NAVAL RESEARCH LABORATORY

NAVAL CENTER FOR SPACE TECHNOLOGY

Attitude Reference Unit (ARU) Critical Item Product Specification

SSD-S-IM058 **11 February 1998**

4555 Overlook Avenue, S.W.
Washington, D.C. 20375-5000

RECORD OF CHANGES

REVISION LETTER	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY
—	11 February 1998	Final RFP Changes	A. Posselt

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

1.0 SCOPE

1.1 General. This Critical Item Product Specification (CIPS) establishes the design, performance, fabrication, testing, verification, and delivery requirements for the Attitude Reference Unit (ARU).

1.2 Classification. The critical item described by this specification shall be designated as specified in Table 1-1. The Engineering Development Model (EDM), or Brassboard Unit, replicates the form, fit, and function of the Flight Unit and is used to verify mechanical and electrical compatibility. The EDM undergoes functional testing to verify functionality but is not exposed to environmental testing. The Flight Unit meets specified requirements and is tested to acceptance test levels. The Qualification Unit meets specified requirements and is tested to qualification test levels where qualification levels are identified, and tested to acceptance test levels where no qualification level is cited.

Table 1-1. Critical Item Classification

Part Number	Nomenclature	Basic Difference
IM023-01	Attitude Reference Unit	Engineering Development Model (Brassboard)
IM023-02	Attitude Reference Unit	Flight Unit
IM023-03	Attitude Reference Unit	Qualification Unit

1.3 Document Overview. This specification addresses the ARU definition, characteristics, design, construction, documentation, logistics, personnel, training, subordinate elements, and qualification requirements. The document is organized as follows:

- Section 1.0, Scope, identifies the item and explains the purpose and contents of this document.
- Section 2.0, Referenced Documents, lists all documents referenced in or required for use with this specification.
- Section 3.0, Requirements, specifies the mechanical, electrical, data, and interface requirements for the ARU. In Section 3.0, requirement numbers (shown as RQMT XXX), appear along the left margins. These requirement numbers are used to clearly mark and number each of the requirements set forth in this Critical Item Product Specification for the ARU. Each requirement number is listed in the Verification Requirements Checklist (Table 4-1), along with the method for verifying the requirement.
- Section 4.0, Quality Assurance Provisions, details the tests to be conducted on the item and the methods of test verification that will be employed.
- Section 5.0, Preparation for Delivery, specifies methods of containing and storing item components.
- Section 6.0, Deliverables and Tasks, specifies tasks to be performed and items to be prepared and delivered as part of this effort.

2.0 REFERENCED DOCUMENTS

2.1 Government Documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement. Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions should be obtained from the contracting agency or as directed by the contracting officer. Documents beginning with the control number "SSD" or "SSP" are program documents controlled by the NRL or NASA and should be obtained from the contracting officer.

2.1.1 Specifications.

Number	Title	Cited in Paragraph
DOD-D-1000	Drawings, Engineering and Associated Lists	3.4.2
DOD-E-8983	General Specification for Extended Space Environment Aerospace Electronic Equipment	3.3.1.1
DOD-W-83575	Wiring Harness, Space Vehicle, Design and Testing, General Specification for	3.3.1.1.5
MIL-B-5087	Bonding, Electrical and Lightning Protection for Aerospace Systems	3.3.2.5.1
MIL-C-17	Cable, Radio Frequency	3.3.1.1.6
MIL-C-24308	Connectors, Electrical, Rectangular Miniature Polarized Shell, Rack and Panel, General Specification for	3.2.2.4 3.3.1.1.5
MIL-C-38999	Connector, Electrical, Circular, Miniature, High Density, Quick Disconnect	3.3.1.1.5
MIL-C-39012	Coaxial Connectors	3.3.1.1.5
MIL-C-55302	Connector, Printed Circuit Subassembly and Accessories	3.3.1.1.5
MIL-F-7179	Finishes, Coatings, and Sealants for the Protection of Aerospace Weapon Systems	3.3.1.2.4
MIL-M-38510H	General Specification For Microcircuits	3.3.1.1.2
MIL-P-50884	Printed Wiring, Flexible and Rigid-Flex	3.3.1.3.4
MIL-P-55110	Printed Wiring Boards, General Specifications	3.3.1.3.4
MIL-S-45743	Soldering, Manual Type, High Reliability, Electrical and Electronic Equipment	3.3.1.3.4
MIL-S-46844	Solder Bath Soldering of Printed Wiring Assemblies	3.3.1.1, 3.3.1.3.4
MIL-T-31000	Technical Data Packages, General Specification for	3.4, 3.4.2
MIL-W-22759	Wire, Electrical, Insulated	3.3.1.1.6

2.1.2 Standards.

2.1.3 Other Publications.

Number	Title	Cited in Paragraph
MIL-STD-198	Military Standard Capacitors, Selection and Use of	3.3.1.1.3
MIL-STD-275	Printed Wiring For Electronic Equipment	3.3.1.3.4
MIL-STD-199	Selection and Use of Resistors	3.3.1.1.3
MIL-STD-454	Standard General Requirements For Electronic Equipment	3.3.4.1
MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment	4.4.4.5
MIL-STD-462	Electromagnetic Interference Characteristics, Measure of	4.4.4.5
MIL-STD-490	Specification Practices	3.4.1
MIL-STD-498	Software Development and Documentation	3.4.1
MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program	3.3.4.2
MIL-STD-2118	Flexible and Rigid-Flex Printed-Wiring for Electronics Equipment, Design Requirements for	3.3.1.3.4
MIL-STD-756	Reliability Modeling and Prediction	3.2.3.4 4.4.2
MIL-STD-810	Environmental Test Methods and Engineering Guidelines	3.2.7.2.5, 3.2.7.2.6
MIL-STD-889	Dissimilar Metals	3.3.1.2.2
MIL-STD-975M(2)	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List	3.3.1.1.2
MIL-STD-1541	Electromagnetic Compatibility Requirements for Space Systems	3.3.2
MIL-STD-1542	Electromagnetic Requirements and Ground Requirements for Space System Facilities	3.3.2
MIL-STD-1546	Materials and Processes Control Program for Space and Launch Vehicles	3.3.1
MIL-STD-1547	Electronic Parts, Materials, and Processes for Space and Launch Vehicles	3.3.1
MIL-STD-1553B	Military Standard Digital Time Division Command/Response Multiplex Data Bus	3.2.1.2.1 3.3.1.1.5.3
MIL-STD-1568	Materials and Processes for Corrosion Prevention and Control in Aerospace Weapons Systems	3.3.1.2.2 3.3.1.2.4

Number	Title	Cited in Paragraph
MIL-HDBK-5	Metallic Materials and Elements for Space Vehicle Structures	3.3.1.2.2
MIL-HDBK-17	Polymer Matrix Composites, Guidelines	3.3.1.2.2
MIL-HDBK-23	Composites	3.3.1.2.2
MIL-HDBK-217	Reliability Prediction of Electronic Equipment	3.2.3.4, 4.2.2
MSFC Spec 522	Design Criteria for Controlling Stress Corrosion Cracking	3.3.1.2.1

NASA NHB5300.4A	Requirements for Soldered Electrical Connections	3.3.1.3.4
NASA S-311-P-4/9	Connectors, Electrical, Polarized Shell, For Spaceflight Use, Detailed Specification For	3.2.2.4
SP-R-0022	General Specification, Vacuum Stability Requirements of Polymeric Material for Spacecraft Application	3.2.2.9
SSD-D-IM003	ICM EMI/EMC Plan	3.3.2
SSD-D-IM006	Failure Reporting Analysis and Corrective Action Procedure	3.3.1.3.2 4.1.3
SSD-D-IM007	Worst Case Analysis, Guidelines and Criteria	3.2.3.6, 3.3.1.3.3, 4.2.1, 4.2.2
SSD-D-IM008	Spacecraft Product Assurance Program Plan	3.2.3.2, 3.2.3.3, 3.2.3.4, 3.3.1, 3.3.1.1.2, 3.3.1.3.7, 4.1, 4.2.2
SSD-D-IM009	Flight Hardware Fabrication, Test, and Repair	3.3.9
SSD-D-IM012	Destructive Physical Analysis	3.3.1.1.4
SSP 30312	Electrical, Electronic, and Electromechanical (EEE), and Mechanical Parts Management and Implementation Plan for International Space Station Program	3.3.1.1.1
SSP 30420	Space Station Grounding Requirements	3.2.7.5.3
SSP 30423	Space Station Requirements for Electromagnetic Compatibility	3.3.1.1.2
SSP 30425	Space Station Program Natural Environment Definition for Design	3.2.7.5.3
SSP 30512	Space Station Ionizing Radiation Design Environment	3.2.2.6, 3.2.7.5.3

2.2 Non-Government Documents. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of the invitation of bids or request for proposal shall apply. In the event of conflict between the documents referenced herein and the contents of this specification, this specification shall take precedence.

Copies of specifications, standards, drawings, and publications required by Suppliers in connection with specified procurement functions should be obtained from the contracting agency or as directed by the contracting officer.

2.2.1 Specifications. Not applicable.

2.2.2 Standards.

Number	Title	Cited in Paragraph
ANSI Y14.5	Dimensioning and Tolerancing	3.2.2.2
ANSI Y32.2	Graphic Symbols for Electrical and Electronic Diagrams	3.3.3.2
ANSI Y32.16	Reference Designations for Electrical and Electronic Parts and Equipments	3.3.3.2
ANSI/J-STD-001	Requirements for Soldering	3.3.1.3.4

2.2.3 Other Publications.

Number	Title	Cited in Paragraph
IPC-A-600D	Acceptability of Printed Wiring Boards	3.3.1.3.4
IPC-D-275	Standard for PCB Design and Assembly	3.3.1.3.4
IPC-FC-250	Performance Specification for Single and Double-Sided Flexible Printed Boards	3.3.1.3.4
IPC-FC-250A-86	Specification for Single and Double-Sided Flexible Wiring	3.3.1.3.4

3.0 REQUIREMENTS

3.1 Item Definition. The item specified herein is the Attitude Reference Unit. It will be used on the International Space Station (ISS) that is under development by the National Aeronautics and Space Administration (NASA). The equipment described by the requirements of this section shall satisfy the requirements for examination, analysis, and tests as specified in section 4.0. The Attitude Reference Unit (referred to herein as the ARU) shall perform the functions of inertial angular rate measurement (or incremental angular measurement) in three mutually orthogonal axes. The ARU provides meaurement and communicates to the flight computer. The ARU will be used to determine vehicle attitude between star tracker updates. Any calibration and compensation required to meet performance requirements shall reside in the ARU. The ARU shall include any required internal power conditioning from the spacecraft power and will interface with the flight computer with the electrical interface as described in this specification.

3.1.1 Interface Definition. The ARU will have the interfaces defined in the subsections below. Signal definitions are as follows:

- Input and output signals will be active high unless otherwise specified. Active high signals are asserted at the higher (more positive) of two logic voltage levels (high-true). Active low signals are asserted at the lower (less positive) of two logic voltage levels (low-true). Active low signals will be identified by an asterisk (*) after the signal name.

3.2 Characteristics.

3.2.1 Performance Requirements. The ARU shall meet the performance requirements and shall provide the capabilities as specified within this document.

3.2.1.1 Gyroscope Performance.

3.2.1.1.1 General. The ARU shall provide inertial angular rate indication about three mutually perpendicular axes.

3.2.1.1.2 Maximum Continuous Input Rates. The unit shall be capable of maximum continuous input rates for each axis of 10 degrees/second.

3.2.1.1.3 Output Scale Factors. The output scale factors for each axis shall be as defined below:

3.2.1.1.3.1 Scale Factor Linearity. Scale factor linearity (after compensation) shall be less than 100 ppm (one sigma) per axis.

3.2.1.1.3.2 Scale Factor Stability. Scale factor stability (after compensation) shall be less than 100 ppm (one sigma) per axis.

3.2.1.1.4 Bias Repeatability. Bias repeatability shall not exceed 0.1 degree/hour (one sigma).

3.2.1.1.5 Angular Random Walk. Angular random walk shall not exceed 0.015 degrees/root-hour (one sigma) per axis.

3.2.1.1.6 Bandwidth. The minimum bandwidth for each of the three gyroscope outputs shall be 20 Hz.

RQMT-100 **3.2.1.1.7 Axis Alignment.** The three gyroscope reference axes shall be mutually orthogonal.

RQMT-110 The physical misalignment of the gyroscope input axes relative to a set of optically derived axes shall not exceed two milliradians.

RQMT-120 The uncertainty in the alignment of the input axes relative to the optical reference axes shall be no greater than 100 microradians.

3.2.1.1.8 Sensitivity. Each incremental angle measurement output shall have a maximum threshold of 10 deg/hour.

3.2.1.1.9 Warm-up Time. The warm-up time for the unit shall not exceed one minute.

3.2.1.2 Output Data Interfaces.

3.2.1.2.1 Output Data. The Command, Telemetry, and Data Handling (CT&DH) System interfaces between the ARU and the flight computer shall be MIL-STD-1553.

RQMT-100 **3.2.1.2.2 ARU Output Sampling Period.** The sample period of the ARU output shall be ≤100 milliseconds.

RQMT-110 Requirements of section 3.2.1 shall be met using this sample period.

RQMT-100 **3.2.1.3 Primary Power.** The ARU may be designed to accept unregulated input power from the Spacecraft's Electrical Power System (EPS) and provide preregulation for use within the subsystem. Switching of input power (i.e., power-on and power-off) shall be accomplished in the EPS, which shall also provide control of inrush current.

RQMT-110 The equipment shall operate as specified herein when supplied with input power having the characteristics specified below, and shall not impose emissions on the power bus in excess of those specified herein.

3.2.1.3.1 Input Voltage. The steady state voltage at the input connector of the equipment will be 30 ± 6 V dc, excluding noise, ripple and transients.

3.2.1.3.2 Source Impedance. The input power will have an equivalent source impedance as depicted in Figure 3-1.

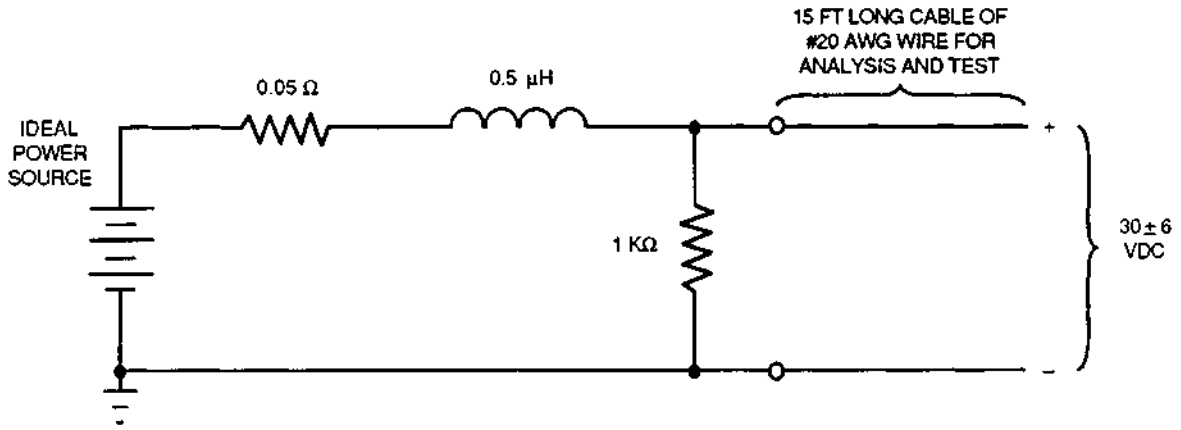


Figure 3-1. Primary Power Input Equivalent Circuit

RQMT-100 **3.2.1.3.3 Isolation.** The equipment shall be compatible with a single-point ground for primary power with separate positive and return wires brought out to the power input connector.

RQMT-110 Primary input power and returns to the equipment shall be isolated from the case (chassis) and secondary power circuitry by a minimum dc resistance of one megohm.

RQMT-120 The case (chassis) or mounting structure shall not be used to conduct power currents.

