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MILITARY HANDBOOK

AVIONICS/ELECTRONICS INTEGRITY

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AMSC: N/A AREA: 15GP

FORWARD

This military handbook is approved for use by the Department of the Air Force and is available for use by all Departments and Agencies of the Department of Defense.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: ASC/ENSI, 2335 Seventh Street, Suite 6, Wright-Patterson Air Force Base, Ohio 45433-7809 using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

The Air Force first established the Avionics/Electronics Integrity Process (AVIP) in the mid-1980s as a "reliability by design" approach to improve electronic products used in military applications. This version of AVIP is a guidance handbook that continues to emphasize reliability by design but now includes linkages to related systems engineering areas and experience from recent programs, program studies, related initiatives, and the latest concepts in integrated product development (IPD). These have contributed to many AVIP updates that offer a better understanding of electronic design, manufacturing, operation, and support. AVIP has evolved to a logical and disciplined systems engineering approach to requirements definition, development, and production of avionics and other electronic products. AVIP defines life, usage, environment, and supportability requirements and process tasks to achieve required performance over the life of the electronics. AVIP employs basic physics, chemistry, and engineering principles to ensure an understanding of the influences of the usage and environments on materials and parts. AVIP also focuses on key product and process characteristics and control of variability of materials, parts and processes.

This document reflects ASC implementation of Department of Defense (DoD) acquisition streamlining initiatives. In concert with the DoD initiatives, this handbook provide performance requirement and process guidance which must be tailored to individual program needs and which promotes innovative design solutions by the contractors. The comprehensive requirement guidance provided is to be used when developing performance based specifications and the process task guidance is to be used in statements of work and other contractual documents. Suggested performance requirement statements are provided with blanks for key parameters which are to be extracted and completed by the government and/or contractor. Rationale, guidance, and lessons learned are provided to aid in this tailoring process. The stated requirements and process tasks, when tailored and applied with other related specifications and handbooks, provide high confidence that the electronic product will function in its intended usage over its life. AVIP is to be used in conjunction with other guides to execute a balanced systems engineering process and to foster an engineering and manufacturing climate that is consistent with IPD concepts.

Substantial changes have been made from the previous edition of AVIP. Performance requirements have been changed to better track user needs, related documents are referenced to avoid duplication, and the format is user friendly. The document has been divided into a handbook and three appendices:

- Appendix A which provides process task guidance on AVIP and AVIP related areas,
- Appendix B which provides examples for translating typical user supportability requirements to AVIP performance requirements, and
- Appendix C which provides a sample specification for avionics/electronics integrity.

FORWARD – Continued

The incorporation of the avionics/electronics integrity philosophy into an integrated engineering and manufacturing process supports the following:

a. Understanding and defining product life requirements.

b. Understanding and defining how and where the equipment will be operated and maintained and the associated environments.

c. Understanding and defining user supportability requirements and constraints.

d. Understanding materials, processes and technologies to include properties, life limits and variabilities.

e. Understanding the stresses imposed by the life cycle usage and environments.

f. Establishing product and process design criteria tailored for the specific application.

g. Identifying key product characteristics, design parameters, and production process characteristics and controlling their impact on cost, performance and supportability.

h. Performing iterative analyses, simulations and trade studies to facilitate a balanced design solution.

i. Conducting incremental developmental and qualification testing to verify analyses and design solutions.

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AVIONICS/ELECTRONICS INTEGRITY HANDBOOK

1. SCOPE

This handbook provides rationale, guidance, and lessons learned for specific avionics/electronics applications and parallels the sample performance specification in Appendix C. This handbook describes the Avionics/Electronics Integrity Process (AVIP) and associated performance requirements which should be tailored and incorporated into appropriate contractual documents and the integrated engineering and manufacturing process to achieve integrity of airborne and ground-based electronics. The suggested performance requirements assist in the development of program performance and verification requirements which encompass equipment life, life-cycle uses, environments, and supportability. The AVIP process enhances systems engineering in the design and production of affordable and reliable avionics/electronics. Previous versions have been successfully tailored and applied by large and small acquisition programs.

1.1 Use

This handbook supports government and/or contractor preparation of comprehensive avionics/electronic integrity requirements for specifications for airborne and ground-based electronic subsystems (e.g., radar, navigation, ground power unit, etc.), equipment, modules, and parts. This handbook, with appendices, also supports development of statements of work, systems engineering management plans, schedules, and other program documentation and tasks. This handbook is applicable, when tailored, to concept exploration, demonstration/validation, engineering and manufacturing development, and production program phases. When tailored appropriately, this handbook is also applicable to acquisition of new, existing and modified existing electronics (including equipment referred to as commercial off-the-shelf (COTS) or non-developmental items (NDI). It can be applied to full or limited acquisition and production contracts. The tailored requirements and verifications from sections 30 and 40 should be incorporated directly into other performance based specifications. This handbook is intended to complement guide specifications and handbooks in other specialty areas.

1.2 Format

Section 30 and 40 of this handbook parallel Sections 3 and 4 of the sample specification and paragraph titles and numbering are in the same sequence. Rationale explaining the reason for each requirement, guidance to assist in the development of each requirement, and a collection of relevant lessons learned are provided. Three appendices are also included.

Appendix A provides a description of the Avionics Integrity process concepts which may be tailored by the procuring activity or contractor for incorporation into the integrated product development process. Where appropriate, recommended guidance paragraphs are provided for statements of work, integrated master plans, integrated master schedules, and other program documentation.

Appendix B provides an example for translating typical user reliability and maintainability requirements into requirements recommended by AVIP.

Appendix C provides a sample specification for specific requirements and verifications. It should be tailored based on guidance in the main handbook.

1.2.1 Requirement/verification package

Sections 30 and 40 of this handbook have been so arranged that the requirements and associated verifications represent a complete package to permit addition and/or deletion for specific program application. A requirement is not specified without one or more associated verifications.

1.3 Responsible engineering office

The office responsible for development and technical maintenance of this Handbook is ASC/ENAI, Wright-Patterson AFB, Ohio. Request for additional information or technical assistance on this Handbook can be obtained from Mr. Craig Wall, ASC/ENAI, Wright-Patterson AFB, OH 45433-7630 (commercial phone number: 513-255-4463, DSN 785-4463, or FAX: 513-255-3466). Any information required relating to Government contracts must be obtained through the contracting officer.

2 REFERENCE DOCUMENTS

Documents cited herein are intended to provide supplemental technical data and guidance. Documents referenced in this handbook should be tailored before contractual use. The documents are listed here to provide guidance for developing requirements for specification sections 3 and 4 and program tasking. Section 2, of the contractual specification, should list all documents required for the program. DoD is currently implementing new policy to minimize use of military specifications and standards. Programs should verify status of all the documents listed and/or cited herein before applying them or referencing them in contracts.

2.1 Government documents

Unless otherwise indicated, the documents specified herein are referenced solely to provide supplemental technical guidance.

SPECIFICATIONS

MIL-D-12468	Decontaminating Agent
MIL-D-50030	Decontaminating Agent, D2

STANDARDS

MIL-STD-21 0	Climatic Extremes for Military Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-470	Maintainability Program Requirements For Systems and Equipments
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1629	Procedures for Performing a Failure Mode, Effects & Criticality Analysis
DoD-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-STD-1757	Lightning Qualification Test Techniques for Aerospace Vehicles and Hardware
MIL-STD-1795	Lightning Protection of Aerospace Vehicles and Hardware
MIL-STD-1800	Human Engineering Performance Requirements for Systems
MIL-STD-1814	Integrated Diagnostics
MIL-STD-1818	Electromagnetic Effects Requirements for Systems
MIL-STD-2165	Testability Program for Electronic Systems and Equipments
MIL-STD-2218	Thermal Design, Analysis, and Test Procedures for Airborne Electronic Equipment

HANDBOOKS

DoD-HDBK-263	Electrostatic Discharge Control, Handbook For Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

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

2.2 Other Government documents
Unless otherwise indicated, the documents specified herein are referenced solely to provide supplemental technical information and data.

NAVMAT P 4855-2

RADC-TR-82-189

(Application for copies should be addressed to ASC/ENAI, Wright-Patterson AFB, OH 45433-7630).

2.3 Order of precedence
In the event of conflict between the text of this handbook and the references cited herein, the text of this handbook should take precedence. Nothing in this handbook, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

REQUIREMENTS
The following subparagraphs carry the same numerical identification and title as the paragraphs and subparagraphs detailed in the sample specification contained in Appendix C.

VERIFICATIONS
The following subparagraphs carry the same numerical identification and title as the paragraphs and subparagraphs detailed in the sample specification contained in Appendix C.

3 REQUIREMENTS FOR AVIONICS/ELECTRONICS INTEGRITY
The electronic subsystem and/or equipment shall provide full required performance when exposed to the actual usage and environments over its life. Specific criteria shall be developed for durability/economic life, usage, environments, and supportability requirements as outlined in the following paragraphs.

REQUIREMENT RATIONALE (3)

This requirement is intended to ensure the equipment is designed with the capacity to meet full performance over it's anticipated life cycle while being economically maintained within the stated supportability constraints.

REQUIREMENT GUIDANCE (3)

This section of the guide specification introduces the tailorable performance and associated verification requirements needed in the contract requirements documents to achieve integrity of airborne and ground-based electronics. The performance requirement above introduces the primary integrity concepts related to usage and environments, durability/economic life, and supportability. See the following subparagraphs for performance requirements related to these primary integrity areas and guidance on tailoring the requirements.

REQUIREMENT LESSONS LEARNED (3)

Highly successful programs meeting customer expectations have balanced cost, performance, and supportability. These programs have generally been ones with disciplined integrated design and manufacturing processes requiring early involvement of the user and manufacturing team members in design decisions. Through this involvement, (1) all aspects of equipment use, (2) exposure to various physical and climatic environments over the durability/economic life, and (3) manufacturing or production risk and process capability were properly considered. Programs unfortunately not applying the same level of discipline, integration, and integrity have experienced varying degrees of success meeting all cost, performance, production, and supportability requirements in a timely and cost effective manner.

4. VERIFICATION OF AVIONICS/ELECTRONICS INTEGRITY

VERIFICATION RATIONALE (4)

To ensure the integrity requirements are being met during the design process, incremental verification is required. Specific details of the verification process are contained in the paragraphs below.

VERIFICATION GUIDANCE (4)

The verification of the avionics/electronics integrity should be accomplished incrementally through analysis, inspections, demonstrations, and tests. Incremental verification should be part of section 4 of development specifications and reflected in the integrated master plan and schedule. A matrix of requirements vs. verification method and program milestone is recommended. The method should reflect the maturity of the design. A notional EMD matrix for durability/economic life is illustrated below. For verification method, A = analysis, T = test (e.g., component, assembly), and QT = formal qualification.

	REQUIREMENT		VERIFICATION/MILESTONE		
			PDR	CDR	FCA
3.1	Durability/Economic Life	4.1	A	A/T	QT

Figure 1. <u>Notional EMD matrix for durability/economic life</u>.

See paragraphs below for specific requirement guidance.

LESSONS LEARNED (4)

Many programs have delayed verification of product capability until the formal qualification test. Problems found that late in the program can be costly to correct and difficult to balance in the total design. In fact, this late in the program schedule some design changes are forced into the software to compensate for hardware problems that are too costly to solve through hardware redesign. AVIP emphasizes incremental verification of all requirements through selective analysis, inspections, demonstrations, and early tests (e.g., engineering development tests (e.g., small scale, coupon, material characterization) and early prototype tests) to allow time for correction before it is too late to modify the design in a timely and cost effective manner. This approach thereby avoids the schedule slips due to numerous redesign loops after the final design has been committed to production and minimizes expensive retrofit of production units.

3.1 Durability/Economic Life Requirements
The durability/economic life of the ___1____ subsystem and/or item (specify) shall be ____2___ years (list each item with its corresponding life). The ____3____ shall meet performance requirements in ____4___ over the durability/economic life during and/or after exposure to the usage and environments specified in paragraphs 3.2 and 3.3 herein and with maintenance specified in paragraph 3.4.

REQUIREMENT RATIONALE (3.1)

The specification of durability/economic life is intended to ensure the equipment design takes into consideration the capability to satisfy performance, affordability and supportability requirements over the life of the equipment (subsystem) without premature wearout, degradation, or deterioration.

REQUIREMENT GUIDANCE (3.1)

Durability/economic life is the total anticipated period of time during which the avionics/electronics equipment should be used and maintained economically. The durability/economic life should be consistent with the maintenance strategy and reflect a maintenance burden acceptable to the customer. The durability/economic life value must reflect such factors as operating hours, number of thermal cycles, vibration cycles, power on/off cycles, maintenance actions, and environments which result in cumulative environmental stresses during that life. These are factors the equipment is expected to experience in both the factory and the field. Durability/economic life requirements should be allocated down through the assembly, subassembly and component levels to ensure consistency with top level system or equipment durability/economic life or platform service life requirements. If the durability/economic life calculations show an assembly or component is expected to fail before the host or platform equipment durability/economic life, then the life-limiting cause should be designed out when cost effective. Otherwise, the equipment or assembly should be labeled as life-limited and provisions included in maintenance planning and maintenance burden calculations to ensure the necessary logistics support requirements are implemented to support the equipment over its durability/economic life.

Blanks 1 and 3 should contain the name of the equipment being specified. Blank 2 should contain a specific number of years where proper consideration is given to (1) the expected design service life for new systems or remaining service life in existing platform(s) for which the equipment is being developed, (2) the anticipated durability/economic life the user expects for the equipment, and (3) the time before technology obsolescence makes the equipment no longer supportable or equipment performance no longer acceptable. Blank 4 should contain a pointer to performance requirements documentation and any other maintenance requirements documentation,

The durability/economic life requirement analysis, definition, and allocation to the component level should be reviewed at major design reviews to ensure agreement between the user, procuring agency, maintenance organization, and contractor that the allocated durability/economic life values at each level of subassembly and identified life-limited equipment or assemblies are appropriate, are consistent with performance and logistics support requirements, and are cost effective. If a balanced design solution is not indicated, further trade studies, analyses, etc should be accomplished. This may result in changes to durability/economic life, performance or supportability requirements. These changes would be incorporated contractually through specification revisions.

REQUIREMENT LESSONS LEARNED (3.1)

Basing a design approach purely on performance has led to many examples where high operating and support costs are required to maintain the system over its life. Systems have been designed which did not consider life cycle usage factors which led to unexpected "premature" wear out, degradation, and/or deterioration. In the past, the only methods to detect wear out has been by noting an unexpected escalating support cost of a mature system or maintenance personnel reporting higher than historical failure rates. Specifying a comprehensive set of integrity-based performance requirements establishes design requirements which can lead to equipment being economically produced and maintained over its lifetime.

4.1 Verification of Durability/Economic Life Requirements
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.1)

Incremental verification during the design process is needed to ensure the final product provides the performance required over the entire durability/economic life when subjected to the usage, environments, and maintenance specified in paragraph 3.2, 3.3, and 3.4 respectively.

VERIFICATION GUIDANCE (4.1)

Verification of the capability of the electronics to operate as specified throughout the durability/economic life should use an incremental process that includes:

a. Analyses. Analyses are used as a method to incrementally evaluate/verify the design of equipment will meet the performance requirements over the durability/economic life, 3.1, when subjected to the design usage of 3.2 and the design environments of 3.3, with maintenance specified in 3.4. These analyses are intended to verify that development of effects such as any cracking, corrosion, wear, deterioration, or electrical overstress will not adversely affect equipment performance or require maintenance in excess of the CMB requirement, 3.4.2.2, while meeting the CFFOP specified in 3.4.1. The analyses include verification that variability associated with materials, manufacturing processes, component parametric tolerances, and aging have no adverse effect on the required performance and support characteristics of the equipment during its durability/economic life. Analysis of the component parametric tolerances and effects of aging must consider usage and environmental requirements over the durability/economic life. Cumulative damage effects from all major fatigue stresses should be considered in these analyses.

The types of analyses include:

– Life prediction using historical data from literature and/or field experience (Caution – this data is often obsolete or averaged).

– Life prediction using material characterization data

– Life prediction analyses using models developed for various failure modes and material, e.g. cumulative damage analysis using such engineering and technology formulas as Miner's ratios for cumulative damage, Coffin-Manson equations for stress/strain, Black's law for electromigration, dielectric breakdown, Ahrennius calculations for determining if the materials minimum activation energy level thresholds will be exceeded during system deployment and operation, and Faraday's Laws to establish corrosion rates of coupled materials including galvanic voltage and anode-cathode ratio analysis in the expected chemical environments.

– Other applicable engineering analysis (e.g., probability of failure as illustrated in Appendix B).

If design changes occur during production, then their impact on durability life must be evaluated by refining the above stated analyses, as necessary. In some cases, additional engineering tests may be necessary.

When existing electronic equipment with no modifications or with relatively minor modifications is selected for a specific application, a tailored AVIP is employed which includes, as a minimum, a durability/economic life assessment that compares old and new usage, environments, and supportability differences. Other AVIP tasks may also be necessary depending on the nature of the modifications and the differences between the existing usage and environments and the new (proposed or intended) usage and environments for the existing equipment. Existing equipment which undergoes major modification is to be treated in the same manner as a new development effort for the purposes of applying AVIP requirements.

VERIFICATION GUIDANCE (4.1) – Continued

A durability/economic life assessment/analysis for application of existing equipment (requiring no modification to a less than major modification) consists of the following steps in general.

– Establish/derive/estimate major stresses (e.g., levels and durations) the existing equipment experiences in its application during each of the various phases of the life cycle; e.g. operating, non-operating, maintenance, repair, transportation, storage. The types of stresses should include, but not be limited to, thermal cycling, power cycling, vibration, time at temperature, chemical, and electrical stresses that cause major failures. The contractor should use existing field and/or historical data in this effort. If no data is available, necessary data may be obtained or generated by using applicable techniques, e.g. engineering analyses, estimation, measurement, testing.

– Determine, derive and/or estimate the types of stresses, in item (a) above, for the same equipment in its new application during various phases of its life cycle. The contractor should include the effects of modifications of the equipment on the stresses. The contractor should utilize the environmental analysis for this task if one is required by the contract as a separate task.

– Compare the stresses (e.g., levels and durations) of (a) and (b) above in terms of their severity and effect on the equipment durability/economic life and reliability. If a direct comparison of stresses is not possible, evaluate the effects of these stresses on the equipment life and reliability using applicable techniques, e.g. Miner's cumulative fatigue damage, reliability physics life models, and tests.

– Where the new application usage and environments are more severe than the existing application, the contractors is to determine new durability/economic life limits or the reliability limitations on the equipment. If the equipment fails to meet requirements in the new application, modifications will be needed and/or the procuring activity will need to change the program. Program changes may be appropriate if supported by economic analysis or other program benefit/needs.

b. Engineering/Development Tests. Engineering/development tests are performed to provide data (when available data is inadequate or non-existent) to verify the requirements of this specification. Small-scale testing on prototype (or production samples where applicable) hardware (e.g., material, components, subassemblies) is conducted to verify the results of the analyses described above and for requirements that are difficult to verify during the durability life test described below. These tests are used to verify design analysis, identify failure mechanisms and/or hot spots not uncovered by the design/analysis activities, determine and/or verify life of the limited life equipments, verify the key product characteristic margins derived during the design process, and increase confidence in successful completion of the durability life test and environmental qualification tests of the end item. Engineering/development tests and surveys include, but are not limited to:

– Small-scale tests
– Coupon tests
– Small-scale tests to verify requirement for failure mechanism such as dielectric breakdown, electromigration
– Breadboard tests (.e.g. determination of natural frequency transfer functions, board deflections)
– Thermal surveys of the electronics
– Thermal surveys of the host platform including ambient environment and cooling system
– Vibration surveys
– Power survey of the host platform

c. Durability life test (DLT). A DLT is conducted on the system(s)/line replaceable unit(s) (LRUs)/line replaceable modules (LRMs) to verify the system/LRU/LRM will perform as specified under the design usage of 3.2 and environments of 3.3 with the maintenance of 3.4 for the durability/economic life of 3.1. When the system consists of multiple LRUs/LRMs and/or software, the DLT should be conducted on the integrated system. When it isn't practical to test the integrated system, but rather to test separate LRUs/LRMs, the test is to simulate all the interfaces and operating parameters the LRU/LRM will have when it is installed as a part of the operational system.

VERIFICATION GUIDANCE (4.1) – Continued

The CFFOP requirement of 3.4.1.1, the CMB requirement of 3.4.1.2, and the durability/economic life requirement of 3.1 should be demonstrated during the DLT. If the contractor has proposed any preventive or scheduled maintenance events (i.e., life limited items), these are to be accomplished and verified during the DLT. The DLT should be structured as follows:

1. Test unit(s) are to represent production configurations as closely as practical.

2. The DLT is to simulate the major environmental and operational cumulative stresses which the equipment will be exposed to during its durability/economic life and which influence its failure processes. The DLT test cycle is established by deriving environmental and operational stress profiles from the design usage of 3.2 and the environments of 3.3. The sequence of simulated missions in the cycle should be representative of the service usage. The environmental and operational stresses include both steady and cyclic or fatigue stresses. Examples of these stresses are thermal cycling, vibration, power cycling, voltage, humidity.

3. The minimum DLT duration should be equivalent to one durability/economic lifetime. As a minimum, one test unit/article is required to complete one lifetime of testing. However, continuation of the DLT beyond the first lifetime is recommended for one or more of the following reasons:

a. To verify and validate corrective actions

b. To verify specified design margins

c. To verify wear out, deterioration, degradation effects of non-life-limited equipments are equal to or greater than the durability/economic life.

d. To identify additional failure mechanisms in the wear out phase

e. To characterize aging effects and assure the product is not adversely affected over the durability/economic life time. The DLT duration is defined as the amount of equipment power on / equipment operating time and is not to be confused with chamber and/or calendar time. The DLT should simulate the required operating time of the equipment over its lifetime.

4. Because of the limitations associated with cost, schedule and test facilities, it may not be practical and/or feasible to simulate all durability/economic life stresses on a real time basis. In such cases, the test profile should exclude usage periods of benign stress to shorten test times. Additionally, time compression techniques which are justified by published technical literature or derived by the contractor through in-house experiments and testing, may be used with prior approval from the PA. The time compression technique, if used, must be combined with the cumulative fatigue damage at durability control points (DCPs) as an approximate measure of fatigue life consumed by the application of fatigue stresses. The DCPs should be identified during the analyses and/or lower level testing in the design phase. Care should be exercised while raising stress levels in the test to achieve time compression as doing so may result in failure mechanisms which are not representative of the intended field usage.

VERIFICATION LESSONS LEARNED (4.1)

5. All failures occurring during DLT should be analyzed and corrective action developed and verified. When a failure occurs during the DLT, the contractor may elect to stop the test and wait until the failure investigation and analysis takes place and a corrective action is identified and implemented. Another option is to repair the unit under test (e.g., by removal and replacement of the failed SRU or part) and continue the test while the failed equipment is being analyzed for the failure cause and corrective action devised. A corrective action may consist of a design change, a part vendor change, a manufacturing process change, or a change in the process controls. Verification of a proposed corrective action is usually achieved when this corrective action implemented on the unit under test undergoes one durability/economic life worth of testing without any failure or maintenance. Verification of a proposed corrective action, in some cases, may also be achieved by analysis, by a separate lower level test, or by a combination of both, when technical justification and rationale exist. The contract should clearly define financial responsibility and liability for changes resulting from the DLT, to include hardware retrofit changes, documentation changes, etc. Liability for deficiencies must be clearly established in the contract.

6. Required portions of environmental qualification tests of 4.3 may be combined with this test.

7. Post-test inspections and data evaluation should be conducted, including a complete teardown and non-destructive inspection (NDI). Destructive inspections may be required if failures are detected/suspected.

8. Provisioning for the required quantity of spares should be made during the test planning in order to facilitate smooth continuation of the DLT when failures occur which require investigation and analysis to determine the root cause, establishment of corrective action, and implementation of the corrective action into the test article. Contractual provisions must be established to ensure availability of required test hardware.

A radar program has experienced field failures of an intermittent type. The source of the intermittence was traced in a large number of instances to part variability and parametric part tolerances drifting with changes in temperature. The root causes of the intermittence were determined to be insufficient design margin, lack of establishing key characteristics, and no durability control points identified or used during the design and manufacture of the equipment.

One program with AVIP requirements performed durability analyses on various durability control points within an LRU. The analyses revealed one component would fail due to thermal fatigue during the durability/economic life. By increasing the stand-off height of the component, lead and solder thermal fatigue stresses were reduced and life was achieved. This had been accomplished prior to drawing release when design changes were relatively easy and inexpensive.

In another program, a component without compliant leads had been selected based only on RF considerations. Durability analyses revealed the component would fail prematurely. By analyzing various lead type configurations, one was selected which met both durability and RF requirements.

3.2 Usage Requirements
The electronics shall meet performance requirements during and after use as specified below.

REQUIREMENT RATIONALE (3.2)

The electronic equipment will experience degradation due to aging and use over the durability/economic life. Stresses accumulating from operational use affect their durability. These stresses should be characterized and addressed in the design process to develop durable hardware.

REQUIREMENT GUIDANCE (3.2)

This section introduces paragraphs which comprise a comprehensive set of tailorable usage performance requirements. The procuring activity, in conjunction with the using command, should develop the usage requirements for the electronic equipment. The usage should be supplied by the procuring activity as part of the request for proposal. The initial planning for the effort should include the time and manpower needed to accomplish this task. This effort should not be passed on to the contractor, except where the procuring activity does not have the capability to accomplish the required task within the available time or during early program phases when requirements are evolving. If the task is delegated to the contractor, time should be included in program integrated master plans and schedules and funds programmed for accomplishing this task.

The contractor should convert the airframe mission profile data to avionics usage profiles and recommend changes (if any) to the procuring activity. The contractor should conduct trade studies to establish cost (e.g., life cycle cost, weight, performance) as a function of life (inspection intervals). The results of these trade studies should be presented to the procuring activity to establish a durability/economic life that is compatible with the expected usage. Usage for electronics should include the variability of service stresses/environments in a specific installation and variations of stresses/environments associated with installations in different platforms. This design usage should be included as part of the contract specifications (Prime Item Development and Fabrication Specifications and the integrated master plan) and should be revised and refined as necessary.

The avionics usage profiles and flowdown to the required level should be reviewed at major design reviews to ensure agreement between the user, procuring agency, maintenance organization, and contractor that the allocated use profiles at each level of subassembly and identified inspection intervals are correct, are consistent with performance and logistics support requirements, are compatible with the allocated durability/economic life values, and are cost effective. The design usage should be determined and agreed upon no later than PDR.

REQUIREMENT LESSONS LEARNED (3.2)

For many programs, a lack of understanding early in the development phase of how the electronic equipment was to be used during its durability/economic life resulted in an inadequate design. The design did not account for some of the stresses that are imposed on the equipment by its usage and associated environments. Consequently, excessive number of failures and maintenance actions occurred resulting in high life cycle costs. In some cases, the using command has modified the usage after the starting the design process. Establishing the required usage information early in the development phase provides a baseline for the design.

4.2 Verification of Usage Requirements.
The data provided in 3.2 is for use in developing design criteria and test plans and procedures for incremental testing, durability/economic life testing, and other ground/flight qualification.
Verification of the parameters is not required.

3.2.1 Usage Requirements for Airborne Equipment.
The electronics shall be installed in/on ____1____ and located ____2____.

REQUIREMENT RATIONALE (3.2.1)

The type of vehicle/system should be known in order for the contractor to assess the different thermal, vibration, acoustic noise, humidity and other environments for which the avionics equipment is to be developed. Location of the equipment within an airframe/system is critical for establishment of environments it will be exposed to over its durability/economic life.

REQUIREMENT GUIDANCE (3.2.1)

The identifier for the host weapon system should be inserted in blank (1). If the program requires the electronics to be installed or used on more than one host weapon system, all the host platforms should be included. The location of each equipment (within/on each airframe) should be specified in blank (2).

REQUIREMENT LESSONS LEARNED (3.2.1)

Some electronics are designed to be installed on a variety of weapon system types. Fighter, helicopter, transport aircraft and other air vehicles such as missiles have substantially different environments and usage requirements. Any changes to the weapon system the equipment will be located on should be determined early to impact the design and prevent costly design changes.

4.2.1 Verification of Usage Requirements for Airborne Equipment
The data provided in 3.2.1 is design information for use in developing design and test criteria.
Verification is not required for this paragraph.

