial refueling
aircraft
air vehicle
avionics
crew system
interface
interoperability
maintainability
operational concept
performance specification
reliability
service life
specification template
structures
subsystem
support systems
survivability
system life cycle
systems engineering
tailorable specification
training system
verification
unmanned air vehicle
weapons

6.7 International interest

Certain provisions of this document may be the subject of international standardization agreements. When change notice, revision, or cancellation of this document is proposed that will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.8 Responsible engineering office

The DoD office responsible for development and technical maintenance of this Joint Service Specification Guide is ASC/ENS, Bldg. 560 (Area B), 2530 Loop Road West, Wright-Patterson AFB OH 45433-7101. Requests for additional information or assistance on this specification can be obtained from DSN 785-1799, commercial (937) 255-/1799, FAX (937) 255-5597. Address e-mail comments to Engineering.Standards@wpafb.af.mil. Any information relating to Government contracts must be obtained through the contracting officer for the program or project under consideration.

AIR SYSTEM

JOINT SERVICE SPECIFICATION GUIDE

APPENDIX A

AIR SYSTEM / AIR VEHICLE REQUIREMENTS LINKAGES

A.1 SCOPE

A.1.1 Scope.

The appendix provides a matrix showing requirements paragraph linkages between the Air System Joint Service Specification Guide (JSSG-2000B) and the Air Vehicle JSSG (JSSG-2001B). The information contained herein is intended for guidance only.

A.2 APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

A.3 REQUIREMENTS LINKAGES

The following matrix shows the paragraph linkages between the requirements of the Air System and the Air Vehicle JSSGs:

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.1.1	Roles and missions	3.1.1	Point performance (flight and ground)
3.1.1	Roles and missions	3.1.1.1	Flight envelope
3.1.1	Roles and missions	3.1.1.1.1	Aerial refueling envelope
3.1.1	Roles and missions	3.1.1.2	Ground performance
3.1.1	Roles and missions	3.1.2	Mission profile(s) performance
3.1.1	Roles and missions	3.1.2.1	Threat environment
3.1.1	Roles and missions	3.1.2.2.1	Weapons delivery
3.1.1	Roles and missions	3.1.7	Communication, radio navigation, and identification
3.1.1	Roles and missions	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.1	Roles and missions	3.1.8.2.2	Defensive countermeasures
3.1.1	Roles and missions	3.1.8.2.3	Terrain following/terrain avoidance
3.1.1	Roles and missions	3.1.8.2.6.1	Chemical and biological hardening
3.1.1	Roles and missions	3.1.8.2.6.2	Chemical and biological personnel protection
3.1.1	Roles and missions	3.1.8.2.6.3	Chemical and biological decontamination

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.1.1	Roles and missions	3.1.8.2.7	Nuclear weapons survivability
3.1.1	Roles and missions	3.1.9.1	Target detection, track, identification, and designation
3.1.1	Roles and missions	3.1.9.2	Integrated earth/space reference accuracy
3.1.1	Roles and missions	3.2.1	Electromagnetic environmental effects
3.1.1	Roles and missions	3.2.2	Natural climate
3.1.1	Roles and missions	3.2.3	Induced environment
3.1.2	Organization	3.1.2	Mission profile(s) performance
3.1.2	Organization	3.1.2.2.1	Weapons delivery
3.1.2	Organization	3.1.7	Communication, radio navigation, and identification
3.1.2	Organization	3.4.2	Communication, radio navigation, and identification interfaces
3.1.3	Deployment and mobilization	3.1.1.1.1	Aerial refueling envelope
3.1.3	Deployment and mobilization	3.1.1.2	Ground performance
3.1.3	Deployment and mobilization	3.1.2	Mission profile(s) performance
3.1.3	Deployment and mobilization	3.4.4	Transportability
3.1.3	Deployment and mobilization	3.4.4.1	Preparation for transport
3.1.4	Mission planning	3.1.3	Mission planning
3.1.4	Mission planning	3.1.7	Communication, radio navigation, and identification
3.1.4	Mission planning	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.4	Mission planning	3.1.8.2.2	Defensive countermeasures
3.1.4	Mission planning	3.1.8.2.3	Terrain following/terrain avoidance
3.1.4	Mission planning	3.1.9.1	Target detection, track, identification, and designation
3.1.5.1.1	Training missions	3.1.1	Point performance (flight and ground)
3.1.5.1.1	Training missions	3.1.1.1.1	Aerial refueling envelope
3.1.5.1.1	Training missions	3.1.1.2	Ground performance
3.1.5.1.1	Training missions	3.1.2	Mission profile(s) performance
3.1.5.1.1	Training missions	3.1.3	Mission planning
3.1.5.1.1	Training missions	3.1.4	Reliability
3.1.5.1.1	Training missions	3.1.5	Maintainability
3.1.5.1.1	Training missions	3.1.7	Communication, radio navigation, and identification
3.1.5.1.1	Training missions	3.3.5	System usage
3.1.5.1.1	Training missions	3.7.1	Embedded training
3.1.5.1.2	Operational deployment	3.1.1	Point performance (flight and ground)
3.1.5.1.2	Operational deployment	3.1.1.1.1	Aerial refueling envelope
3.1.5.1.2	Operational deployment	3.1.1.2	Ground performance
3.1.5.1.2	Operational deployment	3.1.2	Mission profile(s) performance
3.1.5.1.2	Operational deployment	3.1.3	Mission planning
3.1.5.1.2	Operational deployment	3.1.4	Reliability
3.1.5.1.2	Operational deployment	3.1.5	Maintainability

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.1.5.1.2	Operational deployment	3.3.5	System usage
3.1.5.1.2	Operational deployment	3.4.4	Transportability
3.1.5.1.2	Operational deployment	3.4.4.1	Preparation for transport
3.1.5.1.3	Operational missions in peacetime	3.1.1	Point performance (flight and ground)
3.1.5.1.3	Operational missions in peacetime	3.1.1.1.1	Aerial refueling envelope
3.1.5.1.3	Operational missions in peacetime	3.1.1.2	Ground performance
3.1.5.1.3	Operational missions in peacetime	3.1.2	Mission profile(s) performance
3.1.5.1.3	Operational missions in peacetime	3.1.3	Mission planning
3.1.5.1.3	Operational missions in peacetime	3.1.4	Reliability
3.1.5.1.3	Operational missions in peacetime	3.1.5	Maintainability
3.1.5.1.3	Operational missions in peacetime	3.3.5	System usage
3.1.5.1.4	Base escape	3.1.1	Point performance (flight and ground)
3.1.5.1.4	Base escape	3.1.1.1	Flight envelope
3.1.5.1.4	Base escape	3.1.1.2	Ground performance
3.1.5.1.4	Base escape	3.1.2	Mission profile(s) performance
3.1.5.1.4	Base escape	3.1.3	Mission planning
3.1.5.1.4	Base escape	3.1.4	Reliability
3.1.5.1.4	Base escape	3.1.5	Maintainability
3.1.5.1.4	Base escape	3.1.8.2.6.2	Chemical and biological personnel protection
3.1.5.1.4	Base escape	3.3.5	System usage
3.1.5.2.1	Combat surge and sustained	3.1.1	Point performance (flight and ground)
3.1.5.2.1	Combat surge and sustained	3.1.1.1	Flight envelope
3.1.5.2.1	Combat surge and sustained	3.1.1.1.1	Aerial refueling envelope
3.1.5.2.1	Combat surge and sustained	3.1.1.2	Ground performance
3.1.5.2.1	Combat surge and sustained	3.1.2	Mission profile(s) performance
3.1.5.2.1	Combat surge and sustained	3.1.3	Mission planning
3.1.5.2.1	Combat surge and sustained	3.1.4	Reliability
3.1.5.2.1	Combat surge and sustained	3.1.5	Maintainability
3.1.5.2.1	Combat surge and sustained	3.3.5	System usage
3.1.5.2.2	Air alert, loiter, surveillance	3.1.1	Point performance (flight and ground)
3.1.5.2.2	Air alert, loiter, surveillance	3.1.1.1	Flight envelope
3.1.5.2.2	Air alert, loiter, surveillance	3.1.1.1.1	Aerial refueling envelope
3.1.5.2.2	Air alert, loiter, surveillance	3.1.1.2	Ground performance
3.1.5.2.2	Air alert, loiter, surveillance	3.1.2	Mission profile(s) performance
3.1.5.2.2	Air alert, loiter, surveillance	3.1.3	Mission planning
3.1.5.2.2	Air alert, loiter, surveillance	3.1.4	Reliability
3.1.5.2.2	Air alert, loiter, surveillance	3.1.5	Maintainability