3.2.1.3.4 Power Consumption. The power consumption of the equipment shall not exceed 25 watts.

RQMT-100 **3.2.1.3.5 Inrush Current.** The inrush current to the equipment when switching from power-off to power-on in any mode shall not exceed twice the average operating input current, and the input current shall settle to within 10% of the nominal operating value within 200 milliseconds after the application of power.

RQMT-110 The input power equivalent circuit shall be as shown in Figure 3-1.

3.2.2 Physical Characteristics. This paragraph specifies the physical characteristics of the ARU.

RQMT-100 **3.2.2.1 Mass Properties.** The ARU shall be designed for minimum weight consistent with the requirements specified herein and shall not exceed the values listed in Table 3-1. The Contracting Officer's Representative (COR) has established a system of mass properties management to ensure fulfillment of the spacecraft mass properties objectives.

RQMT-110 The Contractor shall periodically provide the COR with mass properties data.

RQMT-120 The data shall include current weight traceability and estimates of its uncertainty, current weight, and the related center of gravity.

RQMT-130 Final mass properties data shall be provided at delivery.

Table 3-1. Weight Limits

Item	Weight (lb)	Mass (kg)
Attitude Reference Unit (ARU)	15	6.8

RQMT-100 **3.2.2.2 Mechanical Size, Configuration and Interface.** The item shall be capable of meeting the following requirements.

RQMT-110 a. Dimensions and tolerancing shall be according to ANSI Y14.5, *Dimensioning and Tolerancing* guidelines.

RQMT-120 b. The ARU shall operate as specified herein when mounted in any orientation.

RQMT-130 c. The Contractor shall furnish to the COR an envelope drawing providing the center of gravity (CG) for the flight article.

RQMT-140 d. The unit, including interior walls and gaskets, shall be either hermetically sealed or have provisions for positive (non-casual) venting according to the environments specified in section 3.2.7.

RQMT-150 e. Sufficient venting shall be provided to allow internal pressure stabilization within 15 minutes of achieving an external pressure of 1×10^{-4} torr.

RQMT-160 f. The unit shall be capable of withstanding repressurization from 1×10^{-4} torr to 775 torr at one torr per second without performance degradation.

RQMT-100 **3.2.2.3 Mounting.** The ARU shall be hard mounted and shall operate as specified when mounted in any orientation.

RQMT-110 The enclosure mounting surfaces shall have a flatness within 0.001 inch per inch or 0.01 inch over the entire mounting surface, whichever is greater, and the footprint surface shall have a smoothness of 63 microns or better. Incidental scratches are allowable if not more than one percent of the mounting surface is disturbed.

RQMT-120 No scratch shall exceed 0.005 inch in depth.

RQMT-100 **3.2.2.4 Connectors.** External connectors shall be provided for power and signals in accordance with MIL-C-24308 or NASA S-311-P-4/9.

RQMT-110 Connector pin assignments shall be defined jointly by the COR and the Contractor.

RQMT-120 The Contractor shall furnish to the COR a fabrication drawing for the cables. Connector pins carrying the same function for redundancy may be located in the same connector.

RQMT-130 The signal and signal return wires for each function shall be located in the same connector and assigned to adjacent pins to allow wire twisting and shielding.

RQMT-140 Keying, polarization or other mechanical means, or combinations thereof, shall be incorporated in connectors to prevent mismating, or incorrect mating, with cable connectors.

RQMT-150 The power bus positive and return shall be on nonadjacent pins.

RQMT-160 Intervening pins shall be kept open.

RQMT-170 The location of connectors and spacing of connectors shall permit access for mate and demate while the ARU is mounted on the vehicle. A minimum edge-to-edge spacing of 0.25 inch is recommended for adjacent connectors.

RQMT-100 **3.2.2.5 Thermal Design.** The thermal design shall be consistent with the maximum, minimum, and differential allowable operating temperatures specified herein, using the following guidelines.

RQMT-110 a. The derating criteria specified herein shall be reflected in the establishment of piece part temperature limits and allowable temperature differences between piece parts, circuit boards, and equipment cases.

RQMT-120 b. Except for mounting surfaces, electrical connectors, exposed fastener hardware, and the areas immediately adjacent to mounting holes, all external surfaces shall be painted black with an emissivity of 0.8 or greater.

RQMT-130 Unpainted areas (excluding the mounting surface) shall not exceed five percent of the total area and no contiguous unpainted areas shall exceed one percent of the total area. Exposed fastener hardware may be painted black.

RQMT-140 c. The thermal interface shall provide for dissipating heat by conduction through the ARU's baseplate to the spacecraft's support structure.

RQMT-150 The ARU's thermal design shall be based on being bolted to a deck surface that is maintained within the temperature specified in Table 3-2.

Table 3-2. Mounting Surface Temperature Requirements

Performance and Calibration Temperature (C°)	On-Orbit Non-Operating Survival Temperatures (C°)	Acceptance Thermal Vacuum and Thermal Cycling Temperatures (C°)	Qualification Thermal Vacuum and Thermal Cycling Temperatures (C°)
-10/+50	-20/+60	-10/+50	-20/+60

RQMT-160 d. Items having greater than 10 watts internal heat dissipation (on an orbital average basis) shall have an actual footprint density greater than 0.5 watts/in^2.

RQMT-170 e. Cutouts or recesses in the item's baseplate are permitted, but the area of these cutouts shall not be counted as contact area.

RQMT-180 f. For thermal analysis purposes, the Contractor shall assume that the unit is wet-mounted using RTV. Thermal conductance between the unit's mounting surface and the deck surface conductance is defined by the item's baseplate area.

RQMT-190 The Contractor shall assume 75 BTU/Hr-F° (40W/C°) per square foot of the unit's baseplate.

RQMT-200 g. The item shall have solar absorptivity and emissivity values as follows:

Emissivity	≥0.85
Absorptivity	Not Applicable

3.2.2.6 Radiation Effects. The Total Dose Hardening of the item shall be accomplished through a combination of piece part selection and control, radiation shielding, and piece part parameter derating. The natural on-orbit radiation environment is defined within NASA's SSP 30512, Figure 3.2.2-2, for Maximum Solar Flare Orbit Averaged Integral Heavy Ion Fluxes.

RQMT-100 **3.2.2.6.1 Radiation Protection.** As a goal, the ARU enclosure shall have a minimum unit wall area density (Material Density x Thickness) at any point of ≥0.411 g/cm2 (0.06 inch aluminum) to limit radiation dosage. Necessary apertures, such as pin and vent holes, may be baffled to meet this requirement.

RQMT-110 For purposes of item shielding analysis, the Contractor shall assume that an additional 0.040 inch of aluminum shielding will be provided by the spacecraft.

RQMT-100 **3.2.2.6.2 Radiation Hardness and Dosage.** The design of the ARU shall be such that all electrical, electronic, and electromechanical (EEE) parts shall be operational after a total radiation dose of 10 kRAD (Si) at the part level over the three-year mission duration without degrading the performance of the item or exceeding the manufacturer's specified limits.

RQMT-110 a. Radiation effects on the item shall in no way impact operation of the spacecraft.

RQMT-120 b. Radiation dosage is specified at the part level. Parts with a total dose tolerance between 3 and 10 kRAD (Si) may be individually approved for usage by the COR. Metal Oxide Semiconductor (MOS) integrated circuits and other radiation susceptible parts shall be acceptable only after process verification has been obtained that all parts meet the total radiation dose requirement. Due to lot-to-lot variations and the different failure mechanisms of MOS parts, the definition of part failure after the specified dose level is:

(1) The part is no longer functional.

(2) Standby device current increases to more than 100% of the pre-radiation specification.

(3) A device noise margin decreases by more than 25% of the pre-radiation level.

(4) Individual device input leakage currents increase by more than 200% of the pre-radiation levels.

RQMT-100 **3.2.2.6.3 Single Event Effects.** Single Event Effects (SEE) hardening shall be accomplished through a combination of piece part selection and control, and circuit/system design such that component performance and effectiveness are not degraded.

RQMT-110 a. For the purposes of analysis, the integral flux versus Linear Event Transfer (LET) environment shall be ≤40 MeV-cm^2/mg.

RQMT-120 b. The ARU shall be resistant to Single Event Upsets (SEU).

RQMT-130 The design of the item shall limit the mean time between SEUs resulting in temporary loss of telemetry or command capability to ≤4.5 x 10^{-3} events per year. The use of high SEU risk device types and technologies listed below requires the approval of the COR for each application:

(1) Semiconductor Memory Devices

(2) Microprocessors and Peripheral Devices

(3) Gate Arrays and other VLSI Devices

(4) Logic Devices or technologies with a heavy ion SEU threshold ≤40 MeV-cm^2/mg.

RQMT-140 c. In the SEU vulnerability assessment, consideration shall be given to:

(1) The device application, mission criticality, and impact of a SEU on mission performance.

(2) The corrective action required.

(3) The anticipated frequency and corrective action for nominal and peak SEU rates.

(4) The mission impact of a corrective action.

RQMT-150 d. The design of the item shall eliminate the possibility of an SEU resulting in a non-recoverable adverse condition or mode.

RQMT-100 **3.2.2.6.4 Single Event Latchup (SEL).** Destructive Single Event Latchups shall not occur.

RQMT-110 Non-destructive SEL shall be cleared through power cycling of the unit.

Note that SEL is caused by penetration of cosmic ray particles into a solid state device, creating a parasitic transistor pair between =Vdd / -Vss. SEL is the result of a single energetic particle injecting a current sufficient to trigger the potential parasitic pn-pn silicon controlled rectifier function into the substrate. This effect is inherent in Complementary-MOS (CMOS) technology. When this effect occurs, a stable low-impedance path is generated, drawing high current through the chip that can cause the device to burn out within 500 μSeconds unless appropriate protection is implemented. In general, the protection against permanent damage requires that the supply current to all susceptible devices be limited such that no single CMOS device can draw excessive current (e.g., greater than 100 ma).

3.2.2.7 Corona Suppression. Proper performance of the ARU shall not be impaired by corona discharge in normal operating environments, and the ARU shall not be a source of corona discharge at atmospheric or hard vacuum.

RQMT-100 **3.2.2.8 Venting.** All enclosures shall be vented to the external environment.

RQMT-110 Any pressure differential encountered during vacuum system pump-down or launch shall cause no damage to any ARU component.

RQMT-100 **3.2.2.9 Outgassing.** Materials shall be selected for low out-gassing characteristics in accordance with SP-R-0022, *General Specification, Vacuum Stability Requirements of Polymeric Material for Spacecraft Application*.

RQMT-110 Deviations from this requirement shall be reported to the COR.

3.2.3 Reliability. The ARU reliability shall be greater than 0.98 based on a three year mission duration with an operating duty cycle of 100% and a host spacecraft temperature of 30˚C.

3.2.3.1 Reserved.

3.2.3.2 Failure Mode, Effects and Criticality Analysis (FMECA). As a part of the design process, a FMECA shall be performed on the ARU in accordance with Section 3 of the SSD-D-IM008, *Spacecraft Product Assurance Program Plan*.

3.2.3.3 Electrical Stress Analysis. As a part of the design process, an electrical stress analysis shall be performed in accordance with Section 3 of the SSD-D-IM008, *Spacecraft Product Assurance Program Plan,* to ensure that the derating criteria of Table 3-1 of that document are not exceeded.

RQMT-100 **3.2.3.4 Reliability Analysis.** As a part of the design process, a reliability analysis shall be performed in accordance with Section 3 of the SSD-D-IM008, *Spacecraft Product Assurance Program Plan*.

RQMT-110 Reliability predictions shall be performed according to Task 202 of MIL-STD-756 or equivalent.

RQMT-120 The specific technique to be used shall be Method 2005 parts stress analysis of MIL-STD-756 or equivalent.

RQMT-130 Electronics part failure rates from MIL-HDBK-217 (or equivalent) shall be used.

RQMT-140 All other sources of part failure data shall require the concurrence of the COR prior to use.

RQMT-150 A space environmental factor, nominal operating conditions (e.g., nominal electrical stresses), and nominal estimated duty cycle shall be used as a baseline for developing part failure rates.

3.2.3.5 Single Point Failure (SPF). Not applicable.

3.2.3.6 Worst Case Analysis. As a part of the design process, a Worst Case Analysis (WCA) shall be performed at the component level in accordance with SSD-D-IM007, *Worst Case Analysis Guidelines and Criteria*, or equivalent.

RQMT-100 **3.2.4 Maintainability.** No scheduled or preventive maintenance shall be required to meet the performance and reliability requirements specified herein.

RQMT-110 Part failures during ground test, checkout, and storage shall be repaired without degrading the performance or reliability characteristics.

RQMT-120 Provisions for fault detection, isolation, and checkout, using multipurpose test equipment, shall be incorporated in the ARU design.

RQMT-130 Testing shall be at the replacement (“black box”) level with the ARU in its installed configuration.

RQMT-100 **3.2.4.1 Access and Mounting.** Access and mounting provisions shall be provided such that checkout, maintenance, adjustment, servicing, and replacement of the space segment and its subassemblies and components can be accomplished with a minimum amount of disassembly and without the excessive use of special tools or equipment.

RQMT-110 Positive positioning and alignment features shall be provided to ensure repeated correct assembly and installation.

RQMT-100 **3.2.4.2 Modular Construction.** Modular construction shall be employed in design of the space segment.

RQMT-110 Whenever possible, modules shall be designed as functionally complete subassemblies that can be tested, adjusted, calibrated, and maintained as single independent units.

3.2.4.3 Fault Detection Capability. As a goal, fault detection, isolation, and checkout capability shall be provided to the subassembly or component level at which replacement will be performed when the space segment is in its installed configuration.

3.2.4.4 Maintenance Provisions. No scheduled or preventive maintenance shall be performed to meet the performance requirements specified herein.

3.2.5 Availability.

3.2.5.1 Space Segment.

3.2.5.1.1 Non-Operating Environment. The ARU shall meet the requirements of this specification without refurbishment or adjustment after exposure to any combination of the conditions specified herein while the equipment is not operating.

3.2.5.1.2 Operating Environment. The ARU shall perform as specified after exposure to the operating environments as applicable for prelaunch, launch, ascent, and on-orbit.

3.2.5.2 Ground Segment - NRL Engineering Node (NEN). Not applicable.

3.2.6 Systems Effectiveness Models. Not applicable.

3.2.7 Environmental Conditions. The ARU shall meet the requirements of this document after exposure to the environments as specified in the following paragraphs.

3.2.7.1 Storage. The ARU in an unpackaged state with protective dust wrapping about the unit(s) shall meet the following requirements after exposure to any combination of the following storage environments defined herein for the two-year storage period.

3.2.7.1.1 Ambient Air Temperature. The ambient air temperature shall be controlled to 24˚C ± 10˚C.

3.2.7.1.2 Ambient Pressure. The ambient pressure will vary between that naturally occurring at sea level and at 5,000 feet.

3.2.7.1.3 Humidity. As a goal, at no time will condensation be allowed to form on the ARU, its test equipment, or protective covers. The relative humidity shall be maintained above 30%.

3.2.7.1.4 Cleanliness. The storage facility will be controlled to meet a controlled environment typical of the NRL's Payload Processing facility.

3.2.7.2 Ground Handling and Transportation. The ARU in its approved container and/or packaging shall meet the requirements of this document after exposure to any combination of the following ground handling and transportation environments.

3.2.7.2.1 Ambient Air Temperature. The ambient temperature of the air external to the shipping container ranges from -10˚C to +50˚C.

3.2.7.2.2 Ambient Pressure. The ambient pressure will vary between 31.3 in. Hg (sea level) and 3.5 in. Hg (50,000 feet).

3.2.7.2.3 Humidity. The relative humidity will range from zero to 100% with condensation in the form of water or ice external to the shipping container. Humidity within the shipping container shall be controlled such that no condensation of moisture or frost occurs on the hardware.

3.2.7.2.4 Acceleration. The maximum steady state acceleration shall not exceed that specified in section 3.2.7.4.3.

3.2.7.2.5 Vibration. When packaged or otherwise prepared for shipment, the ARU shall withstand the vibration environments specified in MIL-STD-810, Method 514.2.

RQMT-100 **3.2.7.2.6 Shock.** The shock levels to the structure subsystem shall be controlled by design of the handling and shipping container.