3.2.1.1 Flight Profiles/Envelope(s)
The flight profiles/envelope(s) shall be as defined in __________.

REQUIREMENT RATIONALE (3.2.1.1)

The flight envelope(s) provide(s) a baseline for determining the stresses the avionics will experience.

REQUIREMENT GUIDANCE (3.2.1.1)

Insert in the blank the flight envelope references which apply. The flight envelope(s) should be provided by the procuring activity as a part of the request for proposal. For existing air vehicles, the data should be obtainable from technical orders, from engineering reports, or from the using command. For new vehicles, the envelope(s) should be based upon the best estimate of functional performance developed by the prime contractor.

REQUIREMENTS LESSONS LEARNED (3.2.1.1)

See 3.2.

4.2.1.1 Verification of Flight Profiles/Envelope(s)
The data provided in 3.2.1.1 is information for use in developing design and test criteria.
Verification is not required.

3.2.1.1.1 Carriage Profiles/Envelope(s)
The carriage profiles/envelope(s) shall be as defined in __________.

REQUIREMENT RATIONALE (3.2.1.1.1)

For avionics located in/on stores (external fuel tanks, pods, weapons), there may be a portion of the aircraft flight envelope where the equipment either cannot function properly or may fail. The limits of these areas define the carriage envelope of the equipment. The avionics may not be required to operate in some areas of the envelope but they must function after excursion to these areas.

REQUIREMENT GUIDANCE (3.2.1.1.1)

Insert in the blank the applicable carriage envelope references. Delete the paragraph if it does not apply.

REQUIREMENTS LESSONS LEARNED (3.2.1.1.1)

See 3.2.

4.2.1.1.1 Verification of Carriage Profiles/Envelope(s).
The data provided in 3.2.1.1.1 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.1.2 Operating Envelope(s).
The operating envelope(s) shall be as defined in __________.

REQUIREMENT RATIONALE (3.2.1.1.2)

For electronics located in/on stores, there may be operational limitations which preclude achieving functional performance requirements over portions of the carriage envelope.

REQUIREMENT GUIDANCE (3.2.1.1.2)

Insert in the blank the operating envelope references that apply. Delete paragraph if it does not apply.

REQUIREMENTS LESSONS LEARNED (3.2.1.1.2)

See 3.2.

4.2.1.1.2 Verification of Operating Envelope(s)
The data in 3.2.1.1.2 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.2 Mission Profiles
Mission profiles (for each weapon system) shall be as defined in __________.

REQUIREMENT RATIONALE (3.2.1.2)

The mission profiles are used to determine the design duty cycles the avionics will experience during the durability/economic life.

REQUIREMENT GUIDANCE (3.2.1.2)

The mission profiles should be provided by the procuring activity as a part of the request for proposal. These may be obtained from the using command. The mission profiles or reference to the profiles should be inserted in the blank.

REQUIREMENT LESSONS LEARNED (3.2.1.2)

The using command may change the mission profiles as the expected usage of the weapon system changes. At some point the mission profiles must be base lined in order to establish the design duty cycles. This must be done as early in the design stage as possible.

4.2.1.2 Verification of Mission Profiles
The data provided in 3.2.1.2 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.3 Mission Mix
Mission mix shall be as defined in __________.

REQUIREMENT RATIONALE (3.2.1.3)

The mission mix is needed to determine the design duty cycle(s) the electronics will experience.

REQUIREMENT GUIDANCE (3.2.1.3)

The mission mix should be provided by the procuring activity as a part of the request for proposal. The mission should be obtained from the using command. The mission mix identifier should be inserted in the blank.

REQUIREMENT LESSONS LEARNED (3.2.1.3)

See 3.2.

4.2.1.3 Verification of Mission Mix
The data provided in 3.2.1.3 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.4 Climatic Profile(s)
Climatic profile(s) for the equipment shall be as defined in __________. The profile(s) shall address the environmental control system (ECS), geographic location(s), and frequency of usage.

REQUIREMENT RATIONALE (3.2.1.4)

Climatic profile(s) provide the foundation for determining a part of the low cycle fatigue design criteria. They provide a basis for determining maximum and minimum operating temperatures, for establishing initial start-up temperature conditions (so thermal expansion magnitude and frequency can be calculated), and for calculating magnitude and frequency of the diurnal cycle and the contributing component from solar radiation.

REQUIREMENT GUIDANCE (3.2.1.4)

The procuring activity should provide expected geographical usage/basing locations and the percentage of life it should be located there. The specific basing should prevent overly conservative worst case projections. If the equipment could be located at one location for its life and that location is particularly severe, it should become the baseline geographic location, except for environmental extremes.

REQUIREMENT LESSONS LEARNED (3.2.1.4)

Military avionics/electronics normally rotate through a variety of geographic locations during their lives. There are cases, however, where a piece of equipment may remain at one location. This single location, such as an extreme northern location, may have more frequent cold starts and have larger temperature changes as a result. Similarly, desert locations may result in large solar generated thermal excursions, particularly in the cockpit.

4.2.1.4 Verification of Climatic Profile(s)
The data provided in 3.2.1.4 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.5 Total Number of Flights
The expected total number of flights over the durability/economic life of 3.1 shall be __________.

REQUIREMENT RATIONALE (3.2.1.5)

An estimate of the total number of flights (including both wartime and peacetime) is needed to determine the number of stress cycles the avionics will experience throughout the durability/economic life.

REQUIREMENT GUIDANCE (3.2.1.5)

The projected total number of flights should be provided by the procuring activity and inserted in the blank.

REQUIREMENT LESSONS LEARNED (3.2.1.5)

See 3.2.

4.2.1.5 Verification of Total Number of Flights
The data provided in 3.2.1.5 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.6 Total Operating Hours
The total expected operating hours for the durability/economic life of 3.1 should be __________.

REQUIREMENT RATIONALE (3.2.1.6)

The total expected operating hours of the product should be established to develop design requirements for the durability/economic life of 3.1.

REQUIREMENT GUIDANCE (3.2.1.6)

The total expected operating hours are derived from the projected usage of the host vehicle (air and ground operating) and the established maintenance concept. Insert the total expected operating hours in the blank. Do not include the number of operating cycles as they will be discussed in 3.2.1.7.

REQUIREMENT LESSONS LEARNED (3.2.1.6)

See 3.2.

4.2.1.6 Verification of Total Operating Hours
The data provided in 3.2.1.6 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.6.1 Mission Operating Hours
The expected total mission operating hours for the durability/economic life of the equipment shall be ____1____ hours. The equipment shall operate (power-on) for ____2____ percent of the total mission operating hours. The electronics shall be capable of being operated continuously, as specified, for ____3____ hours without active cooling. Mission associated ground operating hours shall be ____4____ percent of mission operating hours.

REQUIREMENT RATIONALE (3.2.1.6.1)

Avionics, when operated in the airborne environment, incur stresses which lead to equipment wear out. When the equipment is operated without the benefit of proper cooling, the deterioration and wear out process can be accelerated.

REQUIREMENT GUIDANCE (3.2.1.6.1)

The mission operating hours can be obtained from either historical data or projections and should be inserted in blank 1.

The percent of time the equipment will be operated with power on can be derived from the mission profiles/mission mix and should be inserted in blank 2. When the specification is applied at the weapon system or avionics system/subsystem level, the mission operating hour data should be contained in a table that includes each LRU/LRM.

The number of hours the equipment will be operated without active cooling should be inserted in blank 3. Historical data can be used to establish this requirement.

Some electronics require warm-up time on the ground. Other electronics may require calibration on the ground which is considered part of the mission. For these and other reasons, there may be mission associated ground operating hours which must be accounted for in blank 4.

REQUIREMENT LESSONS LEARNED (3.2.1.6.1)

See 3.2.

4.2.1.6.1 Verification of Mission Operating Hours
The data provided in 3.2.1.6.1 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.6.2 Ground Operating Hours – On-Weapon System
The expected ground operating hours for the durability/economic life of the equipment shall be ____1____ hours. The use of active cooling shall occur ____2____ percent of the ground operating hours. The cooling sources shall have the characteristics specified in ____3____. The equipment shall be capable of being operated continuously as specified without active cooling for ____4____ hours.

REQUIREMENT RATIONALE (3.2.1.6.2)

The electronics should be operated on the ground while installed in the weapon system for the purpose of maintenance, operational readiness checks, and for other reasons. Avionics, when operated on the weapon system while on the ground, incur stresses which leads to equipment wear out. When the equipment is operated without active cooling, the deterioration and wear out can be accelerated. Further, the quality of the externally supplied ground power and cooling may differ from that provided by the main generators and auxiliary power unit, which could result in changes in the deterioration and wear out rates.

REQUIREMENT GUIDANCE (3.2.1.6.2)

The ground maintenance hours can be obtained from historical data or projections and should be inserted in blank 1.

The percent of time during which the equipment will operate using on-board power and cooling can be estimated based upon the maintenance concept for the avionics equipment and the weapon system. The expected operating hours using on-board power/cooling should be stated in blank 2 as a percent of total operating hours.

The remainder of the ground operating hours will use external ground power and cooling sources.

The characteristics of the cooling sources will be as stated in the cooling source specifications and/or technical orders. Insert in blank 3 the source document name(s) and number(s) which define the ground cooling characteristics. Note that cooling supplied to the air vehicle by support equipment may be modified by, as well as controlled by, the air vehicle's environmental control system.

The maximum number of consecutive hours the equipment is expected to be operated without benefit of active cooling should be inserted in blank 4. Historical data should be used to establish this requirement.

REQUIREMENT LESSONS LEARNED (3.2.1.6.2)

Some Air Force technical orders allow avionics to be operated for up to fifteen (15) minutes without cooling. No limitations are established for outside air temperature or for specific equipment operated without cooling. This can impose stresses on the avionics which will lead to greatly accelerated equipment degradation, deterioration, and wear out. Further, the limitation on the time the avionics are allowed to operate without cooling air is difficult to control from an operational standpoint. Also, the power carts which are used by the Air Force are optimized for regulation at maximum power output. When these power carts are used for avionics maintenance, they are typically operating at loads which are a very small portion of the maximum load capability. At these loads, the regulation capability of the unit is at its worst. Thus, the avionics could experience maximum transients and stress.

4.2.1.6.2 Verification of Ground Operating Hours – On-Weapon System
The data provided in 3.2.1.6.2 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.6.3 Ground Operating Hours – Off-Weapon System
The expected off-weapon system ground operating hours shall be ____1____ hours over the durability/economic life. The equipment shall be capable of being operated continuously as specified without active cooling for ____2____ hours.

REQUIREMENT RATIONALE (3.2.1.6.3)

The equipment will be operated off the weapon system for testing and repair. This requirement provides for operating the equipment for maintenance functions (e.g., testing, diagnostics, and repair) where the electronics receive stresses which lead to equipment failure. The need for specifying cooling air is stated in the Requirement Rationale of para 3.2.1.6.2 above.

REQUIREMENT GUIDANCE (3.2.1.6.3)

The value to be inserted in 1 is the predicted time the equipment will undergo testing, diagnostics and repair over its lifetime. The maximum number of hours the equipment is expected to be operated without active cooling should be inserted in blank 2.

REQUIREMENT LESSONS LEARNED (3.2.1.6.3)

See 3.2.1.6.2.

4.2.1.6.3 Verification of Ground Operating Hours – Off-weapon system
The data provided in 3.2.1.6.3 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.7 Number and Type of Operating Cycles
The operating cycles shall be as specified below. Operating cycles shall include equipment on/off cycles, changes in operating modes, and number of missions which impose stress on the equipment.

REQUIREMENT RATIONALE (3.2.1.7)

Stresses are applied to the electronics during normal operation which lead to equipment failure/wear out. These electrical and thermal stresses can be quantified by establishing the number and type of operating cycles.

REQUIREMENT GUIDANCE (3.2.1.7)

The following sections address only the number of cycles. Actual operating hours are discussed in 3.2.1.6.

REQUIREMENT LESSONS LEARNED (3.2.1.7)

See 3.2.

4.2.1.7 Verification of Number and Type of Operating Cycles
The data provided in 3.2.1.7 is design information for use in developing design and test criteria. Verification is not required.

3.2.1.7.1 Operating Cycles in Flight Environment
The expected total number of operating cycles in the airborne environment during the durability/economic life shall be _____1____ with and ____2____ without active cooling. The mix of start-up conditions shall be as shown in ____3____.

REQUIREMENT RATIONALE (3.2.1.7.1)

Operating cycles during flying lead to equipment failure or wear out. The cycles begin at the application of electrical power or cooling prior to and/or after engine start in preparation for flight.

REQUIREMENT GUIDANCE (3.2.1.7.1)

The flight environment operating cycles are determined from the mission profiles and the mission mixes. The total number of flights is used to estimate the number of operating cycles over the durability/economic life. This value is entered in blank 1. Consideration should also be given to the number of operating cycles which may occur without active cooling. This number goes in blank 2.

The mix of start-up conditions for the avionics should be laid out in a table. These start-up conditions should include temperature, vibration, altitude, and humidity environments and rates of change of temperature. Specifically, the rates of change of temperature for the active cooling source should be addressed. The table should be identified in blank 3.

REQUIREMENT LESSONS LEARNED (3.2.1.7.1)

To be provided.

4.2.1.7.1 Verification of Operating Cycles in Flight Environment
Verification is not required.

3.2.1.7.2 Ground Operating Cycles – On-Weapon System
The expected total number of ground operating cycles while installed on the weapon system within the durability/economic life shall be ____1____ with and ____2____ without active cooling. The mix of start-up conditions shall be as shown in ____3____.

REQUIREMENT RATIONALE (3.2.1.7.2)

Some operating cycles will occur while the avionics are on the aircraft but the aircraft is not in flight. This usage of the equipment uses part of its lifetime.

REQUIREMENT GUIDANCE (3.2.17.2)

The maintenance concept and the failure frequency, including cannot duplicates (CND) and retest OK (RTOK), affect the number of times the electronics will be operated on the weapon system on the ground. In blank 1 put an estimate of the number of operating cycles which will occur due to on-weapon system ground operating cycles. Consideration should also be given to the number of ground operating cycles (on-weapon system) which may occur without active cooling. This number goes in blank 2.

The mix of start-up conditions for the avionics should be laid out in a table. These start-up conditions should include temperature, vibration, altitude, and humidity environments and rate of change of temperature. Specifically, the rates of change of temperature for the active cooling source should be addressed. The table should be identified in blank 3.

REQUIREMENT LESSONS LEARNED (3.2.17.2)

See 3.2.

4.2.1.7.2 Verification of Ground Operating Cycles – On-Weapon System
Verification is not required.

3.2.1.7.3 Ground Operating Cycles – Off-Weapon System
The expected total number of off-weapon system operating cycles in the durability/economic life shall be _________.

REQUIREMENT RATIONALE (3.2.1.7.3)

Off-vehicle operating cycles expend the electronics life in addition to all the on-aircraft operational cycles.

REQUIREMENT GUIDANCE (3.2.1.7.3)

The off-vehicle cycles include any functional checks during the development and manufacturing process, acceptance test cycles, and any maintenance test cycles. The projected number of cycles from these situations is placed in the blank.

REQUIREMENT LESSONS LEARNED (3.2.1.7.3)

To be provided.

4.2.1.7.3 Verification of Ground Operating Cycles – Off-Weapon System
Verification is not required.

3.2.2 Usage Requirements for Ground-Based Equipment
The electronics shall be installed in/on __________ and/or located __________.

REQUIREMENT RATIONALE (3.2.2)

See 3.2.1.

REQUIREMENT GUIDANCE (3.2.2)

See 3.2.1.

REQUIREMENT LESSONS LEARNED (3.2.2)

A piece of electronics will normally rotate through a variety of geographic locations during its life. There are cases, however, where a piece of equipment may remain at one location instead of moving around. This single location, such as an extreme northern location, will have more frequent cold starts and have larger delta temperature as a result. Similarly, desert locations will result in large solar generated thermal excursions, particularly in desert environments (also see 3.2).

4.2.2 Verification of Usage Requirements for Ground-Based Equipment
Verification is not required.

3.2.2.1 Number and Type of Operating Conditions
The operating conditions shall be as specified below. Operating conditions shall include equipment on/off cycles, changes in operating modes, and thermal/vibration cycle changes which impose stress on the equipment.

REQUIREMENT RATIONALE (3.2.2.1)

See 3.2.1.7.

REQUIREMENT GUIDANCE (3.2.2.1)

These cycles are derived from the design usage while operating in a field usage and logistics environment. Also, see 3.2.1.

REQUIREMENT LESSONS LEARNED (3.2.2.1)

See 3.2.

4.2.2.1 Verification of Number and Type of Operating Conditions
Verification is not required.

3.2.2.1.1 Operating Hours
The total expected operating hours for the durability/economic life of 3.1 shall be __________.

REQUIREMENT RATIONALE (3.2.2.1.1)

The total expected operating hours of the product should be known in order to establish design requirements and thus allow the contractor to design electronic equipment which will meet the requirements of 3.2 and 3.3.

REQUIREMENT GUIDANCE (3.2.2.1.1)

The total expected operating hours are derived from the projected usage and the established maintenance concept. Insert the total expected operating hours in the blank. Do not include the number of operating cycles as they will be discussed in 3.2.2.1.2.

REQUIREMENT LESSONS LEARNED (3.2.2.1.1)

See 3.2.

4.2.2.1.1 Verification of Operating Hours
The data provided in 3.2.2.1.1 is design information for use in developing design and test criteria.
Verification is not required.

3.2.2.1.2 Operating Cycles
The total number and type of operating cycles, for the durability/economic life in 3.1, shall be __________ and __________ respectively.

REQUIREMENT RATIONALE (3.2.2.1.2)

The total expected operating cycles of the product should be known in order to establish design requirements and thus allow the contractor to design electronic equipment which will meet the requirements of 3.2 and 3.3.

REQUIREMENT GUIDANCE (3.2.2.1.2)

The total expected operating cycles are derived from the projected usage and the established maintenance concept. Insert the total and types of expected operating cycles in the blanks.

REQUIREMENT LESSONS LEARNED (3.2.2.1.2)

See 3.2.

4.2.2.1.2 Verification of Operating Cycles
The data provided in 3.2.2.1.2 is design information for use in developing design and test criteria. Verification is not required.

3.2.2.1.3 Climatic Profile(s)
Climatic profiles for the ground based equipment shall be as shown in __________. These profiles shall address the geographic location(s) and frequency of usage at these location(s).

REQUIREMENT RATIONALE (3.2.2.1.3)

Climatic profile(s) provide the foundation for determining low cycle fatigue design requirements. The following reasons highlight the need to determine the climatic profi1e(s) and their frequency of usage. The profile provides a basis for maximum and minimum operating temperatures, for establishing initial start-up temperature conditions (so thermal expansion magnitude and frequency can be calculated), and for calculating magnitude and frequency of the diurnal cycle and the contributing component from solar radiation.

REQUIREMENT GUIDANCE (3.2.2.1.3)

The procuring activity should provide expected geographical usage/basing locations and the percentage of life it should be located there. If the equipment could be located at one location for its life and that location is particularly severe, it should become the baseline geographic location, except for environmental extremes.

4.2.2.1.3 Verification of Climatic Profile(s)
The data provided in 3.2.2.1.3 is design information for use in developing design and test criteria. Verification is not required.

3.3 Required Environments
This section provides a representative set of tailorable environmental requirements for airborne and ground-based electronics. Environments must be selected and defined for the application (single or multi-platform composite). Other environments unique to an application (e.g., antenna windloading) should be added as needed.

REQUIREMENT RATIONALE (3.3)

The environmental conditions the electronics are exposed to, both while operating and not, impose stresses on the equipment leading to parametric drift and failure. These environments, along with the design usage data established in 3.2, are used to establish equipment design requirements and design margins.

REQUIREMENT GUIDANCE (3.3)

This section provides a representative set of tailorable environmental requirements for airborne and ground-based electronics. Environments must be selected and defined for the application (single or multi-platform composite). Other environments unique to an application (e.g., antenna windloading) should be added as needed. The platform prime contractor is usually the best source for environmental data at the installed locations. The electronics contractor should establish a working relationship with the prime contractor to determine or estimate the expected environmental conditions. It is the responsibility of the electronics contractor to establish the necessary environmental design parameters and design the equipment such that requirements are met. Responsibilities for establishing the design environments should be specifically defined within the contract documentation. When requirements are based upon natural environments resulting from atmospheric/climatic changes, MIL-STD-210 may be used unless there is actual data available for the specific application.

The environmental performance requirements, environmental data at the installed locations, and flowdown to the equipment level should be reviewed at major design reviews to ensure agreement between the user, procuring agency, maintenance organization, and contractor that the necessary environmental design parameters are appropriate, are consistent with performance and logistics support requirements, are compatible with the platform and design usage data, are consistent with the design duty cycle allocations, and are cost effective. The environmental data should be determined and agreed upon no later than PDR. The government should evaluate and agree upon the environmental design parameters developed, with formal approval consistent with approval of contract documentation (e.g., specifications and drawings).

REQUIREMENT LESSONS LEARNED (3.3)

Many of the environments are based on the mission mix and mission profiles established in 3.2. Any changes to these may result in changes to the environments. Understanding the design environment early in the development phase should help eliminate excessive redesign potential and the resulting program delays.

4.3 Verification of Required Environments
The requirements shall be verified as defined in each of the subparagraphs.

VERIFICATION RATIONALE (4.3)

Verification of the capability of the hardware to meet performance requirements before, during and after exposure to the environments defined herein are critical to ensure the product will be supportable and affordable over its planned lifetime.

VERIFICATION GUIDANCE (4.3)

Verification of the capability of the electronics to perform and survive in the design environments of 3.3 should be accomplished incrementally to support critical program milestones. As a minimum, compliance should be demonstrated initially by analyses to support the critical design review (CDR) milestone. Analyses should address all design environments, including any combinations, expected to occur in field operations, and demonstrate successful performance during exposure to worst case conditions. Compliance should be demonstrated by test to support production milestone decision points. Environmental tests should be integrated (combined), per the guidance of MIL-STD-810, to the maximum extent possible. In addition, integrating environmental tests into the durability/economic life test of 4.1, such as high temperature, vibration, is strongly recommended for efficient utilization of test resources and time.

The specific analyses and test(s) to be used to demonstrate compliance with these requirements should be inserted in the subsection blanks.

VERIFICATION LESSONS LEARNED (4.3)

Incorporating environmental qualification tests requirements into the Durability/economic life Test (DLT) saves both schedule time and test chamber time. These verification activities should be integrated to the maximum extent possible.

3.3.1 Usage Environments

The equipment shall be capable of full performance during and after experiencing the cumulative effects of the environments in any combination(s) the equipment is expected to be exposed to over its durability/economic life as specified below. The equipment shall also resist fatigue damage (e.g., cracking and delamination), wear and deterioration/thermal degradation, electrical stresses, parametric drift, dielectric material failure, and corrosion during required usage such that the performance and support capabilities specified in __________ are not degraded over the durability/economic life.

REQUIREMENT RATIONALE (3.3.1)

The environment at the location(s) where the equipment is to be installed should be characterized for the purposes of designing integrity into the equipment. Environmental conditions can vary significantly at different locations within an aircraft, within aircraft of the same type with different missions (e.g. air-to-air vs. air-to-ground), and between different aircraft types. The specific environment at the installation location needs to be accounted for during the analysis and design of the equipment to assure that the life requirements are met. These environments are generally exterior to the electronics and are considered inputs to determine the internal environments and response of the equipment.

REQUIREMENT GUIDANCE (3.3.1)

The installed environment of the equipment 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, and thermal stresses that occur on start-up, dwell, cycling, and shutdown. When equipment is to be installed on platforms (in vehicles) which are not controlled by the equipment developer, the contract must address how the developer is to gather this information and update the technical data as the design progresses. When the environments are derived, and not based on measured data, they may be characterized through the flight test program or by other means. When enough environmental data does not exist for the intended platforms at the time of the proposal, the PA should consider the required period of time and resources required to allow for environmental definition.

REQUIREMENT LESSONS LEARNED (3.3.1)

The temperature, vibration, acoustic noise, and humidity environments are the primary contributors to the problems encountered during operational usage.

4.3.1 Verification of Usage Environments

The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1)

See 4.3.

VERIFICATION GUIDANCE (4.3.1)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1)

See 4.3

3.3.1.1 Temperature
The temperature profiles for the usage requirements of 3.2 shall be __________.

REQUIREMENT RATIONALE (3.3.1.1)

The electronics should withstand internally and externally-induced temperature (e.g., low-cycle) fatigue stresses which occur throughout the host vehicle operating envelope, during ground operations and during other phases of the life cycle for the required durability/economic life and total operating hours (including the durability/economic life specified in 3.1). These fatigue stresses include those caused by the power cycling which occur throughout the durability/economic life of the electronics. Temperature cycling imposes a stress on electronic components due to differences in thermal expansion rates. Elevated temperatures can induce slow, progressive deterioration of component performance due to material degradation and failure when material parameters are exceeded. Temperature changes can cause electronic part parametric drift leading to unstable operation and intermittent type failures.

The characteristics of the Environmental Control System (ECS) help define the environment in which the electronics will operate. The ECS helps control the rate of temperature cycling and the extremes of temperatures which the equipment could experience. The airborne and/or ground based electronics should therefore be designed to efficiently transfer heat between the internal components and the external environment (including integration with the host ECS).

REQUIREMENT GUIDANCE (3.3.1.1)

The temperature profiles at the installation location(s) should be determined and inserted in the blank. If a ground and/or airborne environmental control system (ECS) is used, these temperature profiles should reflect the characteristic of the cooling air provided by the ECS as well those specified in 3.2. For example, the contractor should conduct a trade study addressing the costs (e.g., avionics weight, reliability, aircraft structure, cooling system weight) versus benefits gained prior to making the decision to incorporate a requirement into the equipment design for ECS cooling air. The trade study should consider all heat dissipation paths (e.g., radiation, convection, and conduction) which are available to the electronics. For avionics, a specification or test report will normally describe the ECS of the host vehicle. Further, analysis or test data may be required to define the performance/characteristics of the ECS output at the port where the equipment is to be installed.

REQUIREMENT LESSONS LEARNED (3.3.1.1)

See 3.3.1.

4.3.1.1 Verification of Temperature
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.1)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.1)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.1)

The specific analysis and test to be used to demonstrate compliance with this requirement should be inserted in the blank. Test limits should be established from design usage based on operational experience rather than using default limits established in MIL-STD-810. Compliance should be accomplished in conjunction with the analysis and test used in 4.3.1 and 4.3.1.1.1. Worst-case ECS inputs, including both temperature limits and rates of change of temperature, should be demonstrated prior to production release. Verification of the ECS may be accomplished in a temperature, altitude qualification test with thermocouple monitoring per MIL-STD-2218. For additional guidance, see 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.1)

See 4.3.

3.3.1.1.1 High Temperature
The equipment shall perform as specified in ____1____ during and after exposure to a high temperature of ____2____. After exposure to a high temperature (non-operating and without cooling) of ____3____ for ____4____ hours the equipment shall be able to provide performance specified in ____5____.

REQUIREMENT RATIONALE (3.3.1.1.1)

High temperatures may temporarily or permanently impair the performance of the electronics by changing the electrical parametric characteristics, the physical properties or dimensions of its material(s). Problems that occur as a result of high-temperature exposure are parts binding from differential expansion of dissimilar materials, fixed-resistance resistors changing in values, electronic circuit stability varying with temperature gradients and differential expansion of dissimilar materials, transformers and electromechanical components overheating, and altering of operating/release margins of relays and magnetic or thermally activated devices.

REQUIREMENT GUIDANCE (3.3.1.1.1)

Insert in blank 1 the paragraph or document containing the detailed performance requirements of the equipment. In blank 2 inset the maximum temperature that the electronics must continuously operate at and after exposure to 3 for some period of time 4.

4.3.1.1.1 Verification of High Temperature
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.1.1)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.1.1)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.1.1)

See 4.3.

3.3.1.1.2 Low Temperature
The equipment shall withstand a low temperature of ____1____ during operation. After exposure to a low temperature (non-operating) of ____2____ for ____3____ hours the equipment shall provide performance specified in ____4____.

REQUIREMENT RATIONALE (3.3.1.1.2)

Low temperatures can adversely affect almost all basic materials. As a result, exposure of the electronics to low temperatures may either temporarily or permanently impair their material(s). Some problems that could occur as a result of exposure to cold are hardening and embrittlement of materials, binding of parts from differential contraction of dissimilar materials and the different rates of expansion of different parts in response to temperature transients, changes in performance of transformers, changes in electrical part parametric characteristics, changes in mechanical components tolerances, and condensation and freezing of water.