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.1.5.2.2	Air alert, loiter, surveillance	3.1.7	Communication, radio navigation, and identification
3.1.5.2.2	Air alert, loiter, surveillance	3.3.5	System usage
3.1.5.2.3.1	Non-lethal Mission Task Initiation from Ground/Deck Basing	3.1.1	Point performance (flight and ground)
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.1.1	Flight envelope
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.1.2	Ground performance
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.2	Mission profile(s) performance
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.2.2.1	Weapons delivery
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.4	Reliability
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.7	Communication, radio navigation, and identification
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.8.2.2	Defensive countermeasures
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.9.1	Target detection, track, identification, and designation
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.9.1.1	Multiple target track and weapon delivery support
3.1.5.2.3.1	Non-lethal mission task initiation from ground/deck basing	3.1.9.2	Integrated earth/space reference accuracy
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.1	Point performance (flight and ground)
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.1.1	Flight envelope
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.1.2	Ground performance
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.2	Mission profile(s) performance

Air System		Air Vehicle	
Para #	Title	Para #	Title
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.2.2.1	Weapons delivery
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.4	Reliability
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.7	Communication, radio navigation, and identification
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.8.2.2	Defensive countermeasures
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.9.1	Target detection, track, identification, and designation
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.9.1.1	Multiple target track and weapon delivery support
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.9.2	Integrated earth/space reference accuracy
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.9.3	Air-to-surface accuracy
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.9.4	Weapon and store selection and release control
3.1.5.2.3.2	Lethal engagement from ground/deck basing	3.1.9.5	Gun accuracy and control
3.1.5.2.3.2	Lethal engagement from ground/deck Basing	3.3.5	System usage
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.1	Point performance (ground and flight)
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.1.1	Flight envelope
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.2	Mission profile(s) performance
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.4	Reliability
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.7	Communication, radio navigation, and identification
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.8.2.2	Defensive countermeasures
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.9.1	Target detection, track, identification, and designation
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.1.9.2	Integrated earth/space reference accuracy
3.1.5.2.4.1	Non-lethal mission task initiation from loiter location	3.3.5	System usage
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.1	Point performance (ground and flight)

Air System		Air Vehicle	
Para #	Title	Para #	Title
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.1.1	Flight envelope
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.2	Mission profile(s) performance
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.2.2.1	Weapons delivery
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.4	Reliability
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.7	Communication, radio navigation, and identification
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.8.2.2	Defensive countermeasures
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.9.1	Target detection, track, identification, and designation
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.9.1.1	Multiple target track and weapon delivery support
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.9.2	integrated earth/space reference accuracy
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.9.3	Air-to-surface accuracy
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.9.4	Weapon and store selection and release control
3.1.5.2.4.2	Lethal engagement from loiter location	3.1.9.5	Gun accuracy and control
3.1.5.2.4.2	Lethal engagement from loiter location	3.3.5	System usage
3.1.6.2.1	Mission and one-on-one survivability	3.1.2	Mission profile(s) performance
3.1.6.2.1	Mission and one-on-one survivability	3.1.2.2.1	Weapons delivery
3.1.6.2.1	Mission and one-on-one survivability	3.1.3	Mission planning
3.1.6.2.1	Mission and one-on-one survivability	3.1.7	Communication, radio navigation, and identification
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.1.1.1	Radar cross section
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.1.1.2	Infrared signature
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.1.1.3	Visual signature
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.1.1.4	Acoustic signature
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.1.1.5	Emission control

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.2.2	Defensive countermeasures
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.2.3	Terrain following/terrain avoidance
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.2.4	Ballistic threat survivability
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.2.5.1	Electromagnetic threat survivability
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.2.5.2	Laser threat survivability
3.1.6.2.1	Mission and one-on-one survivability	3.1.8.2.7	Nuclear weapons survivability
3.1.6.2.1	Mission and one-on-one survivability	3.1.9.1	Target detection, track, identification, and designation
3.1.6.2.1	Mission and one-on-one survivability	3.1.9.1.1	Multiple target track and weapon delivery support
3.1.6.2.1	Mission and one-on-one survivability	3.4.1.2	Weapon and store loadouts
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.1	Point performance (ground and flight)
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.1.2	Ground performance
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.8.1.1.1	Radar cross section
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.8.1.1.2	Infrared signature
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.8.1.1.3	Visual signature
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.8.1.1.4	Acoustic signature
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.8.1.1.5	Emission control
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.8.2.4	Ballistic threat survivability
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.8.2.5.1	Electromagnetic threat survivability
3.1.6.2.2	Parked aircraft and ground support survivability	3.1.8.2.5.2	Laser threat survivability
3.1.7.1.1	Air-to-air lethality	3.1.1	Point performance (flight and ground)
3.1.7.1.1	Air-to-air lethality	3.1.1.1	Flight envelope
3.1.7.1.1	Air-to-air lethality	3.1.2	Mission profile(s) performance
3.1.7.1.1	Air-to-air lethality	3.1.2.2.1	Weapons delivery
3.1.7.1.1	Air-to-air lethality	3.1.3	Mission planning
3.1.7.1.1	Air-to-air lethality	3.1.7	Communication, radio navigation, and identification

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.1.7.1.1	Air-to-air lethality	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.7.1.1	Air-to-air lethality	3.1.8.2.2	Defensive countermeasures
3.1.7.1.1	Air-to-air lethality	3.1.8.2.4	Ballistic threat survivability
3.1.7.1.1	Air-to-air lethality	3.1.8.2.5.1	Electromagnetic threat survivability
3.1.7.1.1	Air-to-air lethality	3.1.8.2.5.2	Laser threat survivability
3.1.7.1.1	Air-to-air lethality	3.1.8.2.7	Nuclear weapons survivability
3.1.7.1.1	Air-to-air lethality	3.1.9.1	Target detection, track, identification, and designation
3.1.7.1.1	Air-to-air lethality	3.1.9.1.1	Multiple target track and weapon delivery support
3.1.7.1.1	Air-to-air lethality	3.1.9.2	Integrated earth/space reference accuracy
3.1.7.1.1	Air-to-air lethality	3.1.9.4	Weapon and store selection and release control
3.1.7.1.1	Air-to-air lethality	3.1.9.5	Gun accuracy and control
3.1.7.1.1	Air-to-air lethality	3.4.1.2	Weapon and store loadouts
3.1.7.1.1	Air-to-air lethality	3.4.1.3	Gun interface
3.1.7.1.2	Air-to-surface lethality	3.1.1	Point performance (flight and ground)
3.1.7.1.2	Air-to-surface lethality	3.1.1.1	Flight envelope
3.1.7.1.2	Air-to-surface lethality	3.1.2	Mission profile(s) performance
3.1.7.1.2	Air-to-surface lethality	3.1.2.2.1	Weapons delivery
3.1.7.1.2	Air-to-surface lethality	3.1.3	Mission planning
3.1.7.1.2	Air-to-surface lethality	3.1.7	Communication, radio navigation, and identification
3.1.7.1.2	Air-to-surface lethality	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.7.1.2	Air-to-surface lethality	3.1.8.2.2	Defensive countermeasures
3.1.7.1.2	Air-to-surface lethality	3.1.8.2.4	Ballistic threat survivability
3.1.7.1.2	Air-to-surface lethality	3.1.8.2.5.1	Electromagnetic threat survivability
3.1.7.1.2	Air-to-surface lethality	3.1.8.2.5.2	Laser threat survivability
3.1.7.1.2	Air-to-surface lethality	3.1.8.2.7	Nuclear weapons survivability
3.1.7.1.2	Air-to-surface lethality	3.1.9.1	Target detection, track, identification, and designation
3.1.7.1.2	Air-to-surface lethality	3.1.9.1.1	Multiple target track and weapon delivery support
3.1.7.1.2	Air-to-surface lethality	3.1.9.2	Integrated earth/space reference accuracy
3.1.7.1.2	Air-to-surface lethality	3.1.9.3	Air-to-surface accuracy
3.1.7.1.2	Air-to-surface lethality	3.1.9.4	Weapon and store selection and release control
3.1.7.1.2	Air-to-surface lethality	3.1.9.5	Gun accuracy and control
3.1.7.1.2	Air-to-surface lethality	3.4.1.3	Gun interface
3.1.7.2.1	Cargo transport	3.1.1	Point performance (ground and flight)
3.1.7.2.1	Cargo transport	3.1.1.1.1	Aerial refueling envelope