RQMT-110 The packaged structure subsystem shall be designed to withstand the shock environment of MIL-STD-810, Method 516.2, Procedure II.

RQMT-100 **3.2.7.2.7 Cleanliness.** The package shall maintain the hardware at the cleanliness level specified in paragraph 3.2.7.1.4.

RQMT-110 The ARU shall meet the requirements of this specification during continuous exposure to any combination of the conditions specified herein while the equipment is operating.

3.2.7.3 Prelaunch. The prelaunch phase covers those environments that occur before launch. The ARU shall meet the requirements of this document during and after exposure to the prelaunch environments defined herein.

3.2.7.3.1 Ambient Air Temperature. The ambient air temperature shall be maintained at 23˚C ± 10˚C.

3.2.7.3.2 Ambient Pressure. The ambient pressure will vary between that naturally occurring at sea level and at 6,000 feet.

3.2.7.3.3 Humidity. The relative humidity shall be maintained above 30%. At no time shall condensation be allowed to form on the ARU.

3.2.7.3.4 Acceleration. The maximum steady state acceleration shall not exceed that specified in section 3.2.7.4.3.

3.2.7.3.5 Cleanliness. The assembly, test, and preparation area will be maintained at a normal high bay environment at the NRL's Payload Processing Facility or the NASA Launch Site.

3.2.7.4 Launch and Ascent. The launch and ascent phase covers those environments that occur between terminal countdown and opening of the Shuttle Transportation System (STS) payload bay doors, including environments associated with a one-orbit abort or emergency landing. The space segment need not meet the requirements of this document after exposure to emergency descent environment without refurbishment.

RQMT-100 **3.2.7.4.1 Temperature and Humidity.** The ARU shall operate properly when the temperature of the surroundings and the surface on which it is mounted is maintained at any temperature between -10°C to +50°C for on-orbit operations.

RQMT-110 The ARU shall operate properly during ground testing while exposed to relative humidity ranging from 20 to 90 percent at atmospheric pressure.

RQMT-100 **3.2.7.4.2 Pressure.** The pressure decay curve in the STS payload bay is defined in Figure 3-2. The ARU shall operate properly when the range of ambient pressure is between 13 and 16 psi (atmospheric) and less than 1×10^{-5} torr.

RQMT-110 The ARU shall not be required to operate at partial pressures between these extremes.

3.2.7.4.3 Acceleration. The maximum steady state acceleration shall be as specified on the mass-acceleration curve shown in Figure 3-3.

3.2.7.4.4 Emergency Landing (Launch Abort) Loads. The maximum steady-state load shall be 7 g's (limit) in any direction acting separately.

3.2.7.4.5 Acoustics and Random Vibration.

3.2.7.4.5.1 Acoustic Vibration. Not applicable.

3.2.7.4.5.2 Random Vibration. The ARU shall withstand the vibration environment of Figure 3-4 and Figure 3-5 in three orthogonal axes.

3.2.7.5 Orbital Operations. The orbital operations phase covers those environments that occur between opening of the STS payload bay doors for vehicle deployment, moving from the STS parking orbit to the vehicle docked position, and subsequent operations. The ARU shall meet the requirements of this document during exposure to any combination of the following environments defined herein.

3.2.7.5.1 Natural Thermal Radiation. Not applicable.

3.2.7.5.2 Pressure. The pressure environment during orbital operation shall be a hard vacuum of less that 1×10^{-5} torr.

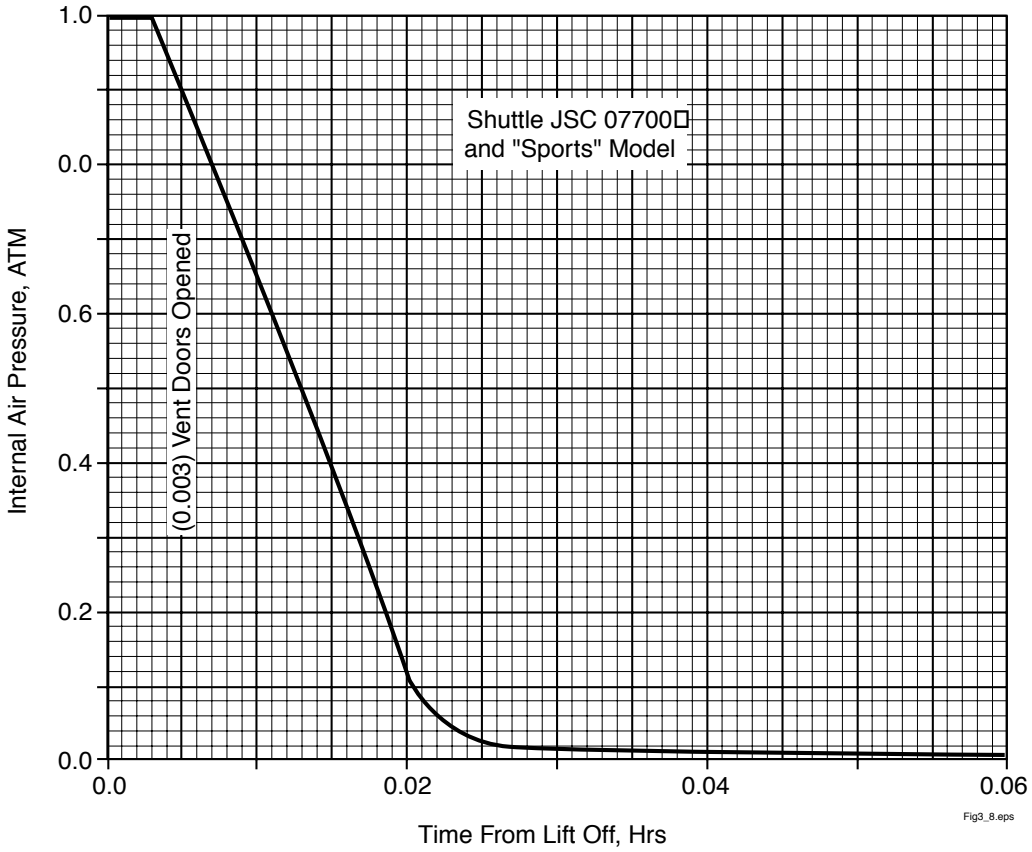
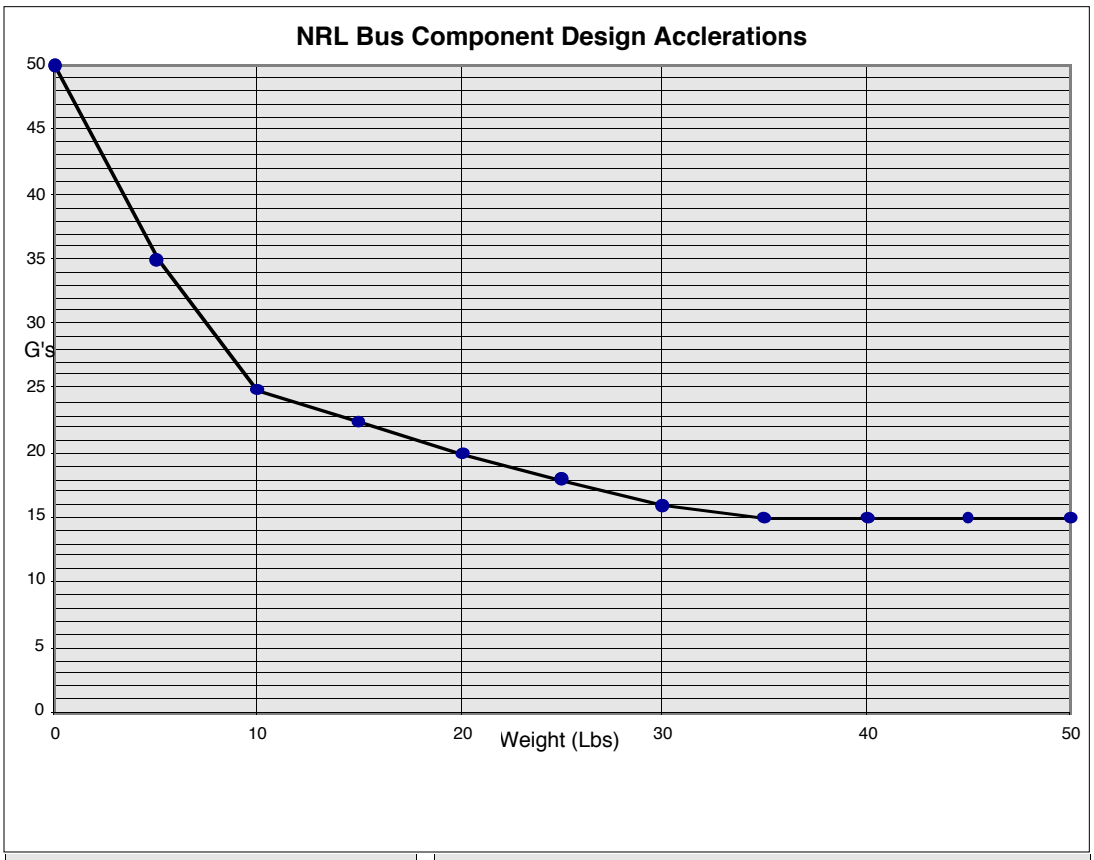


Figure 3-2. STS Ascent Payload Bay Pressure/Time History



Design Accelerations

Component Wt. (Lbs)	G's
0	50
5	35
10	25
15	22.5
20	20
25	18
30	16
35	15
40	15
45	15
50	15

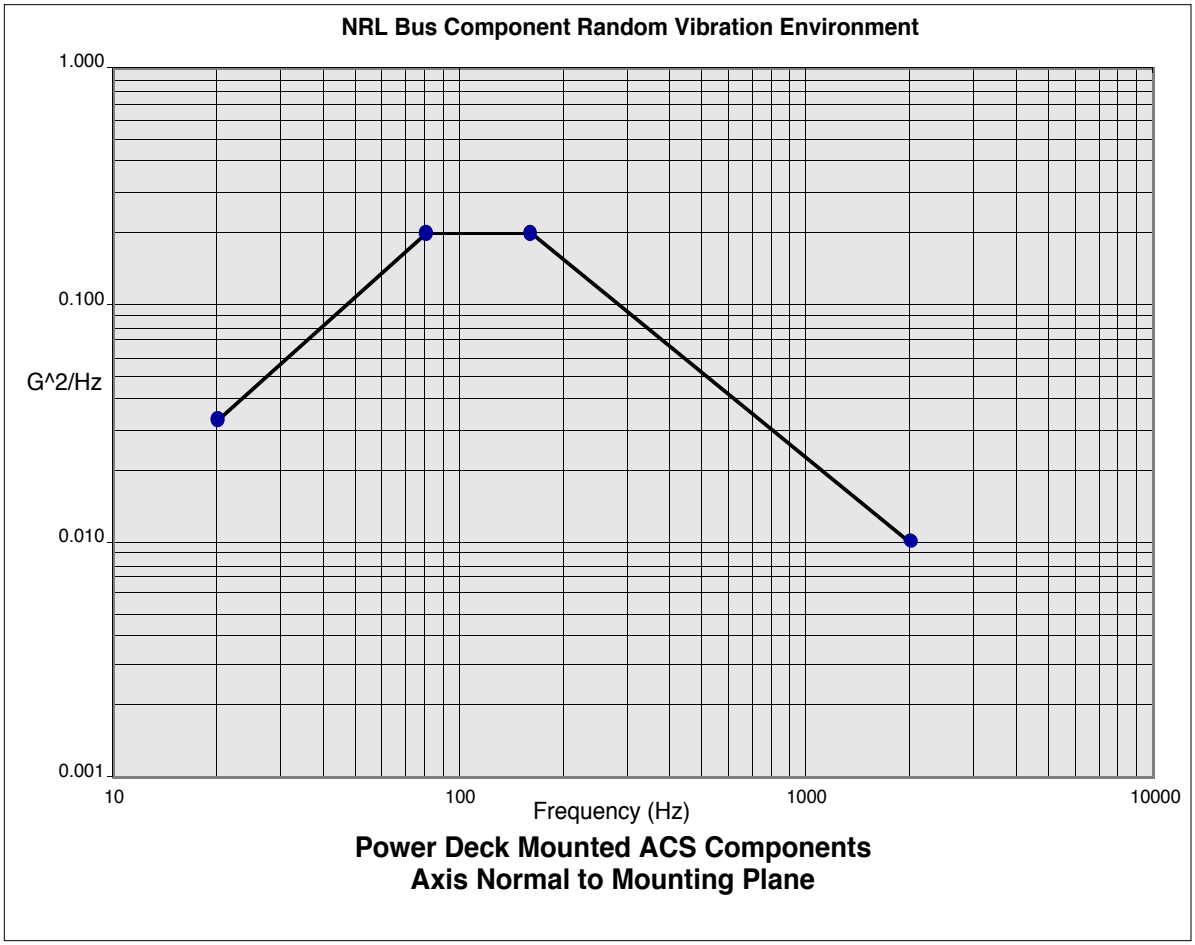
Design Acceleration Philosophy

* These accelerations are to be used for evaluating component Mounting Configurations and Hardware

* Some specialized components such as thrusters may require specialized levels.

TEMP1.pict

Figure 3-3. Acceleration



Flight Environment

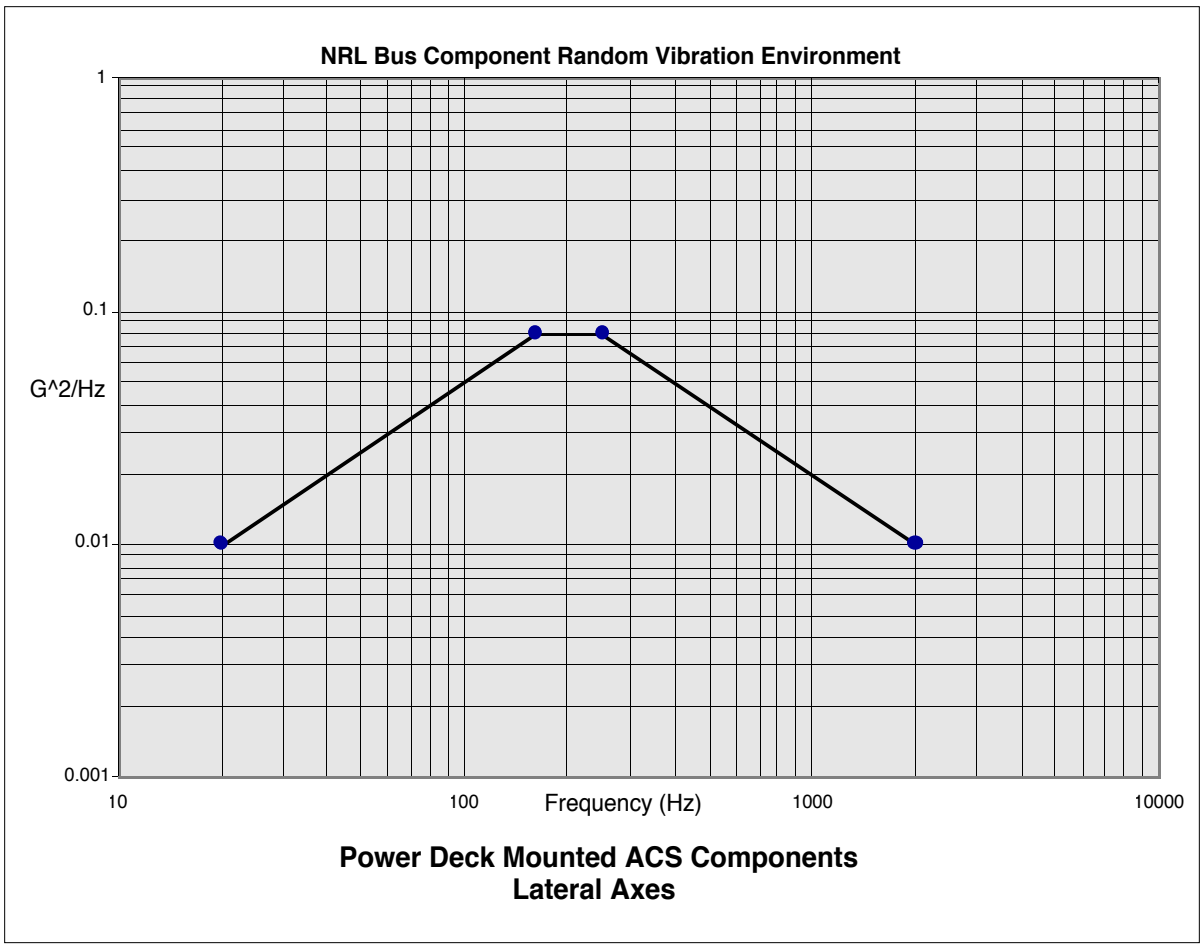
9.3 Grms

Frequency (Hz)	G^2/Hz
20	0.033
80	0.200
160	0.200
2000	0.010

Test Levels

	Margin Above Flight Level (dB)	Duration (Minutes)
Non-Flight Prototypes (Design & Qualification Level)	6	2
Flight Units (Flight Acceptance Level)	0	1
Prototype Flight Unit (Protoflight Acceptance Level)	3	2

Figure 3-4. Random Vibration-Axis Normal to Mounting Plane



Flight Environment

7.4 Grms

Frequency (Hz)	G^2/Hz
20	0.01
160	0.08
250	0.08
2000	0.01

Test Levels

	Margin Above Flight Level (dB)	Duration (Minutes)
Non-Flight Prototypes (Design & Qualification Level)	6	2
Flight Units (Flight Acceptance Level)	0	1
Prototype Flight Unit (Protoflight Acceptance Level)	3	2

Figure 3-5. Random Vibration-Lateral Axes

RQMT-100 **3.2.7.5.3 Particle Radiation.** The ARU will be subjected to galactic cosmic radiation, geomagnetically trapped radiation, and solar flare particles. The spherical geomagnetically trapped dosage for parts as a function of aluminum shielding thickness, for a one-year period including a solar maximum, is shown in Figure 3-6.