REQUIREMENT GUIDANCE (3.3.1.1.2)

Insert in the blanks the minimum temperatures the electronics must continuously operate at 1 and after exposure to 2 for some period of time 3.

REQUIREMENT LESSONS LEARNED (3.3.1.1.2)

See 3.3.1.1.

4.3.1.1.2 Verification of Low Temperature
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.1.2)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.1.2)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.1.2)

To be provided.

3.3.1.1.3 Temperature Shock
The equipment shall perform as specified in ____1____ during and after exposure to a maximum rate of temperature change of ____2____ and ____3____ number of temperature shocks during the required durability/economic life.

REQUIREMENT RATIONALE (3.3.1.1.3)

Temperature shock is caused by sudden changes in the temperature of the surrounding atmosphere and may result in physical damage or deterioration of the electronics. As a result of exposure to sudden temperature changes, operation of the electronics may be affected either temporarily or permanently. Examples of problems that could occur as a result of exposure to sudden changes in temperature are electronic or mechanical failures due to rapid condensation or frost formation, differential contraction or expansion of dissimilar materials, deformation or fracture of components, cracking of surface coatings, and leaking of sealed compartments.

REQUIREMENT GUIDANCE (3.3.1.1.3)

Insert in blank 1 the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank 2 the maximum rate of temperature change the electronics could experience in use.

Indicate when different values are expected for both positive and negative temperature changes. Insert in the blank 3 the total expected number of temperature shocks over the durability/economic life.

REQUIREMENT LESSONS LEARNED (3.3.1.1.3)

See 3.3.1.

4.3.1.1.3 Verification of Temperature Shock
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.1.3)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.1.3)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.1.3)

See 4.3.

3.3.1.2 Vibration
The equipment shall perform as specified in __________ during and after exposure to the vibration profiles and spectra, for the design usage of 3.2, as shown in __________.

REQUIREMENT RATIONALE (3.3.1.2)

The electronics should withstand vibration-induced stresses that occur throughout the host vehicle operating envelope, during ground operations and during other phases of the life cycle for the required durability/economic life and total operating hours (including the durability/economic life specified in 3.1.). Fatigue failures are common in electronic systems as a result of operating in vibration environments. These failures take the form of broken wires, broken component leads, cracked castings, cracked welds, and loose screws. Vibration may also cause shorts due to loss of insulation due to abrasion, opens due to device unseats from sockets, opens from bad contact in friction fit connectors, and foreign object damage due to loose screws or broken components.

REQUIREMENT GUIDANCE (3.3.1.2)

Insert in blank (a) the paragraph number or document containing the detailed performance requirements of the equipment. The vibration spectra at the installation location(s) for each axis should be deteffi1ined and inserted in the blank. When the electronics will be installed in multiple (different) host vehicles or locations within a vehicle, the vibration spectra should include all the worst-case conditions of all the host vehicles/installation locations.

REQUIREMENT LESSONS LEARNED (3.3.1.2)

The rigid mounting of some LRUs in a high vibration environment greatly reduces the life of the equipment. A piece of equipment was hard mounted to the tail section of a helicopter. High vibration was found to cause frequent failures. These failures took the form of broken wires, broken component leads, cracked castings, cracked welds, and loose screws. Vibration may also cause shorts due to loss of insulation due to abrasion, opens due to device unseats from sockets, opens from bad contact in friction fit connectors, and foreign object damage due to loose screws or broken components. A redesign of the equipment to include shock/vibration isolators reduced the number of failures dramatically. Knowledge of the installed environment and its durability impact on the design would have saved both time and money used to solve the problem (note: vibration isolators need to be characterized for life properties as past experience has taught us the characteristics of the materials used to construct these isolators change due to aging effects).

4.3.1.2 Verification of Vibration
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.2)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.2)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.2)

See 4.3.

3.3.1.2.1 Gunfire/Other Vibration
The equipment shall perform as specified in ____1____ during and after exposure to a gunfire/other spectra as shown in ____2____, for ____3____ duration.

REQUIREMENT RATIONALE (3.3.1.2.1)

Gunfire or other (e.g., open weapons bay doors) vibration can cause intermittent electrical contact and electrical and structural fatigue failures.

REQUIREMENT GUIDANCE (3.3.1.2.1)

Insert in blank (1) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (2) the gunfire spectrum of each axis the electronics are expected to experience in use and its duration over the life of the equipment in blank (3).

REQUIREMENT LESSONS LEARNED (3.3.1.2.1)

Lack of gunfire vibration requirements on one program, resulted in equipment experiencing loss of performance and a higher failure rate.

4.3.1.2.1 Verification of Gunfire/Other Vibration
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.2.1)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.2.1)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.2.1)

See 4.3.

3.3.1.3 Acceleration
The equipment shall perform as specified in ____1____ during and after exposure to an acceleration spectra as shown in ____2____.

REQUIREMENT RATIONALE (3.3.1.3)

The avionics equipment should be designed to assure it can withstand the "g" forces that are expected and function without degradation. Acceleration increases the forces acting on equipment and the hardware used to mount the equipment. The forces induced by acceleration can cause structural deflections that interfere with operation, fasteners and mounting hardware to break, bond wires within components to contact ground planes, circuit boards to short out and circuits to open up, inductances and capacitances to change values, motors to slow down, and relays to open or close.

REQUIREMENT GUIDANCE (3.3.1.3)

Insert in blank 1 the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank 2 the maximum acceleration in each axis the electronics could experience in operational use at the installed location(s).

This acceleration requirement should be based on the weapon system's operating limits, including lever arm effects and maximum pitch and roll rates with worst-case weapon system center of gravity, as well as manufacturing and logistics environments. Functional performance is required at these levels.

REQUIREMENT LESSONS LEARNED (3.3.1.3)

The tape drive motor of multichannel digital/analog tape recorder was found to be susceptible to acceleration effects. Analysis during the design did not take into consideration the acceleration forces even though they were specified. Redesign of the motor to increase the torque requirement was required. This could have been avoided if the acceleration factor had been taken into account. Also, see 3.3.1.

4.3.1.3 Verification of Acceleration
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.3)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.3)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.3)

See 4.3.

3.3.1.4 Shock
The equipment shall perform as specified in ____1____ during and after exposure to a shock spectra as shown in ____2____.

REQUIREMENT RATIONALE (3.3.1.4)

The equipment should be able to withstand the shocks encountered in handling, transportation, and service environments. Mechanical shocks can cause failures due to increased or decreased friction, interference between parts, changes in dielectric strength, loss of insulation resistance, variations in magnetic and electrostatic field strength, permanent deformation, and more rapid fatiguing of materials.

REQUIREMENT GUIDANCE (3.3.1.4)

Insert in blank 1 the paragraph number or document containing the detailed performance requirements of the equipment. Insert in the blank 2 the shock spectrum of each axis the electronics could experience during use. Crash shock levels must be included in these spectrums.

REQUIREMENT LESSONS LEARNED (3.3.1.4)

See 3.3.1.

4.3.1.4 Verification of Shock
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.4)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.4)

While the equipment is expected to properly operate during and after every shock within the spectrum defined in 3.3.1.4 above, the equipment does not have to perform either during or following the application crash safety shocks but rather must only be retained in the mounts so as to not injure the aircrew. Also, see 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.4)

See 4.3.

3.3.1.5 Acoustic Noise
The equipment shall perform as specified in ____1____ during and after exposure to an acoustic noise spectra as shown in ____2____, for ____3____ duration.

REQUIREMENT RATIONALE (3.3.1.5)

Acoustic noise emanating from nearby equipment and structures on the weapon system imposes stress on the avionics which leads to failure.

Acoustic noise sources include aircraft guns. engines, propellers, and aerodynamic vibration. The acoustic requirements should reflect the acoustic noise levels the equipment could experience in the operational environment.

REQUIREMENT GUIDANCE (3.3.1.5)

Insert in blank 1 the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank 2 the maximum acoustic noise spectrum the equipment will experience and its duration over the life of the equipment in blank 3.

REQUIREMENT LESSONS LEARNED (3.3.1.5)

To be provided.

4.3.1.5 Verification of Acoustic Noise
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.5)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.5)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.5)

See 4.3.

3.3.1.6 Humidity
The equipment shall perform as specified in ____1____ during and after exposure to relative humidity between ____2____ and ____3____ percent, inclusive, and a temperature range of ____4____, under both operating and non-operating conditions. Fogging or condensation shall not degrade equipment performance specified in ____5____ throughout the durability/economic life.

REQUIREMENT RATIONALE (3.3.1.6)

Humidity degrades dielectrics and, in the presence of inorganic salts, forms electrolytes that may cause electrical shorts. Humidity also reacts with materials to cause corrosion. Corrosion, especially on metals, forms dielectrics that inhibit the flow of current and cause intermittence and/or open circuits. Further, humidity absorbed by various polymer materials causes volumetric expansion which applies stress to materials, equipments, and parts. These phenomena can degrade the equipment and may lead to failure.

REQUIREMENT GUIDANCE (3.3.1.6)

Insert in blanks (1) and (5) the paragraph number or document containing the detailed performance requirements of the equipment. Material characteristics and manufacturing process controls determine the amount of humidity that can be tolerated in the electronics. The minimum and maximum humidity levels the electronics could experience should be entered in blanks (2) and (3) respectively and the associated temperature range in (4).

REQUIREMENT LESSONS LEARNED (3.3.1.6)

Several designs have provided no exit path for condensation to drain from the equipment. This resulted in condensate filling the enclosure and causing electrical/equipment failures. To preclude this situation, a drainage path should be provided in the design, if practical, that permits condensation to drain from the electronics. Also, see 3.3.1.

4.3.1.6 Verification of Humidity
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.6)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.6)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.6)

3.3.1.7 Low-Pressure (Altitude)
The equipment shall perform as specified in __________ during and after exposure to a low pressure or maximum altitude of __________.

REQUIREMENT RATIONALE (3.3.1.7)

Some problems that occur as a result of exposure to reduced pressure are a change in physical and chemical properties of low-density materials, overheating of equipment due to reduced heat transfer, and failure of hermetic seals.

REQUIREMENT GUIDANCE (3.3.1.7)

Insert in blank (a) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (b) the minimum pressure or maximum altitude the electronics could experience in operational usage.

REQUIREMENT LESSONS LEARNED (3.3.1.7)

Low pressure (altitude) has been known to cause problems with high voltage power supplies (HVPS). Air is a dielectric between high voltage potentials. As the density of the air changes, the dielectric constant of the air changes causing corona effects and arcing that can damage the HVPS and nearby electronics.

4.3.1.7 Verification of Low-Pressure (Altitude)
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.7)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.7)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.7)

See 4.3.

3.3.1.8 Solar Radiation
The equipment shall perform as specified in ____1____ during and after exposure to solar radiation of ____2____, for ____3____ hours.

REQUIREMENT RATIONALE (3.3.1.8)

The effects of solar radiation on equipment exposed to indirect, direct or diffused sunshine (e.g., cockpit mounted displays, controls) during operation and unsheltered storage may result in physical damage or deterioration of the electronics. Examples of problems that may occur are electronic circuit instability because of large temperature gradients, differential thermal expansion resulting in fatigue failures and degradation of operating characteristics of relays, magnetic or thermally activated devices.

REQUIREMENT GUIDANCE (3.3.1.8)

Insert in blank (1) the paragraph number or document containing the detailed performance requirements of the equipment. Insert the required solar radiation level(s) and spectrum in blank (2) and duration(s) in blank (3) which the electronics could experience in use over the entire durability/economic life. When a distribution of solar radiation exposure over the durability/economic life is available, the distribution amplitudes and durations should be shown in the blanks.

REQUIREMENT LESSONS LEARNED (3.3.1.8)

UV content has degraded avionics located in cockpits. Display contrast enhancement filters on the F-4, F-15, and F-16 were severely damaged by UV and required costly replacement. UV degrades all organic material. Also, see 3.3.1.

4.3.1.8 Verification of Solar Radiation
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.8)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.8)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.8)

Attempts have been made to expose equipment to actual sunlight in an attempt to verify this requirement. However, the UV content of the sun is highly variable depending on the latitude declination on the earth, season of the year, the time of day, altitude, pollution, and clouds. Thus, only a controlled test environment can actually verify this requirement. Also, see 4.3.

3.3.1.9 Rain

The equipment shall perform as specified in ____1____ during and after exposure to solar radiation of ____2____ for ____3____ hours.

REQUIREMENT RATIONALE (3.3.1.9)

Rain has a variety of effects on material. On impact, it erodes surfaces. After deposition, it degrades the strength of some materials, promotes corrosion of metals, deteriorates surface coatings, and can render the electronics inoperative. After penetration into containers, it causes malfunction of electrical equipment, may freeze inside equipment, which may cause delayed deterioration and malfunction by swelling or cracking of parts, and causes high humidity, which can encourage corrosion and fungal growth. Shielded cables can also be a source of moisture intrusion if cable ends are not properly terminated.

REQUIREMENT GUIDANCE (3.3.1.9)

Insert in blank (1) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (2) the rain environment including wind forces the electronics could experience in use.

REQUIREMENT LESSONS LEARNED (3.3.1.9)

An ECM pod experienced problems associated with the lack of moisture intrusion seals on access panels. During a TDY deployment ECM pods were stored outside in inclement weather. Moisture entered the pod through the access panels allowing mold and corrosion to form. One pod was removed from service due to the extent of the corrosion damage. Moisture intrusion must be taken into account on all equipment used or stored in an outside environment.

4.3.1.9 Verification of Rain

The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.9).

See 4.3.

VERIFICATION GUIDANCE (4.3.1.9)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.9)

To be provided.

3.3.1.10 Fungus
The equipment shall perform as specified in ____1____ during and after fungus growth as described in ____2____.

REQUIREMENT RATIONALE (3.3.1.10)
Fungal growth impairs the functioning or use of equipment by changing its physical properties. Nonresistant materials are susceptible to attack as the fungi break the material down and use it as food. Fungal growth can form undesirable electrical conducting paths across insulating materials or may adversely affect the electrical characteristics of critically adjusted electronic circuits.

REQUIREMENT GUIDANCE (3.3.1.10)
Insert in blank 1 the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank 2, or reference, the fungus requirements.

REQUIREMENT LESSONS LEARNED (3.3.1.10)
The F-4 is reported to have contained nutrient potting material within the wiring connectors resulting in fungus growth which caused numerous intermittent failures in the avionics and electrical system.

4.3.1.10 Verification of Fungus
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.10)
See 4.3.

VERIFICATION GUIDANCE (4.3.1.10)
Use of a certificate of compliance, signed by the manufacturer, that no nutrient materials exists in the equipment has satisfied this requirement in the past. Also, see 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.10)
To be provided.

3.3.1.11 Salt Fog
The equipment shall perform as specified in __________ during and after exposure to a salt fog and salt water environment of __________.

REQUIREMENT RATIONALE (3.3.1.11)
The exposure of the electronics to an environment where there is an aqueous salt atmosphere and salt water environment can cause corrosion due to electrochemical reaction, accelerated stress corrosion, formation of acidic/alkaline solutions following salt ionization in water, impairment of electrical equipment due to salt deposits, production of conductive coatings, and corrosion of insulating materials and metals.

REQUIREMENT GUIDANCE (3.3.1.11)
Insert in blank (a) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (b) the salt fog and salt water environment the electronics could experience in use.

REQUIREMENT LESSONS LEARNED (3.3.1.11)
Improperly accounting for entrapment of salt deposits during the design of equipment has caused intermittent failures to occur.

4.3.1.11 Verification of Salt Fog
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.11)
See 4.3.

VERIFICATION GUIDANCE (4.3.1.11)
See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.11)
To be provided.

3.3.1.12 Sand and Dust

The equipment shall perform as specified in ____1____ during and after exposure to a sand and dust environment of ____2____.

REQUIREMENT RATIONALE (3.3.1.12)

Naturally occurring sand and dust create problems for electronics. Some problems that could occur as a result of exposure to sand and dust are abrasion and erosion of surfaces, penetration of seals, and degradation of electrical circuits.

REQUIREMENT GUIDANCE (3.3.1.12)

Insert in blank (1) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (2) the maximum sand and dust environment the electronics could experience in use.

REQUIREMENT LESSONS LEARNED (3.3.1.12)

The damage inflicted on avionics in Saudi Arabia, especially exterior mounted optics on low flying aircraft required design modification. Electromechanical devices such as video recorders and map readers require durable designs because of the sand and dust environment.

4.3.1.12 Verification of Sand and Dust

The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.12)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.12)

See 4.3. Note. Sand is an abrasive test. Dust is an intrusion, clogging test that is especially relevant to an installed environment.

VERIFICATION LESSONS LEARNED (4.3.1.12)

To be provided.

3.3.1.13 Explosive Atmosphere

The equipment shall be operable in an explosive atmosphere of __________ without causing an explosion.

REQUIREMENT RATIONALE (3.3.1.13)

The electronics should have the ability to operate in flammable atmospheres without causing an explosion. Low levels of energy discharge or electrical arc from devices can ignite mixtures of fuel vapor and air. A "hot spot" on the surface of a hermetically sealed case can ignite fuel vapor and air mixtures.

REQUIREMENT GUIDANCE (3.3.1.13)

Insert in the blank the explosive atmosphere the electronics could experience in operational usage.

REQUIREMENT LESSONS LEARNED (3.3.1.13)

On several occasions, fuel seeped into the area of the anti-collision light. This created an explosive atmosphere, which when coupled with a faulty method of electrical grounding (e.g., creating an arc source) within the light, an explosion occurred which damaged the wing.

4.3.1.13 Verification of Explosive Atmosphere

The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.13)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.13)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.13)

To be provided.

3.3.1.14 Leakage (Immersion)
The equipment shall perform as specified in ____1____ with leakage due to immersion to a maximum depth of ____2____.

REQUIREMENT RATIONALE (3.3.1.14)
Water seeping into electronics can result in electrically conductive bridges which may cause malfunctions or result in corrosion.

REQUIREMENT GUIDANCE (3.3.1.14)
Insert in blank (1) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (2) the maximum immersion depth the electronics could experience in use.

REQUIREMENT LESSONS LEARNED (3.3.1.14)
The wiring on the aircraft can act as conduits for water condensed by changes in temperature and altitude during flight or on the ground. Once the condensation forms within the wire bundles it starts to travel to the lowest point in the harness -usually the LRU. If the connectors are not properly sealed, water will eventually enter the LRU through the connectors, resulting in premature failure or corrosion problems.

4.3.1.14 Verification of Leakage (Immersion)
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.14)
See 4.3.

VERIFICATION GUIDANCE (4.3.1.14)
See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.14)
To be provided.

3.3.1.15 Icing/Freezing Rain
The equipment shall perform as specified in ____1____ during and after exposure to icing/freezing rain as described in ____2____.

REQUIREMENT RATIONALE (3.3.1.15)
Ice and freezing rain induce stresses which could crack or deform structures. These cracks or deformations are possible areas of penetration for moisture, rain and other damaging environments.

REQUIREMENT GUIDANCE (3.3.1.15)
Insert in blank (1) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (2) the maximum icing/freezing rain environment the electronics could experience in use.

REQUIREMENT LESSONS LEARNED (3.3.1.15)
Ice formation can, for example, induce structural failures in antennas and is extremely critical if formed on pitot tubes of the air data system.

4.3.1.15 Verification of Icing/Freezing Rain
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.15)
See 4.3.

VERIFICATION GUIDANCE (4.3.1.15)
See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.15)
To be provided.

3.3.1.16 Electromagnetic and Electrical Power Environments
Information in this area is available in MIL-STD-18l8 for air vehicle issues, MIL-STD-1795 and MIL-STD-1757 for lightning, MIL-STD-461 at the subsystem/equipment level and MIL-STD-704 for electrical power.

REQUIREMENT RATIONALE (3.3.1.16)

Voltages and currents generated through electromagnetic coupling can affect the integrity of electronics through either temporary degradation which may introduce unnecessary maintenance actions because of stored faults (e.g., cannot duplicate) or electronic failure (e.g., burnout). Voltage and frequency variations within the envelopes allowed for electrical power quality can cause similar effects. The requirements associated with the referenced documents are normally addressed in development specifications separately from specific integrity requirements. However, it is essential that the requirements be included to ensure that integrity aspects are considered. Detailed rationale is included in each of the referenced electromagnetic effects documents.

REQUIREMENT GUIDANCE (3.3.1.16)

MIL-STD-18l8 includes electromagnetic effects requirements for systems, including external radio frequency environments, lightning, static electricity, electromagnetic pulse, electrical bonding and electrical grounding. MIL-STD-1795 and MIL-STD-1757 define lightning environments and provide additional design requirements related to lightning. MIL-STD-461 provides interference controls at the subsystem/equipment level for electromagnetic emissions and susceptibility. MIL-STD-704 describes the power quality that will be delivered to the individual equipment. Detailed guidance is included in each of the electromagnetic effects documents. Insert in this section the requirements from these standards, if not covered elsewhere in the particular contract.

REQUIREMENT LESSONS LEARNED (3.3.1.16)

See MIL-STD-1818, MIL-STD-1795, MIL-STD-1757, and MIL-STD-461.

4.3.1.16 Verification of Electromagnetic Environments
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.16)

MIL-STD-1818 contains verification techniques for air vehicle level issues, MIL-STD-1795 and MIL-STD-1757 provide verification techniques for lightning protection requirements, MIL-STD-462 provides verification test methodology for MIL-STD-461. There are no available documents describing techniques to demonstrate performance within the constraints of MIL-STD- 704. Each electromagnetic effects document contains detailed rationale.

VERIFICATION GUIDANCE (4.3.1.16)

Test and analysis should be performed to demonstrate the equipment will provide required performance throughout the envelopes of the power quality provided by the system. Verification techniques are specified in MIL-STD-1818, MIL-STD-1795, MIL-STD-1757, and MIL-STD-462

VERIFICATION LESSONS LEARNED (4.3.1.16)

See MIL-STD-1818, MIL-STD-1795, MIL-STD-1757, and MIL-STD-462.

3.3.1.17 Chemical
The equipment shall perform as specified in ____1____ during and after exposure to a chemical environment as stated in ____2____.

REQUIREMENT RATIONALE (3.3.1.17)

Chemical warfare agents degrade the performance of electronics. The design of the equipment should take such agents into account.

REQUIREMENT GUIDANCE (3.3.1.17)

Insert in blank (1) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (2) the document which contains the chemical environment requirements.

REQUIREMENT LESSONS LEARNED (3.3.1.17)

To be supplied.

4.3.1.17 Verification of Chemical
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.17)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.17)

Much of the information regarding chemical warfare requirement verification is classified. The specific analyses or tests to be used to verify compliance with the requirement in 3.3.1.18 should be inserted in the blank or included in a classified appendix.

VERIFICATION LESSONS LEARNED (4.3.1.17)

To be provided.

3.3.1.17.1 Decontamination

The equipment shall perform as specified in __________ after exposure to decontamination operations with the types and concentrations of decontamination chemicals as stated in __________.

REQUIREMENT RATIONALE (3.3.1.17.1)

Many decontamination materials can deteriorate electronic equipment.

REQUIREMENT GUIDANCE (3.3.1.17.1)

Insert in the blank the document containing the decontamination requirements. Some of the materials to which the equipment may be exposed during decontamination operations are as follows:

(1) Freon D used to clean electronic internal parts prior to replacing an electronic-dielectric coolant fluid. Note: CFCs will eventually be phased out in accordance with the Montreal Convention.

(2) MIL-D-50030, Decontaminating Agent, DS2 – used to neutralize chemical warfare agents on surfaces

(3) MIL-D-12468, Decontaminating Agent, STB – used to neutralize chemical warfare agents on surfaces

(4) Ethylene oxide – used to neutralize bacteriological agents

(5) Water – incorporated as a matrix-dissolving fluid and as steam

(6) Isopropyl alcohol – used as a solvent to wash away contaminants

(7) Additional types of decontamination fluids may be used as the threat changes. The possibilities should be researched when the specification is prepared. Additional data may be included in a classified supplement.

REQUIREMENT LESSONS LEARNED (3.3.1.17.1)

To be provided.

4.3.1.17.1 Verification of Decontamination.

The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.17.1)

Verification is required to assure equipment is not damaged by contact with decontaminating chemicals.

VERIFICATION GUIDANCE (4.3.1.17.1)

Insert in the blank the analyses to be accomplished to verify compliance with decontamination requirements. See 4.3.1.17.

VERIFICATION LESSONS LEARNED (4.3.1.17.1)

To be provided.

3.3.1.18 Nuclear
The equipment shall withstand the nuclear environment defined in __________.

REQUIREMENT RATIONALE (3.3.1.18)

This requirement applies to electronics which are required to operate in, or after, a nuclear event. Typically the nuclear environments to be considered for electronics are electromagnetic pulse (EMP) and transient radiation effects on electronics (TREE). Nuclear radiation can affect the material characteristics of electronics in ways that inhibit operation as intended by design.

REQUIREMENT GUIDANCE (3.3.1.18)

The environment generated by nuclear effects in the area where the equipment is installed should be determined and used in the specification. Nuclear survivability requirements are usually classified. The document that establishes these requirements should be inserted in the blank.

REQUIREMENT LESSONS LEARNED (3.3.1.18)

To be provided.

4.3.1.18 Verification of Nuclear
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.18)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.18)

See 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.18)

To be provided.

3.3.1.19 Logistics Environment
The airborne and/or ground based electronics shall provide full performance over its durability/economic life after exposure to organizational, intermediate, and depot level environments, including ground handling, transportation, storage, and repair of the equipment. The logistics environment shall be __________.

REQUIREMENT RATIONALE (3.3.1.19)

The logistics environment (e.g., shipping, handling, maintenance, ESS and ground operations) involves vibration, shock, thermal, moisture, and other naturally induced stresses. Electrical stresses are induced during maintenance, ground operations, and launch and flight operations. Some avionics systems may see significant electrical "on" time due to ground operations.

REQUIREMENT GUIDANCE (3.3.1.19)

Insert in the blank the logistic environment the electronics will experience. Note: during depot maintenance LRU circuit cards may be tested without external cooling provided to the LRU. Constraints regarding off-equipment maintenance should be addressed.

REQUIREMENT LESSONS LEARNED (3.3.1.19)

Normal and rough handling during shipping, storage, and routine ground operations impose vibration and shock loads on electronics. These handling-induced stresses can lead to a variety of equipment failures.

4.3.1.19 Verification of Logistics Environment
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.19)

Verification is required to demonstrate the logistics environment will not adversely impact the equipment.

VERIFICATION GUIDANCE (4.3.1.19)

The specific analysis and test to demonstrate compliance with this requirement should be inserted in the blank. For further guidance see 4.3.

VERIFICATION LESSONS LEARNED (4.3.1.19)

To be provided.

3.3.1.19.1 Thermal Cycles Associated with Manufacture and Repair
The maximum number of allowable thermal cycles (e.g., de-solder/solder cycles) associated with the manufacture and repair of electronic subassemblies shall be __________.

REQUIREMENT RATIONALE (3.3.1.19.1)

Unit manufacture and repair (e.g., desolder/solder) introduce high levels of localized thermal cycling which causes extreme stresses and shortens the life of the electronics.

REQUIREMENT GUIDANCE (3.3.1.19.1)

The number to be placed in the blank should be developed from the characteristics (e.g., ductility, fracture toughness) of the materials used in fabrication of the equipment. The contractor's experience should indicate there is a maximum number of repair cycles which can be accommodated before the repair process causes additional problems. If the contractor is unable to substantiate any better number, use six (6) cycles. (NOTE: Throw-away of the item is a valid option. The item may be a printed wiring board, a piece part or a similar unit.)

REQUIREMENT LESSONS LEARNED (3.3.1.19.1)

Repeated desolder/solder cycles induce large amounts of damage to PWBs. This damage occurs through several mechanisms. Thermal expansion of the plated through hole and PWB material induces stresses which lead to cracks and open circuits in the thru-hole and metal traces around the hole. Repeated desolder/solder cycles also cause the layers of the PWB to become delaminated and brittle, rendering the board useless. Therefore the number of desolder/ solder cycles should be limited to extend the life of the boards.

4.3.1.19.1 Verification of Thermal Cycles Associated with Manufacture and Repair
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.19.1)

See 4.3.1.19. To verify the electronics can withstand and continue to function properly when subjected to the total number of thermal cycles associated with repair.

VERIFICATION GUIDANCE (4.3.1.19.1)

See 4.3.1.19.

VERIFICATION LESSONS LEARNED (4.3.1.19.1)

To be provided.