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.1.7.2.1	Cargo transport	3.1.2	Mission profile(s) performance
3.1.7.2.1	Cargo transport	3.1.3	Mission planning
3.1.7.2.1	Cargo transport	3.1.9.2	Integrated earth/space reference accuracy
3.1.7.2.1	Cargo transport	3.3.6.2	Marking of cargo compartments
3.1.7.2.1	Cargo transport	3.4.5	Cargo and payload
3.1.7.2.1	Cargo transport	3.4.5.1	Cargo handling
3.1.7.2.1	Cargo transport	3.4.5.2	Cargo weight and balance
3.1.7.2.2	Personnel transport	3.1.1	Point performance (ground and flight)
3.1.7.2.2	Personnel transport	3.1.1.1	Flight envelope
3.1.7.2.2	Personnel transport	3.1.1.1.1	Aerial refueling envelope
3.1.7.2.2	Personnel transport	3.1.1.2	Ground performance
3.1.7.2.2	Personnel transport	3.1.2	Mission profile(s) performance
3.1.7.2.2	Personnel transport	3.1.3	Mission planning
3.1.7.2.2	Personnel transport	3.1.9.2	Integrated earth/space reference accuracy
3.1.7.2.2	Personnel transport	3.3.6.2	Marking of cargo compartments
3.1.7.2.2	Personnel transport	3.4.3.3.1	Passenger accommodation
3.1.7.2.2	Personnel transport	3.4.3.3.2	Passenger ingress/egress and escape
3.1.7.2.2	Personnel transport	3.4.3.3.3	Passenger crashworthiness and survival
3.1.7.2.2	Personnel transport	3.4.5.1	Cargo handling
3.1.7.2.2	Personnel transport	3.4.5.2	Cargo weight and balance
3.1.7.2.2	Personnel transport	3.4.8	Ship compatibility
3.1.7.2.2	Personnel transport	3.4.10	Furnishings
3.1.7.3	Reconnaissance/ surveillance	3.1.1	Point performance (ground and flight)
3.1.7.3	Reconnaissance/ surveillance	3.1.2	Mission profile(s) performance
3.1.7.3	Reconnaissance/ surveillance	3.1.3	Mission planning
3.1.7.3	Reconnaissance/ surveillance	3.1.7	Communication, radio navigation, and identification
3.1.7.3	Reconnaissance/ surveillance	3.1.9.2	Integrated earth/space reference accuracy
3.1.7.4	Aerial refueling (tanker)	3.1.1	Point performance (flight and ground)
3.1.7.4	Aerial refueling (tanker)	3.1.1.1.1	Aerial refueling envelope
3.1.7.4	Aerial refueling (tanker)	3.1.2	Mission profile(s) performance
3.1.7.4	Aerial refueling (tanker)	3.1.3	Mission planning
3.1.7.4	Aerial refueling (tanker)	3.1.7	Communication, radio navigation, and identification
3.1.7.4	Aerial refueling (tanker)	3.1.9.2	Integrated earth/space reference accuracy
3.1.7.5	System reach	3.1.1	Point performance (ground and flight)
3.1.7.5	System reach	3.1.1.1	Flight envelope
3.1.7.5	System reach	3.1.1.1.1	Aerial refueling envelope
3.1.7.5	System reach	3.1.2	Mission profile(s) performance
3.1.7.6	Electronic support jamming	3.1.1	Point performance (ground and flight)

Air System		Air Vehicle	
Para #	Title	Para #	Title
3.1.7.6	Electronic support jamming	3.1.1.1	Flight envelope
3.1.7.6	Electronic support jamming	3.1.1.1.1	Aerial refueling envelope
3.1.7.6	Electronic support jamming	3.1.2	Mission profile(s) performance
3.1.7.6	Electronic support jamming	3.1.8	Survivability
3.1.7.6	Electronic support jamming	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.7.6	Electronic support jamming	3.1.8.2.2	Defensive countermeasures
3.1.7.6	Electronic support jamming	3.2.3	Induced environment
3.1.7.6.1	Electronic support jamming effectiveness	3.1.1	Point performance (ground and flight)
3.1.7.6.1	Electronic support jamming effectiveness	3.1.1.1	Flight envelope
3.1.7.6.1	Electronic support jamming effectiveness	3.1.1.1.1	Aerial Refueling Envelope
3.1.7.6.1	Electronic support jamming effectiveness	3.1.2	Mission profile(s) performance
3.1.7.6.1	Electronic support jamming effectiveness	3.1.8	Survivability
3.1.7.6.1	Electronic support jamming effectiveness	3.1.8.2.1	Threat detection, identification, prioritization, awareness, and response
3.1.7.6.1	Electronic support jamming effectiveness	3.1.8.2.2	Defensive countermeasures
3.1.7.6.1	Electronic support jamming effectiveness	3.2.3	Induced environment
3.1.7.7	Search and rescue	3.1.1	Point performance (ground and flight)
3.1.7.7	Search and rescue	3.1.1.1	Flight envelope
3.1.7.7	Search and rescue	3.1.1.1.1	Aerial refueling envelope
3.1.7.7	Search and rescue	3.1.2	Mission profile(s) performance
3.1.7.7	Search and rescue	3.4.3.3.1	Passenger accommodation
3.1.7.7	Search and rescue	3.4.3.3.2	Passenger ingress/egress and escape
3.1.7.7	Search and rescue	3.4.5.1	Cargo handling
3.1.7.7	Search and rescue	3.4.8	Ship compatibility
3.1.7.7	Search and rescue	3.4.10	Furnishings
3.1.8	Reserve modes	3.1.10	Reserve modes
3.1.8	Reserve modes	3.3.9	Security
3.1.9	Lower-tier mandated requirements	3.1.11	Lower-tier mandated requirements
3.1.9	Lower-tier mandated requirements	3.3.1	Propulsion
3.1.9	Lower-tier mandated requirements	3.3.1.1	Engine compatibility and installation
3.1.9	Lower-tier mandated requirements	3.3.1.1.1	Air induction system
3.1.9	Lower-tier mandated requirements	3.3.1.1.2	Nozzle and exhaust systems