RQMT-110 A factor of two shall be added as a minimum margin for part application.

RQMT-120 Any part used shall meet the requirements of this document with a minimum total radiation dose of 1 x 10^4 Rads (Si) consistent with SSP 30512, SSP 30420, and SSP 30425.

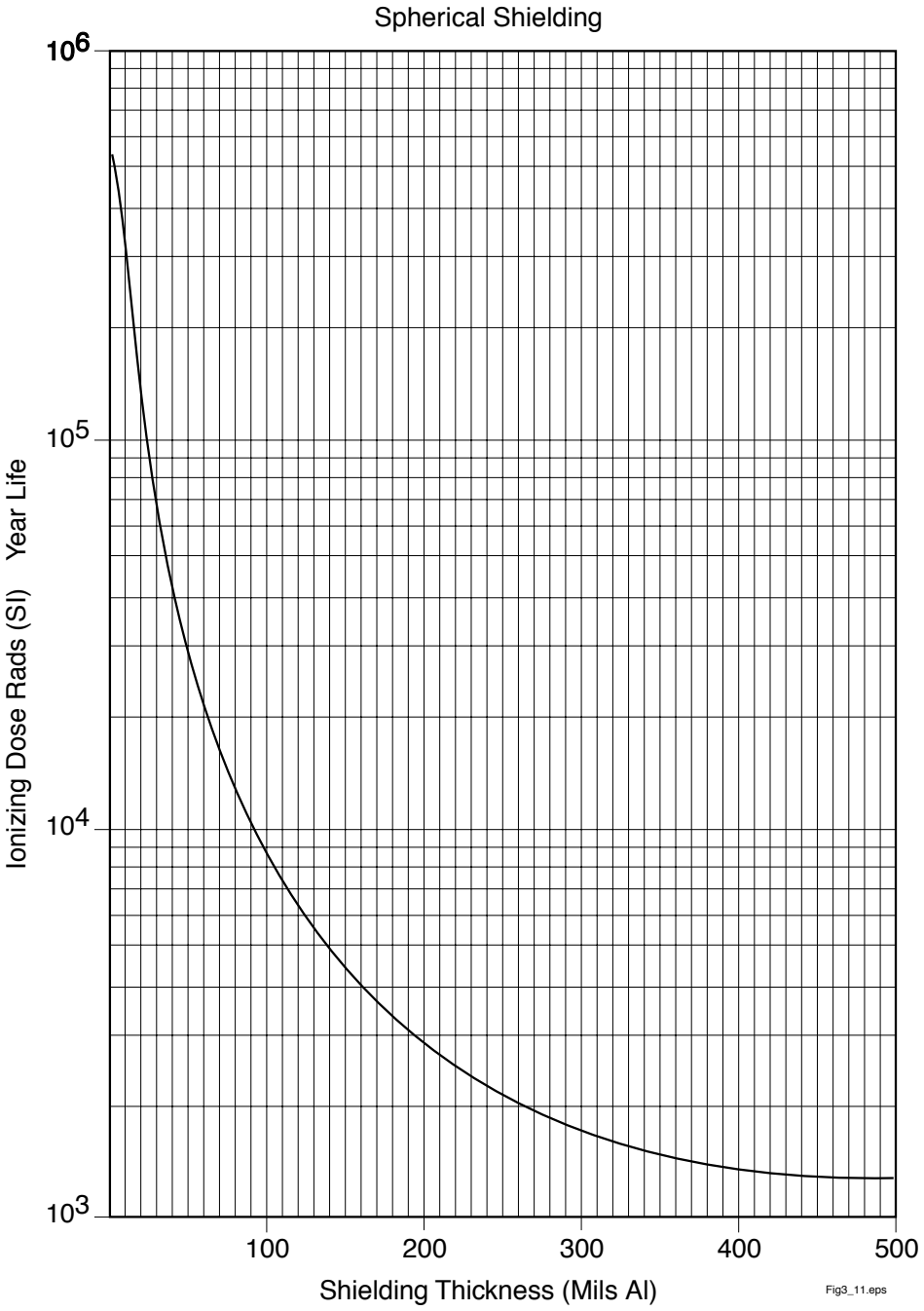
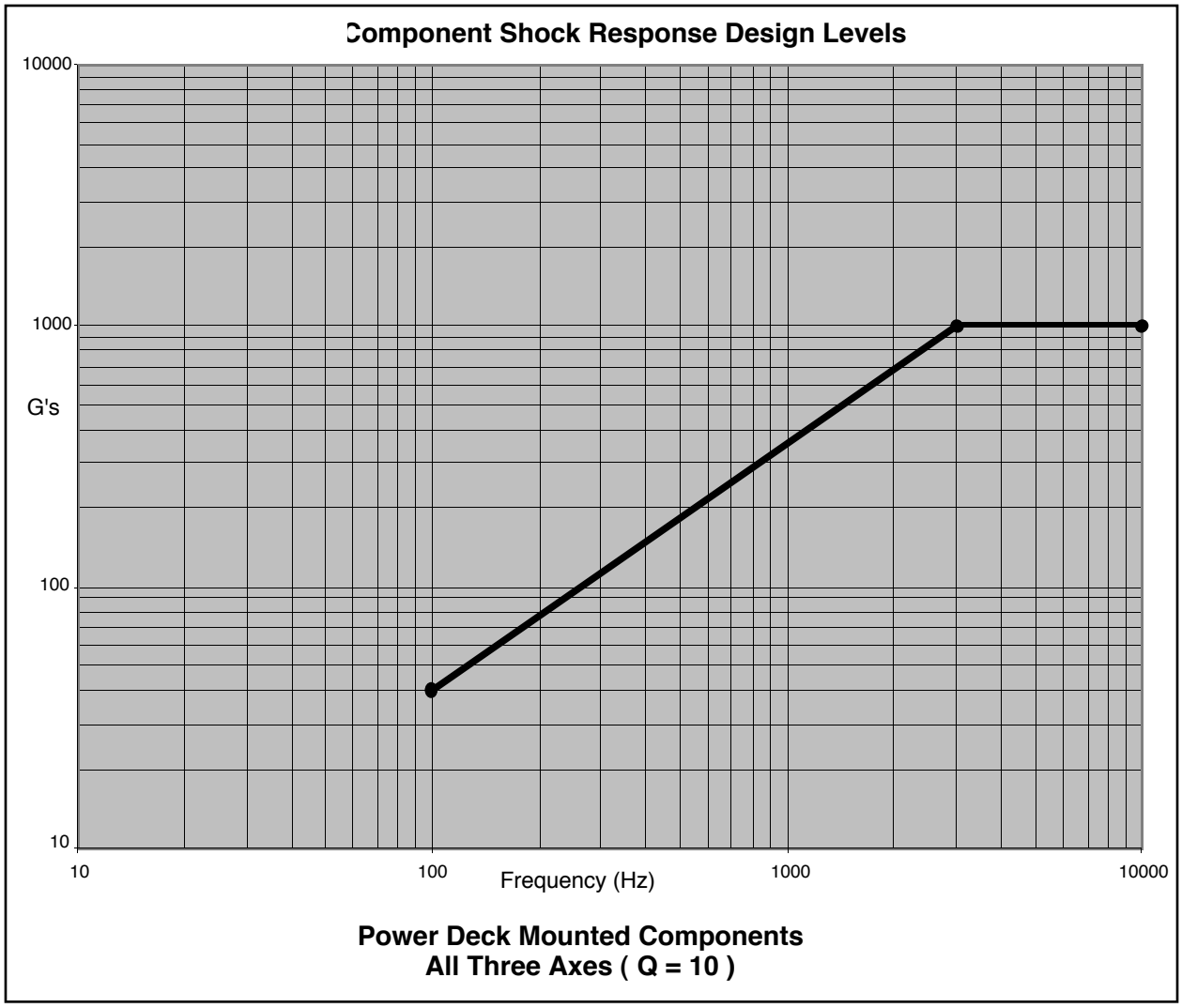


Figure 3-6. Radiation Dose as a Function of Shielding Thickness

3.2.7.5.4 Acceleration. The accelerations experienced by the ARU during operating periods of orbital transfer shall not exceed launch loads in any direction.

3.2.7.5.5 Pyrotechnic Shock. The ARU shall withstand ordnance-induced (pyrotechnic) shock in each of three orthogonal axes as shown in Figure 3-7. The orientation of the axes is optional. The response levels shown in Figure 3-7 apply to the equipment mounting surface.



Design Environment
Shock Response Spectrum Levels

Frequency (Hz)	G's
100	40
3000	1000
10000	1000

Figure 3-7. Pyrotechnic Shock

3.2.7.5.6 Meteoroids. Not applicable.

3.2.7.6 Reserved.

3.2.8 Nuclear Control Requirements. Not applicable.

RQMT-100 **3.2.9 Transportability.** The ARU shall be capable of meeting the requirements of this specification after shipment by air or surface carrier.

RQMT-110 Protective packing and packaging shall be provided to withstand environmental conditions associated with shipping, storage, and handling that are expected to exceed the conditions specified in section 3.2.7.

RQMT-120 Special packaging shall be used as necessary to assure that transportation methods do not impose design penalties.

3.3 Design and Construction. The following subparagraphs describe the general requirements for design and construction that are applicable to the ARU.

RQMT-100 **3.3.1 Materials, Processes, and Parts.** Parts, materials, and processes (PMP) implementation shall meet the general guidelines specified within MIL-STD-1546 and MIL-STD-1547 (or equivalent).

RQMT-110 PMP shall be selected and controlled according to the requirements of SSD-D-IM008, *Spacecraft Product Assurance Program Plan*.

RQMT-100 **3.3.1.1 Electronic Piece Parts.** Design and fabrication of electronic components shall meet the general guidelines specified within DOD-E-8983 and MIL-S-46844 (or equivalent).

RQMT-110 The selection and control procedures shall emphasize quality and reliability to meet the mission requirements, including all environmental degradation effects, and to minimize total life cycle cost for the system.

RQMT-120 The materials employed in the design shall be selected to assure maximized reliability and performance in the specified environment within the volume and weight constraints.

RQMT-130 The selection of parts, materials, and processes shall maximize commonality and thereby minimize the variety of parts, related tools, and test equipment required in fabrication, installation, and maintenance.

RQMT-140 No identical parts (e.g., electrical connectors, fittings) shall be used where inadvertent interchange of items or interconnections could cause a malfunction.

RQMT-100 **3.3.1.1.1 Parts Selection and Use.** The ARU shall use NASA's SSP 30312 as a guide.

RQMT-110 Otherwise, electronic parts shall be designed and selected for high reliability and long life in storage, test, and in operational use in the launch environment and during on-orbit operations in the space environment.

RQMT-120 All parts shall be hermetically sealed.

RQMT-130 Parts and materials which have been installed in an assembly and which are then removed from an assembly for any reason shall not be used in any item of spaceflight hardware.

RQMT-140 Justification for the use of nonstandard or non-approved parts shall be provided to the COR by a Non-Standard Parts Approval Request (NSPAR).

RQMT-100 **3.3.1.1.2 EEE Parts Program.** The intent of the EEE Parts Program is to provide the highest reliability level available within the program and schedule limitations. The radiation hardness characteristics of all parts will be established, implemented and maintained. Standard parts will be selected according to the following order of preference:

a. MIL-STD-975 Grade 1 and 2 or NASA SSP 30423

b. JANS and JANB microcircuits per MIL-M-38510 not listed in MIL-STD-975

c. JANTXV, JANTX and JANS semiconductor devices

d. Passive devices procured under established reliability for level of "S" and "R"

e. Industrial grade parts, specified for -40˚ C to +85˚C operation, and

f. All other parts selection shall be considered nonstandard and shall be submitted to the COR via the use of NSPARs.

RQMT-110 The Contractor shall procure EEE parts and perform the necessary specified screening requirements as delineated in SSD-D-IM008, *Spacecraft Product Assurance Program Plan*.

RQMT-120 This document shall also be used for establishment of the Contractor's parts program.

3.3.1.1.3 Capacitors and Resistors. MIL-STD-198 and MIL-STD-199 (or equivalent) shall be used as guidance for the selection of capacitors and resistors.

3.3.1.1.4 Other Devices. Relays, crystals, and Radio Frequency (RF) filters shall be procured to a Specification Control Drawing (SCD) that shall delineate the applicable qualification, screening, Destructive Physical Analysis (DPA) (refer to SSD-D-IM012), and receiving inspection requirements.

RQMT-100 **3.3.1.1.5 Electrical Connectors.** External connectors shall conform to the requirements of DOD-W-83575 (or equivalent) and as specified herein.

RQMT-110 Receptacle connectors for external connectors carrying wires to be shielded in external cabling shall be capable of being fitted with Electromagnetic Interference (EMI) backshells on the mating plug connector unless filtering is provided within the ARU assembly.

RQMT-120 Receptacle connectors for external connections, carrying wires to be unshielded in external cabling, shall be fitted with COR-approved EMI filter pins for all conductors carried by the connector. Connectors should conform to the requirements of MIL-C-24308, MIL-C-38999, MIL-C-39012, or MIL-C-55302 (or equivalent).

RQMT-130 The signal and signal return wires for each function shall be located in the same connector and shall be assigned adjacent pins to allow wire twisting and shielding. Keying, polarization, or other mechanical means, or combinations thereof, should be incorporated in connectors to prevent mismating, or incorrect mating, with cable connectors.

RQMT-140 One set of connector mates shall be supplied with each ARU.

RQMT-100 **3.3.1.1.5.1 Connector Savers.** Connector savers and ESD dust covers for all external connectors shall be provided on each connector from the time that it is installed in the ARU assembly until the item is packaged for delivery to the NRL.

RQMT-110 The connector saver shall be secured to the item and shall not be removed until shipment, except when absolutely necessary for the assembly or disassembly of the unit.

RQMT-120 In the latter case, the removal shall be entered in the item logbook.

RQMT-130 One set of connector savers shall be supplied with each ARU.

RQMT-100 **3.3.1.1.5.2 Coaxial Connectors.** All coaxial connectors, if used, shall be of the SMA type and the pin connectors shall be compatible with the Cannon D*MA type using #20 contacts (male on the power connector).

RQMT-110 One set of connector mates shall be supplied with each ARU.

RQMT-100 **3.3.1.1.5.3 MIL-STD-1553 Bus Connectors.** Connectors for the 1553 bus, if used, shall be twinax, screw attachment keyed coax connectors: TROMPETER BJ 3159 AC-201 for the primary bus and TROMPTER BJ 3159 ACFL-201 for the redundant bus or equivalent.