3.3.1.20 High Power Microwave
The equipment shall withstand the high power microwave environment defined in __________.

REQUIREMENT RATIONALE (3.3.1.20)

Some systems may be exposed to high power microwaves from threats or other sources. Some of these power levels can damage sensitive electronics.

REQUIREMENT GUIDANCE (3.3.1.20)

The environment generated by high power microwaves in the area where the equipment is installed should be determined and used in the specification. These requirements are usually classified. The document that establishes these requirements should be inserted in the blank.

REQUIREMENT LESSONS LEARNED (3.3.1.20)

To be provided.

4.3.1.20 Verification of High Power Microwave
Verification of the capability of the electronics to requirements of 3.3.1.20 shall be by __________.

VERIFICATION RATIONALE (4.3.1.20)

See 4.3.

VERIFICATION GUIDANCE (4.3.1.20)

See 4.3

VERIFICATION LESSONS LEARNED (4.3.1.20)

To be provided.

3.3.1.21 Corrosion/Chemical Induced Deterioration
The equipment shall withstand the corrosion/chemical induced environment environments defined in __________.

REQUIREMENT RATIONALE (3.3.1.21)

During service usage, electronic equipment is subjected to chemical environments which can lead to material deterioration and corrosion. Deterioration and/or corrosion, if uncontrolled, can cause electronics failures.

REQUIREMENT GUIDANCE (3.3.1.21)

The blank should specify the document defining the chemical environment in which the equipment is anticipated to be employed. Corrosion which affects the operation or maintenance of the equipments should not occur during the durability/economic life for the specified usage, environments, and maintenance. Corrosion prevention systems should remain effective over the durability/economic life for the specified usage and environment. Corrosion prevention and control should be addressed early in the development process to insure the correct materials are used. Special attention should be given to the manufacturing processes and application of corrosion protection materials to meet life requirements.

As a first step, all environments and conditions, including their combinations, which are expected to cause and promote corrosion during the durability/economic life of the electronics, should be identified. The capabilities of the selected or candidate materials to operate as specified under these environments and conditions for the specified life, then, should be evaluated. Strength requirements for the materials selected should be established. Any limitations of the material should be identified and alternatives evaluated.

When the corrosion prevention or protection provisions have an effective life less than the electronics' durability/economic life, the contractor should establish plans and procedures for replacement or remanufacturing of these provisions at designated periods during the equipment's life cycle. For safety critical and mission critical hardware items with life limited corrosion protection provisions, preventive maintenance actions such as repair or replacement of corrosion protection, should be planned at designated intervals in order to prevent corrosion related failures from occurring during the equipment life cycle. These plans and procedures will become a part of the overall life management plan. Guidance for the design, selection of materials and processes, and their applications to provide the requisite resistance to humidity, salt fog, and other chemical environments is found in NAVMAT P 4855-2 Design Guidelines for Prevention and Control of, Avionics Corrosion Tables 5.2 and 5.3.

REQUIREMENTS LESSONS LEARNED (3.3.1.21)

To be provided.

4.3.1.21 Verification of Corrosion/Chemical Induced Deterioration
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.21)

Verification is required to evaluate the effectiveness of the corrosion prevention and control provisions and of the ability of the electronics to perform in the specified chemical/corrosive environment(s).

VERIFICATION GUIDANCE (4.3.1.21)

The effectiveness of the corrosion prevention process should be verified prior to employing the process on production hardware. Both the corrosion prevention process and the design should be validated and verified prior to production release. Repair of production units prior to and after delivery should be performed using the validated repair process.

The adequacy of the corrosion control process should be verified during the durability life test whenever possible. Life limited parts should be periodically inspected at the opportunistic or preventive maintenance timelines established for the hardware, and the housings opened during the test, to determine the capability of the design and corrosion prevention process to meet the requirements (Note: preventative maintenance must be acceptable to the user prior to implementation).

VERIFICATION LESSONS LEARNED (4.3.1.21)

Failure to know the limitations of the design to corrosion, and the capability of the corrosion repair procedures and the correct interval for applying the procedures have caused materials to deteriorate beyond repair and cause catastrophic failures with mission loss, aircraft loss, and loss of life.

3.3.1.22 Precipitation Static

The electronics shall perform as specified in ____1____ during and after exposure to the precipitation static environment of ____2____.

REQUIREMENT RATIONALE (3.3.1.22)

Precipitation static is a charge built up on an air vehicle due to the flow of particles (e.g., rain, snow, dust,) or air across the surfaces. Discharges of this static could result in structural damage to the aircraft and the bum out of unprotected electronics. Flight safety may be involved in some instances.

REQUIREMENT GUIDANCE (3.3.1.22)

Insert in blank (1) the paragraph number or document containing the detailed performance requirements of the equipment. Insert in blank (2) the characteristics of the precipitation static environment.

REQUIREMENT LESSONS LEARNED (3.3.1.22)

Guidelines need to be established for protection of equipment located outside the aircraft metallic structure which may be damaged due to the migration of static charges across the aircraft surfaces.

4.3.1.22 Verification of Precipitation Static

The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.3.1.22)

See discussion under 3.3.1.22 rationale.

VERIFICATION GUIDANCE (4.3.1.22)

Insert in the blanks the analyses and/or tests used to verify compliance to requirements.

VERIFICATION LESSONS LEARNED (4.3.1.22)

To be provided.

3.4 Supportability Requirements

REQUIREMENT RATIONALE (3.4)

Supportability requirements are required to ensure the hardware is built and configured in a fashion compatible with the user's required operational readiness and logistics support strategies and constraints.

REQUIREMENT GUIDANCE (3.4)

This section provides tailorable supportability requirements that are part of the integrity process. Additional supportability requirements from other sources may be appropriate. Supportability requirements highlighted in AVIP include reliability (3.4.1), critical failure free operational period (3.4.1.1), cumulative maintenance burden (3.4.1.2), avionics fault tolerance (3.4.1.3), battle damage tolerance (3.4.1.4); maintainability (3.4.2); Diagnostics and testability (3.4.3), test verticality/test commonality (3.4.3.1), BIT false failure indications (3.4.3.2), testability (3.4.3.3); sensitivity of parts, assemblies, and equipment to electrostatic discharge (ESD) (3.4.4); and provisions for life management (3.4.5).

The supportability requirements and contractor's design solution for meeting those requirements should be reviewed at major design reviews. This will ensure agreement between the user, procuring agency, maintenance organization, and contractor that they are appropriate, are consistent with performance and logistics support requirements, are compatible with the systems engineering and integrity design analysis and trades, and are cost effective.

REQUIREMENT LESSONS LEARNED (3.4)

To be supplied

4.4 Verification of Supportability Requirements.

VERIFICATION RATIONALE (3.4)

Verification of the ability of the equipment to meet the supportability requirements is critical in determining the ultimate affordability and operational effectiveness of the developed system. These capabilities should be demonstrated prior to full rate production commitments.

VERIFICATION GUIDANCE (4.4)

Incremental verification is recommended to ensure deficiencies are identified in the most timely, cost effective manner. See subparagraphs for specific verification guidance.

3.4.1 Reliability
The __________ reliability shall be based upon the concepts of durability/economic life, avionics fault tolerance, battle damage tolerance, reduced unscheduled maintenance, cumulative maintenance burden, and reliability centered maintenance (RCM) as specified below.

REQUIREMENT RATIONALE (3.4.1)

Traditional reliability programs have been based on the concept of random failure. AVIP adds design discipline and comprehensive requirements to improve reliability and minimize maintenance burden over the durability/economic life of electronics equipment. A widely used maintenance policy for military avionics has been to perform corrective maintenance when the equipment fails, with little or no preventive maintenance. This policy can drive the design to excessive redundancy and/or robustness to achieve the required durability/reliability. This tends to increase the system/subsystem/equipment complexity. This policy or practice may also lead to the need for sophisticated fault detection/fault isolation system. These factors tend to increase the costs of the hardware, of the support system, and of the maintenance burden, and therefore lead to user and maintainer dissatisfaction. It is, therefore, necessary to have a maintenance plan which is based on the criticality of the hardware and the economics of the reliability driven maintenance burden.

REQUIREMENT GUIDANCE (3.4.1)

Insert program/equipment name the blank. The requirements as stated in 3.4.1.1-3.4.1.4 apply to acquisition programs where the contractor is given only the system level requirements for an electronic system and is responsible for developing all the subsystems/LRUs including allocation of various functions to these subsystems/LRUs. In this case, the criticality of various subsystems/LRUs will depend on the system architecture established by the contractor. For the acquisition programs where the system architecture is already known (i.e. the criticality of the items has already determined), the wording of 3.4.1.1-3.4.1.4 should be tailored accordingly, and the criticality of various items should be identified.

All hardware items will be categorized into at least four categories (e.g. safety critical, mission critical, durability critical, other/expendables) through the failure modes, effects and criticality analysis (FMECA) process. Guidance for conducting FMECAs is in MIL-STD-1629. During the preliminary design (when all the hardware design details are not yet known), a functional level FMECA is performed and the impact of all probable failure modes on flight safety, mission capability, availability, and other economic aspects and consequences, is analyzed. This failure consequence evaluation determines the criticality of the hardware items as described earlier in this section. This criticality determination is to be based on the consequence of failures rather than the traditional "failure rate predictions". Based on this criticality determination, design criteria are applied as the design progresses, and durability/economic life analyses and other engineering analyses/tests are conducted. As the detailed design progresses, the criticality analysis is refined using the hardware level FMECA. The life predictions for, and the consequences of failures of, design details are determined and analyzed. Subsequently, various maintenance trade-offs are considered depending on the life predictions and the criticality of the hardware items. For example, life limited items which are safety critical, mission critical or durability critical are usually assigned preventive maintenance at designated time intervals. See Appendix A for more guidance.

REQUIREMENT LESSONS LEARNED (3.4.1)

To be provided.

4.4.1 Verification of Reliability
Verification of reliability requirements are covered in 4.4.1.1–4.4.1.4 below.

3.4.1.1 Failure Free Operation

The critical failure free operational period (CFFOP) shall be __________ (missions and/or years) with __________ probability of a maintenance event.

REQUIREMENT RATIONALE (3.4.1.1)

This requirement is intended to address the ability of the system/equipment to provide capability needed for a mission and/or safety over a specified period of time. The probability requirement recognizes the statistical nature of physical processes. Loss of a safety critical capability should be a very low probability. Some maintenance of mission critical functions may be acceptable to the user. This requirement does not preclude some failures within the system/equipment from occurring as long as the system continues to provide required capability with the failures (e.g., redundant items).

REQUIREMENT GUIDANCE (3.4.1.1)

The goal is for the CFFOP to be greater than or equal to the durability/economic life. If the CFFOP is less than the durability/economic life (i.e., life limited items are part of the equipment) and/or causes the probability of maintenance exceeds the requirement, life management provisions should be provided (see 3.4.5).

The critical failure free operational period (CFFOP), as defined in 6.1, is the operating period of the equipment during which the probability of impacting a mission for a maintenance action is below a specified value. CFFOP is usually applied to an item or function with respect to organizational level maintenance. For safety critical applications, the CFFOP should be much larger than the durability/economic life and the probability of meeting the required performance during the CFFOP should be very high. For mission critical applications, the CFFOP and probability of meeting the required performance during the CCFOP can be adjusted based on user inputs such as number of mission aborts due to failures that lead to loss of required performance. Achievement of the durability/economic life requirement may be supported by scheduled preventive maintenance, on a non-interference basis, at specific intervals less than the required durability/economic life. This decision should be based on an economic analysis conducted early in development and user requirements. Without this economic assessment, the minimum CFFOP should be equal to or greater than the required durability/economic life. A list containing each avionics/electronic subsystem/equipment with it's corresponding CFFOP and probability of maintenance (e.g., safety critical, mission critical) is recommended for inclusion as part of the specification requirement.

For durability critical items, the same guidance applies as for safety and mission critical items. Because of the importance of durability critical items, the design should include ample margin to preclude early and unscheduled maintenance which could adversely impact the operational capability and availability of the weapon system.

For other noncritical items, both the required durability/economic life and the CFFOP may be less than the required operational durability/economic life of the system/subsystem. The specific requirements should be based on an economic evaluation of the logistics impact of maintaining these items. These parts may be maintained on either a corrective or preventive basis in service as long as the allowable cumulative maintenance burden (CMB) is not exceeded. Preventive maintenance tasks should be identified using the Reliability Centered Maintenance (RCM) decision logic taking into consideration any limited life items. Without an economic evaluation, the durability/economic life of the item should be equivalent to the service life or durability/economic life of the host system/subsystem. See Appendices A and B for more guidance.

REQUIREMENT LESSONS LEARNED (3.4.1.1)

To prevent loss of life and aircraft, safety critical applications must assure that a situation cannot occur that leads to loss of the required performance. Although less severe than safety related performance losses, but still very important, is the need to avoid loss of the ability to perform an assigned mission because of failures in the system. Past systems in both categories have been developed that did not provide the required performance when failures occurred with the end result less than desired – loss of aircraft and lives or a critical mission scrubbed thus reducing the war fighting capacity. Redundancy has been used in flight critical and some mission critical applications as a method to reduce the probability of a loss of required performance.

4.4.1.1 Verification Failure Free Operation
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.1.1)

Verification of the requirements set forth in 3.4.1.1 is needed to fully assess the product's ability to provide full required performance over the specified period of time. See 4.4.1 for additional guidance.

VERIFICATION GUIDANCE (4.4.1.1)

This requirement should be verified during the DLT. Incremental verification by analysis, simulation, and/or initial design testing is recommended. Tracking of field data as it is accrued for some period of time is also recommended. See 4.4.1 for additional guidance.

VERIFICATION LESSONS LEARNED (4.4.1.1)

To be provided.

3.4.1.2 Cumulative Maintenance Burden (CMB)
The __________ (O/I/D-level) cumulative maintenance burden (work hours for all maintenance) shall not exceed __________ (work hours/time period) over the durability/economic life. The maintenance burden includes all efforts associated with false BIT indications (para 3.4.3.2) and problems/anomalies that cannot be duplicated.

REQUIREMENT RATIONALE (3.4.1.2)

This requirement when tied together with 3.4.1.1, limits both the rate of occurrence of critical failures and the overall maintenance burden the user is expected to encounter over the durability/economic life of the product. This requirement is intended to cover all maintenance actions -scheduled/preventive, unscheduled, false failure indications. This requirement excludes routine servicing (refueling, munitions loading, etc.).

REQUIREMENT GUIDANCE (3.4.1.2)

See Appendix B.

REQUIREMENT LESSONS LEARNED (3.4.1.2)

Maintenance burden has been a long-term problem with many of the systems fielded in the past. The maintenance burden in some instances has outstripped the capacity, causing aircraft to be grounded and mission to be flown with less than full performance capability. By attempting to design out failures and control the maintenance burden these types of problems can be avoided.

4.4.1.2 Verification of Cumulative Maintenance Burden
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.1.2)

Verification of the capability of the equipment to meet the CMB demonstrates the systems capacity to be economically maintained and supported.

VERIFICATION GUIDANCE (4.4.1.2)

This requirement should be verified during the DLT. Incremental verification by analysis, simulation, and/or initial design testing is recommended. Tracking of field data as it is accrued for some period of time is also recommended. See 4.4.1 for additional guidance.

VERIFICATION LESSONS LEARNED (4.4.1.2)

To be provided.

3.4.1.3 Avionics Fault Tolerance
Avionics equipments that perform __________ critical (e.g., safety, mission) functions as defined in __________ shall be fault tolerant. Fault tolerance is the capability of an avionics equipment to sustain damage or partial failure without jeopardizing safety and/or mission capability.

REQUIREMENT RATIONALE (3.4.1.3)

Fault tolerance is the capability of an avionics equipment to sustain damage or partial failure without jeopardizing safety and/or mission capability. This is required to ensure both safety of the aircraft and a high probability of successful mission completion. See 3.4.1.

REQUIREMENT GUIDANCE (3.4.1.3)

Fill in the first blanks with the types of functions required to be performed by the equipment that require fault tolerance capability. The second blank should be filled in with the document or analysis which defines the equipment as safety, mission, etc critical. See 3.4.1 for additional guidance.

REQUIREMENT LESSONS LEARNED (3.4.1.3)

To be provided.

4.4.1.3 Verification of Avionics Fault Tolerance
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.1.3)

Verification is required to assure the fault tolerance requirement is met for the selected Equipments. Safety and mission critical applications for obvious reasons of engineering prudence must be verified to the maximum extent practical.

VERIFICATION GUIDANCE (4.4.1.3)

FMECA can be used to verify this requirement. Use of the DLT and environmental test results in conjunction with intentional fault insertion can be used to assess but not assure if this requirement is met. Testing alone should not encounter enough number of failures or failure combinations to verify this requirement.

VERIFICATION LESSONS LEARNED (4.4.1.3)

Fault insertion and results of testing have never been enough to verify the fault tolerance of an equipment or system. Analysis must be heavily relied on and the test and fault insertion results used to supplement the analysis. Many systems/equipments have experienced field failures rendering the system/equipment inoperative and these failures were never encounter in the laboratory testing process. Analysis of the failures revealed many of the failures could have been prevented by performing analyses during the design and would not have been encountered during operational use.

3.4.1.4 Battle Damage Tolerance
The Avionics System shall support the survivability requirements as defined in __________, by physically protecting and/or separating redundant systems to the maximum extent possible.

REQUIREMENT RATIONALE (3.4.1.4)

Equipment is sometimes installed in areas subject to battle damage. This may lead to failure of safety critical equipments. There may be alternate locations or design configurations that minimize this possibility.

REQUIREMENT GUIDANCE (3.4.1.4)

Damage tolerance requirements should be implemented on safety-critical and/or mission-critical hardware items. This requires application of durability and damage tolerance design criteria of 3.4. Application of these criteria facilitates conservative or robust design.

REQUIREMENT LESSONS LEARNED (3.4.1.4)

Lessons learned during war time operations have shown the need to provide battle damage tolerance. Small arms fire (e.g., on landing or low altitude terrain following operations) has to be taken into consideration as well as cannon fire. Fuel tanks use fire suppressants and flight surface control cables and hydraulics use redundancy and separation to provide the battle damage tolerance. Fly by wire systems such as the F-16 use redundancy in the critical wiring. Location of flight critical avionics has also been used to minimized battle damage vulnerability. Redundant equipment/LRUs/LRMs which provided limited backup should one be damaged are used in some cases. For example, the F-15E has two avionics interface units which, while not identical, are able to back up each others' primary capabilities should one fail or incur battle damage.

4.4.1.4 Verification of Battle Damage Tolerance
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.1.4)

See 4.4.1

VERIFICATION GUIDANCE (4.4.1.4)

A combination of analysis and the verifications of 3.1, 3.2, and 3.3 are recommended for this requirement.

VERIFICATION LESSONS LEARNED (4.4.1.4)

To be provided.

3.4.2 Maintainability

4.4.2 Verification of Maintainability
Verification of maintainability requirements are covered in 4.4.2.1–4.4.2.2 below.

3.4.2.1 Maintainer Skill Compatibility
The equipment shall be maintainable at the organizational level in the environments specified in __________ by maintainers specified in __________. The equipment shall be maintainable at the intermediate level in the environments specified in __________ by maintainers specified in __________. The equipment shall be maintainable at the depot level in the environments specified in __________ by maintainers specified in __________ (e.g., skill levels + chem gear). Reliability Centered Maintenance is allowable to achieve the CFFOP and/or CMB requirements in 3.4.1.1.

REQUIREMENT RATIONALE (3.4.2.1)

Design for the maintenance environment can prevent maintenance induced failures and ensure maintenance burden is within the resources and capabilities of the user. Further guidance may be found in MIL-STD-470, MIL-STD-1472, and/or MIL-STD-1800.

REQUIREMENT GUIDANCE (3.4.2.1)

See 3.4.1. MIL-STD-470, MIL-STD-1472, and/orMIL-STD-1800 may be used as guides to determine this and other maintainability requirements.

REQUIREMENT LESSONS LEARNED (3.4.2.1)

To be provided.

4.4.2.1 Verification of Maintainer Skill Compatibility
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.2.1)

See MIL-STD-471, MIL-STD-1472, and/or MIL-STD-1800 as guides to determine maintainability verification needs.

VERIFICATION GUIDANCE (4.4.2.1)

The DLT may be used as verification of the number of maintenance events. If total resource burden is to be verified, see MIL-STD-471, MIL-STD-1472, and/or MIL-STD-1800 for guidance.

VERIFICATION LESSONS LEARNED (4.4.2.1)

To be provided.

3.4.2.2 Mean Time To Repair (MTTR)
The equipment shall be repairable at the ____(O, I or D)____ level, by maintainers specified in 3.4.2.1, above, in a mean time of __________ clock hours/minutes.__________ percent of failures shall be repairable within __________ clock hours/minutes.

REQUIREMENT RATIONALE (3.4.2.1)

Verification of the capability of the equipment, technical data and support equipment to meet the MTTR requirement is critical in demonstrating the system's ability to be cost effectively supported and maintained.

VERIFICATION GUIDANCE (4.4.2.2)

A formal demonstration is usually accomplished here. See MIL-STD-471, MIL-STD-1472, and/or MIL-STD-1800 for guidance. Operational demonstrations, using "blue suit" maintenance resources are also appropriate for some applications.

REQUIREMENT LESSONS LEARNED (3.4.2.1)

To be provided.

4.4.2.2 Verification of Mean Time To Repair (MTTR)
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.2.2)

See MIL-STD-471 and MIL-STD-1800 as a guide to determine maintainability verification needs.

VERIFICATION GUIDANCE (4.4.2.2)

A formal demonstration is usually accomplished here. See MIL-STD-471 and MIL-STD-1800 for guidance.

VERIFICATION LESSONS LEARNED (4.4.2.2)

To be provided.

3.4.3 Diagnostics and Testability
The ____1____ shall provide detection and isolation of all known or expected faults to the repairable or replaceable item(s) required for the level of maintenance. Fault detection and isolation shall be accomplished using any combination of ____2____.

REQUIREMENT RATIONALE (3.4.3)

This process is necessary to ensure that a failed hardware item can be detected and isolated correctly. It should ensure consideration of diagnostics and testability requirements early in the design process. Further guidance may be found in MIL-STD-1814.

REQUIREMENT GUIDANCE (3.4.3)

Blank (1) is filled in the system/subsystem/equipment name. The blank (2) is normally filled in with "built-in test (BIT), built-in test equipment (BITE), automatic test systems, trouble shooting via computer assisted procedures, ancillary tools and test equipment, or manual technical data procedures." Specifying 100% fault detection and isolation allows tradeoffs of various techniques to meet user constraints. Further guidance may be found in MIL-STD-1814.

REQUIREMENT LESSONS LEARNED (3.4.3)

A major contributor to the maintenance burden can be time wasted troubleshooting failures that have not been properly indicated by BIT or other techniques. Coupled with the test verticality requirements of 3.4.3.1, reliability and maintenance burden should be improved.

4.4.3 Verification of Diagnostics and Testability
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.3)

To verify whether the testing approach during the design process provides the required fault isolation, the requirement defined in paragraph 3.4.3 should be verified by analyses, and/or test(s).

VERIFICATION GUIDANCE (4.4.3)

Insert the analyses, and/or test(s) into the blanks. These analyses and/or test(s) should be used to verify the requirements of section 3.4.3 to ensure: the fault isolation is correct at all maintenance levels. The durability/economic life test and any maintainability demonstrations should be part of these verifications. Full up diagnostics software should be used.

VERIFICATION LESSONS LEARNED (4.4.3)

To be provided.

3.4.3.1 Test Verticality/Test Commonality

The __________ shall provide compatibility of test tolerances (cone of tolerance), ranges, sequences, interfaces, and techniques for duplication of failure indications as failed items move through their maintenance levels. Exchange of pertinent system health and test failure data between all levels of test and maintenance shall be provided. Test levels include hierarchical levels of BIT, organizational, intermediate and depot. Each level of test shall be capable of exercising the diagnostics and built-in test routines of all test levels below it (e.g. depot test shall use organizational and intermediate tests). Each level of test shall make use of the reporting capability and diagnostics and health data of all test levels below it.

REQUIREMENT RATIONALE (3.4.3.1)

This process is necessary to ensure that each hardware item will function properly when placed in the next higher level of assembly or maintenance. It should ensure establishment of test hierarchy and test coverage at all levels of assembly and maintenance.

REQUIREMENT GUIDANCE (3.4.3.1)

Testing at each level of integration (e.g., system, LRU/LRM, SRU, component) using the required test limits is critical to the supportability and producibility of the avionics/electronic system. As the system is integrated together from the lower level assemblies into the higher level assemblies, the corresponding test limits on a given circuit parameter should follow the established cone-of-tolerance that is concurrently developed. The test limits should also take into account the effects of environments and aging. The test limits depend on the equipment's level of integration and are based on the key product characteristics and their tolerances. The testing at different levels and selection of test points must account for the field usage and environments. The test limits which directly correspond to the parameter tolerances, should allow for tolerance accumulation. The variability of the key product characteristics (KPCs) and key production processes (KPPs) established during the design should be analyzed to find the required test limits (derived from their tolerances and margins) best supported by the design, manufacturing, test equipment and field support processes.

REQUIREMENT LESSONS LEARNED (3.4.3.1.)

A major contributor to the maintenance burden experienced during the Persian Gulf War was inadequate test verticality and test commonality. The investigation after the war found that the individual tests performed on specific functions at each level of maintenance (e.g., Organizational, Intermediate and Depot) differed. This difference in test employment resulted in a lack of test coverage of the circuit function, when compared to the operating environment. This investigation also found that environmental effects (e.g., temperature, vibration) caused slight variations in circuit parameters. The result was parameters out of and/or near the specified tolerance limits. At higher levels of integration, tolerance accumulation resulted in a test point/circuit parameter outside of the test limits. Therefore, many failures could not be duplicated.

4.4.3.1 Verification of Test Verticality/Test Commonality

The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.3.1)

To verify whether the testing approach during the design process provides the required test coverage, and employs common/traceable tests at the different levels of the avionics system, each test limit defined in paragraph 3.4.2 should be verified by analyses, and/or test(s). These analyses and/or tests should ensure that the cone of tolerance and test commonality is maintained over all levels of integration.

VERIFICATION GUIDANCE (4.4.3.1)

Insert the analyses, and/or test(s) into the blanks. These analyses and/or test(s) should be used to verify the requirements of section 3.4.3.1. The durability/economic life test and any maintainability demonstrations should be part of this verification. Full up diagnostics software should be used.

VERIFICATION LESSONS LEARNED (4.4.3.1)

To be provided.

3.4.3.2 BIT False Failure Indications
BIT false failure indications, including intermittent and transient fault indications, causing aborts and/or maintenance actions shall be treated as failures and shall be included in the calculation of CFFOP & CMB (3.4.1.1 and 3.4.1.2).

REQUIREMENT RATIONALE (3.4.3.2)

See 3.4.3. BIT false indications increase maintenance burden and is misleading to both the aircrew and the maintenance personnel.

REQUIREMENT GUIDANCE (3.4.3.2)

This process is necessary to ensure that BIT is accurate and does not become a nuisance to the users. It should ensure consideration of BIT requirements early in the design process. The requirement may be specified as a function of failure criticality. Further guidance may be found in MIL-STD-1814.

REQUIREMENT LESSONS LEARNED (3.4.3.2)

Historically, BIT false alarms have been specified as a percentage (typically 2-5%) of total faults. In highly reliable systems, a small number of false BIT indications can be a very high percentage of total faults. Requirements recommended here are more realistic and are intended to satisfy the user.

4.4.3.2 Verification of BIT False Failure Indications
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.3.2)

See 4.3.1.

VERIFICATION GUIDANCE (4.4.3.2)

See 4.3.1.

VERIFICATION LESSONS LEARNED (4.4.3.2)

To be provided.

3.4.3.3 Testability
Specific testability requirements shall be __________ or as referenced in __________.

REQUIREMENT RATIONALE (3.4.3.3)

Testability is an important attribute for supportability. Also, see 3.4.3.

REQUIREMENT GUIDANCE (3.4.3.3)

MIL-STD-2165 is widely accepted as the design and program guidance for testability. Another document for reference is the Rome Air Development Center (RADC) Testability Notebook RADC-TR-82-189. Also, see 3.4.3.

REQUIREMENT LESSONS LEARNED (3.4.3.3)

To be provided.

4.4.3.3 Verification of Testability
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.3.3)

See 4.4.3.

VERIFICATION GUIDANCE (4.4.3.3)

See 4.4.3.

VERIFICATION LESSONS LEARNED (4.4.3.3)

To be provided.