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.1.9	Lower-tier mandated requirements	3.3.1.2	Air vehicle propulsion control
3.1.9	Lower-tier mandated requirements	3.4.12	Government furnished equipment and directed contractor furnished equipment
3.2	Environment	3.2.1	Electromagnetic environmental effects
3.2	Environment	3.2.2	Natural climate
3.2	Environment	3.2.3	Induced environment
3.2	Environment	3.2.4	Performance limiting environmental conditions
3.3.1.1	System architecture	3.3.3.2	Computer hardware scalability
3.3.1.1	System architecture	3.3.4	Architecture
3.3.1.1.1	Growth	3.3.12	Growth provisions
3.3.1.1.1	Growth	3.3.3.1	Computer hardware reserve capacity
3.3.1.1.1	Growth	3.3.3.2	Computer hardware scalability
3.3.1.1.2	Interchangeability	3.3.2	Interchangeability
3.3.1.2	System service life	3.1.8.2.6.1	Chemical and biological hardening
3.3.1.2	System service life	3.3.5	System usage
3.3.1.2	System service life	3.3.5.1	Service life
3.3.1.2	System service life	3.3.5.1.1	Damage/fault tolerance
3.3.1.2	System service life	3.3.5.1.2	Operation period/inspection
3.3.1.2	System service life	3.3.6.2	Marking of cargo compartments
3.3.1.2	System service life	3.4.3.2.1.6.1	Accessibility
3.3.1.2	System service life	3.4.3.2.1.6.1.1	Mounting, installation and alignment
3.3.1.3	Manpower and personnel	3.1.5	Maintainability
3.3.1.3	Manpower and personnel	3.1.6	Integrated combat turnaround time
3.3.1.3	Manpower and personnel	3.4.3	Human/vehicle interface
3.3.1.3	Manpower and personnel	3.4.3.1.5	Controls and displays
3.3.1.3	Manpower and personnel	3.4.3.1.6	Warnings, cautions and advisories
3.3.1.3	Manpower and personnel	3.4.3.2	Maintainer/vehicle interface
3.3.1.3	Manpower and personnel	3.4.3.2.1	Air vehicle states
3.3.1.3	Manpower and personnel	3.4.3.2.1.2	Air vehicle stabilization
3.3.1.3	Manpower and personnel	3.4.3.2.1.4	Diagnostic function interface
3.3.1.3	Manpower and personnel	3.4.3.2.1.4.1	Power-off transition
3.3.1.3	Manpower and personnel	3.4.3.2.1.4.2	Power-on transition
3.3.1.3	Manpower and personnel	3.4.3.2.1.4.3	Servicing indications
3.3.1.3	Manpower and personnel	3.4.3.2.1.5	Servicing interfaces
3.3.1.3	Manpower and personnel	3.4.3.2.1.5.1	Stores loading
3.3.1.3	Manpower and personnel	3.4.3.2.1.5.2	Certifying the air vehicle for flight
3.3.1.3	Manpower and personnel	3.4.3.2.1.6.1.1	Mounting, installation and alignment
3.3.1.3	Manpower and personnel	3.4.3.2.1.6.1.2	Adjustment controls
3.3.1.3	Manpower and personnel	3.4.3.2.1.6.1.3	Weight, lift and carry limitations and identification
3.3.1.4	Asset identification	3.3.6.1	Asset identification
3.3.2	Diagnostics	3.3.7	Diagnostics and health management
3.3.2	Diagnostics	3.3.7.1	Diagnostics fault detection and fault isolation

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.3.2	Diagnostics	3.3.8.2	Crash recording
3.3.2	Diagnostics	3.4.3.2.1.4	Diagnostic function interface
3.3.2	Diagnostics	3.4.3.2.1.4.1	Power-off transition
3.3.2	Diagnostics	3.4.3.2.1.4.2	Power-on transition
3.3.2	Diagnostics	3.4.3.2.1.4.3	Servicing indications
3.3.2	Diagnostics	3.4.3.2.1.5.1	Stores loading
3.3.2	Diagnostics	3.4.3.2.1.5.2	Certifying the air vehicle for flight
3.3.3	Nuclear surety	3.4.1.1.1	Nuclear weapon interface
3.3.4	Electromagnetic environmental effects (E^3)	3.2.1	Electromagnetic environmental effects
3.3.5	System security	3.3.9	Security
3.3.5	System security	3.4.3.2.1.3	Maintainer/vehicle interface authorization
3.3.5	System security	3.4.3.2.1.4.1	Power-off transition
3.3.5	System security	3.4.3.2.1.4.2	Power-on transition
3.3.6	System safety	3.1.4	Reliability
3.3.6	System safety	3.3.10	Safety
3.3.6	System safety	3.3.10.1	Air vehicle noncombat loss rate
3.3.6	System safety	3.3.10.1.1	Fire and explosion protection
3.3.6	System safety	3.3.10.2.1	Crash worthiness
3.3.6	System safety	3.3.10.2.2	Energetics
3.3.6	System safety	3.3.11	Flying qualities
3.3.6	System safety	3.3.11.1.1	Primary requirements for air vehicle states in common atmospheric conditions
3.3.6	System safety	3.3.11.1.1.1	Allowable levels for air vehicle normal states
3.3.6	System safety	3.3.11.1.1.2	Allowable levels for air vehicle extreme states
3.3.6	System safety	3.3.11.1.1.3	Primary requirements for failure states
3.3.6	System safety	3.3.11.1.1.3.1	Probability of encountering degraded levels of flying qualities due to failures while operating within the ROSH or ROTH
3.3.6	System safety	3.3.11.1.1.3.2	Allowable levels for specific air vehicle failure states
3.3.6	System safety	3.3.11.1.1.3.3	Failures outside the ROTH
3.3.6	System safety	3.3.11.1.2	Flying qualities degradation in atmospheric disturbances
3.3.6	System safety	3.3.11.1.3	Control margins
3.3.6	System safety	3.3.5.1.1	Damage/fault tolerance
3.3.6	System safety	3.3.5.1.2	Operation period/inspection
3.3.6	System safety	3.3.6.2	Marking of cargo compartments
3.3.6	System safety	3.3.7	Diagnostics and health management
3.3.6	System safety	3.3.7.1	Diagnostics fault detection and fault isolation

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.3.6	System safety	3.4.1.2	Weapon and store loadouts
3.3.6	System safety	3.4.1.3	Gun interface
3.3.6	System safety	3.4.3.2.1.3	Maintainer/vehicle interface authorization
3.3.6	System safety	3.4.3.2.1.4.1	Power-off transition
3.3.6	System safety	3.4.3.2.1.4.2	Power-on transition
3.3.6	System safety	3.4.3.2.1.4.3	Servicing indications
3.3.6	System safety	3.4.3.2.1.5.1	Stores loading
3.3.6	System safety	3.4.3.2.1.5.2	Certifying the air vehicle for flight
3.3.6	System safety	3.4.3.2.1.6.1.1	Mounting, installation and alignment
3.3.6	System safety	3.4.3.2.1.6.1.2	Adjustment controls
3.3.6	System safety	3.4.3.2.1.6.1.3	Weight, lift and carry limitations and identification
3.3.6	System safety	3.4.5.1	Cargo handling
3.3.6	System safety	3.4.5.2	Cargo weight and balance
3.3.6	System safety	3.4.8.1	Shipboard tipback and turnover
3.3.7	Stores/weapons	3.1.2.2.1	Weapons delivery
3.3.7	Stores/weapons	3.1.8.1.1.1	Radar cross section
3.3.7	Stores/weapons	3.1.8.1.1.2	Infrared signature
3.3.7	Stores/weapons	3.1.8.1.1.3	Visual signature
3.3.7	Stores/weapons	3.1.8.1.1.5	Emission control
3.3.7	Stores/weapons	3.1.9.1	Target detection, track, identification, and designation
3.3.7	Stores/weapons	3.1.9.1.1	Multiple target track and weapon delivery support
3.3.7	Stores/weapons	3.1.9.3	Air-to-surface accuracy
3.3.7	Stores/weapons	3.1.9.4	Weapon and store selection and release control
3.3.7	Stores/weapons	3.1.9.5	Gun accuracy and control
3.3.7	Stores/weapons	3.3.10.2.2	Energetics
3.3.7	Stores/weapons	3.4.1.1	Store interface
3.3.7	Stores/weapons	3.4.1.1.1	Nuclear weapon interface
3.3.7	Stores/weapons	3.4.1.1.2	Standard electrical interface
3.3.7	Stores/weapons	3.4.1.1.3	Store alignment
3.3.7	Stores/weapons	3.4.1.1.4	Ejector unit cartridges
3.3.7	Stores/weapons	3.4.1.2	Weapon and store loadouts
3.3.7	Stores/weapons	3.4.1.3	Gun interface
3.3.8	System usage information collection and retrieval	3.1.7	Communication, radio navigation, and identification
3.3.8	System usage information collection and retrieval	3.3.7	Diagnostics and health management
3.3.8	System usage information collection and retrieval	3.3.7.1	Diagnostics fault detection and fault isolation
3.3.8	System usage information collection and retrieval	3.3.8.1	Information collection