RQMT-110 One set of connector mates shall be supplied with the ARU.

3.3.1.1.6 Wires and Cable. Wiring and cable shall conform to the requirements of MIL-W-22759 or MIL-C-17 (or equivalent).

3.3.1.2 Materials. Materials shall be able to withstand the environments of the following subparagraphs.

RQMT-100 **3.3.1.2.1 Materials Selection.** Materials shall be selected to minimize flammability and toxicity hazards.

RQMT-110 Use of combustible materials shall be kept to a minimum, with particular emphasis on those which generate toxic products of combustion.

RQMT-120 Materials shall be selected which have demonstrated their suitability for the intended application and shall be consistent with MIL-STD-1568 (or equivalent).

RQMT-130 MSFC Spec 522, Table I, will be used for material selection where possible or practical. Where practical, fungus inert materials shall be used.

RQMT-100 **3.3.1.2.2 Metallic Materials.** Metallic materials shall be corrosion resistant by nature or shall be corrosion inhibited by means of protective coating.

RQMT-110 Protection of dissimilar metal combinations shall be in accordance with MIL-STD-889 (or equivalent).

RQMT-120 Structural properties of materials for use in the Space Segment shall be taken from MIL-HDBK-5 for metals, MIL-HDBK-17 for plastics, and MIL-HDBK-23 for sandwich composites (or their equivalents).

RQMT-130 Use of dissimilar metals shall be avoided.

RQMT-140 Base metals intended for inter-metallic contact that form galvanic couples shall be plated with those metals that reduce the potential difference or shall be suitably insulated by a nonconducting finish.

RQMT-150 Electrical bonding methods shall include provisions for corrosion protection of mating surfaces. With the exception of solder, the use of tin is prohibited. Note that semiconductors containing tin which have been subjected to stabilization bake at 190°C to 215°C for four or more hours under a protective inert gas atmosphere are acceptable for use.

3.3.1.2.3 Magnetic Materials. Magnetic cleanliness is important. The use of magnetic materials should be avoided whenever possible. Magnetic materials shall be used only if necessary for equipment operation. The materials used should minimize permanently induced and transient magnetic fields.

RQMT-100 **3.3.1.2.4 Finishes.** Protective methods and materials for cleaning, surface treatment, and applications of finishes and protective coatings shall conform to MIL-F-7179 and MIL-STD-1568 (or equivalent).

RQMT-110 Neither cadmium nor zinc coatings shall be used.

3.3.1.2.5 Outgassing. Materials shall be selected for low out-gassing characteristics. Materials exhibiting TML of 1.0% or less and Collected Volatile Condensable Material (CVCM) values of 0.1% or less as per SP-R-0022 should be used. Any materials that fail to meet these criteria will be identified to the COR.

3.3.1.3 Processes. Selected processes shall meet the requirements of the following subparagraphs.

RQMT-100 **3.3.1.3.1 Traceability.** A system for categorizing electronic parts into sets of homogeneous groups and tracing those parts through the fabrication, assembly, test, and delivery cycles shall be maintained.

RQMT-110 a. The item's parts and material shall be traceable from the initial source of material through the completed hardware.

b. Parts will be traced by part number, serial number (when available), and lot number.

RQMT-120 (1) Fabrication records (i.e., travellers), capable of providing two-way traceability from the first stages of assembly through final acceptance testing, shall be maintained.

RQMT-130 Specific entries shall be made, recording this information as parts are installed.

RQMT-140 The Contractor shall provide traceability records as shown in Table 3-3.

Table 3-3. Traceability and Lot Control

Part	Relevant Information
Electronic Piece Parts	Mfg/Date/Lot Code
Printed Circuit Boards	Serial Number
Potting/Adhesives/Coatings	Batch Number
Plating of Electronic Housings	Production/Manufacturer Lot Number
Modules and Assemblies	Serial Number
Connectors	Manufacturer Lot Number and Date Code
Chassis Case/Structures	Lot/Heat Treat Number

c. All electronics piece parts installed will be identified and documented in order to be traceable to a specific manufacturer, lot number, or data lot code. A record will be prepared for each flight unit that provides the following information for each EEE part that is installed:

(1) Part Number and Location

(2) Manufacturer

(3) Lot Number or Data Code

(4) Serial Number (when necessary).

d. The records will include the traceability of critical materials (including sampling test records), processes, pre-acceptance testing records, and sources of supply to the greatest extent practical. The records will be identifiable to the item's serial number.

3.3.1.3.2 Failure Reporting and Corrective Action System. A closed-loop Failure Reporting, Analysis, and Corrective Action (FRACA) system for reporting, analysis, and corrective action shall be in effect for failures occurring during the acceptance testing phases. The FRACA system will determine whether failures are caused by design deficiencies, human error, defective parts, infant mortality, test equipment, environmental exposure, or software. NRL's FRACAS practices are defined in SSD-D-IM006, *Failure Reporting Analysis and Corrective Action Procedure* (or equivalent).

3.3.1.3.3 Part Stress Derating. The application of all EEE parts in the design shall be derated such that the applied stresses do not exceed the derating criteria contained in SSD-D-IM007, *Worst Case Analysis Guidelines and Criteria* (or equivalent).

RQMT-100 **3.3.1.3.4 Soldering and Other Processes.** Soldering and other processes shall be consistent with the requirements of NASA NHB 5300.4A.

RQMT-110 a. Soldering and other processes shall be specified in Contractor-approved process specifications that employ the guidelines of NASA NHB 5300.4A; ANSI/J-STD-001; MIL-S-46844, *Solder Bath Soldering of Printed Wiring Assemblies*; or MIL-S-45743, *Soldering, Manual Type, High Reliability, Electrical and Electronic Equipment*, or their equivalents.

RQMT-120 b. Other special processes (e.g., adhesive bonding, plating, etc.) shall be fabricated according to the Contractor's approved process specifications.

RQMT-130 c. Printed Circuit Boards (PCBs) used in the fabrication of the equipment shall conform to the requirements of the following documents or their equivalents:

- MIL-P-55110, *Printed Wiring Boards, General Specifications*
- IPC-D-275, *Standard for PCB Design and Assembly*
- MIL-STD-275, *Printed Wiring for Electronic Equipment*
- IPC-FC-250, *Performance Specification for Single and Double-Sided Flexible Printed Boards*
- MIL-P-50884, *Printed Wiring, Flexible and Rigid-Flex*
- IPC-A-600D, *Acceptability of Printed Wiring Boards*
- MIL-STD-2118, *Flexible and Rigid-Flex Printed-Wiring for Electronic Equipment, Design Requirements for*
- IPC-FC-250A-86*, Specification for Single and Double-Sided Flexible Wiring*

3.3.1.3.5 Mechanical Piece Parts. Not applicable.

3.3.1.3.6 Surface Finishes. The exposed surfaces of the ARU shall have an emissivity greater than or equal to 0.85.

RQMT-100 **3.3.1.3.7 High Reliability Parts Processing.** Each lot of parts used in the ARU shall be subjected to high reliability parts processing in order to gain confidence that parts to be used are free from incipient failures and to precipitate failure in any marginal devices.

RQMT-110 The processing shall be as defined in SSD-D-IM008, *Spacecraft Product Assurance Program Plan*.

RQMT-100 **3.3.1.3.8 Control of Electro-Static Sensitive Parts.** Integrated circuits, discrete semiconductors, and thin film resistors of 10,000 ohm or greater resistance shall be protected from electrostatic discharge (ESD).

RQMT-110 These items shall be handled according to ESD control disciplines such that throughout the receiving, fabrication, assembly, and handling process they are not exposed to an ESD exceeding 100 volts.

RQMT-120 Part packages, shipping containers, and storage and handling container shall be plainly marked with the CAUTION note of "ELECTROSTATIC SENSITIVE" or equivalent.

RQMT-100 **3.3.2 Electromagnetic (EMC) Environment.** The ARU and its Ground Support Equipment (GSE) shall be designed and constructed such that each item is compatible with itself and with its known operational environments.

RQMT-110 The electromagnetic compatibility requirements shall be in accordance with MIL-STD-1541 and SSD-D-IM003 (or equivalent) .

RQMT-120 All support facilities, including test facilities and launch base facilities, shall comply with the grounding requirements of MIL-STD-1542 and SSD-D-IM003 (or equivalent).

3.3.2.1 Conducted Emission. The ARU shall meet the conducted emissions levels defined within Figure 3-8.

3.3.2.2 Conducted Susceptibility. The ARU shall not exhibit malfunctions, degradation of performance, or deviation from specifications when subjected to the levels defined in Figure 3-9.

3.3.2.3 Radiated Susceptibility. The ARU shall be designed to operate without malfunction, undesirable response, or deviation from specified performance tolerances when subjected to the radiated emissions specified herein.

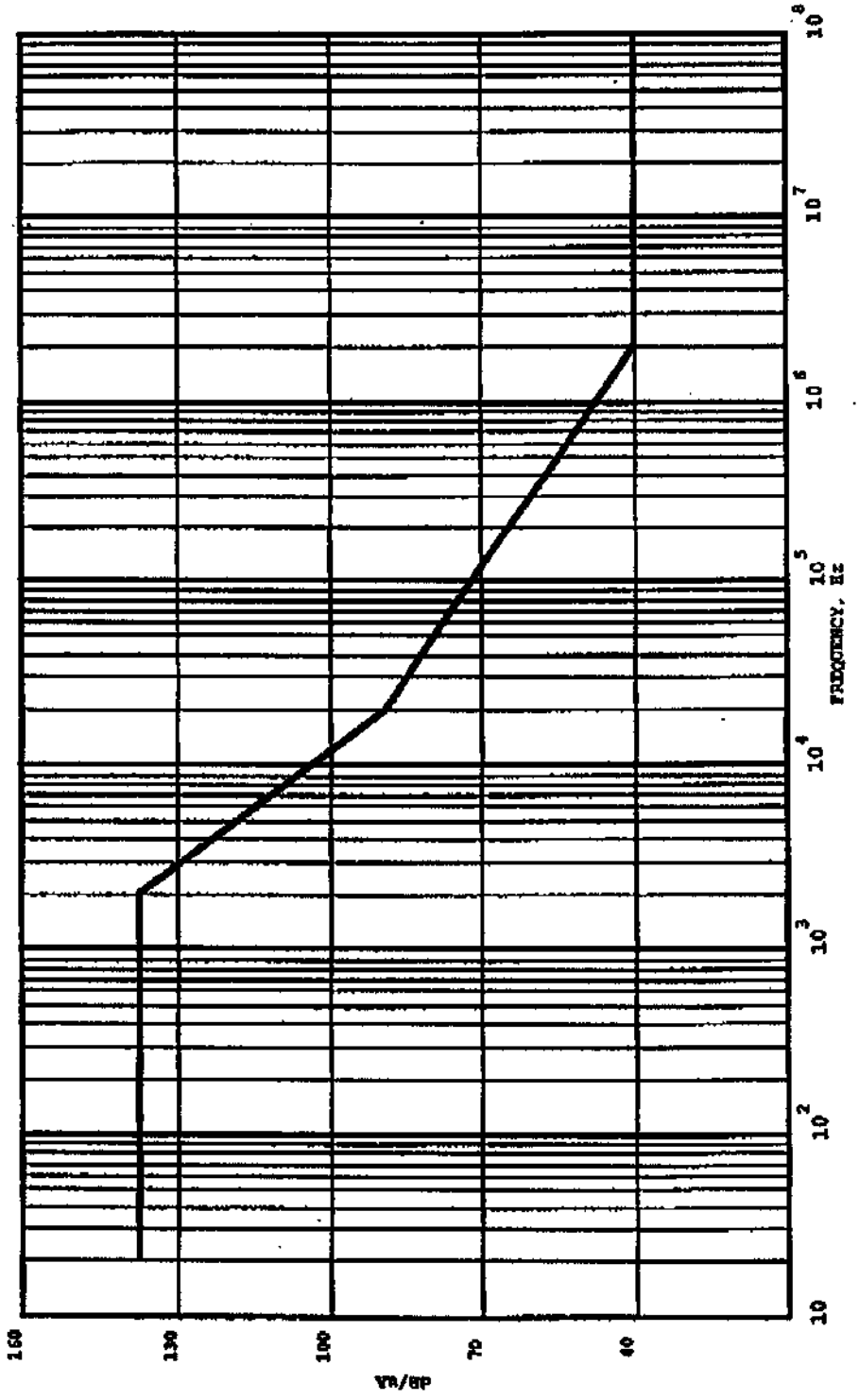


Figure 3-8. Allowable Conducted Emissions, Narrowband, on 28 V dc Bus

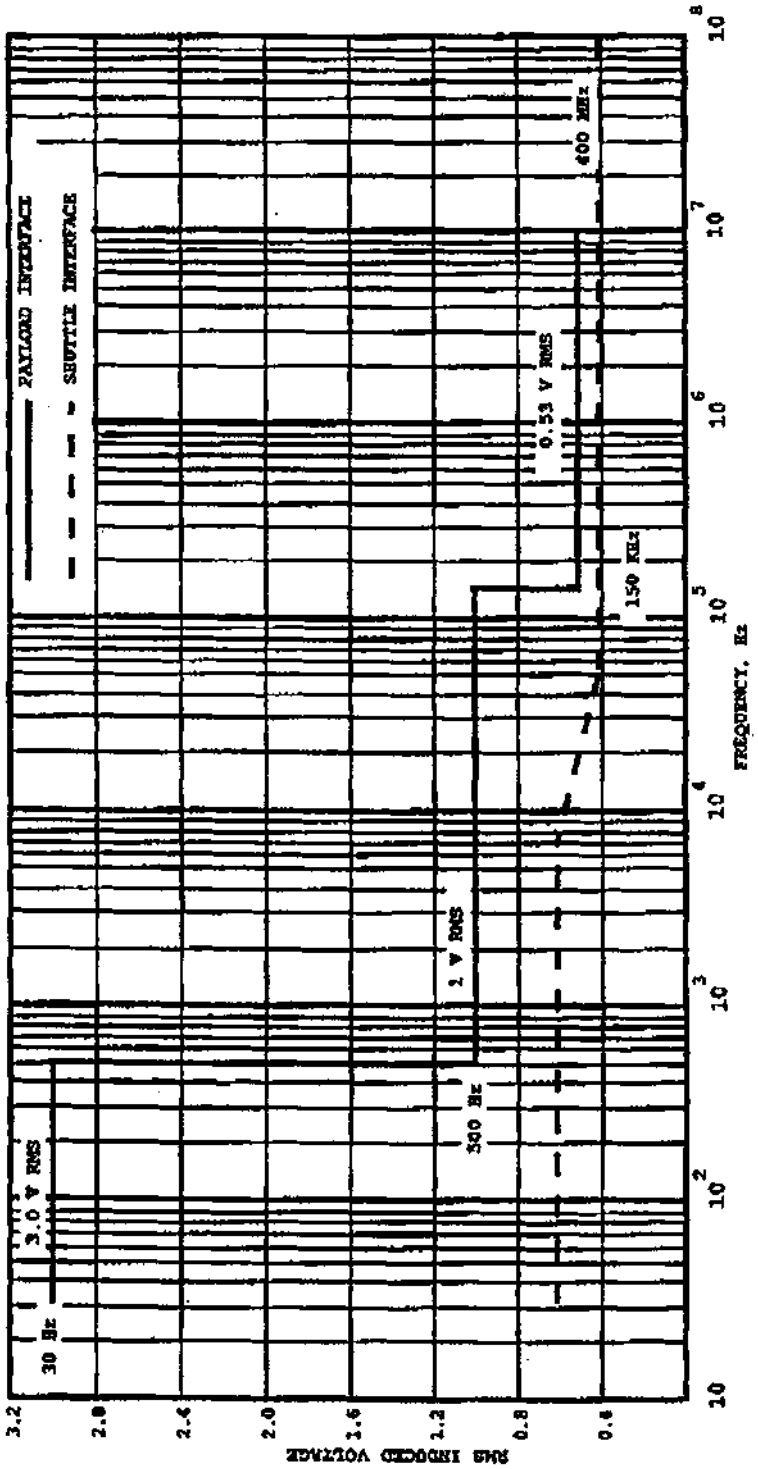


Figure 3-9. Limits for Conducted Susceptibility on 28 V dc Bus

RQMT-100 **3.3.2.3.1 Narrowband Susceptibility.** The ARU shall withstand the modulated continuous wave (MCW) apparent field strength of Table 3-4.