3.4.4 Sensitivity of Parts, Assemblies, and Equipment to Electrostatic Discharge (ESD)
The equipment shall incorporate provisions to eliminate or minimize, to the maximum extent possible, the susceptibility to damage induced by ESD. Electronic parts, assemblies, and equipment which are sensitive to electrostatic discharge shall be identified and controlled in accordance with __________.

REQUIREMENT RATIONALE (3.4.4)

An electrostatic discharge (ESD) can destroy electronic parts and items and can occur at any time in the development, manufacturing, use, and logistics support.

REQUIREMENT GUIDANCE (3.4.4)

Insert in the blank the document name that establishes the ESD program to be implemented in the development and manufacturing process. DoD-HDBK-263 and DoD-STD-1686 may be used as a guide. Failed parts should be handled in accordance with ESD protection to preclude invalid failure analysis.

REQUIREMENT LESSONS LEARNED (3.4.4)

To be provided.

4.4.4 Verification of Sensitivity of Parts, Assemblies, and Equipment to Electrostatic Discharge (ESD)
The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.4)

An electrostatic discharge (ESD) can destroy a microcircuit and can occur at any time in the development, manufacturing, or repair process.

VERIFICATION GUIDANCE (4.4.4)

The contractor should incorporate protective devices within the design and process controls to preclude failure due to ESD. The effectiveness of these devices and process controls should be verified by analysis. Also, the contractor should establish and implement procedures to control the adverse effects of ESD in the manufacturing and repair process. MIL-STD-1686 may be used as a guide. Any procedures used to prevent or control damage should be included in the tech data.

Insert in the blank the document describing the contractor's ESD control program.

VERIFICATION LESSONS LEARNED (4.4.4)

To be provided.

3.4.5 Provisions for Life Management

Life limited safety critical items shall have RCM provisions (e.g., hardware, software, technical data) to measure and track operational usage, failures and/or stresses such as elapsed time, fault history, on/off cycles, temperature, vibration. Life limited mission critical and/or durability critical equipments are recommended to contain these provisions. Provisions for durability/economic life management shall be __________. **Caution**: **Field data collection and agreement with the user is required to implement this requirement**.

REQUIREMENT RATIONALE (3.4.5)

Measurement and tracking of usage and/or environments for safety and mission critical items helps identify potential problem areas before a failure occurs and, in turn, helps determine corrective action for the problem. It also helps determine how the actual usage and environments differ from the planned usage and environments the equipment was designed for.

REQUIREMENT GUIDANCE (3.4.5)

The requirement for life management provisions must be evaluated on a case-by-case basis. Item criticality, durability characteristics, design flexibility and environmental stress severity all must be considered when determining the need for life management provisions. The contractor should develop programs and hardware to measure operational usage and stresses, and establish a tracking system to identify problem areas and institute corrective action. It is important to have a thorough understanding of how the user activity will collect and process life management information. Insert in the blank the capability and process for meeting the life management provision requirement.

REQUIREMENT LESSONS LEARNED (3.4.5)

To be provided.

4.4.5 Verification of Provisions for Life Management

The requirement shall be verified by __________.

VERIFICATION RATIONALE (4.4.5)

Verification of life management provisions is required to ensure the necessary capability exists to collect, track and analyze operational usage, failure history and environmental stresses.

VERIFICATION GUIDANCE (4.4.5)

Initial verification is accomplished through inspection of drawings and other documentation. Durability analyses and engineering/development tests of 4.5 are used to verify some of the life management provisions. Final verification usually occurs in the durability life test of 4.5 and in the flight test program (if feasible). The data gathered from these tests can also be used to refine the life management plan. Insert in the blank the required verification technique.

VERIFICATION LESSONS LEARNED (4.4.5)

To be provided.

5 PACKAGING

If this section is applicable, all deliverable items shall be prepared for shipment as directed by the acquisition activity.

6 NOTES

Section 6 is not contractually binding. It contains information of a general or explanatory nature, and no requirements shall appear within this section. It should contain information designed to assist in determining the applicability of the specification.

6.1 Intended Use

Information relative to the use of the item or area covered by the specification shall be included under this heading.

6.2 Acquisition Requirements

This paragraph shall contain all the options which must be exercised by the contracting officer in invitations for bids, contracts, or other purchasing documents. Options shall be listed in the sequence in which they appear in the specification. Acquisition requirements shall appear as 6.2 and shall include the following information as a minimum:

a. Title, number, and date of this specification.

b. The specific issue of individual document(s) referenced in section 2.

6.3 Key Word Listing

The specification shall contain a listing of subject terms (key words) which would allow identification of the document during retrieval searches. Subject terms may be descriptors, keywords, posting terms, identifiers, open-ended terms, subject headings, acronyms, code words, or any words or phrases that identify the principal subjects covered in the specification, and that conform to standard terminology and are exact enough to be used as subject index entries.

avionics design
electronics design
reliability
maintainability
design integrity

6.4 Definitions, Acronyms and Terms

Any definitions, acronyms and terms required to insure there is no misinterpretation of meaning or usage.

6.5 Responsible Engineering Office

The office responsible for development and technical maintenance of the specification should be listed here. Include the office symbol and address, the name of the person who can be contacted, along with their phone and FAX numbers.

APPENDIX A

AVIONICS/ELECTRONICS INTEGRITY PROCESS TASKS

1 INTRODUCTION

1.1 Scope
This appendix provides guidance for Avionics/Electronics Integrity process tasks which are to be tailored and incorporated into the contract to achieve integrity of airborne and ground-based electronics. The integrity process tasks are applicable to various phases of weapon system and equipment acquisition. When properly applied, these tasks can result in products which are economical to produce, reliable in operation, and affordable to maintain.

1.2 Purpose
This appendix provides tailorable AVIP and AVIP related process and task guidance that is fundamental to a fully integrated program effort. Customer's expectations are met by effectively considering all the activities and factors influencing the "integrity" of the products. Equipments produced with additional emphasis on integrity activities should have a higher probability of meeting the specified performance requirements when subjected to the intended use and environments over the durability/economic life. Key to effective acquisition of products which comply with customer requirements is a disciplined design process which translates user requirements into performance requirements and product features and characteristics which satisfy the stated need. The integrity process facilitates this objective through development of product technical requirements based on the intended application and performance of tasks supportive of these technical requirements. Technical performance requirements are addressed previously in the handbook. The purpose of this appendix is to provide guidance on structuring requests for proposals (RFPs), contractual statements of work (SOWs), integrated master plans and schedules (IMP/IMS), contract data requirements lists (CDRL) and other contractual documentation.

1.3 Applicability
Integrity process activities apply to procurement of airborne and ground based electronic systems, subsystems, support systems, training systems, and equipment such as navigation sets, radios, altimeters, radar, controls and displays, computers, stores management sets, flight control computers, engine controls, electronic test and servicing equipment, memory loader verifiers, field-deployable mission planning systems, etc. This process is applicable, when properly tailored, to all program phases. When tailored, this handbook also applies to acquisition and/or modification of existing military and commercial products.

1.4 Use
This appendix is intended for use by any group or agency, program office or contractor. This appendix provides guidance on recommended process tasks for inclusion into statements of work, data item descriptions for CDRLs, and other program documentation associated with avionics/electronics integrity. Rationale, guidance, lessons learned and instructions on the various process tasks are presented. This appendix is intended to be used in conjunction with other integrated engineering and manufacturing process guidance documents (e.g., MIL-STD-499 on systems engineering, MIL-STD-1814 on Integrated Diagnostics, and the ASC Manufacturing Development Initiative (MDI) Handbook, etc.).

1.5 Tailoring
This section provides guidance on tailoring avionics integrity tasks. Suggested AVIP focus for various program phases is:

a. Concept Exploration. Conduct initial analysis of product usage and environments. Perform supportability, performance and cost trade studies. Develop preliminary life projections and analysis.

b. Demonstration/Validation. Continue and refine requirements definition. Refine weapon system service life and allocate as durability/economic life to subsystems/equipments. Develop preliminary projections of cost, supportability and performance constraints. Conduct preliminary materials characterization activities to include small scale/prototype testing, etc. Conduct initial producibility studies to include process characterization and capability studies. Develop preliminary technical requirements for the product.

1.5 Tailoring – Continued

c. Engineeringi Manufacturing Development. Finalize and establish baseline design and manufacturing process requirements. Identify key product and process characteristics. Conduct design analysis that includes suitability and risk assessments. Conduct incremental design verification and process verification, variability reduction and capability studies. Develop quality assurance and life management provisions.

d. Production. Implement key process controls and variability reduction/control plans. Continue variability

reduction and improvement studies. Develop and start initial tracking and assessment of field performance. Implement life management procedures. Refine quality assurance provisions.

e. Operation and Support. Execute life management requirements as required. Continue field tracking and assessment.

The following table matches integrity process activities to typical program specifications, statements of work (SOW), contract data requirements lists (CDRL), integrated master schedules (IMS), and integrated master plans (IMP).

TABLE A-I. Integrity process activities.

SPECIFICATION	SOW	CDRL	IMS	IMP
- Identify life, usage, environment, supportability, and other AVIP require-ments.	-Tailor applicable AVIP process activities from Appendix A. (Map specification perfor-mance requirements to process.) - Deliver with proposal	- Incorporate integrity data requirements directly into Integrated Master Plans/ Schedules. - Report results via technical report data item. - Test plans and procedures tailored to section 3/4 of the Procurement speci-fication. - Unique, standalone AVIP CDRL require-ments are not recom-mended.	- Describe and schedule the contractor's design process and show how it integrates with other tasks and milestones. - Develop entrance and exit criteria for each milestone based on program requirements. - Identify critical paths - Deliver with proposal	- Define required design and manu-facturing process activities, to include all subcontractors and suppliers. - Identify the extent that MIL-SPECS, Standards, and/or commercial standards will be used and recom-mended tailoring. - Relate all activities to specification requirements. - Deliver with proposal.

2 REFERENCE DOCUMENTS

Documents cited herein are intended solely to provide supplemental technical data and guidance and should only be used as reference documents. DoD is currently implementing new policy to minimize use of military specifications and standards. Programs should verify status of all the documents listed and/or cited herein.

2.1 Government documents

Unless otherwise indicated, the documents specified herein are referenced solely to provide supplemental technical information and data.

STANDARDS

MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-470	Maintainability Program Requirements For Systems and Equipments

MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-499	Systems Engineering (Draft)
MIL-STD- 704	Aircraft Electric Power Characteristics
MIL-STD- 785	Reliability Program for System and Equipment Development and Production
MIL-STD-1388-1	Logistic Support Analysis
MIL-STD-1530	Aircraft Structural Integrity Program, Airplane Requirements
MIL-STD-1629	Procedures for Performing a Failure Mode, Effects & Criticality Analyses
MIL-STD-1757	Lightning Qualification Test Techniques for Aerospace Vehicles and Hardware
MIL-STD-1783	Engine Structure Integrity Program
MIL-STD-1795	Lightning Protection of Aerospace Vehicles and Hardware
MIL-STD-1803	Software Development Integrity Program (SDIP)
MIL-STD-1814	Integrated Diagnostics
MIL-STD-1818	Electromagnetic Effects Requirements for Systems
MIL-STD-1843	Reliability-Centered Maintenance for Aircraft, Engines and Equipment
MIL-STD-2165	Testability Program for Electronic Systems and Equipments

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

2.2 Other documents

Unless otherwise indicated, the documents specified herein are referenced solely to provide supplemental technical information and data.

ASC MDI Handbook	ASC Manufacturing Development Initiative Handbook

(Application for copies should be addressed to ASC/ENAI, Wright-Patterson AFB, OH 45433-7630).

2.3 Order of precedence

In the event of conflict between the text of this appendix and the references cited herein, the text of this appendix should take precedence. Nothing in this appendix, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3 AVIP PROCESS/TASK GUIDANCE

The avionics/electronic integrity process is intended to be part of a complete integrated engineering and manufacturing effort that is applied within an integrated product development environment. AVIP should not be construed as additional activities to be applied over and above other system engineering processes. AVIP supports and complements integrated engineering and manufacturing by adding appropriate emphasis on equipment life, usage, environment, and supportability requirements. AVIP is intended to be the foundation from which design activities are structured. Implementation of AVIP in a stand alone fashion violates its intent and should not be pursued. Proper tailoring and application of avionics/electronic integrity processes should instill a systems engineering approach that addresses performance, cost and supportability characteristics with the proper balance at the proper points in an acquisition program.

AVIP supports the principal tasks or stages in the systems engineering process that is iterative over the life of a product. The systems engineering "engine" is presented below and illustrated in Figure A-1. Further discussions of these paragraphs and the figure can be found in MIL-STD-499 of the latest issue.

3 AVIP PROCESS/TASK GUIDANCE – Continued

a. Requirements Analysis. This task is an iterative analysis of customer needs, objectives, and requirements in the context of customer missions, utilization environments, and identified system characteristics to determine functional and performance requirements for each product function. This information will include identification of the host vehicle (platform(s), flight envelopes, mission profiles, expected operating hours, environmental conditions, operating life, maintenance concept and any other constraints levied on the system.

b. Functional Analysis/ Allocation. This task is definition and integration of a functional architecture to the depth needed to support synthesis of solutions for people, products, and processes and management of risk. Included in this phase are preliminary design analyses, trade studies, identification of key product and process characteristics, and preliminary selection of parts, materials, processes, and technologies.

c. Synthesis. This task is the definition and design of solutions for each logical set of functional and performance requirements in the functional architecture and the integration of them as a physical architecture. The detailed design phase of the process results in a final product and process design. The detailed design tasks expands the earlier efforts to the lowest levels of product indenture. This includes definition of design criteria and key product characteristics and key production processes with their associated target values and tolerances which are balanced through detailed trade studies and analyses.

d. Systems Analysis and Control. This is a broad task that includes progress measurement, evaluation and tradeoff of alternatives, selection of preferred alternatives, and documentation of data and decisions. Initiation of small scale testing, material characterization tasks, and engineering development testing are performed to support the design process. Detailed trade studies are performed to develop a balanced design solution considering cost, performance, producibility, and supportability. The result of this phase being a product and process design with the proper balance of performance, cost and supportability characteristics that is ready for the production phase.

e. Life Management. The life management phase includes the measurement of field performance and supportability characteristics against customer requirements and obtains feedback that can be used to update design or processes. This phase can be a joint government/contractor effort to determine any deviation from expected performance, supportability or availability and to determine the root cause and corrective action(s).

3.1 Integrated Program Organization

The procuring activity and contractor(s) should establish and maintain an organizational structure, e.g., Integrated Product Team(s), that will implement the integrity-based design and manufacturing processes in accordance with the Integrated Master Plan and will ensure all technical disciplines and other players needed to accomplish the program are included in the team membership.

3.2 Avionics/Electronics Integrity segments of the Request for Proposal

The Request for Proposal (RFP) should include systems performance requirements (detail and completeness may vary with program phase), a model statement of work (SOW), and provide instructions to the offeror for preparation of the proposal.

3.2.1 Government Requirements Document

The procuring activity integrated product team will normally translate user needs and requirements and other program constraints into a performance based system requirements document (SRD) or technical requirements document (TRD) for the RFP. The AVIP parts of this document are created using Sections 3 and 4 of the sample specification contained in Appendix C and the main handbook as a guide.

3.2.2 Instructions to Offerors

Instructions to offerors for discussion of the tailored AVIP approach in the proposal and delivery of integrated master plans and schedules should be in the RFP.

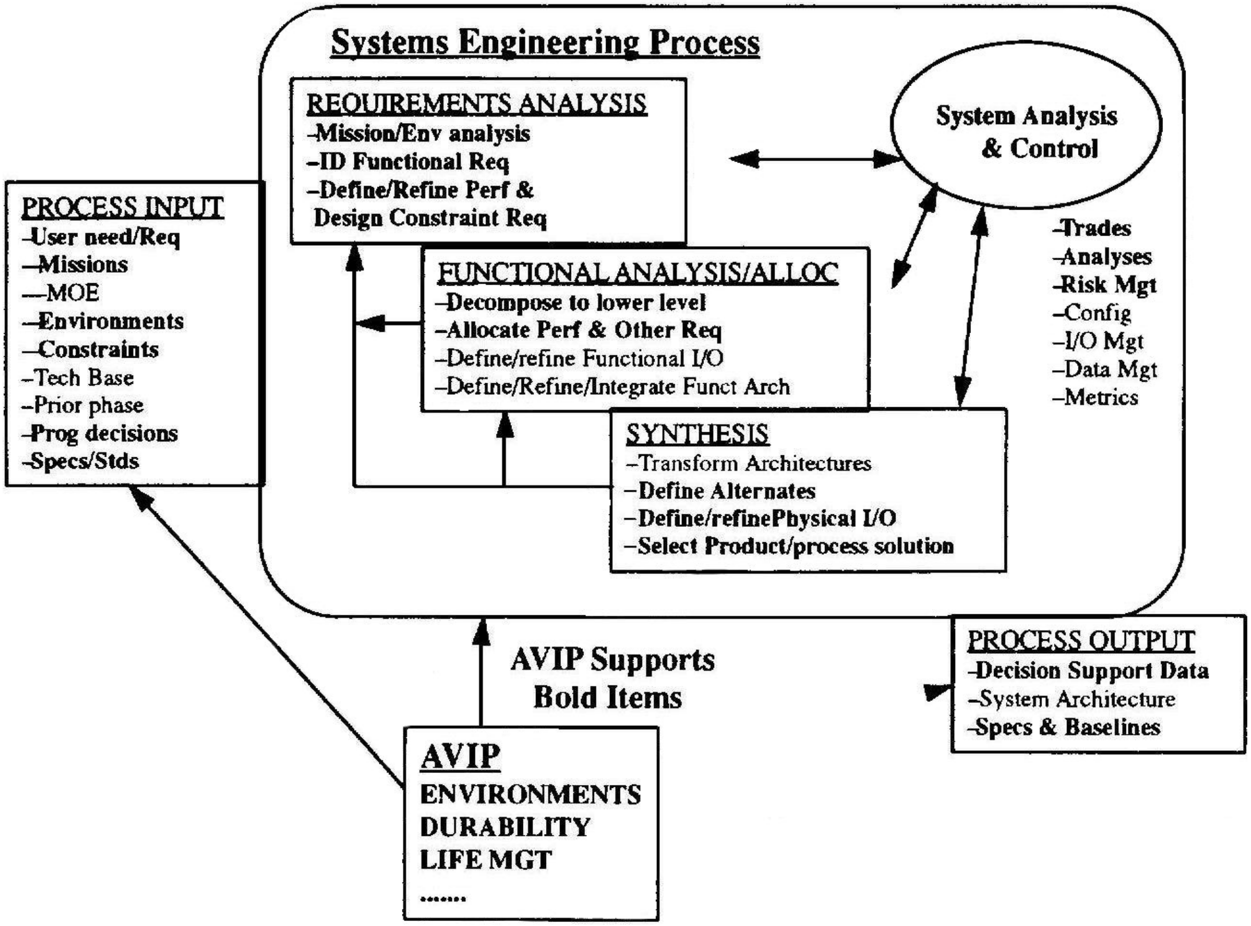

Figure A-1. AVIP Contribution to Systems Engineering.

3.2.2.1 IMP Content

Specific content varies depending upon the nature and phase of the acquisition program, need for specific information required to manage the program, need for adequate transitions between program phases, and need for entrance and exit criteria for major program milestones. The following information is a suggested content for an IMP. AVIP should be part of the IMP and tailoring is to be accomplished as part of RFP preparation.

a. Reference documents. The applicable issue for the document cited including the documents approval date and dates of any applicable amendments and revisions shall be referenced.

b. Introduction. This section contains information relative to the aims and scope of integrated management, engineering, and manufacturing process, background of the avionics/electronic development, description of the avionics/electronic airborne or ground based system or subsystem to be developed, time phasing of tasks relative to the program milestones described in the integrated master schedule, and procedures for updating the IMP.

c. Main Body. The plan defines the contractor's integrated management, engineering, and manufacturing process, i.e., the specific tasks and activities to be accomplished in a logical sequence for the design, development, qualification, manufacture and maintenance of the avionics/electronic system, subsystem, or LRU/M. The IMP includes the development tasks, the interrelationships and responsibilities or various functional organizations and any anticipated risks and risk management approaches. AVIP tasks and their relationship to systems engineering and manufacturing should be included. Suggested tasks are presented below. The main handbook and Appendices B and C provide additional guidance.

– Durability/Economic Life – Describe the trade studies, tasks, analyses, tests, and demonstrations which shall be used to demonstrate compliance with performance requirements as tailored for a particular acquisition program.

3.2.2.1 IMP Content – Continued

– Usage Requirements – Describe the approach, tasks, and activities for establishing the usage performance requirements as tailored for a particular acquisition program.

– Environments – Describe the trade studies, tasks, analyses, tests, and demonstrations which shall be used to demonstrate compliance with performance requirements as1ailored for a particular acquisition program.

– Supportability – Describe the trade studies, tasks, analyses, tests, and demonstrations which shall be used to demonstrate compliance with performance requirements as tailored for a particular acquisition program.

– Life Management – Describe the trade studies, tasks, analyses, tests, and demonstrations which shall be used to define and justify life management as tailored for a particular acquisition program (user input required).

d. Responsibilities and flow diagrams. Include in this section detailed descriptions of responsibilities, flow diagrams, and other information needed to define the scope and operation of the integrated management, engineering, and manufacturing process flow diagram; delineation of responsibilities (contractor, AFMC, and using command) together with milestones; intercommand reporting requirements, procedures, and format; and flow diagrams for tracking the equipment during operational use.

e. Summary. This section contains a brief discussion of the primary considerations for achieving the intent of the integrated management, engineering, and manufacturing process for particular avionics/electronic systems, subsystems, or LRU/M under development. Each of these items shall contain references to the particular section where it is discussed in detail.

f. IMP Data Item DescriI1tion. Guidance and/or a Data Item Description (DID) used for any Integrated Master Plan should contain the format and content preparation instructions for describing the contractor's approach to tasks necessary to meet the requirements of the contract as tailored to a particular acquisition. The IMP as described in this guidance contains data content formerly required by the Avionics/Electronic[sic] Integrity Program[sic] Master Plan. The program team(s) needs to review the IMP and related documentation to ensure that the integrated management, engineering, and manufacturing process (including AVIP items) guidance is appropriately integrated into performance and design specifications, test procedures, test results, and manufacturing procedures and drawings.

3.2.2.2 Integrated Master Schedule (IMS)

The Integrated Master Schedule (IMS) is the detailed, time dependent, task oriented schedule of work required to accomplish the complete program effort and its relationships to the events, accomplishments, and accomplishment criteria identified in the IMP. The IMS is normally an integrated program network schedule to include events defined in the IMP and further detailed to include all of the tasks required to complete each milestone and event. AVIP tasks should be part of this schedule.

The Integrated Master Schedule (IMS) defines the time interrelationships in the contractors' integrated engineering, manufacturing, and management process. It includes networked tasks, schedule criteria, major milestone, and event exit criteria for achieving the contract requirements and products or line items. The Integrated Master Schedule (IMS) also describes the contractor's assessment of possible exceptions, potential problem or risk areas, and recommended solutions. The Integrated Master Schedule (IMS) serves as a basis for evaluating progress in complying with contract requirements and determining contractual compliance. Normally, the Integrated Master Schedule (IMS) is periodically revised as changes occur and specifically reviewed as part of major design reviews or management reviews.

a. IMS Content. The logic and durations of the tasks in the Integrated Master Schedule are developed by the program team(s). Prior to release of a Request for Proposal on a competitive acquisition, the IMS should be limited to major milestones, events, and tasks. The offerors' proposals, however, should include a greater level of detail reflecting the specific tasks based on their proposed system and resources required to develop and/or produce the system. Identification and management of program risk begins with the generation and evaluation of the IMS. Specific guidance to define specific guidelines for generating proposed IMS network schedule needs to be accomplished by the IPT as part of RFP preparation and documented in the SOW and instructions to offerors for the Cost/Price and Schedule volumes of the proposals.

3.2.2.2 Integrated Master Schedule (IMS) – Continued

In general the IMS network schedule will show the critical path. All network schedule information should be consistent with the Integrated Master Plan (IMP) milestones. The IMS network schedule should be traceable using a traceable numbering system that ties the tasks in the network schedule to the IMP and the WBS. Events and tasks associated with a specific minimum WBS list or with specific integrity process tasks can be established by the IPT in the instructions to offerors or through later agreement within the IPT. The IMS should also include supporting narrative for the network diagram that explains the basis for the durations for tasks, especially those tasks on the critical path, and for those tasks designated as high risk. Any unusual aspects of the scheduled approach to the program should also be described. The lMS should also include a description of the schedule management system and how it is used to plan, coordinate, integrate, control, and manage the schedule of the program. If a specific item on the IMS network includes critical subcontract effort, separate IMS documentation for both the prime contractor effort and subcontractor effort should be provided. With this level of information, the IPT should be able to track progress of the development including avionics/electronics integrity tasks.

b. IMS Data Item Description. Guidance and/or a Data Item Description (DID) used for any Integrated Master Schedule should contain the format and content preparation instructions for describing the contractor's approach to tasks necessary to meet the requirements of the contract as tailored to a particular acquisition. The program team(s) needs to review the IMS and related documentation to ensure that the integrated management, engineering, and manufacturing process guidance is appropriately integrated into performance and design specifications, test procedures, test results, and manufacturing procedures and drawings. This DID is applicable to the acquisition of military avionics/electronic systems, subsystems, or line replaceable units/modules (LRU/M).

RATIONALE (3.2.2.2)

A number of Air Force acquisition programs have experienced cost and schedule problems during development and production because of lack of adequacy and timeliness of reliability, producibility, and durability considerations. The AVIP is intended to address these issues in a timely and cost effective manner.

GUIDANCE (3.2.2.2)

AVIP promotes a structured and disciplined engineering process with the goal of ensuring electronics will perform their intended function for the durability/economic life with a balance of performance, cost, and supportability considerations. Early in the design phase, the integrated product team should develop a thorough understanding of how the avionics/electronics product will be used. This will include the environments the electronics will be exposed to and operated in by the user during operation, maintenance, storage, transportation, and deployment. This understanding will provide the design team with the stress stimuli parameters to determine the cumulative stresses and damage the electronics will experience during the durability/economic life cycle. It is also used to identify and quantitatively baseline the key properties, characteristics and variabilities of materials, parts and processes which must be controlled to provide required capabilities. This information is then used and analyzed and evaluate the equipment to ensure a balanced design. The process incorporates engineering/development tests as applicable to establish the maturity of the design and manufacturing processes. Incremental verification of the system takes place through analyses, lower level engineering tests, and finally a Durability/economic life Test (DLT). Life management and quality assurance provisions should be established. All of these activities should be planned, scheduled, and integrated with other program efforts.

LESSONS LEARNED (3.2.2.2)

Historically, many programs have not planned or scheduled comprehensive systems engineering efforts that link and properly phase the tasks of all appropriate disciplines. AVIP ensures the consideration of all usages, environments, and support by the customer. These factors are analyzed throughout the development process to ensure the equipment is capable of required performance while experiencing the cumulative effects of the environments in any combination the equipment is expected to experience during its durability/economic life. The major focus is on designing for product robustness established such that the operational and maintenance capability is not degraded for the durability/economic life. This includes fatigue damage (cracking and delamination), wear and deterioration/thermal degradation, electrical stresses, dielectric material failure, and corrosion. In this context, life provisions are analyzed throughout the development process and established based on the optimization of durability analysis (which determines the repair/replacement interval from a structural fatigue or wear out standpoint), economic analysis (which determines the optimum repair/replace interval from a cost standpoint), durability/economic life testing, and/or other technical analysis and trade studies. Based upon these iterative design analyses and trade studies performed during the development process, a durability/economic life greater than the host system service life (e.g., safety critical item) or less than (e.g., life limited) the host system service life may be determined by the product team(s) as required for some items.

AVIP tasks and trade studies are intended to be an effort which provides a balanced approach considering cost, schedule and performance. The trade studies should include consideration of the product, production processes, Special Tooling and Special Test Equipment and Support Equipment (ST/STE/SE). The absolute requirements ("must haves") form the baseline effort. However, design margins are desirable and appropriate for every requirement, and it is intended that the contractor have the flexibility to address how much margin is applied within the program constraints (cost and schedule). It is hoped, but not required, that additional capability, above the requirements, can be found within these constraints. The government will identify the required and desired capabilities in the statement of work and the system technical requirements/system requirements document. (TRD/SRD). The contractor will develop a design which prioritizes to the user's needs and considers "desired capabilities" as customer benefits which could accomplish the missions in a more cost and/or performance effective and efficient manner.