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.3.8	System usage information collection and retrieval	3.3.8.2	Crash recording
3.3.8	System usage information collection and retrieval	3.3.9	Security
3.3.8	System usage information collection and retrieval	3.4.3.2.1.5.2	Certifying the air vehicle for flight
3.3.9	Human systems	3.1.8.2.6.2	Chemical and biological personnel protection
3.3.9	Human systems	3.1.8.2.6.3	Chemical and biological decontamination
3.3.9	Human systems	3.3.10.2.2	Energetics
3.3.9	Human systems	3.3.11	Flying qualities,
3.3.9	Human systems	3.3.11.1.1	Primary requirements for air vehicle states in common atmospheric conditions
3.3.9	Human systems	3.3.11.1.1.1	Allowable levels for air vehicle normal states
3.3.9	Human systems	3.3.11.1.1.2	Allowable levels for air vehicle extreme states
3.3.9	Human systems	3.3.11.1.1.3	Primary requirements for failure states
3.3.9	Human systems	3.3.11.1.1.3.1	Probability of encountering degraded levels of flying qualities due to failures while operating within the ROSH or ROTH
3.3.9	Human systems	3.3.11.1.1.3.2	Allowable levels for specific air vehicle failure states
3.3.9	Human systems	3.3.11.1.1.3.3	Failures outside the ROTH
3.3.9	Human systems	3.3.11.1.2	Flying qualities degradation in atmospheric disturbances
3.3.9	Human systems	3.3.11.1.3	Control margins
3.3.9	Human systems	3.4.1.3	Gun interface
3.3.9	Human systems	3.4.10	Furnishings
3.3.9	Human systems	3.4.3	Human/vehicle interface
3.3.9	Human systems	3.4.3.1.1	Aircrew anthropometrics
3.3.9	Human systems	3.4.3.1.2	Aircrew ingress/egress
3.3.9	Human systems	3.4.3.1.3	Emergency escape
3.3.9	Human systems	3.4.3.1.4	Aircrew survival and rescue
3.3.9	Human systems	3.4.3.1.5	Controls and displays
3.3.9	Human systems	3.4.3.1.6	Warnings, cautions and advisories
3.3.9	Human systems	3.4.3.1.7	Interior vision
3.3.9	Human systems	3.4.3.1.8	Exterior vision
3.3.9	Human systems	3.4.3.2	Maintainer/vehicle interface
3.3.9	Human systems	3.4.3.2.1	Air vehicle states
3.3.9	Human systems	3.4.3.2.1.1	Maintainer/aircrew communication
3.3.9	Human systems	3.4.3.2.1.2	Air vehicle stabilization
3.3.9	Human systems	3.4.3.2.1.4	Diagnostic function interface

Air System		Air Vehicle	
Para #	**Title**	**Para #**	**Title**
3.3.9	Human systems	3.4.3.2.1.4.1	Power-off transition
3.3.9	Human systems	3.4.3.2.1.4.2	Power-on transition
3.3.9	Human systems	3.4.3.2.1.4.3	Servicing indications
3.3.9	Human systems	3.4.3.2.1.5	Servicing interfaces
3.3.9	Human systems	3.4.3.2.1.5.1	Stores loading
3.3.9	Human systems	3.4.3.2.1.5.2	Certifying the air vehicle for flight
3.3.9	Human systems	3.4.3.2.1.6.1	Accessibility
3.3.9	Human systems	3.4.3.2.1.6.1.1	Mounting, installation and alignment
3.3.9	Human systems	3.4.3.2.1.6.1.2	Adjustment controls
3.3.9	Human systems	3.4.3.2.1.6.1.3	Weight, lift and carry limitations and identification
3.3.9	Human systems	3.4.5.1	Cargo handling
3.3.10	Basic modes of operation	3.1.2	Mission profile(s) performance
3.3.10	Basic modes of operation	3.1.3	Mission planning
3.3.10	Basic modes of operation	3.1.5	Maintainability
3.3.10	Basic modes of operation	3.1.6	Integrated combat turnaround time
3.3.10	Basic modes of operation	3.1.7	Communication, radio navigation, and identification
3.3.10	Basic modes of operation	3.1.8.1.1.5	Emission control
3.3.10	Basic modes of operation	3.3.7	Diagnostics and health management
3.3.10	Basic modes of operation	3.3.8.1	Information collection
3.3.10	Basic modes of operation	3.3.9	Security
3.3.10	Basic modes of operation	3.4.3.2	Maintainer/vehicle interface
3.3.10	Basic modes of operation	3.4.9	Support equipment interfaces
3.4	Interfaces	3.1.3	Mission planning
3.4	Interfaces	3.1.7	Communication, radio navigation, and identification
3.4	Interfaces	3.4.2	Communication, radio navigation, and identification interfaces
3.4	Interfaces	3.4.4	Transportability
3.4	Interfaces	3.4.6.1.1	Ground refueling interfaces
3.4	Interfaces	3.4.6.1.2	Defueling interfaces
3.4	Interfaces	3.4.6.2.1	Receiver interfaces
3.4	Interfaces	3.4.6.2.2	Tanker interfaces
3.4	Interfaces	3.4.8	Ship compatibility
3.4	Interfaces	3.4.8.1	Shipboard tipback and turnover
3.4	Interfaces	3.4.9	Support equipment interfaces
3.4	Interfaces	3.4.10	Furnishings
3.4	Interfaces	3.4.11.1	Primary fuel
3.4	Interfaces	3.4.11.2	Alternate fuel
3.4	Interfaces	3.4.11.3	Restricted fuel
3.4	Interfaces	3.4.11.4	Emergency fuel
3.4	Interfaces	3.4.12	Government furnished equipment and directed contractor furnished equipment
3.4.1	Supply support	3.3.2	Interchangeability

Air System		Air Vehicle	
Para #	Title	Para #	Title
3.4.1	Supply support	3.3.5.1	Service life
3.4.1	Supply support	3.3.5.1.2	Operation period/inspection
3.4.1	Supply support	3.3.6.1	Asset identification
3.4.1	Supply support	3.3.7	Diagnostics and health management
3.4.1	Supply support	3.3.7.1	Diagnostics fault detection and fault isolation
3.4.1	Supply support	3.4.10	Furnishings
3.4.1	Supply support	3.4.12	Government furnished equipment and directed contractor furnished equipment
3.4.1	Supply support	3.4.3.1.1	Aircrew anthropometrics
3.4.1	Supply support	3.6	Logistics support
3.4.1	Supply support	3.8	Disposal
3.4.2	Facility interfaces	3.4.7	Facility interfaces
3.4.3	Common support equipment	3.1.6	Integrated combat turnaround time
3.4.3	Common support equipment	3.4.9	Support equipment interface
3.5	Manufacturing	3.5	Manufacturing
3.6.1	Maintenance concept	3.1.5	Maintainability
3.6.1	Maintenance concept	3.4.9	Support equipment interface
3.6.2	System capability and procedure information	3.1.4	Reliability
3.6.2	System capability and procedure information	3.1.5	Maintainability
3.6.2	System capability and procedure information	3.3.7	Diagnostics and health management
3.6.2	System capability and procedure information	3.3.7.1	Diagnostics fault detection and fault isolation
3.6.2	System capability and procedure information	3.4.9	Support equipment interface
3.6.2	System capability and procedure information	3.7.1	Embedded training
3.6.3	Protective structures	3.4.7	Facility interfaces
3.6.4	Packaging, handling, storage, and transportation	3.4.4	Transportability
3.6.4	Packaging, handling, storage, and transportation	3.4.4.1	Preparation for transport
3.7.1	Training capability	3.7.1	Embedded training
3.7.2	Training types	3.7.1	Embedded training
3.7.3	On-equipment training	3.7.1	Embedded training
3.8	Disposal	3.8	Disposal

AIR SYSTEM

JOINT SERVICE SPECIFICATION GUIDE

APPENDIX B

REFERENCED DOCUMENTS MATRIX

B.1 SCOPE

B.1.1 Scope.

This appendix is for guidance only. This appendix identifies the documents referenced in this specification guide. It is not intended to be part of a program specification. Rather, it is provided to assist users of the specification guide in developing a program-unique specification by identifying in a single location all the documents referenced in this specification guide. Applicable documents required in a program-unique specification after tailoring this guide specification are to be listed in section 2 of the tailored air system program specification.

B.2 APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

B.3 REFERENCED DOCUMENTS

Table B.3-I lists the documents referenced in the Air System Joint Service Specification Guide in column 1. Column 2 of the table indicates in which paragraphs the documents are referenced. Documents cited in the guidance sections are candidate references that may be cited in sections 3 or 4 of a tailored program-unique specification. It is emphasized that these candidate references are subject to program-specific tailoring. Note that policy documents including, but not limited to, regulations, instructions, and directives, may not be cited as mandatory references in the tailored specification. Nor may guidance documents, such as MIL handbooks, be cited as mandatory.