RQMT-110 Modulation of a carrier frequency up to 400 MHz shall be 30% and at a frequency which is critical to the subsystem.

RQMT-120 If a critical frequency is not apparent, 400 or 1000 Hz shall be used.

RQMT-130 Modulation of carrier frequencies higher than 400 MHz shall simulate the modulation used in the equipment, but at a reduced level sufficient to produce an indication.

Table 3-4. Radiated Susceptibility Limits

Frequency/Range	Radiated Electric Field Level
14 kHz to 200 MHz	5 V/m
200 MHz to 8 GHz	60 V/m
8 GHz to 10 GHz	20 V/m
2.2 GHz	161 V/m
8.5 GHz	79 V/m
13.7 GHz to 15.2 GHz	250 V/m

3.3.2.3.2 Broadband Susceptibility. Not applicable.

3.3.2.4 Radiated Emissions. The subsystem shall be designed to limit radiated emissions to the levels specified herein.

3.3.2.4.1 Narrowband Emissions. The apparent field strength of narrowband emissions at one meter from the subsystem shall be limited to the values shown in Table 3-5 and Figure 3-10.

Table 3-5. Narrowband Electrical Field Emissions

Frequency	Emissions
14 kHz to 10 MHz	56 dBμV/m
10 MHz to 259 MHz	Increasing log-linearly with increasing frequency from 56 to 86 dBμV/m (16 dB per decade)
259 MHz to 10 GHz	Increasing log-linearly with increasing frequency from 46 to 72 dBμV/m (16 dB per decade)
13.5 to 15.5 GHz	76 dBμV/m

3.3.2.4.2 Broadband Emissions. Not applicable.

3.3.2.5 Design Requirements. As a minimum the following design requirements shall apply relative to the electromagnetic radiation requirements specified herein.

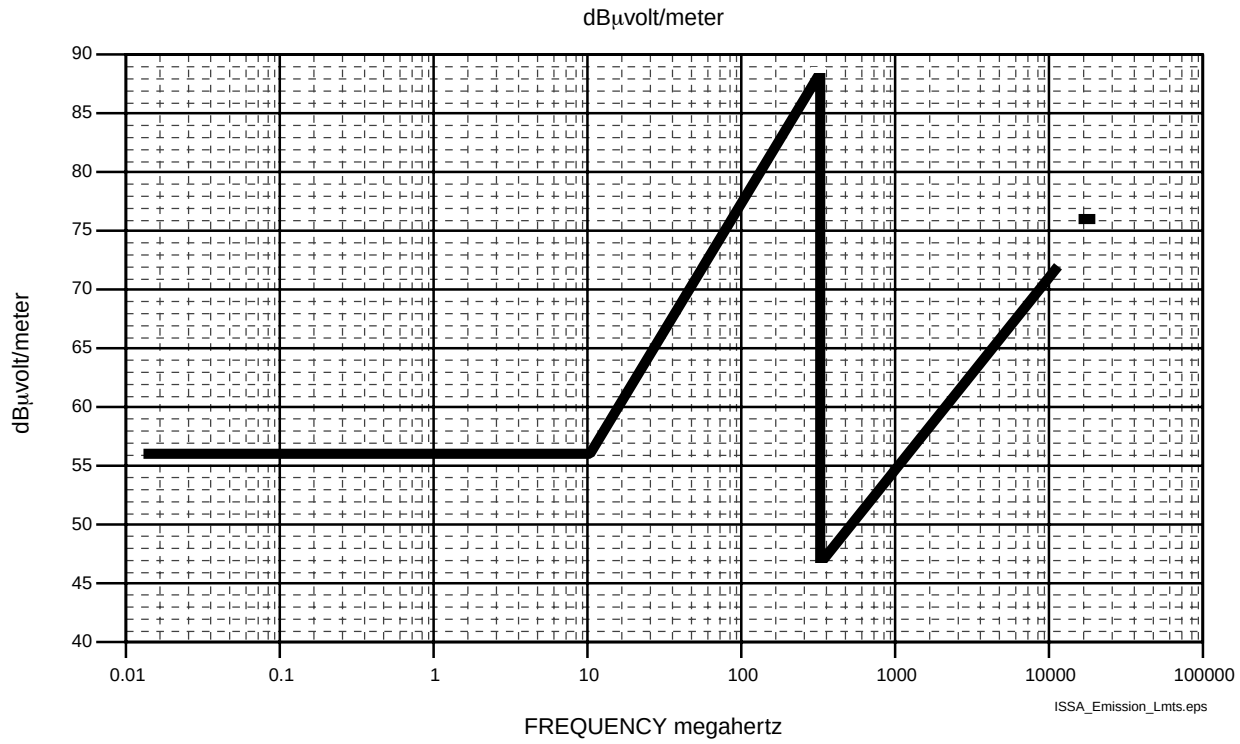


Figure 3-10. Narrowband Radiated Emission Limits

RQMT-100 **3.3.2.5.1 Electrical Bonding.** Electrical bonding shall be in accordance with MIL-B-5087, Class R (or equivalent).

RQMT-110 The electrical bonding of the equipment and structure shall:

a. Prevent the accumulation of static charge on any structure, equipment case, metal part, conductor or semi-conducting material and prevent damage of equipment due to lightning discharge or electrostatic discharge.

b. Provide a low impedance path to the electrical reference point for the conduction of fault current, instrumentation currents, and electro-magnetic currents.

c. Prevent electromagnetic wave or current nonlinear rectification.

d. Reduce to a minimum any shock hazard to personnel.

e. Provide a unipotential mass that can be used as a reference point for electrical measurements.

RQMT-120 The subsystem shall be designed such that the direct current (DC) resistance between any two points on the enclosure does not exceed 0.025 ohm total or 0.0025 ohm per joint.

RQMT-100 **3.3.2.5.2 Finishes for Bonding.** The surface finish for electrical bonding shall be bare metal or a qualified conductive finish such as Iridite l4 or Alodine l000.

RQMT-110 Nonconducting coatings such as anodized aluminum shall not be used.

RQMT-120 If abrasives or scrapers are used to remove any protective finish, they shall be the kind that produce a clean, smooth surface without removing excessive materials under the finish.

RQMT-130 Abrasives that would cause corrosion if embedded in the metal shall not be used.

RQMT-100 **3.3.2.5.3 Equipment Enclosure.** The equipment enclosure shall be electrically conductive and shall be designed to minimize electromagnetic propagation and pickup from external sources.

RQMT-110 The enclosure shall be designed to provide a shielding effectiveness of 65 dB to the predominant interference sources within. (Shielding effectiveness need not include leakage at connectors.)

RQMT-120 Provisions for installation shall be such that there shall be a continuous, low impedance path from the equipment enclosure to the basic structure of the platform to permit bonding of the equipment.

RQMT-130 The direct current resistance from enclosure to structure shall not exceed 2.5 milliohms.

RQMT-140 Mechanical discontinuities in the enclosure, such as covers, inspection plates, and joints, shall be kept to a minimum.

RQMT-150 Covers shall be secured by methods that prevent conductive metal particles generated from screw threads or EMI gaskets becoming mobile within the enclosure.

RQMT-160 A low impedance current path shall be provided across the interface of each discontinuity so as not to degrade the electromagnetic shielding effectiveness of the enclosure.

3.3.2.5.4 Signal Categories. Signals carried on internal interconnecting wiring shall be categorized as follows:

- Category 1 - Power, bi-level status signals, non-time critical control signals, relay control signals, and low-speed analog signals with noncritical circuit loop impedance requirements.
- Category 2 - Digital signals, including data, strobes and clocks, with speeds less than 15 Mbps; other signals, including clocks and timing pulses, with frequencies of less than 15 MHz; and low-speed analog signals with critical loop impedance requirements.
- Category 3 - Digital signals, including data, strobes and clocks, with speeds of 15 Mbps or greater; video signals; and other signals, including clocks and timing pulses, with frequencies of 15 MHz or higher.

RQMT-100 **3.3.2.5.4.1 Signal Shielding.** Internal interconnecting wiring carrying Category 3 signals, as specified herein, shall be coax, shall be routed in the most direct manner possible, and shall be terminated with connectors designed for the application as specified herein.

RQMT-110 Category 2 signals shall be carried on shielded wires or twisted, shielded pairs. Category 1 signals need not be shielded.

RQMT-100 **3.3.2.5.4.2 Signal Segregation.** Internal interconnecting wiring shall be segregated by signal category as specified herein.

RQMT-110 Wiring carrying Category 1 signals shall be segregated from wiring carrying Category 2 and 3 signals with a parallel spacing of at least five centimeters between segregated groups. Category 2 and 3 signals need not be segregated from each other.

RQMT-120 Segregated wire groups shall cross at right angles when crossing is necessary.

RQMT-100 **3.3.2.5.4.3 External Connectors.** External connectors for Category 3 signals shall be a coax type, either single or multiple, as specified herein.

RQMT-110 External connectors for Category 2 signals and their returns shall be dedicated to that category only and shall be of the EMI type with backshell as specified herein. Backshells need not be fitted internally in the unit.

RQMT-120 External connectors for Category 1 signals shall be fitted with EMI filter pins and shall contain only Category 1 signals and their returns.

RQMT-130 Returns for Category 1 and 2 signals shall terminate on pins adjacent to the signal to facilitate twisting of external wiring.

RQMT-140 Shields for internal wiring shall not be terminated on connector pins.

RQMT-100 **3.3.2.5.4.4 Connector Mounting.** Connectors shall be mounted in a manner to provide a ground path through the enclosure to the structure of the platform.

RQMT-110 The dc resistance measured from the connector shell to the equipment enclosure structure shall not exceed 2.5 milliohms.

RQMT-100 **3.3.2.5.4.5 Power Connectors.** Separate, dedicated receptacle connectors shall be provided for primary power inputs.

RQMT-110 EMI filters shall be provided for primary power inputs and shall be housed in a separate EMI shield enclosure contained within the overall envelope of the unit enclosure.

RQMT-120 As a goal, redundant connector pins shall be provided for all primary power and return paths.

RQMT-100 **3.3.2.5.4.6 Test Connectors.** Separate, dedicated receptacle connectors shall be provided if required to support unit testing.

RQMT-110 Test connections shall be terminated only in a test connector.

RQMT-120 If used, test receptacle connectors shall be provided with dummy mating plugs to be fitted when the test connector is not in use.

RQMT-130 The dummy plugs shall provide effective EMI shielding for the receptacle connectors.

RQMT-100 **3.3.2.5.4.7 Special Connectors.** Separate, dedicated receptacle connectors shall be provided as required for functions such as data bus terminations and unit personality coding as appicable.

RQMT-110 The connector type shall be selected, as specified herein, based on the signal category terminated in the connector.

RQMT-120 Mating plugs for special receptacle connectors shall be fabricated to provide the necessary coding jumpers or terminating loads, and to provide effective EMI shielding for the receptacle connector and the circuit elements contained in the plug assembly.

RQMT-100 **3.3.2.6 Corona Suppression.** The ARU's design shall be such that corona shall not exist.

RQMT-110 The effects of outgassing and residual pressure shall not cause arcing or breakdown of insulation.

RQMT-100 **3.3.3 Nameplates and Product Marking.** The ARU and its subassemblies shall be identified with a part number and a serial number.

RQMT-110 The same part number shall be used to identify like materials, processes, and details.

RQMT-120 The Contractor shall assign a new part number to a superseded part that is not interchangeable with respect to interface, reliability, safety, logistics, traceability, or performance.

3.3.3.1 Identification. The ARU shall display the following information.

- ARU
- Part Number and Dash Number
- Serial Number
- Contractor's Part Number and Change Letter
- Contractor Name or Trademark
- Contract Number

3.3.3.2 Electrical and Electronic Reference Designation Symbols. Electrical and electronic reference designations and symbols for external electrical connectors shall be affixed to the equipment in accordance with the requirements of ANSI Y32.16, *Reference Designations for Electrical and Electronic Parts and Equipments*, and ANSI Y32.2, *Graphic Symbols for Electrical and Electronic Diagrams*.

3.3.3.3 Test Articles. All development units (engineering models) shall be permanently marked "NOT FOR FLIGHT USE - DEVELOPMENT ONLY."

3.3.4 Workmanship.

RQMT-100 **3.3.4.1 General.** The ARU shall be manufactured, processed, tested, and handled such that finished items are of sufficient quality to ensure reliable operation, safety, and service life in the operational environments.

RQMT-110 All parts and assemblies shall be designed, constructed, and finished in a quality manner intended to produce defect-free equipment.

RQMT-120 Particular attention shall be given to critical operations such as soldering, plating, painting, riveting, machine screw assembly, welding, brazing, deburring, cleaning, and marking of parts and assemblies.

RQMT-130 The items shall be free of defects that would interfere with operational use, such as excessive scratches, nicks, burrs, loose material, fluxes, contamination, and corrosion.

RQMT-140 Workmanship shall meet the guidelines of MIL-STD-454, *Standard General Requirements For Electronic Equipment, Requirement 9* (or equivalent).

RQMT-100 **3.3.4.2 Contamination Control.** Contamination control and cleaning of the unit shall follow the guidelines of MIL-STD-1246, *Product Cleanliness Levels and Contamination Control Program* (or equivalent).

RQMT-110 The unit shall be free from all visible contamination, such as fingerprints, particles, corrosion products, metal chips, scale, oil, grease, preservatives, adhesives, and any foreign material.

RQMT-120 Motors and bearings shall be assembled in a Class 1,000 (or better) clean room. Labyrinth seals may be used to provide this level of protection.

RQMT-130 Motors shall be capable of being operated in a commercial shop environment without degradation.

RQMT-140 Units with contacts or parts in close proximity to conductive surfaces that cannot be cleaned and inspected after assembly shall be controlled during fabrication to assure a cleanliness level of 200D, in accordance with the guidelines of MIL-STD-1246 (or equivalent).

3.3.5 Interchangeability. Assemblies, components, and parts having identical part numbers shall, where practicable, be interchangeable.

RQMT-100 **3.3.6 Safety.** The unit shall be designed so that when stored, transported, or operated in accordance with applicable procedures, it will not cause damage to itself or to other equipment or cause injury to personnel.

RQMT-110 Precautionary markings shall be provided, as necessary, to warn personnel of the presence of hazardous conditions and the precautions to be observed to ensure the safety of personnel and equipment.

RQMT-120 The Contractor shall provide industrial safety activities that include implementation of accident prevention measures to protect all personnel and equipment under contract while in or on Contractor-controlled facilities.

RQMT-130 These activities shall be in accordance with applicable local, state and federal safety requirements and regulations.

3.3.7 Human Performance/Human Engineering. Not applicable.

RQMT-100 **3.3.8 Computer Resources.** Computer resources include all computer programs and associated computational equipment included within the ARU. Computational equipment includes both the equipment which executes symbolically expressed instructions and the associated peripheral devices. These computer resources shall be designed and developed in accordance with an integrated plan that minimizes the system life cycle cost.

RQMT-110 The system design shall provide ample memory and processing margins to accommodate contingencies and growth.

RQMT-100 **3.3.9 Standards of Manufacture.** General production requirements for the Space Segment shall be in accordance with SSD-D-IM009, *Flight Hardware Fabrication, Test and Repair* (or equivalent).

RQMT-110 Manufacturing standards and processes not covered by this specification that are critical to achieving the performance of the module specified herein shall require prior approval of the COR.

RQMT-100 **3.3.9.1 Processes and Controls.** The manufacturing processes and controls shall provide a Contractor-controlled baseline that ensures subsequent production items can be manufactured which are identical to, or better in performance, quality, and reliability than, initial production items used for qualification or flight demonstrations.

RQMT-110 These process controls shall be documented to give visibility to the procedures and specifications by which all processes, operations, inspections, and tests are to be accomplished by the Contractor.

RQMT-120 This internal Contractor documentation shall include the name of each component or part, each material required, the point it enters the manufacturing flow, and the controlling specification or drawing.