3.2.2.3 Source Selection Plans and Standards

Source selection plans and standards provide the evaluators ground rules that are used to select the best value offer for contract award. Evaluation standards should include AVIP and relate directly to the instructions to offerors.

3.2.3 Statement-of-Work (SOW)

This section defines tasks and interfaces required to integrate AVIP with the overall program and to identify data requirements that the contractor will use to communicate with the procuring activity and others needing the information. The tasks are intended to be tailored and integrated by the RFP preparation IPT and/or contractors for compatibility with customer requirements, program risk, program phase, and procuring organization's acquisition strategy. Suggested AVIP and AVIP related tasking follows.

RATIONALE (3.2.3)

The Statement of Work should have tasks that represent an integrated program with integrity concepts presented in this guide specification tailored for the particular program.

GUIDANCE (3.2.3)

The SOW should be generated by the RFP preparation IPT and/or contractor to ensure it identifies efforts required to design, develop, integrate, certify, qualify, validate, and produce the hardware/software in accordance with program requirements. A tailored SOW for commercial off the shelf (COTS) and non-developmental items (NDI) still needs to require tasks for meeting the performance requirements and be "fit for use" in the environments and design usage the product(s) will see as deployed. Therefore, all tasks that are needed to identify the necessary information to validate the COTS/NDI item(s) as suitable for the application must be incorporated into the SOW.

LESSONS LEARNED (3.2.3)

The AVIP tasks are incorporated where possible with other program tasks in the Statement of Work (SOW). This practice provides an integrated program acquisition where no separate process is allowed to be ignored or given more emphasis than the rest, but each process is kept in proper balance with the rest of the program. The SOW provides tailored contractor tasking where appropriate to ensure that specific tasks are completed as part of the acquisition process. The SOW also provides requirements for reporting information to the procuring agency and other government or associate contractor organizations. If the tasks completed early are not reported on at their completion, or soon thereafter, the body of knowledge that produced their results will dissipate and the information will not be reconstructed usefully or used as inputs to other tasks. For this reason, time lines are established within the Contract Data Requirements List (CDRL) section of the SOW to obtain all required data items. As a result of Acquisition Reform initiatives, the Data Item Descriptions (DID) recommended for CDRLs of future contracts should use Contractor format and cost-effective data delivery such as via electronic means, when practical. If specific guidance regarding content of the DIDs is needed, the DID content should be addressed in the Instructions to Offerors.

3.2.3.1 Systems Engineering

AVIP is integral to the systems engineering process for all program phases. Systems engineering tasks in the SOW for requirements analysis, functional analysis/allocation, synthesis, technical performance measures, and other tasks described in paragraph 3, above, and Figure A-1 should include AVIP.

RATIONALE (3.2.3.1)

See paragraph 3.

GUIDANCE (3.2.3.1)

See paragraph 3 and MIL-STD-499.

LESSONS LEARNED (3.2.3.1)

To be supplied.

3.2.3.2 Design Criteria, Key Product Characteristics, and Key Production Processes
The contractor shall translate the __________ (system, subsystem, etc.) performance requirements into specific design criteria. Specific criteria shall be based on user requirements, including durability/economic life, usage, environments, and supportability. The contractor shall designate those design criteria which are key product characteristics (KPCs) and their associated key production process(es) (KPP). KPCs and KPPs, along with their target values and limits, shall be identified and documented in __________. Each of the identified KPPs shall be developed and verified during EMD and used and controlled in production and support. KPCs and KPPs, within each level of documentation, shall be marked conspicuously ("flagged") and references provided to facilitate traceability of these characteristics.

RATIONALE (3.2.3.2)

Every system has some design criteria or characteristics that are both important to meeting customer requirements and need special attention to control during production and maintenance. These are key product characteristics (KPCs) and the method(s) used to control KPCs are the key production processes (KPPs). Focusing attention on these KPCs and their associated KPPs that display the greatest contribution to fit, performance, durability/economic life or manufacturability provides control of variations which can affect scrap, rework, testing, inventory, labor cost, economics of operations, schedule, and customer operating and maintenance costs. This also ensures that the equipment is designed and produced for the stress levels it will experience over its durability/economic life. The goal is always to minimize the number of KPCs and/or KPPs during the design process. This concept of key characteristics and processes, their identification and flow down to the part level, and their use in component and materials selection and process control is becoming a quality standard in commercial and military industries.

A typical avionics/electronics subsystem or equipment consists of a number of functional and physical design characteristics and many components and materials. It is important to identify KPCs early in the design phase, redesign to eliminate the KPC, and/or devise plans and processes for controlling their variation. Controlling the variation in a KPC may involve identifying and controlling the associated component or material characteristics and the associated process characteristics. KPCs and KPPs are developed from the normal requirements flow down process as illustrated in Figure A-2. Here, system attributes are performance requirements derived from user needs (weapon range, altitude, environments, reliability, maintainability, etc.), design features are unique to the specific solution (engine thrust, amplifier power, etc.), and KPCs and KPPs are key lower level design criteria needed to provide the higher level design feature(s).

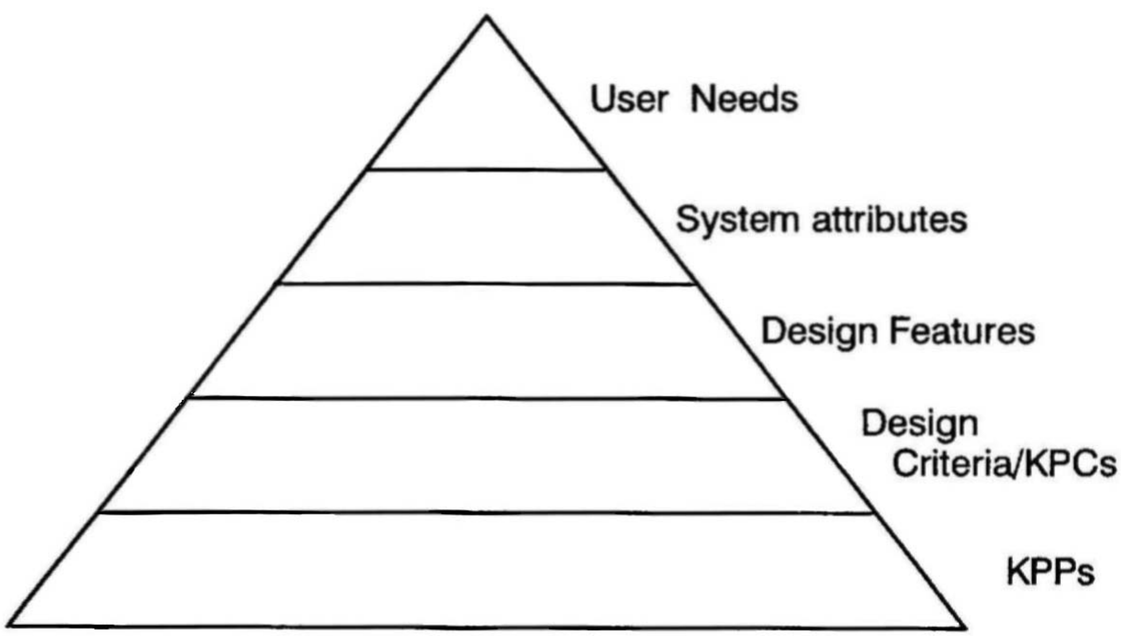

Figure A-2. KPC and KPP derivation.

GUIDANCE (3.2.3.2)

The first step in the design process is to thoroughly understand the customer's needs and requirements. These needs and requirements will be the basis for establishing all design criteria and identifying the KPCs. During the preliminary design process, top level design criteria, KPCs, and KPPs are identified. As the design progresses, these are refined and identified at lower levels of assembly (i.e., subsystem, LRU, module, SRU, etc.). The flow down and traceability must be coordinated and documented by the program team(s) members. KPCs and KPPs should include design allowables, stress concentrations, control of manufacturing process variations and physical dimensions, and design margins appropriate for the equipment criticality. The KPCs and KPPs should also include consideration of the effects of fatigue cracking and fracture, dielectric breakdown, electromigration, growth of intermetalics, material phase changes, and materials properties deterioration under use (corrosion) as derived at each level of system indenture (parts, SRU and modules, LRU), where appropriate. Design margin is usually needed in early development to accommodate uncertainties in manufacturing, operation and support. The design margin is also used to accommodate immaturity in the analytical process where critical functions are at stake. Derating is one approach to design margin. If used, derating should be based on expected usage and environments.

The creation of design criteria traceability matrices or tables is recommended. The matrices will also help ensure the implementation of test verticality into the design process. One suggested table to track design criteria, KPCs, and KPPs is provided in Table A-II. This table provides examples of design criteria to be used for material and part selection and characterization, equipment sizing, limitations on the selected manufacturing processes, etc. KPCs and KPPs should be highlighted in the tables and verification defined.

As the KPCs are identified, associated KPPs which include the key process characteristics and the key component and material characteristics, will be identified. The capability of KPPs should be determined using process capability studies or other appropriate approaches. Determinations regarding process capability should be statistically based wherever feasible. When statistical process control (SPC) is used as a means to control KPPs, the control method should utilize variables type data (actual values) rather than attributes type data (go/no-go or pass/fail) whenever feasible. Attributes based approaches are of limited usefulness in assessing true process performance and require relatively large sample sizes. The KPPs will include establishing the target values around which variation must be controlled or minimized. Failure to maintain the KPPs that control the KPCs will result in a deviation from the design tolerance and will most likely result in a system performance anomaly or increased cost. Control ranges of KPPs that are necessary to maintain or minimize the target KPC are determined. Some ranges can be determined during the preliminary design phase based on historical data and lessons learned. Others require further study, such as design of experiments (DOE) or other analysis tools. The failure mode effects and criticality analysis (FMECA) is one such tool which can be used to analyze and document the KPPs along with related failure modes, failure mechanisms, and KPC. Care should be exercised in selecting and using the design tools (i.e. analyses, modeling, simulation, etc.) to ensure their validity and compatibility with the selected parts, materials and processes.

As the design is refined, the key characteristics should be continuously reviewed to determine if the product design is balanced in terms of the cost, required performance, safety, reliability, durability/economic life, supportability and producibility. Further guidance on the key characteristics and processes can be found in ASC's "Manufacturing Development Guide," 30 November 1993.

TABLE A-II. Design criteria/KPCs/KPPs (parts/modules/LRUs).

DESIGN CRITERIA	CRITERIA/KPCs	KPP	VERIFIED BY _________
Design allowables			
Thermal fatigue life	_________	_________	____surveys____ analyses____ tests
Vibration fatigue life	_________	_________	____surveys____ analyses____ tests
	_________	_________	____surveys____ analyses____ tests
Stress concentrations			
Lead bend radius	_________	_________	____surveys____ analyses____ tests
Minimum conductor thickness	_________	_________	____surveys____ analyses____ tests
	_________	_________	____surveys____ analyses____ tests
Manufacturing variables			
Lead thickness	_________	_________	____surveys____ analyses____ tests
Material contamination	_________	_________	____surveys____ analyses____ tests
	_________	_________	____surveys____ analyses____ tests
Electrical			
Voltage	_________	_________	____surveys____ analyses____ tests
Current density	_________	_________	____surveys____ analyses____ tests
	_________	_________	____surveys____ analyses____ tests
Mechanical			
Max junction temp	_________	_________	____surveys____ analyses____ tests
Thermal expansion coefficient	_________	_________	____surveys____ analyses____ tests
mismatch between ____ and ____	_________	_________	____surveys____ analyses____ tests
Chemical			
Galvanic couple protection	_________	_________	____surveys____ analyses____ tests
Galvanic couple maximum voltage	_________	_________	____surveys____ analyses____ tests

LESSONS LEARNED (3.2.3.2)

Experience gained in the Persian Gulf War highlighted the need for improvements in the military avionics/electronics system design and development process. Although the system functional performance was adequate in the war, a severe strain was placed on the logistics and support system due to the large number of maintenance actions and support equipment required. It was found that a large portion of the maintenance burden was due to high incidence of intermittent failures. A majority of theses failures could not be duplicated at the aircraft or confirmed in the maintenance shop. Further investigation revealed that the design process that had been used did not have adequate identification and control of the KPCs and KPPs.

A number of acquisition programs in the past have experienced problems during transition from the design and development phase into the production phase. These problems include incompatibility between the design and the manufacturing processes, and the lack of stable and capable manufacturing processes. Identifying the key manufacturing processes and their key characteristics, and devising a control plan for them during the EMD phase will ensure a smoother transition into production and will significantly reduce the producibility problems.

LESSONS LEARNED (3.2.3.2) -Continued

Historically "derating criteria" have been applied to the parts contained in the avionics/electronic equipment. These traditional derating criteria have been derived from general industry practice and from a consensus of opinions on adequate levels of protection from operational stresses. Typical derating criteria included maximum junction temperatures and maximum power dissipation for semiconductor devices, maximum forward and reverse voltages for capacitors, maximum power dissipation for resistors, etc. Often, specific derating requirements have been mandated within contracts issued by the procuring agencies. These derating criteria are seldom traceable to a direct cause and effect relationship with failure mechanisms such as time dependent dielectric breakdown, electromigration, thermal and vibration fatigue, etc. This derating practice many times results in the under-design of some hardware items and the over-design of other hardware items. It is, therefore, prudent to establish any derating criteria based upon the design usage and environments the equipment will encounter during its durability/economic life.

3.2.3.3 Other Integrity Programs

AVIP shares program planning and control, design requirements analysis, and durability/economic life evaluation testing philosophies with the other ASC integrity program initiatives. This similarity is especially apparent in the operational usage and environmental areas. Also, most avionics/electronics programs involve software and software timing, tolerances, sizing, and throughput affect performance and reliability. The SOW should therefore contain tasks consistent with all appropriate ASC integrity programs.

The Aircraft Structural Integrity Program (MIL-STD-1530), Mechanical Systems Integrity Program (MIL-STD-1798), Software Development Integrity Program (MIL-STD-1803), and Engine Structural Integrity Program (MIL-STD-1783) are candidates here.

RATIONALE (3.2.3.3)

Available in referenced documents.

GUIDANCE (3.2.3.3)

Available in referenced documents.

LESSONS LEARNED (3.2.3.3)

Available in referenced documents.

3.2.3.4 Reliability and Maintainability Programs

Some of the tasks described in MIL-STD-785, MIL-STD-470, and other sources are complementary to AVIP. The program team(s) should ensure the tasks are consistent and result in integrated tasks related to achieving program requirements. Tasks for SOW and/or IMP/IMS consideration are:

– FRACAS (MIL-STD-785)
– Reliability Allocations, modeling, predictions (MIL-STD-785)
– Environmental Stress Screening (MIL-STD-785)
– FMECA (MIL-STD-1629)
– RCM (MIL-STD-1843)
– Maintainability Plans (MIL-STD-470)
– Maintainability Analysis (MIL-STD-470)
– Maintainability Demos (MIL-STD-471)

RATIONALE (3.2.3.4)

AVIP replaces most of the traditional reliability and maintainability tasks. The remaining valid parts, listed in paragraph 3.2.3.4 above, still need to be considered.

GUIDANCE (3.2.3.4)

FMECA – it is important to do a top down analysis of the criticality of the mission function and translate through design indenture the criticality of the function as it is actually integrated into the design. At the circuit path and design detail level, deterministic methods to control and prevent failure of the critical item need to be established in the design Attention to critical design features at this level will ensure that critical failures will not occur when the system is deployed and used as intended. FMECA may also be used for KPPs.

GUIDANCE (3.2.3.4) – Continued

Reliability Predictions – Prediction of AVIP reliability requirements (critical failure free operating period, cumulative maintenance burden, etc.) is needed to track the design and to interface with logistics support analysis (LSA). The MIL-HDBK-217 prediction methodology, referenced in MIL-STD-785, is not recommended here. That approach assumes random failures without regard to root cause or variances with individual applications. Independent analyses and/or comparisons with similar applications may be more appropriate. However, the parts count reliability prediction technique of MIL-STD-785 may be useful in the early design for inputs to the LSA since it is a technique for predicting reliability when the detailed design data are not yet available. Reliability by design and life prediction approaches are required under AVIP.

FRACAS – Although AVIP focuses on eliminating failure mechanisms through better design process implementation, some failures will occur. Early elimination of failure trends is a major contributor to reliability growth and attaining the needed operational durability. To be effective, a closed loop coordinated process should be required of the system/equipment contractor in EMD to track failures in development testing. FRACAS beyond EMD should also be considered.

Environmental Stress Screening (ESS) – A well-tailored integrity program may contain several forms of testing/screening to mature the designed in reliability as well as to determine whether the contract performance requirements have been and/or are continuing to be achieved. No one set of tests selected from environmental tests, generic environmental stress screens, durability life tests, or other reliability testing can be recommended as appropriate for every program. The appropriate mix of tests must be tailored to fit specific program constraints and stability of production processes. If production processes are stable, ESS may not be cost effective. Additional guidance is in the referenced documents.

LESSONS LEARNED (3.2.3.4)

To be supplied.

3.2.3.5 Integrated Diagnostics and Testability Program

The SOW should contain tasks from the appropriate integrated diagnostics standards, especially those areas which address test verticality, diagnostics maturation, and other diagnostics tasks shown to optimize supportability of the weapon system. The tests for parameters and/or functions at the lowest assembly levels shall be subsets of the tests at higher levels of assembly. As a minimum, test methods (instrumentation, test points, test parameters, test conditions, and test limits) for factory testing, built in test (BIT), field test and depot testing shall be established for all KPCs. These test methods shall be established using the principles of test verticality and test commonality.

RATIONALE (3.2.3.5)

This process is necessary to ensure that a hardware item will function properly when placed in the next higher level of assembly or maintenance. It will ensure establishment of adequate test hierarchy and test coverage at all levels of assembly and maintenance.

GUIDANCE (3.2.3.5)

Diagnostic development practices should be part of the IMP and IMS. Guidance for the Integrated Diagnostic Program is outlined in MIL-STD-1814. A subset is the Testability Program outlined in MIL-STD-2165A. The AVIP adds emphasis on the subject of testability by focusing development and manufacturing engineering decisions on diagnostic concepts and testability guidelines. The AVIP emphasis is test verticality.

Testing at each level of integration (system, LRU/LRM, SRU, component) using the appropriate test limits is critical to the supportability and producibility of the avionics/electronic system. As the system is integrated together from the lower level assemblies into the higher level assemblies, the corresponding test limits on a given circuit parameter should follow the established cone-of-tolerance that is concurrently developed. The test limits should also take into account the effects of environments and aging. The test limits depend on the equipment's level of integration and are based on the Key Product Characteristics and their tolerances. The testing at different levels and selection of test points must account for the field usage and environments. The test limits which directly correspond to the parameter tolerances, should allow for tolerance accumulation. The variability of the KPCs and KPPs should be analyzed to find the appropriate test limits (derived from their tolerances and margins) best supported by the design, manufacturing, test equipment and field support processes.

LESSONS LEARNED (3.2.3.5)

A major contributor to the maintenance burden experienced during the Persian Gulf War on one major subsystem was inadequate test verticality and test commonality. The investigation after the war found that the individual tests procedures performed on specific functions at each level of maintenance (Organizational, Intermediate and Depot) differed. This difference in test employment resulted in a lack of test coverage of the circuit function, when compared to the operating environment. This investigation also found that environmental effects (temperature, vibration) caused slight variations in circuit parameters. The result during operation was a parameter out of or nearly outside of outside of specified tolerance limits which triggered a BIT alert indicating "non-performance." This condition contributed to the excursion beyond the established cone of tolerance that resulted in the alert. The identical condition could not be found on the ground where the parameters and operating environments could not be replicated. The result was an extraordinary number of cannot duplicate (CND) occurrences.

3.2.3.6 Logistics Support Analysis (LSA)

AVIP is intended to improve durability/economic life, reliability, maintainability, and supportability of avionics/electronics while balancing long term impacts to logistics support and economic life. The SOW should contain tasks consistent with the integrity programs' links with the LSA process (e.g., life management, life predictions, reliability predictions, etc.). MIL-STD-1388-1 provides guidance in this area.

RATIONALE (3.2.3.6)

Available in referenced documents.

GUIDANCE (3.2.3.6)

Available in referenced documents.

LESSONS LEARNED (3.2.3.6)

To be supplied.

3.2.3.7 Electromagnetic Effects and Electrical Power

Design for the electromagnetic environment and electrical power interface is related to AVIP tasks. The SOW paragraphs normally associated with this area should be sufficient for handling its integrity aspects. Information in this area is available in MIL-STD-1818 for air vehicle issues, MIL-STD-1795 and MIL-STD-1757 for lightning, MIL-STD-461 at the subsystem/equipment level and MIL-STD-704 for electrical power.

RATIONALE (3.2.3.7)

Available in referenced documents.

GUIDANCE (3.2.3.7)

Available in referenced documents.

LESSONS LEARNED (3.2.3.7)

Available in referenced documents.

3.2.3.8 AVIP Verification and Qualification

Test planning/procedures tasks in the SOW and section 4.0 of program specifications should include AVIP verifications. Incremental verification should also be reflected in the IMP and IMS. Development of the life cycle environmental profile, the durability life test profile, and the durability life test procedures including the test chamber and test fixturing requirements and test readiness criteria is part of this task.

RATIONALE (3.2.3.8)

Incremental verification and qualification of the product to the durability/economic life, environments, and supportability requirements are key aspects of AVIP. See main handbook, para 3.1 for expanded rationale.

GUIDANCE (3.2.3.8)

A matrix of requirements vs. verification method and program milestone is recommended to define the incremental verification strategy. This is an expansion of requirement/verification matrices used in the past in development specifications. The verification method chosen should reflect the maturity of the design at the milestone. A notional EMD matrix for durability/economic life is illustrated below. In this example, A = analysis, T = test (component, assembly, etc.), and QT = formal qualification test.

REQUIREMENT		VERIFICATION/MILESTONE		
		PDR	CDR	FCA
3.1 Durability/Economic Life	4.1	A	A/T	QT

Figure A-3. Notional EMD matrix for durability/economic life.

The incremental verification results are discussed at design reviews and/or documented in appropriate reports. The contract must be structured to provide enough test articles to conduct verification/qualification within program schedules. See main handbook, para 3.1 for more guidance.

LESSONS LEARNED (3.2.3.8)

See main handbook, para 3.1.

3.2.3.9 Integrated Master Plan and Schedule

The Contractor shall develop and/or maintain the Integrated Master Plan (IMP).

The Contractor shall develop and/or maintain the Integrated Master Schedule (IMS).

RATIONALE (3.2.3.9)

AVIP activities need to be planned and scheduled to be sure they are integrated with the overall program.

GUIDANCE (3.2.3.9)

The IMP and IMS are normally delivered with the proposal and updated throughout the program. Development of an IMP and IMS for subsequent phases may be a program task. Data Item Descriptions are discussed in 3.2.2.1 and 3.2.2.2.

LESSONS LEARNED (3.2.3.9)

To be supplied.

3.2.3.10 AVIP Technical Reporting

AVIP should be included in appropriate systems engineering technical reports, test plans/procedures and test reports and discussed at design reviews. Data requirements that should be considered for the above SOW tasks are:

– AVIP Status Reports – Ensures the contractor correctly develops and/or interprets performance requirements such as design usage, design environments, and design criteria.

– Technical Reports – Documents trade studies, durability/economic life analysis, usage damage/stress tolerance requirements analyses, corrosion prevention and control, and life management.

– Test Plans/Procedures – Test plans are normally requested in the contractor's proposal, incorporated into the IMP and IMS, and can be statused in management reviews or Status Report. Test procedures documentation for government review can be provided by data items, such as Test Inspection Reports, which includes a content requirements for procedures used in testing.

– Test Reports – Documents tests results such as, durability/economic life test and environmental qualification, using data items, such as Test/Inspection Reports.

RATIONALE (3.2.3.10)

Visibility into the design and verification process ensures AVIP incorporation.

GUIDANCE (3.2.3.10)

The contractor should translate the system and subsystem requirements into specific design criteria to be used for material/part selection, equipment sizing, design and analysis, limitations on the selected manufacturing processes, programmatic issues and limitations, statutes and agreements in effect as of the date of contract issue, and test verification of the subsystem/equipment. The criteria should be derived from and based on the requirements section of AFGS-87244 as tailored for the specific program acquisition. Specific criteria should be developed for durability/economic life, damage/stress tolerance, and supportability requirements. The design criteria should be established such that each part, item, design detail, and material will support the durability/economic life requirement. These criteria should include design allowables, stress concentrations, and control of manufacturing process variations and dimensional tolerances, and design margins appropriate for the equipment criticality. The design criteria should also include the effects of fatigue cracking and fracture, dielectric breakdown, electromigration, growth of intermetalics, material phase changes, and materials properties deterioration under use (corrosion) as derived at each level of system indenture.

LESSONS LEARNED (3.2.3.10)

If the tasks completed early are not reported at their completion, or soon thereafter, the body of knowledge that produced their results will dissipate and the information will not be completely reconstructed. SOW tasks, IMP and/or IMS should incorporate appropriate time lines for review of the detailed design data prior to major reviews.

For the AVIP Status Report,
DI-MGMT-80368, "Status Report," has been used.

For the Technical Reports,
DI-ILSS-81021, "System/Design Trade Study Report,"
DI-MISC-80508, "Technical Report -Study/Services," or
DI-MISC-80711, "Scientific and Technical Reports"
have been used.

For the Test Plans/Procedures,
DI-MGMT-80368, "Status Report," and
DI-NDTl-80809A, "Test Inspection Reports"
have been used.

For the Test Reports,
DI-NDTl-80809A, "Test Inspection Reports," has been used.

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APPENDIX B

USER SUPPORTABILITY REQUIREMENTS TRANSLATION

1 INTRODUCTION

1.1 Scope

This appendix provides a methodology for translating typical user supportability requirements into integrity requirements for a program performance specification and for tracking results of a durability/economic life test.

1.2 Purpose

Proper translation of user needs into performance specifications, allocation of the requirements to elements of the system being developed, and verification performance are key to effective acquisition of products meeting customer needs. This appendix provides definitions and examples to assist in the translation and allocation process.

1.3 Applicability

This integrity process applies to airborne and ground based electronic systems, subsystems, support systems, training systems, and equipment such as navigation sets, radios, altimeters, radar, controls and displays, computers, stores management sets, flight control computers, engine controls, electronic test and servicing equipment, memory loader verifiers, field-deployable mission planning systems, etc.

1.4 Use

This appendix is intended for use by any group, agency, program office, or contractor, to incorporate avionics/electronic program requirements into a program, subcontract or major vendor item. Definitions, equations, examples and instructions are presented.

2 REQUIREMENTS DEFINITIONS

2.1 User Requirements

The typical user states supportability requirements in terms meaningful in the operation and support environment. The following terms and definitions apply in the integrity process. The integrated product team, including the user, should define these requirements.

a. Service Life – Defines the period of time the user expects to use the equipment and/or host vehicle.

b. Break Rate – The percent of missions affected by maintenance of a mission critical item.

c. Mission Reliability – Percent mission without critical failure or,1 minus break rate.

d. Fix Rate – The time required for repairs. This is usually specified in hours and percentages (e.g., 50% in 2 hours or less and 95% in 4 hours or less).

e. Missions per Time Period – The number of missions planned for the equipment (per year, per service life. etc.).

f. Manpower Spaces per Aircraft – Defines the repair time and/or people available for equipment maintenance.

g. Maintenance Manhours/Flight Hour – Defines repair time available for equipment maintenance (alternate to e).

h. Mean Time Between Maintenance Actions (MTBMA) – Defines the average time between maintenance actions over the life of a product. This parameter is sometimes provided with or instead of break rate.

2.2 AVIP Performance Requirements
This is a review of the AVIP performance requirements and related definitions presented earlier in section 6.0. The user requirements of 2.1 are translated to appropriate AVIP requirements for contractual specifications.

a. Durability/Economic Life – the number of years an equipment will be in inventory and the number of operating hours in that period. This requirement is derived from the service life of the host vehicle but may be less depending on technology tradeoffs, planned upgrades, or other factors. An equipment may have components with expected lives greater than or less than the equipment durability/economic life. A typical normalized maintenance demand curve for a notional item with a normal failure distribution and a mean life greater than the 20-year equipment durability/economic life is illustrated in figure B-1. The goal is always zero failures during the equipment life. The low, gradually increasing maintenance demand during the equipment life represents the statistical nature of production processes and aging of components as they experience life stresses.