TABLE B.3-I. Documents referenced in the Air System Joint Service Specification Guide.

Document Title and Date	Reference Location
Air Force Doctrine Document 1, September 1997	3.1.7.3 Requirement Rationale
AFI 63-104 Operational Flight Program	6.1.25 Definition
AFI 63-1001	3.3.1.2 Requirement Guidance
DoD Instruction 5000.2 Operation of the Defense Acquisition System	3.1.1 Guidance 3.3 Requirement Rationale 3.3.1.3 Requirement Rationale

Document Title and Date	Reference Location
Integrated Performance Based Business Environment Guide	6.5 Specification Tree
Joint Pub 1-02, 15 Apr 98	6.3 Definitions
Joint Technical Architecture	3.4 Requirement Guidance
MIL-HDBK 1785 System Security Engineering Program Management Requirements	4.3.5 Verification Discussion
MIL-STD-130 Identification Marking of U.S. Military Property	3.3.1.4 Requirement Guidance
MIL-STD-461Requirements for the control of Electromagnetic Interference Characteristics of Subsystems and Equipment	3.3.4 Requirement Lessons Learned 4.3.4 Verification Lessons Learned
MIL-STD-464 Electromagnetic Environmental Effects Requirements for Systems	3.3.4 Requirement Guidance 3.3.4 Requirement Lessons Learned
MIL-STD 882 System Safety	3.3.6 Requirement Guidance
MIL-STD-1366, Transportability Criteria	3.6.4 Requirement Guidance
MIL-STD-2073-1, DoD Standard Practice for Military Packaging	3.6.4 Requirement Guidance
NAVAIRINST 13120.1, Fixed Wing Aircraft Structural Life Limits	3.3.1.2 Requirement Guidance
NAVAIRINST 13130.1, Rotary Wing Aircraft Structural Life Limits	3.3.1.2 Requirement Guidance
Performance Based Product Definition Guide	6.5
“Specifications and Standards - A New Way of Doing Business” SECDEF Memorandum of 29 June 1994	Foreword

AIR SYSTEM

JOINT SERVICE SPECIFICATION GUIDE

APPENDIX C

SYSTEM INTEGRITY CONCEPT

C.1 SCOPE

C.1.1 Scope.

This appendix comprises a discussion of the system integrity concept. This appendix is for guidance only.

C.2 APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

C.3 SYSTEM INTEGRITY CONCEPT DISCUSSION

System integrity is not a performance requirement per se; however, it impacts numerous aeronautical system requirements and their verification. It is an overarching expectation that performance will be achieved and sustained for a period of time without corrective action; and that when the performance does degrade below minimums, it can be restored by corrective action. Examples include an engine that would continue to provide its minimum rated thrust throughout a given period of usage without maintenance actions, or aircraft structures that continue to provide the necessary strength to allow safe and effective flight throughout its use conditions for a specified period.

System integrity is tied very closely to concepts sometimes expressed as robust systems and robust design. Robust systems are insensitive to the environments experienced throughout the system's life cycle and easily repaired under adverse conditions. Robust design is a system designed such that its performance is insensitive to variations during its manufacturing or in its operational environment–including maintenance, transportation, and storage–and the system continues to perform acceptably throughout its life cycle despite component drift or aging.

A key viewpoint in understanding the implications of a robust approach to system integrity is that a “break” does not simply equate to a failure to operate. Rather, a more stringent perspective is necessary. That is, a “break” occurs when an item no longer provides its required performance. Is the system still usable given such a break? Maybe, but the performance required is no longer being delivered. Thus, operational conditions and tempo may make it necessary to operate at degraded levels, but the warfighter will need to understand the ramifications.

The implications are that system integrity can only be realized via a tightly integrated set of complementary performance expectations and achievements. These include

a. the environments to which the system (and its associated equipment) is exposed,
b. the utilization profiles of the system (and it associated equipment),
c. the relationship between the performance an item must provide and the tolerances to which it must be built,
d. the margin for performance degradation that must be designed into the items to provide the durability needed for cost effective operations and support,
e. the capability of the manufacturing processes to provide products that achieve the requisite performance, and
f. the capability of the maintenance processes to restore the expected performance.

C.3.1 Integrity concept.

Figure C-1 conceptually addresses the problem that a comprehensive approach to system integrity is intended to address. That is, over time, the performance of items changes. Changes may come abruptly, which is frequently the case with electronic parts that tend to operate close to their initial performance and then suddenly cease to function. Changes may also occur gradually, even in electronic components, as aging, stresses and strains, wear, etc. impact the capability of the component to operate at or near its initial performance. The purpose of a comprehensive system integrity approach is to understand how the performance of an item changes with its manufacturing, operating, and support conditions and to plan for it in terms of identifying the most appropriate installed performance expectations, designs, manufacturing processes, maintenance, and sustainment procedures.

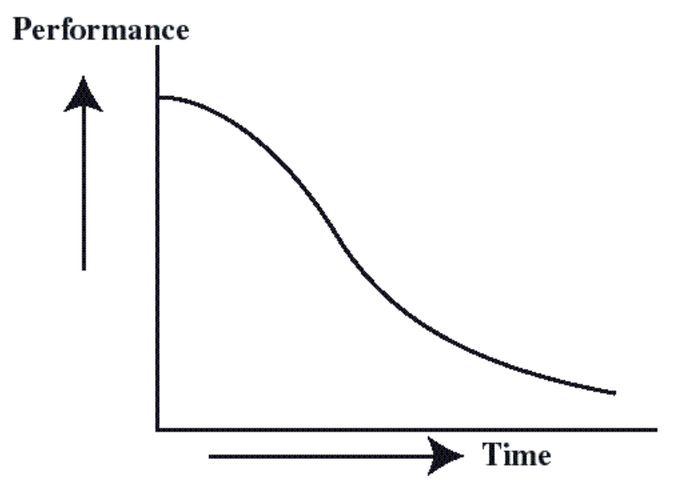


FIGURE C-1. Performance versus time.

The implications of this performance degradation are illustrated in Figure C-2. The performance required is the minimum performance expected (Pr) over some period of time (Tu). After that time, the performance may degrade to unacceptable levels. As a result, a performance margin (Pm) must be established and

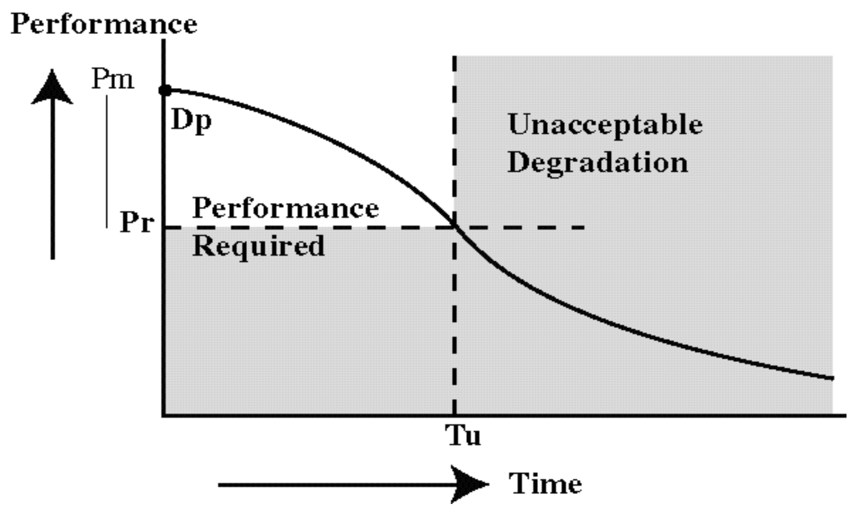


FIGURE C-2. Required performance and unacceptable degradation.

designed to (Dp) if the item is expected to maintain the minimum performance over a given time period. Thus, the performance values selected for use in a specification represent the minimum performance that is acceptable (Pr) with verifications that confirm that adequate performance margins (Pm) have been established to maintain that minimum performance (Pr) throughout the given time period Tu).