RQMT-130 The documentation shall indicate required tooling, facilities and test equipment, the manufacturing check points, the quality assurance verification points, and the verification procedures corresponding to each applicable process or material listed.

RQMT-140 The specifications, procedures, drawings, and supporting documentation shall reflect the specific revisions in effect at the time the item(s) used for qualification were produced.

RQMT-150 When approved by the COR, these flowcharts and referenced specifications, procedures, drawings, and supporting documentation shall become the manufacturing process control baseline and shall be retained by the Contractor for reference.

RQMT-160 Any changes to the baseline processes used, or the baseline documents used, when approved by the COR, shall be recorded by the Contractor following the production of the first item.

RQMT-100 **3.3.9.2 Production Lots.** Parts shall be grouped together in individual production lots during the various stages of their manufacture to ensure that all devices in a production lot are assembled during the same time period, using the same production materials, tools, methods, and controls.

RQMT-110 Items which cannot be adequately tested after assembly without destruction of the item, such as explosive ordnance devices, propulsion components, and complex electronics, shall have production lot controls implemented during manufacturing to ensure a uniform quality and reliability level of the entire lot.

RQMT-120 Each production lot shall be manufactured, tested, and stored as a single batch.

RQMT-130 Lot numbers shall be assigned to each production lot.

RQMT-100 **3.3.9.3 Contamination Control and Cleanliness.** Cleanliness requirements for each subsystem shall be determined and controlled on an individual basis.

RQMT-110 The ARU flight elements shall be protected from contamination during fabrication, integration, testing, storage, handling, transportation, and at the launch base.

RQMT-120 Satisfaction of the contamination requirements during prelaunch, launch, ascent, on-orbit, and abort operations shall be demonstrated by analysis.

RQMT-130 The item shall be monitored and periodically examined for cleanliness and cleaned as required, including before preparation for shipment from Contractor's facility to the NRL's facility and again before integration with the launch vehicle.

RQMT-100 **3.3.9.4 Connectors.** Connector keying or equivalent means shall be used to prevent mismating.

RQMT-110 All connectors shall be clearly labeled in addition to having the physical means to prevent improper connection.

3.3.9.5 Positive Locking Devices. If used, screw-type hardware on the ARU shall employ positive locking. Lockwashers shall not be used.

RQMT-100 **3.4 Documentation.** Documentation shall be consistent with the Contractor's established operation practices.

RQMT-110 Documentation shall be prepared according to the tailored guidelines of MIL-T-31000 (Developmental Design) or its equivalent.

RQMT-120 The results of trade studies, analyses, and development efforts shall be documented to support critical design decisions and milestone technical reviews during the course of the system development.

RQMT-100 **3.4.1 Specifications.** Specifications shall include all planning, design, responsibilities, and procedures. This text shall include, in detail, the specifics needed to accomplish any function within the documents themselves.

RQMT-110 Specifications shall be prepared according to the guidelines of MIL-STD-490, MIL-STD-498, and the appropriate Data Item Descriptions (DID), or their equivalents.

RQMT-120 These documents shall be subject to change control procedures and every proposed engineering change shall consider the effect of that change on these documents so that compatibility is maintained.

RQMT-100 **3.4.2 Drawings.** Specifications and hardware shall be supported by drawings according to the tailored guidelines of MIL-T-31000 (Developmental Design) and DOD-D-1000 or their equivalents.

RQMT-110 The final ARU documentation shall be such that subsequent production items can be produced or procured that are essentially equivalent in all respects to those initially tested or delivered.

RQMT-120 This final documentation shall also be adequate to allow the rapid incorporation of changes and modifications that have been approved by the COR.

RQMT-130 Documentation describing ARU operational procedures shall include contingency procedures to minimize the impact of possible on-orbit anomalies.

3.4.3 Software Support Documentation. All software support documentation shall be prepared according to the contractor's standard practices.

3.4.4 Test Plans and Procedures. All test plans and procedures shall be documented so that testing of the ARU can be accomplished by skilled engineering personnel.

3.4.5 Reserved.

3.5 Logistics.

RQMT-100 **3.5.1 Support Concept.** No scheduled or preventive maintenance shall be required to meet the performance and reliability requirements specified herein.

RQMT-110 Fault detection, isolation, and checkout shall be conducted at the module level, at which point replacement shall occur.

3.5.2 Support Facilities. Not applicable.

3.5.3 Hardware Support. Not applicable.

3.5.4 Computer Software Support. Not applicable.

3.6 Personnel. Not applicable.

3.7 Training. Not applicable.

3.8 Precedence. The order of precedence of the requirements specified herein is:

a. Safety

b. Missions

c. Space Vehicle Functions

d. Configuration Allocations

e. Quality Factors

f. All other requirements are considered equal in order of precedence.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General. This section describes the analyses, tests, and inspections required for the Attitude Reference Unit (ARU) verification process. A quality assurance (QA) program shall be implemented according to the requirements of SSD-D-IM008, *Spacecraft Program Requirements and Guideline*s. The analyses, tests, and inspections specified in Table 4-1 (included at the end of this section) shall be conducted to verify that all requirements specified in section 3.0 have been achieved.

4.1.1 Responsibility for Tests. The Contractor shall perform all or any part of the verification requirements of this specification required by the COR. In the event the COR elects to perform any part or all of the tests or have them performed by others, the Contractor shall either write the test procedures for approval by the COR, or comment and mutually agree upon the test procedures provided by the COR.

4.1.2 Notification of Tests. The COR will be notified five days before the start of testing. In addition, the COR reserves the right to have either government or Industrial representatives from the COR and/or NASA witness selected tests.

4.1.3 Nonconformance Reporting. When a nonconformance occurs during testing, the Contractor shall discontinue testing and report the nonconformance to the COR using the guidelines of SSD-D-IM006, *Failure Reporting Analysis and Corrective Action Procedure* (or equivalent). The Contractor shall document all troubleshooting steps to be accomplished and obtain approval from the COR before undertaking troubleshooting and/or repair actions.

4.2 Analysis. Analyses shall be performed as specified in Table 4-1 to verify the requirements of section 3.0. The analytical methods that may be used include engineering analyses in the specified technical discipline, similarity to a previously verified requirement, review of Contractor drawings and data, use of experience, or prior testing. Formal submittal of analysis data and documentation shall be as specified in section 3.0 unless otherwise specified by the COR.

4.2.1 Worst-Case Analysis. The Contractor shall perform a worst-case analysis in accordance with SSD-D-IM007, *Worst Case Analysis, Guidelines, and Criteria (*or equivalent) to verify that the equipment will meet the performance requirements of paragraph 3.2.1 over the line voltage, external system loads, part parameters, and temperature variations anticipated during its operating life. The effects of part parameter variations shall be determined by setting the parts that have a measurable impact on the equipment performance parameter being evaluated at the value that results in the greatest variation in equipment performance. Those parts whose parameter variations do not have measurable impact on the equipment performance parameter of interest may be set at nominal values. Line voltage, external system loads, and temperature shall be set at worst-case conditions.

4.2.2 Reliability Analysis. The Contractor shall perform a reliability analysis on the equipment to verify attainment of the reliability requirements specified in paragraph 3.2.3 and to identify any potential areas of equipment reliability improvement. The reliability analysis shall include the following:

a. The Contractor shall perform an electrical stress analysis to verify proper part application in compliance with the part derating criteria of SSD-D-IM007.

b. The Contractor shall perform a Failure Modes, Effects, and Criticality Analysis (FMECA) according to SSD-D-IM008, *Spacecraft Product Assurance Plan*, to consider equipment circuitry failure modes and their effects on adjacent circuits, equipment inputs, and equipment outputs. Special emphasis shall be placed on eliminating failure propagation and potential safety hazards. The FMECA shall produce a single-point failure summary.

c. The Contractor shall perform a reliability prediction to verify achievement of the reliability requirement specified in paragraph 3.2.3. This reliability prediction shall conform to the prediction requirements of MIL-STD-756, *Reliability Modeling and Prediction (*or equivalent), and shall utilize the part failure rate data of MIL-HDBK-217, *Reliability Prediction of Electronic Equipment (*or equivalent). A space flight environment, a mission time of three years with continuous operation, and a baseplate temperature of 30°C shall be utilized in this prediction.

4.3 Inspections. Inspections shall be performed as specified in Table 4-1 to verify the requirements of section 3.0. Visual and other techniques shall be used to satisfy this requirement. Visual inspections shall be accomplished without magnification and with vision corrected to not worse than 20/30 and under a white light having an intensity of 100 foot-candles minimum at the point of inspection. Wipe tests, water break tests, ultraviolet inspection, special

lights, and mirrors are considered aids to visual inspection. Inspections shall be conducted at the last point of assembly at which each detail can be cleaned, if necessary, and inspected.

4.4 Tests. The tests specified in Table 4-1 shall be conducted on the ARU to verify the requirements of section 3.0. The analyses, inspections and tests specified in Table 4-1 shall be conducted on the ARU for purposes of acceptance by the COR, design verification, and to demonstrate equipment capability. The Contractor shall prepare and submit all test plans and test procedures for COR approval. Approval of the test plans and test procedures shall not relieve the Contractor of responsibility to perform adequate design verification and demonstration of equipment capabilities.

4.4.1 Functional Tests. The Contractor shall develop functional test procedures to verify the requirements of section 3.0, as specified in Table 4-1, and shall submit them for approval to the COR.

4.4.2 Performance Tests. The Contractor shall develop performance test procedures to verify the requirements of section 3.0, as specified in Table 4-1, and shall submit them for approval to the COR. The performance tests shall verify requirements of section 3.0 and quantify the performance of each individual unit. Performance tests shall verify specified power supply fluctuations and various interface signal levels.

4.4.3 Special Parameter Monitoring. The Contractor shall develop criteria and procedures for critical parameter monitoring during environmental tests to verify the requirements of section 3.0, as specified in Table 4-1. The Contractor shall submit these for approval to the COR, prior to the Contractor's preparation of detailed test procedures. Critical parameters shall include, as appropriate, test chamber temperature, test article temperature, pressure, test voltages and currents, test acoustic spectrum and level, test vibration spectrum and level, illumination, particle or radiation flux, instrument response and telemetry, and contamination.

4.4.4 Environmental Tests. Environmental tests shall be conducted at acceptance and qualification levels. Responsibilities for environmental tests are listed below:

- Burn-In: Contractor
- Temperature Cycling: Contractor
- Thermal Vacuum: Contractor
- Random Vibration: Contractor
- System Level Random Vibration* COR
- EMI/EMC: Contractor
- Pyrotechnic Shock*: COR

*Conducted as part of spacecraft-level testing program.

4.4.4.1 Burn-In. The total burn-in requirement shall be 200 hours (i.e., for each redundant side or element). The following conditions shall apply (to each redundant side or element) during this time:

a. A minimum of 40 hours of burn-in shall be accomplished at other than ambient temperature. This requirement shall be satisfied during normal temperature cycling and thermal vacuum testing with the unit functionally operating at temperature extremes and during ramping activities.

b. The final 50 hours of burn-in shall be accomplished with the hardware being failure free. This requirement may be accomplished either during temperature cycling/thermal vacuum or ambient temperature or in combination, as dictated by the normal test sequence.

4.4.4.2 Temperature Cycling Test. Temperature cycling tests shall consist of seven (or 13) cycles with minimum two-hour dwell at each temperature extreme. Performance testing shall be accomplished prior to and during the two temperature extremes of the first cycle, during the temperature extremes of the last cycle, and following the last cycle. Functional testing shall be accomplished during all temperature extremes of cycles two through six. Critical parameter monitoring shall be accomplished during all ramps. Temperature cycles, tests, and monitoring requirements (acceptance and qualification) are shown in Figure 4-1. Test verification that the hottest region on the subsystem's external surface be less than 10°C above the mounting surface is not required.

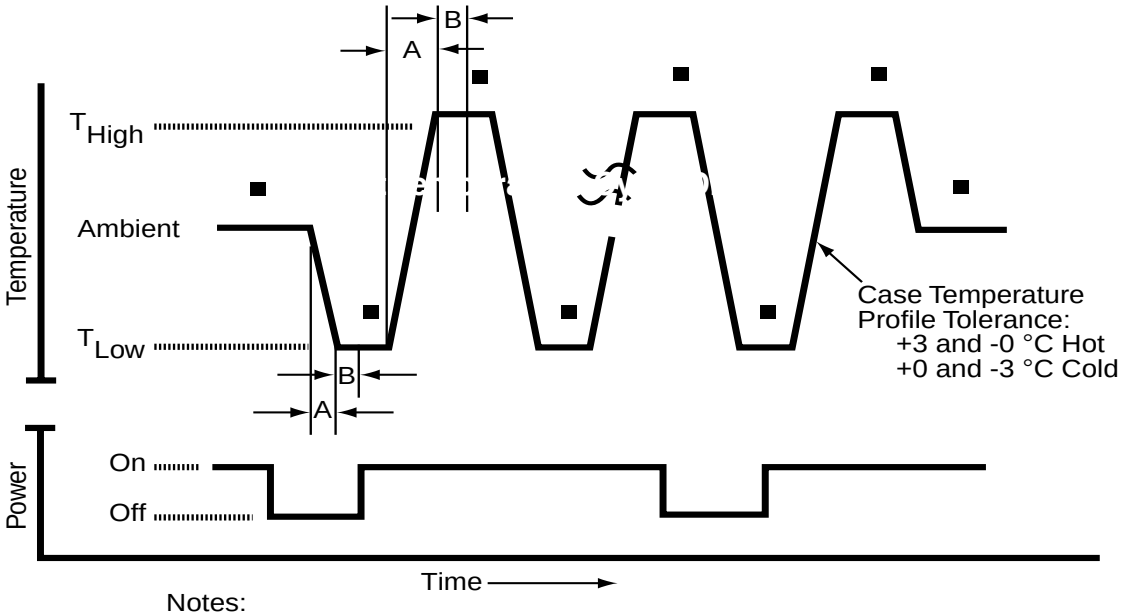
4.4.4.3 Thermal Vacuum Test. Thermal vacuum testing shall consist of one (or three) thermal cycle(s) at a pressure of 1×10^{-5} Torr or less with a minimum six-hour dwell at each of the temperature extremes. Performance test-

Procedure	No. of Cycles	T_{High}	T_{Low}
Qualification	13	60°C	-20°C
Acceptance	7	50°C	-10°C

■ Perform Functional Test

A Transition Rates as High as Practical, Not to Exceed 5°C/Min

B Two Hours Minimum for Temperature Stabilization



Notes:

1. Specimen Performance Will Be Monitored During Temperature Transients When Power is On.

2. At the End of Testing Day, Temperatures May Be Allowed to Return to Ambient Without Regard to Rate.

3. Functional Test at the First and Last Thermal Cycle Shall Be Run at 24, 30, and 36 Volts.

Figure 4-1. Temperature Cycle

ing shall be performed prior to the cycle, during each of the temperature extremes, and after the cycle. Critical parameter monitoring shall be accomplished during temperature transitions. Thermal vacuum requirements (acceptance and qualification) are shown in Figure 4-2. Test verification that the hottest region on the subsystem's external surface be less than 10° C above the mounting surface is not required.

4.4.4.4 Random Vibration. The random vibration test spectrum shall be equalized utilizing a control system with filters having a bandwidth of 10 Hz, or less, over the test frequency bandwidth of 20 to 2000 Hz. A true RMS or direct reading acceleration spectral density meter shall be used to monitor the vibration level. Random vibration data shall be presented as an acceleration spectral density versus frequency plot.