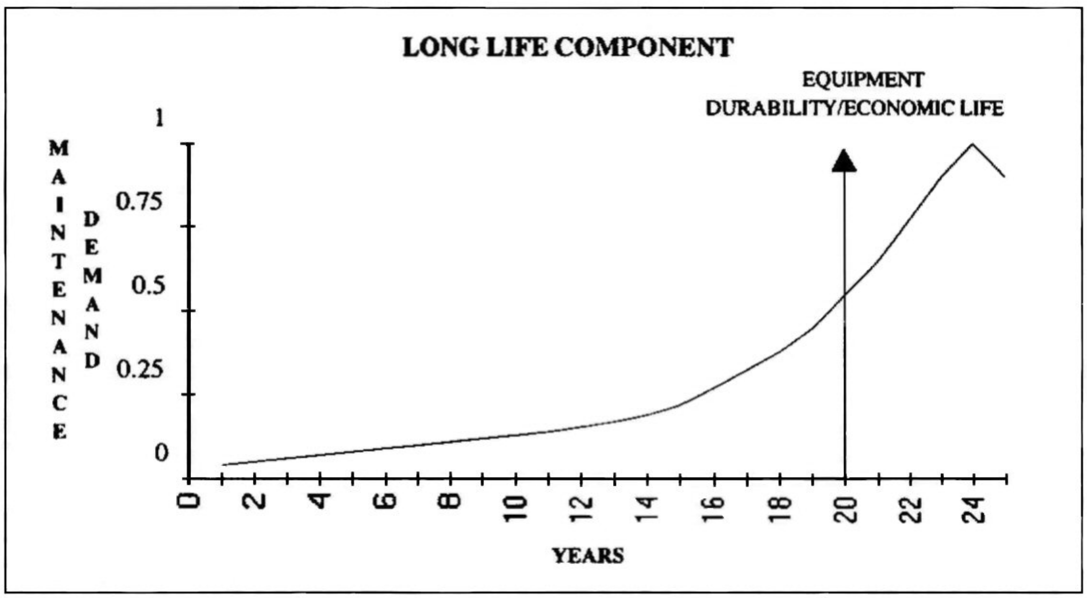

Figure B-1. A typical normalized maintenance demand curve for a notional item with a normal failure distribution and a mean life greater than the 20-year equipment durability/economic life.

Components with a mean life less than the equipment durability/economic life are called life limited items. Figure B-2 illustrates normalized maintenance demand for a notional life limited item with a normal distribution of failures. This item has a 5-year life and would be replaced several times in the 20-year durability/economic life of the equipment. With replacement at failure, successive failure distributions widen and approach uniform (a group of incandescent bulbs is a good here). These items are generally undesirable but, economics and technology can be overriding factors.

20.2 AVIP Performance Requirements – Continued

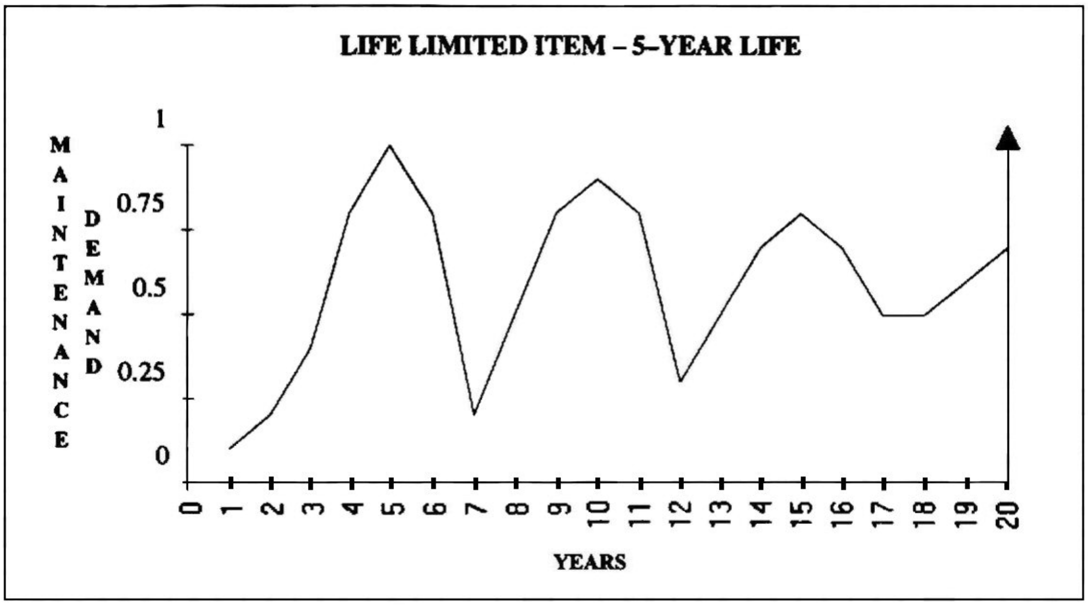

Figure B-2. Normalized maintenance demand for a notional life limited item with a normal distribution of failures.

b. Critical Failure Free Operating Period (CFFOP) – That portion of the durability/economic life that an equipment's probability of unscheduled maintenance of a critical item (mission, safety, etc.) remains below the specified probability without preventive maintenance. CFFOP is usually derived from a user specified break rate or weapon system reliability. The goal is always for the CFFOP to be at least equal to the durability/economic life.

c. Probability of Maintenance or Failure – The probability an equipment will fail and/or require maintenance in a specified time period. This probability can be specified by equipment criticality (mission, safety, etc.). This requirement is usually derived from a user specified break rate or weapon system reliability.

d. Cumulative Maintenance Burden (CMB) – Total maintenance work hours available per time period (usually one year). Includes time for both scheduled and unscheduled maintenance.

e. Mean Time To Repair (MTTR) – Mean time to complete a maintenance action. This time usually includes initial checkout, troubleshooting, remove, replace, and final operation check.

f. Scheduled Maintenance – Preventive maintenance and/or maintenance of non-critical items and/or failure indications that can be scheduled and performed without conflicting with the mission.

g. Unscheduled Maintenance – Unexpected maintenance of critical items and/or critical failure indications that must be accomplished before the next mission.

20.3 Requirements Translation Equations

a. Durability/Economic Life:

– Number of years – based on user needs and technology tradeoffs

– Number operating hours – based on number of missions and average length of mission plus expected operation during maintenance and servicing the equipment and/or host platform.

b. CFFOP = Total mission/maintenance hours / break rate times number of missions

c. Probability of Maintenance (unscheduled):

– Mission Critical = break rate (or 1 minus weapon system reliability)

– Safety Critical = safety rate – user safety requirement needed

d. CMB = Number of maintenance people times work hours per person per time period or (Operating Hours per time period/MTBMA) times MTTR or maintenance manhours/flight hour times flight hours/time period.

e. Calculated Parameters (may be useful for LSA input and during durability/economic life testing):

– Mission Critical Maintenance Demand/System/Year = Break Rate x Missions per Year (average)

– Safety Critical Maintenance Demand/System/Year = P(Safety Maintenance) x Missions per Year

– Max Maintenance Demand/System = CMB / M1TR / # Maintainers or Op Hours / MTBMA

3 REQUIREMENTS TRANSLATION EXAMPLES

3.1 Example Number 1: Notional User Requirements

The Air Force C-XX is developing a system requirements document for engineering/manufacturing development (EMD) of a new navigation system. The following user requirements are provided.

a. Host vehicle service life – 20 years (remaining)

b. Break Rate – 2%, preventive maintenance allowed

c. Fix Rate – 50% in 1.6 hours, 95% in 4 hours

d. Missions per Time Period – 100/system/year (4 hour mission + 1 hour weapon system maintenance expected)

e. Maintenance Manpower Spaces – 2.0 maintenance people or 6400 work hours/year (1500–1640 hours per person per year per shift is typical)

f. Safety – 1 failure in 1000 missions (an emergency backup mode is available)

3.1.1 AVIP Performance Requirements Translation

The following translation applies the equations of 20.3.

a. Durability/Economic Life:

– 20 years (assumed for this exercise)

– 10,000 operating hours (100 missions/year x 20 years x (4+1) operating and system maintenance hours)

b. CFFOP = 10,000 operating hours / (0.02 x 2000 missions) = 250 hours (.5 years of operation)

c. Probability of Maintenance per mission:

– Mission Critical = 0.02 (break rate)

– Safety Critical = 0.001 (1 per 1000 missions)

d. CMB = 6400 maintenance work hours/year (2 shifts)

e. MTTR = 1.6 hours: max repair time = 95% in 4 hours

3.1.2 Notional Maintenance Demand Rate Charts

The performance specifications derived in 3.1.1 above allow some tradeoffs during equipment design. A notional design and notional durability/economic life test results are illustrated in the following calculations and charts.

a. Calculated Maintenance Demand Rates:

– Mission Critical = 0.02 x 100 missions/year = 2 demands/year/system (average)

– Safety Critical = 0.001 x 100 missions/year = 0.1 demands/year/system (average)

– Max Demand rate = 6400 maintenance hours / 1.6 hour MTIR / 100 systems / 2.0 maintainers
= 20 demands/year/system (note that designing for a lower MTIR would allow a higher demand rate.

b. Mission/Safety Critical Maintenance Chart. The following chart is a theoretical/notional plot of mission critical maintenance demands that might be demonstrated in a durability/economic life test. The chart includes a small number of unexpected demands (i.e., unscheduled maintenance) that gradually increase as the equipment ages. Such demands are typical of components designed to last beyond the equipment durability/economic life and are generally the result of manufacturing flaws or failure modes that were not detected or corrected during development. One life limited item is also shown. Preventive maintenance at the 5-year points truncates the distribution and keeps the demand rate of the life limited item from causing total mission critical demand to exceed the requirement. The 5-year interval easily exceeds the CFFOP 0.5-year minimum requirement. Total demand rate is the sum of demand for life limited items and unexpected demands. Safety critical maintenance demands would be the same as mission critical except at a much lower level. The charts are based on the examples in 20.2.

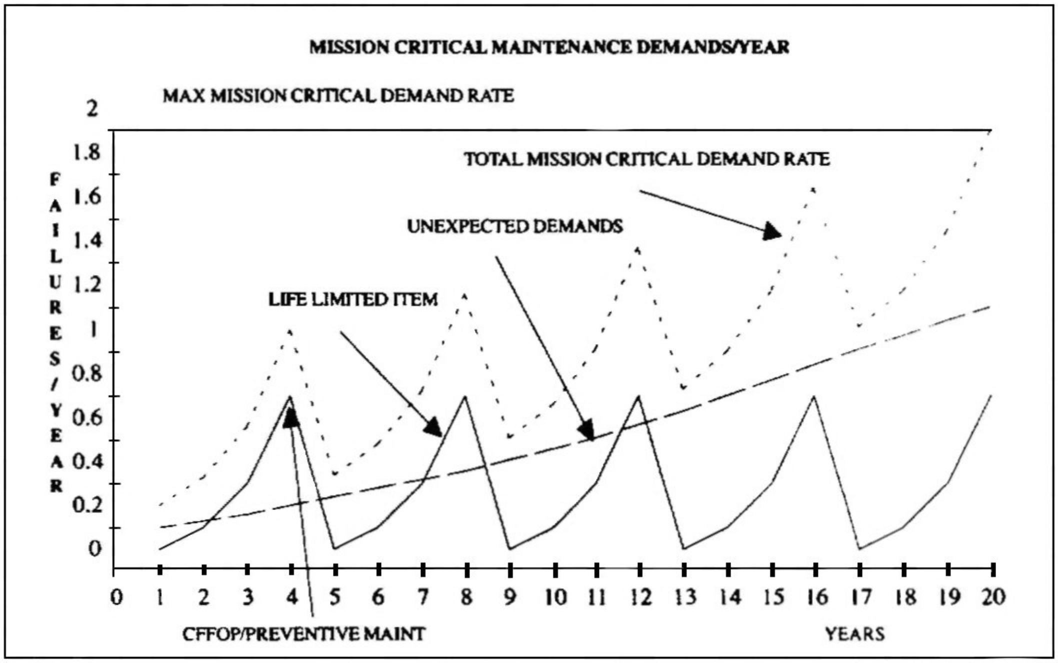

Figure B-3. Theoretical/notional plot of mission critical maintenance demands that might be demonstrated in a durability/economic life test.

c . Total Maintenance Demand Chart. The following chart is a theoretical/notional plot of total maintenance demands that might result in a durability/economic life test.. The lower part of the chart is the mission critical demand discussed above. Maintenance demand for safety critical items is too small to show on this chart. One noncritical life limited item is shown. This life limited item does not cause the maximum demand to exceed the requirement and does not require preventive maintenance. Noncritical unexpected demand is also shown. The max demand rate is the sum of safety critical demands, mission critical demands, and other noncritical demands. The non-critical demands can be scheduled maintenance that does not affect mission. Normal distributions are assumed for this illustration.

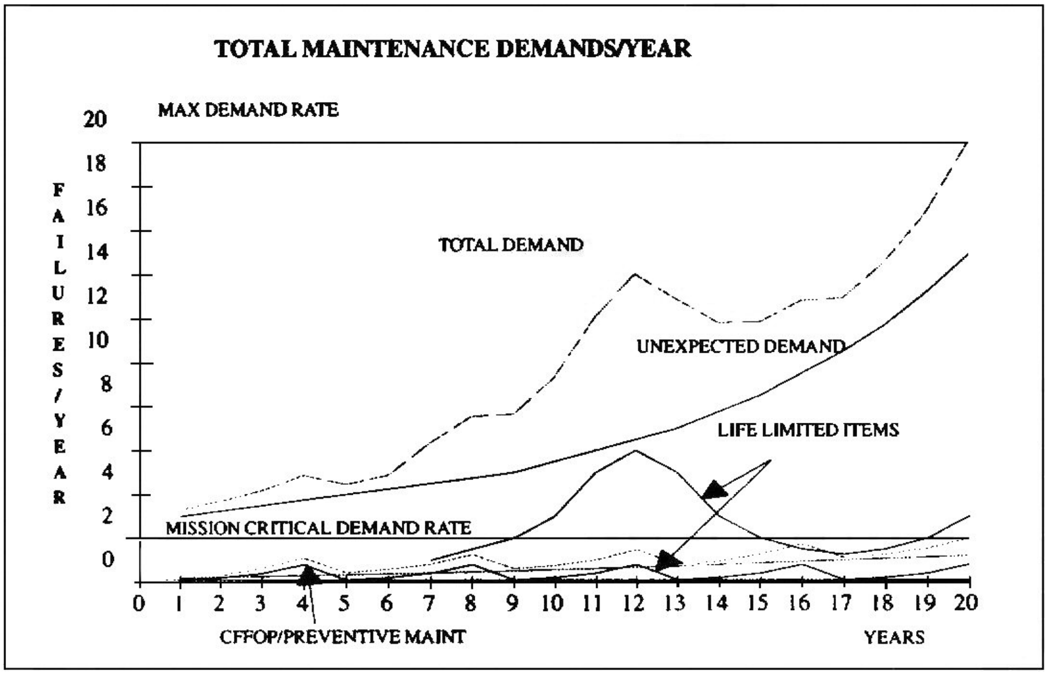

Figure B-4. Theoretical/notional plot of total maintenance demands that might result in a durability/economic life test.

3.2 Example Number 2: Notional User Requirements
The Air Force F-XX needs a new electronic warfare system. The following user requirements are provided.

a. Host vehicle service life – 15 years (remaining)

b. Mission Reliability – 98%,no preventive maintenance

c. Mean Time Between Maintenance – 50 hours

d. Fix Rate – 50% in 1.5 hours, 95% in 2.5 hours.

e. Missions per Time Period – 100/system/year (2 hour mission + 2.3 hour weapon system maintenance expected)

f. Maintenance Manhours/Flight Hour – 0.05, 1 maintainer

g. Safety – N/ A (no safety items involved)

3.2.1 AVIP Performance Requirements Translation
The following translation applies the equations of 20.3.

a. Durability/Economic Life:

– 15 years (assumed for this exercise)

– 5,000 operating hours (100 missions/year x 15 years x 2 + 2.3 operating and system maintenance hours)

b. CFFOP = 15 years (no preventive maintenance is allowed on this system)

c. Probability of Maintenance over life:

– Mission Critical = 1–0.98 = 0.02

d. CMB = 0.05 MMH/FH x 100 missions/year x 2 flight hours/mission = 10 maintenance hours/year/system or, Alternate: CMB = (5000 hr/15 years/50 MTBM) x 1.5 MTTR = 10 maintenance hours/year/system (the user has supplied redundant requirements here)

e. MTTR = 1.5 hours, 95% of maintenance in 2.5 hours

3.2.2 Maintenance Demand Rates
Maintenance demand is calculated as in example 1. Charts for this example would be similar to example 1 except that no preventive maintenance is allowed (this requirement should be examined thoroughly with the user).

a. Calculated Maintenance Demand Rates:

– Mission Critical = 0.02 x 100 missions/year = 2 demands/year/system (average)

– Max Demand Rate = 10 maintenance hours per year / 1.5 hour MTTR / 1 maintainer = 6.6 demands/year/system

3.3 Example Number 3: ALR-XX
The Air Force is developing a new electronic warfare system for multiple aircraft. The following user requirements are provided (this example is based on an actual program -some numbers are altered for illustrative purposes).

a. Maximum vehicle service life – 20 years (remaining)

b. Missions in Service Life – 8000

c. Operating Hours – 15,800

d. Break Rate – 0.15%, no preventive maintenance

e. Combat Capable Rate (CCR) – 500 sorties (sorties between critical maintenance)

f. Fix Rate – 50% in 1.5 hours, 95% in 2.5 hours.

g. Mean Repair Time – 0.35 hours O-Level, 1 hour I-Level

h. Manpower spaces – 1.5 (2 shift operation)

i. Safety – N/ A (no safety items involved)

j. Total Non-Mission Capable Maintenance (TNMCM) – 0.75% (% of maintenance shift clock hours used)

k. Preventive Maintenance Interval – 500 sorties (1.25 years of operation)

3.3.1 AVIP Performance Requirements Translation
The following translation applies the equations of 20.3.

a. Durability/Economic Life:

– 20 years (assumed for this exercise)

– 15,800 operating hours (8000 missions)

b. CFFOP:

– Preventive Maintenance Interval – 500 sorties or 1.25 years

– Probability of Maintenance – Mission Critical = 0.15

d. CMB = TMCM x CMB = 0.0075 x 2 shifts x 1640 hours/shift/year x 1.5 maintainers = 36.9 work hours, or 1.5 maintainers x 1640 hours/shift/year x 2 shifts = 4920 work hours (this illustrates conflicting inputs which should trigger dialogue with the user – we will use 36.9 work hours)

e. MTTR = 0.35 hours O-Level, 1 hour I-Level

3.3.2 Maintenance Demand Rates
Maintenance demand is calculated as in example 1 for life test criteria.

a. Calculated Maintenance Demand Rates:

– Mission Critical = 0.0015 x 8000 missions/20 years = 0.6 demands/year/system (average) or, 8000 sorties/500 CCR/20 years = 0.8 demands/system/year (another user input conflict)

– Max Demand Rate = 36.9 maintenance hours per year/1.35 hour MTTR/1.5 maintainers = 18.2 demands/year/system (we have added the MTTRs for O and I level on the assumption that repairs are completed at both levels before returning the aircraft to service – check with user)

3.3.3 Durability Life Test Results
Two systems were subjected to an accelerated life test. The systems performed well in test as shown below.

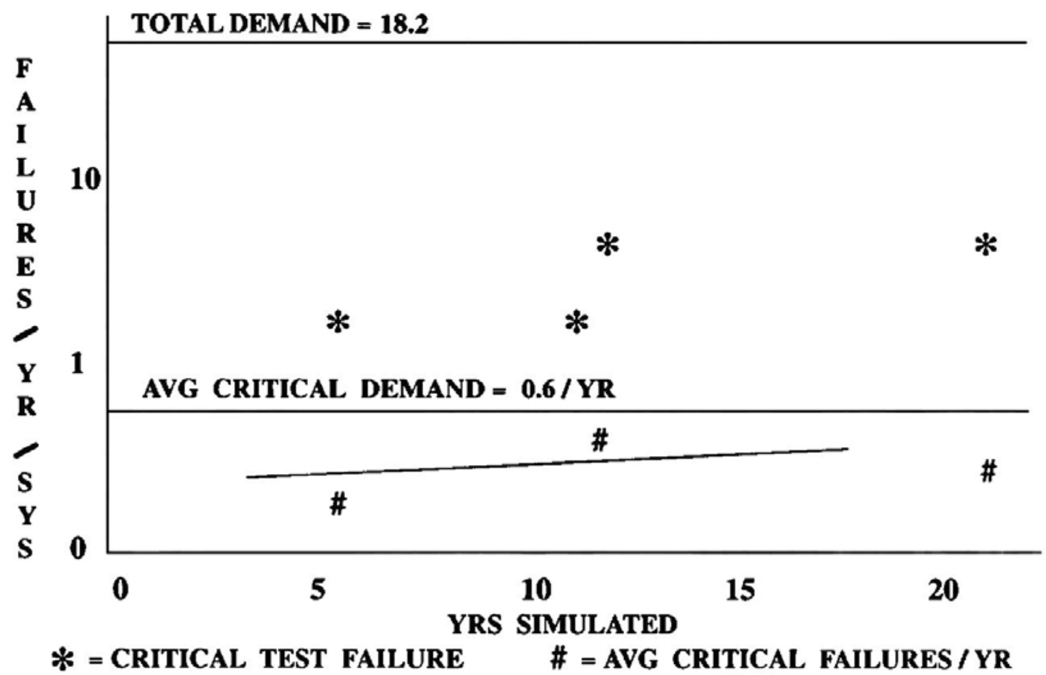

Figure B-5. Durability Life Test Results.

APPENDIX C

AVIONICS/ELECTRONICS INTEGRITY SAMPLE GUIDE SPECIFICIATION

1. SCOPE

1.1 Purpose
This appendix is a sample specification that describes the Avionics/Electronics Integrity Process (AVIP) performance requirements which should be tailored and incorporated into appropriate contractual specifications to achieve integrity of airborne and ground-based electronics. The suggested performance requirements assist in the development of program specific requirements which encompass equipment life, life-cycle uses, environments, and supportability. This handbook is intended to complement guide specifications and handbooks in other specialty areas to create complete performance-based specifications.

1.2 Applicability
This sample specification supports government and/or contractor development of comprehensive avionics/electronic integrity performance requirements for airborne and ground-based electronic subsystems (e.g., radar, navigation, ground power unit, etc.), equipment, modules, and parts. Those specification(s) should incorporate appropriate parts of this document. This sample specification is applicable, when appropriately tailored, to concept exploration, demonstration/validation, engineering and manufacturing development, and production program phases. When tailored, this sample specification is also applicable to acquisition of new, existing and modified existing electronics (including equipment referred to as commercial off-the-shelf (COTS) or non-developmental items (NDI). It can be applied to full or limited acquisition and production contracts.

1.3. Tailoring
This sample specification is not intended for contractual purposes without tailoring since supplemental information for specific application is required (e.g., application-specific environmental and usage criteria may be derived from operational and engineering analyses on equipment or subsystems being procured for use in specific systems or platforms). When analyses show that the requirements suggested in this sample specification are not appropriate for that procurement, the requirements may be tailored appropriately. The main handbook has more guidance in this area.

1.4. Structure
The suggested performance requirements specification paragraphs are included in Section 3 with corresponding verification requirements included in Section 4. The supplemental information required to complete the specification sentences is identified by blanks within this sample specification.

1.5. Responsible Engineering Office
The office responsible for development and technical maintenance of this Handbook is ASC/ENAI, Wright-Patterson AFB, Ohio. Request for additional information or technical assistance on this Handbook can be obtained from Mr. Craig Wall, ASC/ENAI, Wright-Patterson AFB, OH 45433-7630 (commercial phone number: 513-255-4463, DSN 785-4463, or FAX: 513-255-3466). Any information required relating to Government contracts must be obtained through the contracting officer.

2 RECOMMENDATION FOR GUIDE SPECIFICATION APPLICABLE DOCUMENTS
Performance oriented documents referenced in this appendix, and listed below, should be tailored before contractual use. Section 2, of the contractual specification, should list all documents required for the program.

2.1 Government Documents

2.1.1 Specifications, Standards, and Handbooks
The following specifications, standards, and handbooks form a part of this specification to the extent indicated. The main handbook and Appendix A also contains representative lists and further guidance for completing the TBDs for this section. DoD is currently implementing new policy to minimize use of military specifications and standards.

Programs should verify status of all the documents listed and/or cited herein before applying them or referencing them in contracts.

SPECIFICATl0NS

TBD

STANDARDS

MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-1757	Lightning Qualification Test Techniques for Aerospace Vehicles and Hardware
MIL-STD-1795	Lightning Protection of Aerospace Vehicles and Hardware
MIL-STD-1818	Electromagnetic Effects Requirements for Systems
TBD	

HANDBOOKS

TBD

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

2.2 Other documents
The following documents form a part of this specification to the extent indicated.

TBD

2.3 Order of Precedence
In the event of a conflict between the text of this guide and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been authorized by the procuring activity.

3 REQUIREMENTS FOR AVIONICS/ELECTRONICS INTEGRITY
The electronic subsystem and/or equipment shall provide full required performance when exposed to the actual usage and environments over its life. Specific criteria shall be developed for durability/economic life, usage, environments, and supportability requirements as outlined in the following paragraphs.

3.1 Durability/Economic Life Requirements
The durability/economic life of the ______ subsystem and/or item (specify) shall be ______ years (list each item with its corresponding life). The ______ shall meet performance requirements in ______ over the durability/economic life during and/or after exposure to the usage and environments specified in paragraphs 3.2 and 3.3 herein and with maintenance specified in paragraph 3.4.

3.2 Usage Requirements
The electronics shall meet performance requirements during and after use as specified below.

3.2.1 Usage Requirements for Airborne Equipment
The electronics shall be installed in/on __________ and located __________.

3.2.1.1 Flight Profiles/Envelope(s)
The flight profiles/envelope(s) shall be as defined in __________.

3.2.1.1.1 Carriage Profiles/Envelope(s)
The carriage profiles/envelope(s) shall be as defined in __________.

3.2.1.1.2 Operating Envelope(s)
The operating envelope(s) shall be as defined in __________.

3.2.1.2 Mission Profiles
Mission profiles (for each weapon system) shall be as defined in __________.

3.2.1.3 Mission Mix
Mission mix shall be as defined in __________.

3.2.1.4 Climatic Profile(s)
Climatic profile(s) for the equipment shall be as defined in __________. The profile(s) shall address the environmental control system (ECS), geographic location(s), and frequency of usage.

3.2.1.5 Total number of flights
The expected total number of flights over the durability/economic life of 3.1 shall be __________.

3.2.1.6 Total Operating Hours
The total expected operating hours for the durability/economic life of 3.1 should be __________.

3.2.1.6.1 Mission Operating Hours
The expected total mission operating hours for the durability/economic life of the equipment shall be __________ hours. The equipment shall operate (power-on) for __________ percent of the total mission operating hours. The electronics shall be capable of being operated continuously, as specified, for __________ hours without active cooling. Mission associated ground operating hours shall be __________ percent of mission operating hours.

3.2.1.6.2 Ground Operating Hours – On-Weapon System
The expected ground operating hours for the durability/economic life of the equipment shall be __________ hours. The use of active cooling shall occur __________ percent of the ground operating hours. The cooling sources shall have the characteristics specified in __________. The equipment shall be capable of being operated continuously as specified without active cooling for __________ hours.

3.2.1.6.3 Ground Operating Hours – Off-Weapon System
The expected off-weapon system ground operating hours shall be __________ hours over the durability/economic life. The equipment shall be capable of being operated continuously as specified without active cooling for __________ hours.

3.2.1.7 Number and Type of Operating Cycles
The operating cycles shall be as specified below. Operating cycles shall include equipment on/off cycles, changes in operating modes, and number of missions which impose stress on the equipment.

3.2.1.7.1 Operating Cycles in Flight Environment
The expected total number of operating cycles in the airborne environment during the durability/economic life shall be __________ with and __________ without active cooling. The mix of start-up conditions shall be as shown in __________.

3.2.1.7.2 Ground Operating Cycles – On-Weapon System
The expected total number of ground operating cycles while installed on the weapon system within the durability/economic life shall be __________ with and __________ without active cooling. The mix of start-up conditions shall be as shown in __________.