If the expected period of use needs to be longer (for example as a result of design trades, performance reallocations, cost impacts etc), the performance margin (and the resulting design point) must also increase to ensure the performance the item delivers meets or exceeds the minimum performance required over that extended time, as illustrated in Figure C-3. In establishing a design point, it becomes essential to understand how the performance of an item changes with time and the time interval over which that minimum performance must be realized without corrective action. Care must be taken, frequently in concert with the warfighter, not to change the time interval arbitrarily. Once the design margins are set (even well advanced in definition) changing the duration of a period of "no corrective actions" can result in significant redesign and even reallocation of performance requirements. The warfighter may, at his discretion, choose to operate the item beyond its design limits. Agreement must be reached early enough in development so that cost-effective design points can be established with the understanding that the item may not provide the minimum performance required if it is operated beyond the durations established.

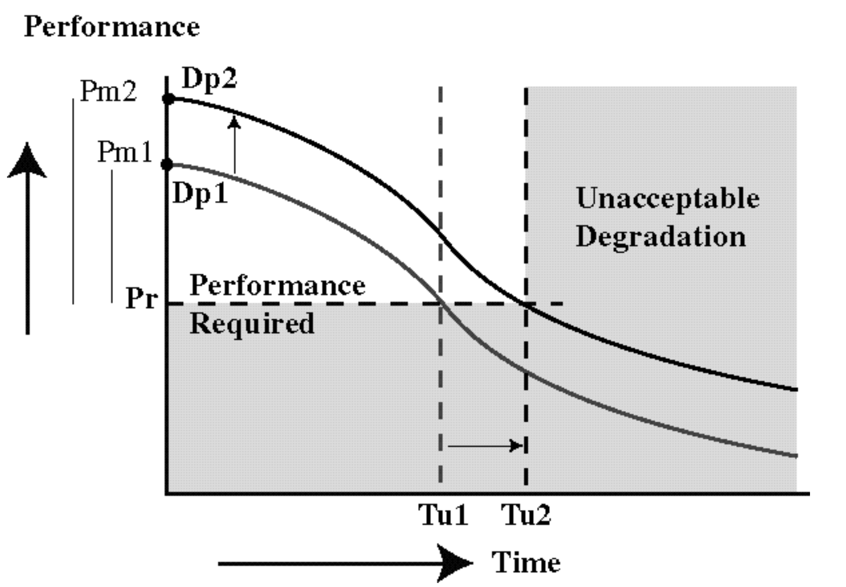


FIGURE C-3. Extending the time period.

Some items may only experience degradation when they are used. Other items may exhibit the majority of their degradation not from time in a given state, but rather from the number of times they are turned on and off (for example electrical equipment) or the number of times they are cycled from a lower to higher power state (such as engines). Other items may exhibit degradation simply from storage (for example batteries, some propellants etc). Thus an understanding must be gained of both the use and non-usage conditions and their impact on the item's performance.

Unfortunately, performance degradation is not the only factor that must be addressed to establish a design point. For example, manufacturing process variation (Figure C-4) adds margins that must be considered. Larger design margins need to be allocated for manufacturing processes that exhibit a wide range of variability than for those that exhibit a narrower range, illustrated as the difference between two manufacturing processes. As a result, contractors with more capable processes may be able to design and build the product at less expense than those with less capable processes.

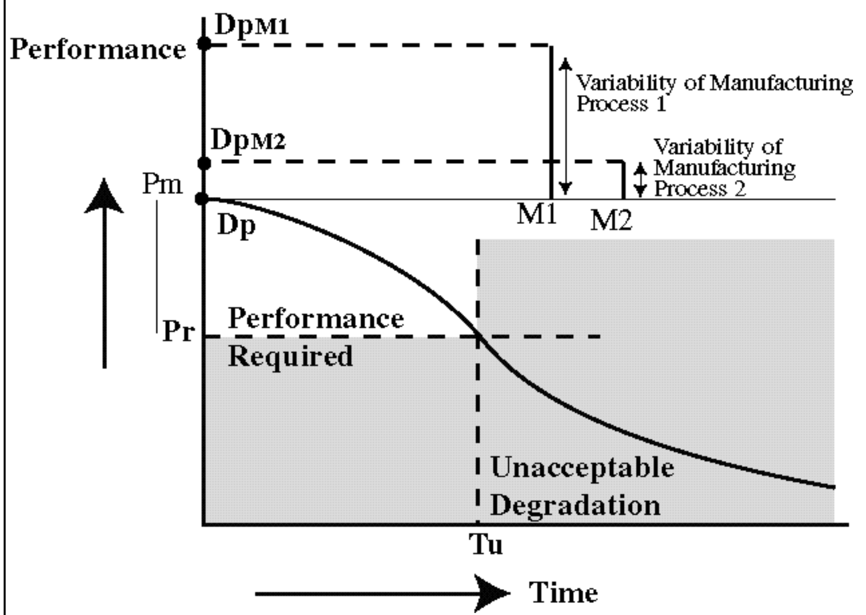


FIGURE C-4. Manufacturing impacts.

In either case, however, the contractor must understand the capability of his processes. This is one reason to establish the performance expected and the duration for which it is expected rather than to specify an arbitrarily higher expected performance.

Another factor is the impact of materials (nominally illustrated in Figure C-5). Some materials can be more wear tolerant than others and exhibit less performance degradation over a given period, thus resulting in an ability to lower the performance margin and a change in the design point from Dp1 to Dp2. Alternatively, this figure could also be representative of a different design that is more tolerant of the environments experienced by the item.

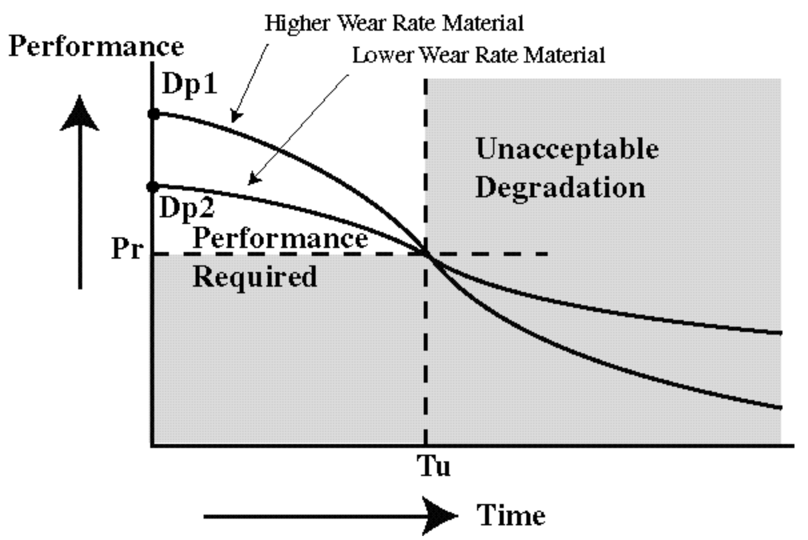


FIGURE C-5. Material impacts.

The support environment and impacts on the support system must also be incorporated. What happens when performance eventually degrades below the performance required? It will be necessary to ensure that performance maintenance procedures are devised to recover the performance such as that illustrated in Figure C-6. Thus, planned maintenance actions need to be part of the system design to keep the required performance at acceptable levels (e.g., changing a battery at a scheduled time).

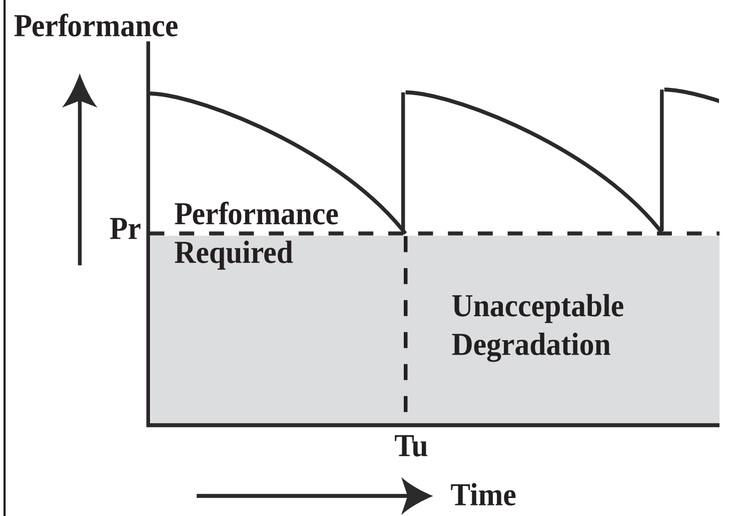


FIGURE C-6. Performance maintenance.

Other parameters should (must?) be considered as well. These may include additional performance margins to handle variations in or margins needed to compensate for

a. crew capabilities,
b. operating conditions,
c. item criticality to mission success or safety,
d. the degree of certainty in performance variation versus time
e. time windows to schedule/perform performance maintenance (e.g., how good was the estimate of when performance maintenance needed to be conducted)

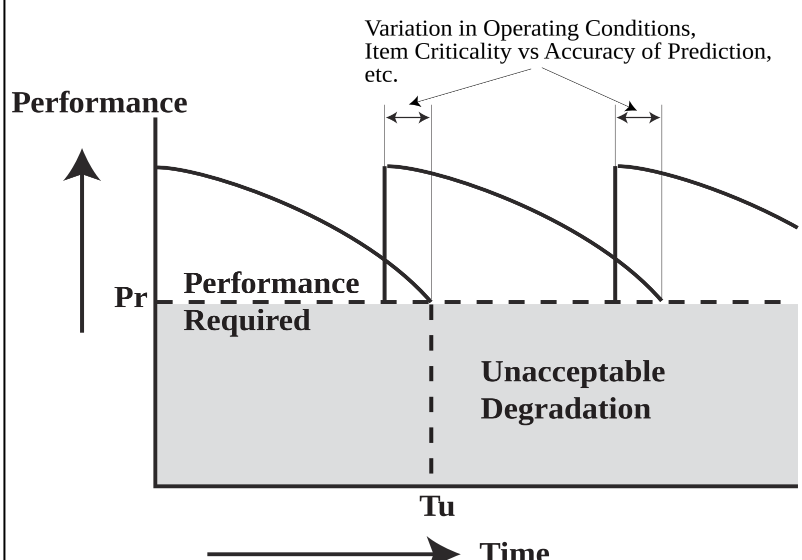


FIGURE C-7. Performance maintenance margins.

While methods of handling uncertainty in the estimation of when to conduct performance maintenance include providing an additional performance margin or to shorten the interval between periodically recurring performance maintenance actions, these may not prove to be the most cost-effective methods. They may work well when the uncertainty in Tu is small and/or the cost of additional performance margin is minimal. However, they may not be suitable when variations in operational conditions, material wear rates and characteristics, and other factors result in significant variation in performance versus time. In these circumstances, inspections, planned as part of maintenance activities and included in the system design, may prove to be of benefit.

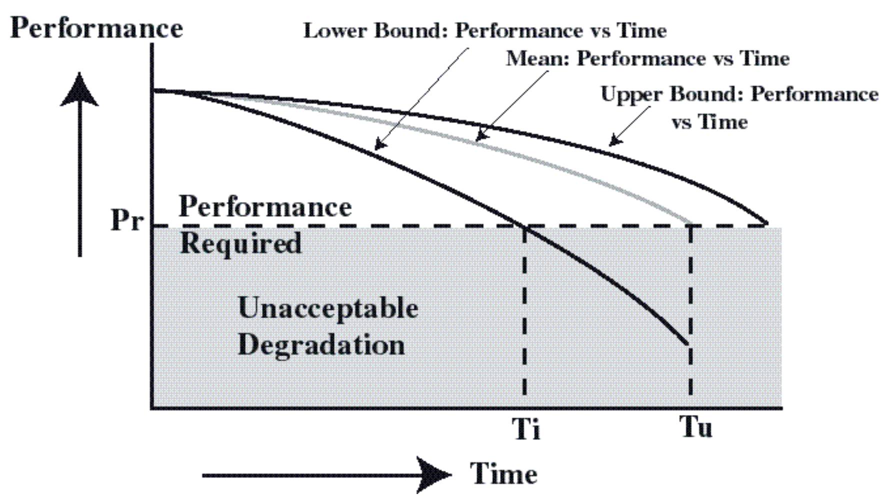


FIGURE C-8. Performance vs time uncertainty.

If a suitable performance versus time relationship can be determined such that an item will be known to exceed its minimum required performance with a high degree of certainty for some known period, inspections can be scheduled to examine the item prior to the point at which performance variation results in a significant likelihood of failure to achieve required performance. Such a relationship is depicted in Figure C-8. Note that, while the mean value of the performance vs. time relationship shows a “long” Tu, the lower boundary (confidence limits need to be established) of the performance vs. time relationship indicates a significant probability (significance would be based on the confidence limits used) that the item would fail to provide the required performance at some time, Ti. Inspections could be scheduled prior to Ti. If such inspections revealed that the item was operating near the upper boundary, an option would be to take no further action. If the item were operating below the mean, it may be time for performance maintenance actions. The decisions on what action to take would depend on the performance as inspected, its relationship to the performance variation curves, and the time interval between the inspection point and an estimate of when the performance provided will no longer exceed the minimum required.

From a design solution perspective, there are numerous alternatives to implementing a system integrity approach. These include

a. Establishing an interval (Tu) at which time performance maintenance will be performed.
b. Establishing performance margins to control when Tu occurs and ensuring such margins incorporate impacts of material wear, aging, operational variation, manufacturing process variation, uncertainty in estimating Tu, etc.
c. Inspecting item performance at interval Ti, at which point it is known with a high degree of certainty that item performance meets or exceeds the performance required.
d. Tracking item performance over time (flight history information), and using that information as the trigger point for performance maintenance and to provide "measured" data to refine the performance versus time curves.
e. Incorporating diagnostics that signal when performance has degraded below an established threshold (the performance required, Pr, or some margin above it).
f. Etc.

The determining factor on what combination of approaches is appropriate can be driven by

a. Requirements such as system life cycle and safety
b. Cost-benefit of inspection versus planned remove, replace and refurbish or throw away
c. Cost-benefit of implementing diagnostics or tracking flight history information
d. Etc.

Regardless of the way performance degradation is addressed in the design, our job is to state what is expected (performance required over a given duration) and then verify that all pertinent factors were addressed in the design. These factors include the planned (expected) utilization of items, the characteristics of parts/materials and their relationship to an item's performance, maintenance concepts, component/material wear characteristics versus utilization, the environments in which items are used, the support structure etc. Further, these factors must be sufficiently understood, documented, and accounted for in order to enable the needed planning for cost-effective performance maintenance.

Under the performance-based business environment concept, there are additional factors to consider. For example, procurement of replacement parts/items using approaches such as f^3i (form, fit, function, and interface) or a MBTP (modified build to print - where the contractor is given the latitude of using his own production processes rather than those used in the original design and manufacturing). In principle, both reprocurement approaches are backed by sufficient data. The reality may be somewhat different.

With the MBTP approach, the risk lies in adequate characterization of the original manufacturing processes and incorporating that information accurately in the design package as a requirement to meet. These risks may be small. On the other hand, the F^3I relies on having a complete and accurate characterization of all the product characteristics that *significantly* affect the item's performance. The ability to ensure such characterization is where the risk lies. This risk can be mitigated by ensuring that a comprehensive, as installed, full cycle (i.e., complete verification using all the criteria employed in the original incremental verifications used to confirm that required performance would be achieved throughout EMD). This can get very expensive–so expensive that it can preclude employment of the approach.

A strategy to mitigate the risks is necessary. One method to decrease the overall costs could involve being more thorough with parts/items that are mission- or safety-critical and less thorough with other parts/items. Still, the dilemma remains as to "how thorough" verifications need to be to establish that sufficient verification has been accomplished. While there are no easy answers, handling this situation as a risk with emphasis on consequences of failure can redress some of the problems. For example, is the consequence of failure loss of life or is it simple injury? Is the consequence inability to detect a target or is it mission survival? Considering these factors may provide some relief on the thoroughness of the verifications needed. Some level of risks to be accepted may need to be addressed in reprocurement actions. These types of issues tend to provide a strong argument for tracking supplier capability (capability as evidenced by the consistent quality of his products) and using this information in selecting appropriate reprocurement sources.

Custodians:
Army - AV
Navy - AS
Air Force - 11

Preparing Activity:
Air Force - 11

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