3.2.1.7.3 Ground Operating Cycles – Off-Weapon System
The expected total number of off-weapon system operating cycles in the durability/economic life will be __________.

3.2.2 Usage Requirements for Ground-Based Equipment
The electronics shall be installed in/on __________ and/or located __________.

3.2.2.1 Number and Type of Operating Conditions
The operating conditions shall be as specified below. Operating conditions shall include equipment on/off cycles, changes in operating modes, and thermal/vibration cycle changes which impose stress on the equipment.

3.2.2.1.1 Operating Hours
The total expected operating hours, for the durability/economic life of 3.1 shall be __________.

3.2.2.1.2 Operating Cycles
The total number and type of operating cycles, for the durability/economic life in 3.1, shall be __________ and __________ respectively.

3.2.2.1.3 Climatic Profile(s)
Climatic profiles for the ground based equipment shall be as shown in __________. These profiles shall address the geographic location(s) and frequency of usage at these location(s).

3.3 Required Environments
This section provides a representative set of tailorable environmental requirements for airborne and ground-based electronics. Environments must be selected and defined for the application (single or multi-platform composite). Other environments unique to an application (e.g., antenna windloading) should be added as needed.

3.3.1 Usage Environments
The equipment shall be capable of full performance during and after experiencing the cumulative effects of the environments in any combination(s) the equipment is expected to be exposed to over its durability/economic life as specified below. The equipment shall also resist fatigue damage (e.g., cracking and delamination), wear and deterioration/thermal degradation, electrical stresses, parametric drift, dielectric material failure, and corrosion during required usage such that the performance and support capabilities specified in __________ are not degraded over the durability/economic life.

3.3.1.1 Temperature
The temperature profiles for the usage requirements of 3.2 shall be __________.

3.3.1.1.1 High Temperature
The equipment shall perform as specified in __________ during and after exposure to a high temperature of __________. After exposure to a high temperature (non-operating and without cooling) of __________ for __________ hours the equipment shall be able to provide performance specified in __________.

3.3.1.1.2 Low Temperature
The equipment shall withstand a low temperature of __________ during operation. After exposure to a low temperature (non-operating) of __________ for __________ hours the equipment shall provide performance specified in __________.

3.3.1.1.3 Temperature Shock
The equipment shall perform as specified in _________ during and after exposure to a maximum rate of temperature change of __________ and __________ number of temperature shocks during the required durability/economic life.

3.3.1.2 Vibration
The equipment shall perform as specified in __________ during and after exposure to the vibration profiles and spectra, for the design usage of 3.2, as shown in __________.

3.3.1.2.1 Gunfire/Other Vibration
The equipment shall perform as specified in __________ during and after exposure to a gunfire/other spectra as shown in __________ for __________ duration.

3.3.1.3 Acceleration
The equipment shall perform as specified in ______ during and after exposure to an acceleration spectra as shown in

3.3.1.4 Shock
The equipment shall perform as specified in __________ during and after exposure to a shock spectra as shown in __________.

3.3.1.5 Acoustic Noise
The equipment shall perform as specified in __________ during and after exposure to an acoustic noise spectra as shown in __________, for __________ duration.

3.3.1.6 Humidity
The equipment shall perform as specified in __________ during and after exposure to relative humidity between __________ and __________ percent, inclusive, and a temperature range of __________, under both operating and non-operating conditions. Fogging or condensation shall not degrade equipment performance specified in __________ throughout the durability/economic life,

3.3.1.7 Low Pressure (Altitude)
The equipment shall perform as specified in __________ during and after exposure to a low pressure or maximum altitude of __________.

3.3.1.8 Solar Radiation
The equipment shall perform as specified in __________ during and after exposure to solar radiation of _________, for __________ hours.

3.3.1.9 Rain
The equipment shall perform as specified in __________ during and after exposure to solar radiation of _________, for __________ hours.

3.3.1.10 Fungus
The equipment shall perform as specified in __________ during and after fungus growth as described in _________.

3.3.1.11 Salt Fog
The equipment shall perform as specified in __________ during and after exposure to a salt fog and salt water environment of __________.

3.3.1.12 Sand and Dust
The equipment shall perform as specified in __________ during and after exposure to a sand and dust environment of __________.

3.3.1.13 Explosive Atmosphere
The equipment shall be operable in an explosive atmosphere of __________ without causing an explosion.

3.3.1.14 Leakage (Immersion)
The equipment shall perform as specified in ____1____ with leakage due to immersion to a maximum depth of ____2____.

3.3.1.15 Icing/Freezing Rain
The equipment shall perform as specified in __________ during and after exposure to icing/freezing rain as described in __________.

3.3.1.16 Electromagnetic and Electrical Power Environments
Information in this area is available in MIL-STD-1818 for air vehicle issues, MIL-STD-1795 and MIL-STD-1757 for lightning, MIL-STD-461 at the subsystem/equipment level and MIL-STD-704 for electrical power.

3.3.1.17 Chemical
The equipment shall perform as specified in __________ during and after exposure to a chemical environment as stated in __________.

3.3.1.17.1 Decontamination
The equipment shall perform as specified in __________ after exposure to decontamination operations with the types and concentrations of decontamination chemicals as stated in __________.

3.3.1.18 Nuclear
The equipment shall withstand the nuclear environment defined in __________.

3.3.1.19 Logistics Environment
The airborne and/or ground based electronics shall provide full performance over its durability/economic life after exposure to organizational, intermediate, and depot level environments, including ground handling, transportation, storage, and repair of the equipment. The logistics environment shall be __________.

3.3.1.19.1 Thermal Cycles Associated with Manufacture and Repair
The maximum number of allowable thermal cycles (e.g., de-solder/solder cycles) associated with the manufacture and repair of electronic subassemblies shall be __________.

3.3.1.20 High Power Microwave
The equipment shall withstand the high power microwave environment defined in __________.

3.3.1.21 Corrosion/Chemical Induced Deterioration
The equipment shall withstand the corrosion/chemical induced environment environments defined in __________.

3.3.1.22 Precipitation Static
The electronics shall perform as specified in __________ during and after exposure to the precipitation static environment of __________.

3.4 Supportability Requirements

3.4.1 Reliability
The __________ reliability shall be based upon the concepts of durability/economic life, avionics fault tolerance, battle damage tolerance, reduced unscheduled maintenance, cumulative maintenance burden, and reliability centered maintenance (RCM) as specified below.

3.4.1.1 Failure Free Operation
The critical failure free operational period (CFFOP) shall be __________ (missions and/or years) with __________ probability of a maintenance event.

3.4.1.2 Cumulative Maintenance Burden (CMB)
The __________ (O/I/D-level) cumulative maintenance burden (work hours for all maintenance) shall not exceed __________ (work hours/time period) over the durability/economic life. The maintenance burden includes all efforts associated with false BIT indications (para 3.4.3.2) and problems/anomalies that cannot be duplicated.

3.4.1.3 Avionics Fault Tolerance
Avionics equipments that perform __________ critical (e.g., safety, mission) functions as defined in __________ shall be fault tolerant. Fault tolerance is the capability of an avionics equipment to sustain damage or partial failure without jeopardizing safety and/or mission capability.

3.4.1.4 Battle Damage Tolerance
The Avionics System shall support the survivability requirements as defined in __________ by physically protecting and/or separating redundant systems to the maximum extent possible.

3.4.2 Maintainability

3.4.2.1 Maintainer Skill Compatibility
The equipment shall be maintainable at the organizational level in the environments specified in __________ by maintainers specified in __________. The equipment shall be maintainable at the intermediate level in the environments specified in __________ by maintainers specified in __________. The equipment shall be maintainable at the depot level in the environments specified in __________ by maintainers specified in __________ (e.g., skill levels + chem gear). Reliability Centered Maintenance is allowable to achieve the CFFOP and/or CMB requirements in 3.4.1.1.

3.4.2.2 Mean Time To Repair (MTTR)
The equipment shall be repairable at the (O, I or D) level, by maintainers specified in 3.4.2.1, above, in a mean time of __________ clock hours/minutes. __________ percent of failures shall be repairable within __________ clock hours/minutes.

3.4.3 Diagnostics and Testability
The __________ shall provide detection and isolation of all known or expected faults to the repairable or replaceable item(s) required for the level of maintenance. Fault detection and isolation shall be accomplished using any combination of __________.

3.4.3.1 Test Verticality/Test Commonality
The __________ shall provide compatibility of test tolerances (cone of tolerance), ranges, sequences, interfaces, and techniques for duplication of failure indications as failed items move through their maintenance levels. Exchange of pertinent system health and test failure data between all levels of test and maintenance shall be provided. Test levels include hierarchical levels of BIT, organizational, intermediate and depot. Each level of test shall be capable of exercising the diagnostics and built-in test routines of all test levels below it (e.g. depot test shall use organizational and intermediate tests). Each level of test shall make use of the reporting capability and diagnostics and health data of all test levels below it.

3.4.3.2 BIT False Failure Indication
BIT false failure indications, including intermittent and transient fault indications, causing aborts and/or maintenance actions shall be treated as failures and shall be included in the calculation of CFFOP & CMB (3.4.1.1 and 3.4.1.2).

3.4.3.3 Testability
Specific testability requirements shall be __________ or as referenced in __________.

3.4.4 Sensitivity of Parts, Assemblies, and Equipment to Electrostatic Discharge (ESD)
The equipment shall incorporate provisions to eliminate or minimize, to the maximum extent possible, the susceptibility to damage induced by ESD. Electronic parts, assemblies, and equipment which are sensitive to electrostatic discharge shall be identified and controlled in accordance with __________.

3.4.5 Provisions for Life Management
Life limited safety critical items shall have RCM provisions (e.g., hardware, software, technical data) to measure and track operational usage, failures and/or stresses such as elapsed time, fault history, on/off cycles, temperature, vibration. Life limited mission critical and/or durability critical equipments are recommended to contain these provisions. Provisions for durability/economic life management shall be __________. **Caution: Field data collection and agreement with the user is required to implement this requirement.**

4 VERIFICATION OF AVIONICS ELECTRONICS INTEGRITY

4.1 Verification of Durability/Economic Life Requirements
The requirement shall be verified by __________.

4.2 Verification of Usage Requirements
The data provided in 3.2 is for use in developing design criteria and test plans and procedures for incremental testing, durability/economic life testing, and other ground/flight qualification. Verification of the parameters is not required.

4.2.1 Verification of Usage Requirements for Airborne Equipment
The data provided in 3.2.1 is design information for use in developing design and test criteria. Verification is not required for this paragraph.

4.2.1.1 Verification of Flight Profiles/Envelope(s)
The data provided in 3.2.1.1 is information for use in developing design and test criteria. Verification is not required.

4.2.1.1.1 Verification of Carriage Profiles/Envelope(s)
The data provided in 3.2.1.1.1 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.1.2 Verification of Operating Envelope(s)
The data in 3.2.1.1.2 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.2 Verification of Mission Profiles
The data provided in 3.2.1.2 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.3 Verification of Mission Mix
The data provided in 3.2.1.3 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.4 Verification of Climatic Profile(s)
The data provided in 3.2.1.4 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.5 Verification of Total Number of Flights
The data provided in 3.2.1.5 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.6 Verification of Total Operating Hours
The data provided in 3.2.1.6 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.6.1 Verification of Mission Operating Hours
The data provided in 3.2.1.6.1 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.6.2 Verification of Ground Operating Hours – On-Weapon System
The data provided in 3.2.1.6.2 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.6.3 Verification of Ground Operating Hours (Off-weapon system)
The data provided in 3.2.1.6.3 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.7 Verification of Number and Type of Operating Cycles
The data provided in 3.2.1.7 is design information for use in developing design and test criteria. Verification is not required.

4.2.1.7.1 Verification of Operating Cycles in Flight Environment
Verification is not required.

4.2.1.7.2 Verification of Ground Operating Cycles – On-Weapon System
Verification is not required.

4.2.1.7.3 Verification of Ground Operating Cycles – Off-Weapon System
Verification is not required.

4.2.2 Verification of Usage Requirements for Ground-Based Equipment
Verification is not required.

4.2.2.1 Verification of Number and Type of Operating Conditions
Verification is not required.

4.2.2.1.1 Verification of Operating Hours
The data provided in 3.2.2.1.1 is design information for use in developing design and test criteria. Verification is not required.

4.2.2.1.2 Verification of Operating Cycles
The data provided in 3.2.2.1.2 is design information for use in developing design and test criteria. Verification is not required.

4.2.2.1.3 Verification of Climatic profile(s)
The data provided in 3.2.2.1.3 is design information for use in developing design and test criteria. Verification is not required.

4.3 Verification of Required Environments
The requirements shall be verified as defined in each of the subparagraphs.

4.3.1 Verification of Usage Environments
The requirement shall be verified by _____________.

4.3.1.1 Verification of Temperature
The requirement shall be verified by __________.

4.3.1.1.1 Verification of High Temperature
The requirement shall be verified by __________.

4.3.1.1.2 Verification of Low Temperature
The requirement shall be verified by __________.

4.3.1.1.3 Verification of Temperature Shock
The requirement shall be verified by __________.

4.3.1.2 Verification of Vibration
The requirement shall be verified by __________.

4.3.1.2.1 Verification of Gunfire/Other Vibration
The requirement shall be verified by __________.

4.3.1.3 Verification of Acceleration
The requirement shall be verified by __________.

4.3.1.4 Verification of Shock
The requirement shall be verified by __________.

4.3.1.5 Verification of Acoustic Noise
The requirement shall be verified by __________.

4.3.1.6 Verification of Humidity
The requirement shall be verified by __________.

4.3.1.7 Verification of Low Pressure (Altitude)
The requirement shall be verified by __________.

4.3.1.8 Verification of Solar Radiation
The requirement shall be verified by __________.

4.3.1.9 Verification of Rain
The requirement shall be verified by __________.

4.3.1.10 Verification of Fungus
The requirement shall be verified by __________.

4.3.1.11 Verification of Salt Fog
The requirement shall be verified by __________.

4.3.1.12 Verification of Sand and Dust
The requirement shall be verified by __________.

4.3.1.13 Verification of Explosive Atmosphere
The requirement shall be verified by __________.

4.3.1.14 Verification of Leakage (Immersion)
The requirement shall be verified by __________.

4.3.1.15 Verification of Icing/freezing Rain
The requirement shall be verified by __________.

4.3.1.16 Verification of Electromagnetic and Electrical Power Environments
The requirement shall be verified by __________.

4.3.1.17 Verification of Chemical
The requirement shall be verified by __________.

4.3.1.17.1 Verification of Decontamination
The requirement shall be verified by __________.

4.3.1.18 Verification of Nuclear
The requirement shall be verified by __________.

4.3.1.19 Verification of Logistics Environment
The requirement shall be verified by __________.

4.3.1.19.1 Verification of Thermal Cycles Associated with Manufacture and Repair
The requirement shall be verified by __________.

4.3.1.20 Verification of High Power Microwave
The requirement shall be verified by __________.

4.3.1.21 Verification of Corrosion/Chemical Induced Deterioration
The requirement shall be verified by __________.

4.3.1.22 Verification of Precipitation Static
The requirement shall be verified by __________.

4.4 Verification of Supportability Requirements

4.4.1 Verification of Reliability
Verification of reliability requirements are covered in 4.4.1.1-4.4.1.4 below.

4.4.1.1 Verification of Failure Free Operation
The requirement shall be verified by __________.

4.4.1.2 Verification of Cumulative Maintenance Burden
The requirement shall be verified by __________.

4.4.1.3 Verification of Avionics Fault Tolerance
The requirement shall be verified by __________.

4.4.1.4 Verification of Battle Damage Tolerance
The requirement shall be verified by __________.

4.4.2 Verification of Maintainability
Verification of maintainability requirements are covered in 4.4.2.1-4.4.2.2 below.

4.4.2.1 Verification of Maintainer Skill Compatibility
The requirement shall be verified by __________.

4.4.2.2 Verification of Mean Time To Repair (MTTR)
The requirement shall be verified by __________.

4.4.3 Verification of Diagnostics and Testability
The requirement shall be verified by __________.

4.4.3.1 Verification of Test Verticality/Test Commonality
The requirement shall be verified by __________.

4.4.3.2 Verification of BIT False Failure Indications
The requirement shall be verified by __________.

4.4.3.3 Verification of Testability
The requirement shall be verified by __________.

4.4.4 Verification of Sensitivity of Parts, Assemblies, and Equipment to Electrostatic Discharge (ESD)
The requirement shall be verified by __________.

4.4.5 Verification of Provisions for Life Management
The requirement shall be verified by __________.

5 This section is not applicable.

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 guide specification entitled Avionics/Electronic Integrity, is intended for use as guidance for developing a weapon system's avionics/electronic integrity subsystem level specification.

6.2 Acquisition Requirements
Acquisition documents must specify the following:

a. Title, number, and date of the specification.

b. Issue of the documents referenced in Section 2 to be cited in the solicitation.

c. _________________.

6.3 Key Word Listing
The following subject terms (key words) allow identification of the document during retrieval searches.

avionics design
electronics design
reliability
maintainability
design integrity

6.4 Definitions
Within this sample guide specification, the following definitions apply.

6.4.1 Aging
1) The deterioration of materials properties from stress chronologically accrued over the service life; with often resulting loss of functional performance. 2) To acquire a desirable quality by standing undisturbed for some time (e.g., age hardened metals and composites, wine, cheese.)

6.4.2 Analysis
An in-depth review (not test) to determine the extent to which the product/process/service undergoing review will meet the requirements.

6.4.3 Break Rate
A user reliability requirement stated as a percentage of missions that generate maintenance of mission critical items.

6.4.4 Commercial Off-the-Shelf
Readily available product or services that is designed primarily for non-military use.

6.4.5 Critical
Necessary to accomplish mission and/or safety requirements, and whose absence will create a major adverse event.

6.4.6 Critical Failure
Loss of a critical function (see below).

6.4.7 Critical Failure Free Operating Period (CFFOP)
A segment of the durability life during which the probability of impacting a mission for maintenance of critical items stays below a specified value without preventive maintenance (i.e., percent of sorties impacted by maintenance). The CFFOP parameters are usually calculated from user break rate and safety requirements.

6.4.8 Critical function
A function that is essential to safety and/or mission (e.g.. aircraft flight control, weapons release, etc.).

6.4.9 Cumulative Maintenance Burden
The cumulative number of maintenance hours, at various maintenance levels, in all or portions of the durability/economic life of the equipment.

6.4.10 Damage tolerance
The ability of electronic equipment to resist failure due to the presence of flaws, cracks, or other damage resulting from manufacture and/or usage stresses.

6.4.11 Defect
An abnormal flaw or condition which should not be present in a product and can be avoided with quality process technology.

6.4.12 Derating
Using an item such that the stresses applied during operation are lower than the stresses the item was designed to withstand.

6.4.13 Design allowable
The value of a material property which a certain percentage of the population of values (usually 90 or 99%), is expected to exceed, with a certain confidence level (usually 95%).

6.4.14 Durability
Ability to withstand expected stresses for a specified usage period with required maintenance.

6.4.15 Durability control point
Hardware material element (e.g. lead, solder joint, component, etc.), the life characteristics of which control and determine the durability and life of the hardware.

6.4.16 Durability critical item
An item whose failure may result in a major economic impact by requiring costly maintenance and/or part repair and replacement, which if not performed would significantly degrade performance and operational readiness.

6.4.17 Durability/Economic Life
An equipment life specified in the way it will be produced, operated, and maintained over its life (expressed in terms of turn-on/off cycles, operating mode changes, etc.) and in the number of years it will be in inventory. Durability/economic life is determined by an analysis of operational and maintenance concepts and costs to establish a requirement consistent with the service life of the entire system of which the equipment is a part.

6.4.18 Durability/Economic Life Test (DLT)
A combined environment test which simulates the operational usage and environments which the equipment is expected to experiences over its durability/economic life.

6.4.19 Durability/Economic Life Test profile
A chronological decomposition of the life cycle environmental profile which incorporates all of the cumulative stresses and cumulative damage that the production articles are expected to undergo during the design usage and total environments over the item service life

6.4.20 Failure
Any condition which indicates that the electronics will not perform its intended function (BIT indication, aircrew squawk, equipment malfunction, etc.).

6.4.21 Integrity
The essential characteristics of equipment that allow specific performance, reliability, safety and supportability to be achieved under specified operational conditions over a defined durability/economic lifetime.

6.4.22 Inspection
Investigation to determine conformance to cursory aspects of process or product (e.g., physical attributes for "workmanship".)

6.4.23 Key Product Characteristic (KPC)
A measurable design detail or parameter whose variation has a great influence on product performance, fit, durability/economic life, supportability, or other important requirement. These characteristics require key control characteristics.

6.4.24 Key Production Process (KPP)
A production process which controls a key product characteristic. Fabrication processes, assembly processes, test processes, inspection processes, and parts/materials selection processes are examples.

6.4.25 Key Product Feature (KPF)
An important trait or property of the product critical to its cost, performance and/or supportability (radar range, processor speed, etc.).

6.4.26 Life Limited Items
Items with a design life less than the durability/economic life of the higher level assembly.

6.4.27 Maintainable
The capability of being held to or restored to specified performance capability when subjected to established support procedures.

6.4.28 Maintenance
The process of applying the established procedures to a product or service to retain or return the item to full mission performance or readiness.

6.4.29 Maintenance action/event
Any expenditure of maintenance hours (repair, calibration, troubleshooting, false failure indications, preventive maintenance, opportunistic repairs, etc.).

6.4.30 Margin
The amount allowed or available between the specification limit and the functional limit (value where circuit will no longer perform properly) of the design or manufacturing parameter. See figure C-1.

6.4.31 Mission-critical item
An item whose failure would (a) prohibit the execution of a critical mission, (b) significantly reduce the operational mission capability, or (c) significantly increase the system vulnerability during a critical mission. These items require more stringent design criteria and tighter manufacturing process controls than those required by durability critical items.

6.4.32 Opportunistic Maintenance
Maintenance performed on an item when it is "down," already having some other maintenance performed.

6.4.33 Other/expendable items
All items of a system or subsystem not classified as safety, mission, durability critical, or durability non-critical. The failure of these items could be handled during routine maintenance and would not impact mission, safety, or operational readiness.

6.4.34 Preventive Maintenance
Maintenance performed to prevent a failure from occurring.

6.4.35 Reliability-centered maintenance (RCM)
RCM is a disciplined logic or methodology used to identify preventive, corrective, and opportunistic maintenance requirements for weapon systems and equipment consistent with RCM principles (see MIL-STD-1843).

6.4.36 Safety-critical item
An item whose failure would cause loss of the weapon system or injury/death of personnel or extensive damage to critical equipment or structure. These items require very stringent design criteria and tighter manufacturing process controls.

6.4.37 Scheduled Maintenance
Preventive maintenance and/or maintenance of non-critical items that can be scheduled and performed without conflicting with the mission.

6.4.38 Single point failure
The failure of an item which would result in failure of the system and is not compensated for by redundancy or alternative procedure.

6.4.39 Supportability
The ability of the avionics/electronics to be kept in a state of operational readiness.

6.4.40 Test
A technical process used to verify the product or process through rigorous methods used to extract the expected performance to its established requirements.

6.4.41 Test Commonality
A common set of parameters tested at all levels of assembly under the same set of environmental conditions. Parameter or function tests at the lowest levels of assembly should be subsets of tests at higher levels of assembly, ensuring the required product functionality when integrated into higher level assemblies.

6.4.42 Test Verticality
The ability of the testing to verify performance and duplicate failure indications at all levels of integration and system maintenance.

6.4.43 Tolerance
The permissible variation allowed in a given design or manufacturing parameter; for example, specification limits. See figure C-1.

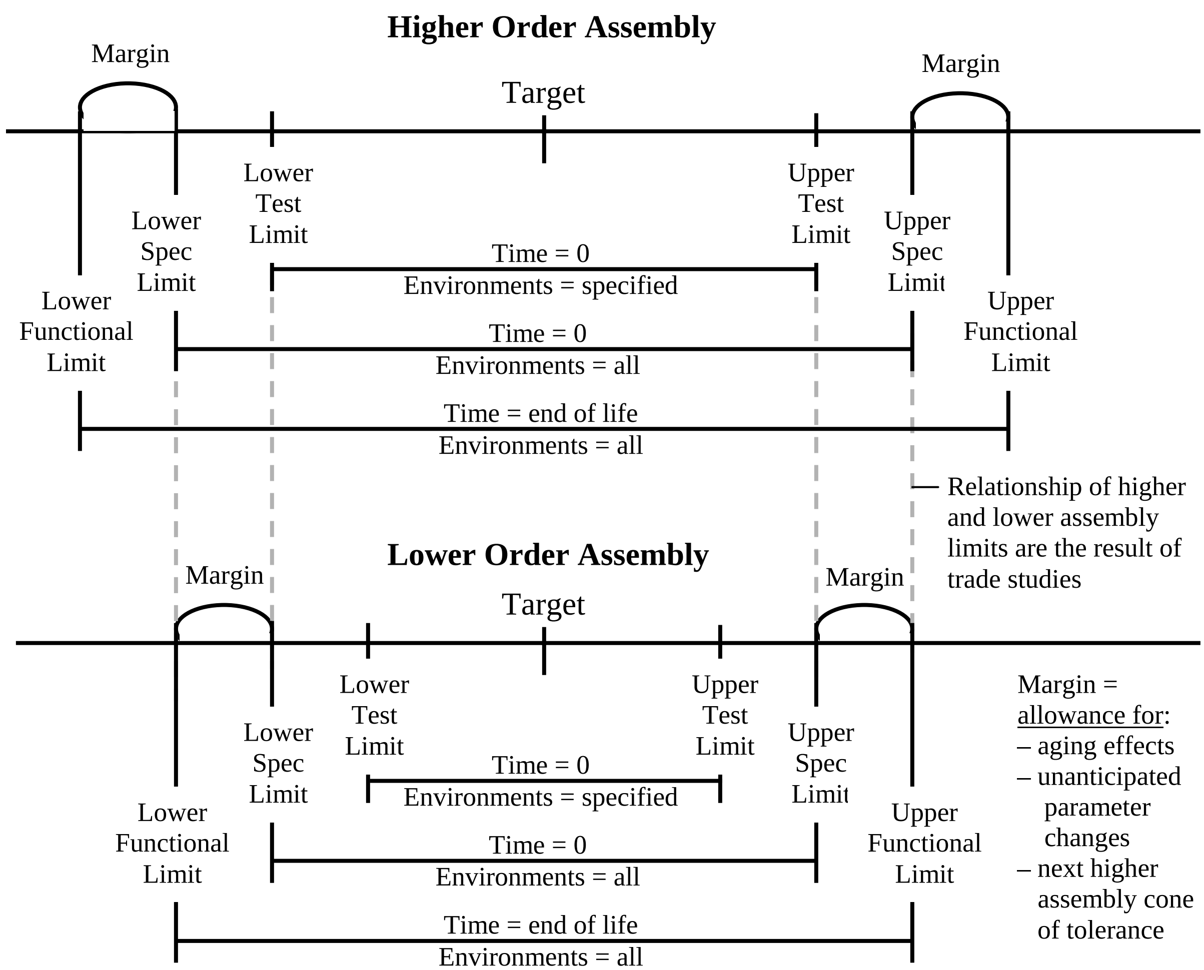

Figure C-1. <u>Tolerance and Margin Relationship</u>.

6.4.44 Unscheduled Maintenance
Unexpected maintenance of critical items that must be accomplished for mission and/or safety reasons.

6.5 Acronyms
Within this sample guide specification, the following acronyms apply.

AVIP – Avionics/Electronics Integrity Program

CA – Corrective Action

CFFOP – Critical Failure Free Operating Period

CMB – Cumulative Maintenance Burden

DCP – Durability Control Point

DLT – Durability/economic life Test

ECS – Environmental Control System

EMC – Electromagnetic Capability

EMI – Electromagnetic Interference

ESD – Electrostatic Discharge

ESS – Environmental Stress Screening

LRU – Line Replaceable Unit

PA – Procuring Activity

PWB – Printed Wiring Board

6.6 Responsible engineering office
The office responsible for development and technical maintenance of this guide specification is ASC/ENAI, Wright-Patterson AFB, Ohio. Request for additional information or technical assistance on this guide specification can be obtained from Mr. Craig Wall, ASC/ENAI, Wright-Patterson AFB, OH 45433-7630 (commercial phone number: 513-255-4463, DSN 785-4463, or FAX: 513-255-3466). Any information required relating to Government contracts must be obtained through the contracting officer.

Custodian:
Air Force -11

Preparing Activity:
Air Force -11

Project No. 15GP-F110

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