4.4.4.4.1 Test Method. A representative unit that is dynamically similar to the test unit shall be mounted on the rigid fixture and vibration exciter. The axis orientation shall be optional. The control and monitor accelerometers on the fixture shall be located as determined during fixture evaluation. The associated amplifiers and signal conditioning equipment for proper sensitivities and calibrations shall be adjusted, and an end-to-end check shall be conducted to verify proper control of the vibration system. Random vibration equalization to the specified spectrum and overall g rms level shall be accomplished. Tolerances are as follows:

Power Spectral Density:

20 Hz to 1000 Hz	±1.5 dB
1000 Hz to 2000 Hz	±3.0 dB

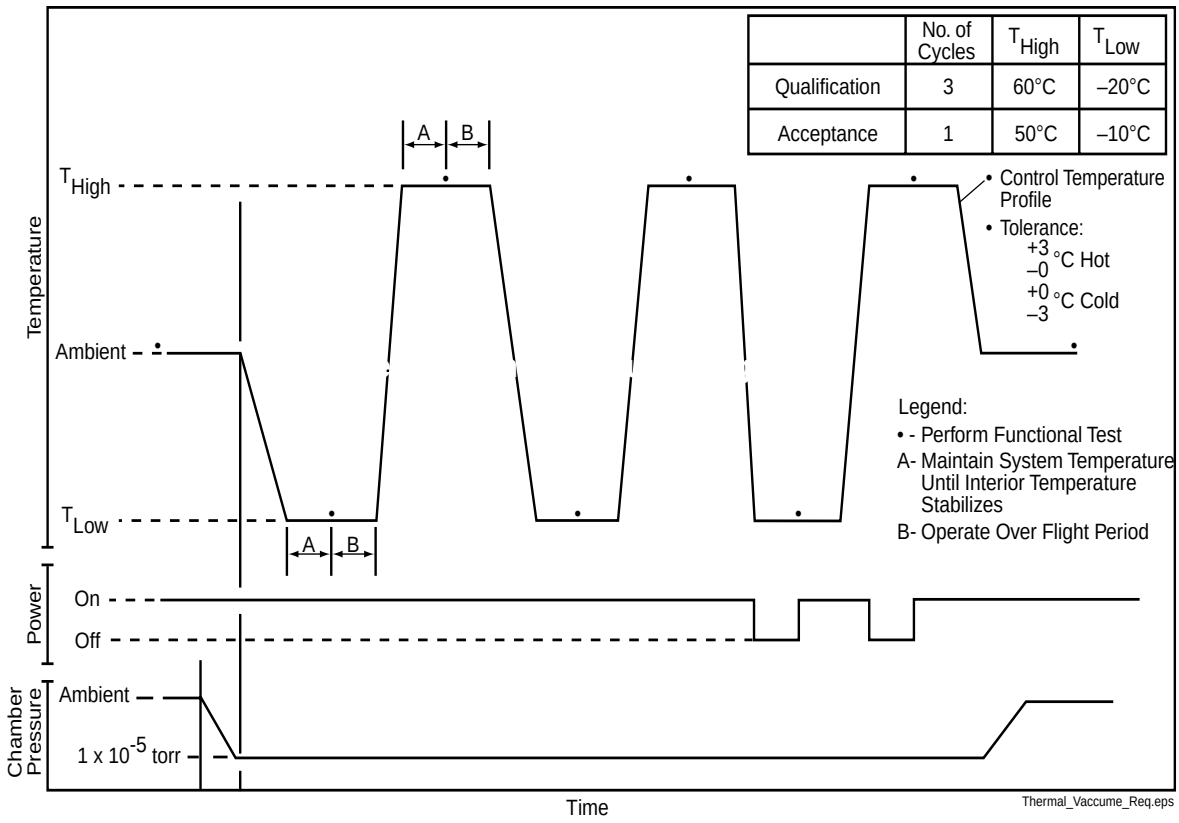


Figure 4-2. Thermal Vacuum Testing

Overall grms ±5%

If a representative unit is not available, the actual test item may be used with the approval of the COR. Where an actual test item must be used, the equalization level shall be reduced to approximately 20 percent of the specified overall g rms level and only after the vibration system protective devices have been demonstrated prior to mounting the test unit to the vibration fixture. Vibration system protective devices shall be set up and demonstrated to verify that they are set at the proper levels and functioning properly. The test unit shall be installed on the vibration fixture and shall be subjected to the random vibration test levels specified in section 3.0 in each of three orthogonal axes. A power spectral density plot shall be made to verify and record proper equalization for each of the three orthogonal axes.

4.4.4.5 Electromagnetic Compatibility Tests. The Contractor shall conduct EMC tests on the ARU qualification unit to verify compliance with section 3.0. EMC tests shall be based on MIL-STD-461 and MIL-STD-462 to meet the requirements of this specification. For existing products, this requirement may be met by analysis or by similarity.

4.4.4.6 Pyrotechnic Shock Tests. The COR will conduct pyrotechnic shock tests on the spacecraft to verify compliance with the test levels specified in section 3.0.

4.4.4.7 Acoustic Tests. Not applicable.

Table 4-1. Verification Requirements Checklist

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
3.0	REQUIREMENTS	X					
3.1	Item Definition	X					
3.1.1	Interface Definition			X			
3.2	Characteristics	X					
3.2.1	Performance Requirements	X					
3.2.1.1	Gyroscope Performance	X					
3.2.1.1.1	General	X					
3.2.1.1.2	Maximum Continuous Input Rates				X		
3.2.1.1.3	Output Scale Factors	X					
3.2.1.1.3.1	Scale Factor Linearity				X		
3.2.1.1.3.2	Scale Factor Stability				X		
3.2.1.1.4	Bias Repeatability				X		
3.2.1.1.5	Angular Random Walk				X		
3.2.1.1.6	Bandwidth				X		
3.2.1.1.7	Axis Alignment				X		
RQMT-100					X		
RQMT-110					X		
RQMT-120					X		
3.2.1.1.8	Sensitivity				X		
3.2.1.1.9	Warm-up Time				X		
3.2.1.2	Output Data Interfaces	X					
3.2.1.2.1	Output Data			X			
3.2.1.2.2	ARU Output Sampling Period			X			
RQMT-100				X			
RQMT-110				X			
3.2.1.3	Primary Power			X			
RQMT-100				X			

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-110				X			
3.2.1.3.1	Input Voltage			X			
3.2.1.3.2	Source Impedance			X			
3.2.1.3.3	Isolation			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
3.2.1.3.4	Power Consumption				X		
3.2.1.3.5	Inrush Current				X		
RQMT-100					X		
RQMT-110					X		
3.2.2	Physical Characteristics	X					
3.2.2.1	Mass Properties			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
3.2.2.2	Mechanical Size, Configuration and Interface			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
RQMT-140				X			
RQMT-150				X			
RQMT-160				X			
3.2.2.3	Mounting			X			
RQMT-100				X			

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-110				X			
RQMT-120				X			
3.2.2.4	Connectors			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
RQMT-140				X			
RQMT-150				X			
RQMT-160				X			
RQMT-170				X			
3.2.2.5	Thermal Design				X	X	
RQMT-100					X	X	
RQMT-110					X	X	
RQMT-120					X	X	
RQMT-130					X	X	
RQMT-140					X	X	
RQMT-150					X	X	
RQMT-160					X	X	
RQMT-170					X	X	
RQMT-180					X	X	
RQMT-190					X	X	
RQMT-200					X	X	
3.2.2.6	Radiation Effects		X				
3.2.2.6.1	Radiation Protection		X				
RQMT-100			X				
RQMT-110			X				

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
3.2.2.6.2	Radiation Hardness and Dosage		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.2.2.6.3	Single Event Effects		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
RQMT-150			X				
3.2.2.6.4	Single Event Latchup (SEL)		X				
RQMT-100			X				
RQMT-110			X				
3.2.2.7	Corona Suppression		X				
3.2.2.8	Venting		X				
RQMT-100			X				
RQMT-110			X				
3.2.2.9	Outgassing		X				
RQMT-100			X				
RQMT-110			X				
3.2.3	Reliability	X					
3.2.3.1	Reserved	X					
3.2.3.2	Failure Mode, Effects and Criticality Analysis (FMECA)		X				
3.2.3.3	Electrical Stress Analysis		X				
3.2.3.4	Reliability Analysis		X				

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
RQMT-150			X				
3.2.3.5	Single Point Failure (SPF)	X					
3.2.3.6	Worst Case Analysis		X				
3.2.4	Maintainability		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
3.2.4.1	Access and Mounting		X				
RQMT-100			X				
RQMT-110			X				
3.2.4.2	Modular Construction	X					
RQMT-100		X					
RQMT-110		X					
3.2.4.3	Fault Detection Capability			X			
3.2.4.4	Maintenance Provisions			X			
3.2.5	Availability	X					
3.2.5.1	Space Segment	X					
3.2.5.1.1	Non-Operating Environment		X				
3.2.5.1.2	Operating Environment				X	X	
3.2.5.2	Ground Segment - NRL Engineering Node (NEN)	X					
3.2.6	Systems Effectiveness Models	X					

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
3.2.7	Environmental Conditions	X					
3.2.7.1	Storage	X					
3.2.7.1.1	Ambient Air Temperature		X				
3.2.7.1.2	Ambient Pressure		X				
3.2.7.1.3	Humidity		X				
3.2.7.1.4	Cleanliness		X				
3.2.7.2	Ground Handling and Transportation	X					
3.2.7.2.1	Ambient Air Temperature		X				
3.2.7.2.2	Ambient Pressure		X				
3.2.7.2.3	Humidity		X				
3.2.7.2.4	Acceleration		X				
3.2.7.2.5	Vibration		X				
3.2.7.2.6	Shock		X				
RQMT-100			X				
RQMT-110			X				
3.2.7.2.7	Cleanliness		X				
RQMT-100			X				
RQMT-110			X				
3.2.7.3	Prelaunch	X					
3.2.7.3.1	Ambient Air Temperature		X				
3.2.7.3.2	Ambient Pressure		X				
3.2.7.3.3	Humidity		X				
3.2.7.3.4	Acceleration		X				
3.2.7.3.5	Cleanliness		X				
3.2.7.4	Launch and Ascent	X					
3.2.7.4.1	Temperature and Humidity				X	X	
RQMT-100					X	X	

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-110					X	X	
3.2.7.4.2	Pressure				X	X	
RQMT-100					X	X	
RQMT-110					X	X	
3.2.7.4.3	Acceleration		X				
3.2.7.4.4	Emergency Landing (Launch Abort) Loads		X				
3.2.7.4.5	Acoustics and Random Vibration	X					
3.2.7.4.5.1	Acoustic Vibration	X					
3.2.7.4.5.2	Random Vibration.				X	X	
3.2.7.5	Orbital Operations	X					
3.2.7.5.1	Natural Thermal Radiation	X					
3.2.7.5.2	Pressure				X	X	
3.2.7.5.3	Particle Radiation		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.2.7.5.4	Acceleration		X				
3.2.7.5.5	Pyrotechnic Shock		X				
3.2.7.5.6	Meteoroids	X					
3.2.7.6	Reserved	X					
3.2.8	Nuclear Control Requirements	X					
3.2.9	Transportability		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.3	Design and Construction	X					
3.3.1	Materials, Processes, and Parts		X				

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-100			X				
RQMT-110			X				
3.3.1.1	Electronic Piece Parts		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
3.3.1.1.1	Parts Selection and Use		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
3.3.1.1.2	EEE Parts Program		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.3.1.1.3	Capacitors and Resistors		X				
3.3.1.1.4	Other Devices		X				
3.3.1.1.5	Electrical Connectors		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
3.3.1.1.5.1	Connector Savers		X				

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
3.3.1.1.5.2	Coaxial Connectors		X				
RQMT-100			X				
RQMT-110			X				
3.3.1.1.5.3	MIL-STD-1553 Bus Connectors.		X				
RQMT-100			X				
RQMT-110			X				
3.3.1.1.6	Wires and Cable		X				
3.3.1.2	Materials		X				
3.3.1.2.1	Materials Selection		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
3.3.1.2.2	Metallic Materials		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
RQMT-150			X				
3.3.1.2.3	Magnetic Materials		X				
3.3.1.2.4	Finishes		X				
RQMT-100			X				

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-110			X				
3.3.1.2.5	Outgassing		X				
3.3.1.3	Processes		X				
3.3.1.3.1	Traceability		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
3.3.1.3.2	Failure Reporting and Corrective Action System		X				
3.3.1.3.3	Part Stress Derating		X				
3.3.1.3.4	Soldering and Other Processes		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
3.3.1.3.5	Mechanical Piece Parts	X					
3.3.1.3.6	Surface Finishes		X				
3.3.1.3.7	High Reliability Parts Processing		X				
RQMT-100			X				
RQMT-110			X				
3.3.1.3.8	Control of Electro-Static Sensitive Parts		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.3.2	Electromagnetic (EMC) Environment					X	
RQMT-100						X	

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-110						X	
RQMT-120						X	
3.3.2.1	Conducted Emission					X	
3.3.2.2	Conducted Susceptibility					X	
3.3.2.3	Radiated Susceptibility					X	
3.3.2.3.1	Narrowband Susceptibility					X	
RQMT-100						X	
RQMT-110						X	
RQMT-120						X	
RQMT-130						X	
3.3.2.3.2	Broadband Susceptibility	X					
3.3.2.4	Radiated Emissions						
3.3.2.4.1	Narrowband Emissions					X	
3.3.2.4.2	Broadband Emissions	X					
3.3.2.5	Design Requirements	X					
3.3.2.5.1	Electrical Bonding		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.3.2.5.2	Finishes for Bonding		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
3.3.2.5.3	Equipment Enclosure		X				
RQMT-100			X				
RQMT-110			X				

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
RQMT-150			X				
RQMT-160			X				
3.3.2.5.4	Signal Categories		X				
3.3.2.5.4.1	Signal Shielding		X				
RQMT-100			X				
RQMT-110			X				
3.3.2.5.4.2	Signal Segregation		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.3.2.5.4.3	External Connectors		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
RQMT-140			X				
3.3.2.5.4.4	Connector Mounting		X				
RQMT-100			X				
RQMT-110			X				
3.3.2.5.4.5	Power Connectors		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.3.2.5.4.6	Test Connectors		X				

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
3.3.2.5.4.7	Special Connectors		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
3.3.2.6	Corona Suppression		X				
RQMT-100			X				
RQMT-110			X				
3.3.3	Nameplates and Product Marking			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
3.3.3.1	Identification			X			
3.3.3.2	Electrical and Electronic Reference Designation Symbols			X			
3.3.3.3	Test Articles			X			
3.3.4	Workmanship	X					
3.3.4.1	General			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
RQMT-140				X			
3.3.4.2	Contamination Control			X			

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
RQMT-140				X			
3.3.5	Interchangeability			X			
3.3.6	Safety		X				
RQMT-100			X				
RQMT-110			X				
RQMT-120			X				
RQMT-130			X				
3.3.7	Human Performance/Human Engineering	X					
3.3.8	Computer Resources		X				
RQMT-100			X				
RQMT-110			X				
3.3.9	Standards of Manufacture			X			
RQMT-100				X			
RQMT-110				X			
3.3.9.1	Processes and Controls			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
RQMT-140				X			
RQMT-150				X			
RQMT-160				X			
3.3.9.2	Production Lots			X			

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
3.3.9.3	Contamination Control and Cleanliness			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
3.3.9.4	Connectors			X			
RQMT-100				X			
RQMT-110				X			
3.3.9.5	Positive Locking Devices			X			
3.4	Documentation			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
3.4.1	Specifications			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
3.4.2	Drawings			X			
RQMT-100				X			
RQMT-110				X			
RQMT-120				X			
RQMT-130				X			
3.4.3	Software Support Documentation	X					

Table 4-1. Verification Requirements Checklist (Continued)

Design Requirements		Verification Method					Test Requirements
Paragraph No.	Title	Not Applicable	Analysis	Inspection	Acceptance Test	Qualification Test	
3.4.4	Test Plans and Procedures			X			
3.4.5	Reserved	X					
3.5	Logistics	X					
3.5.1	Support Concept			X			
RQMT-100				X			
RQMT-110				X			
3.5.2	Support Facilities	X					
3.5.3	Hardware Support	X					
3.5.4	Computer Software Support	X					
3.6	Personnel	X					
3.7	Training	X					
3.8	Precedence	X					

5.0 PREPARATION FOR DELIVERY

5.1 General. Preparation for delivery shall be in accordance with the terms specified in this Section.

5.2 Packaging and Packing.

5.2.1 Containers. Individual containers shall be utilized to allow removal of the item for inspection without destruction of the container or of the wrappers affixed to the item. If paper wrapping is used on the item, the wrapping paper shall be acid free. As an objective, the container shall provide equal protection, without use of special tools, to items repackaged following inspection.

5.2.2 Special Instructions. If the item requires special attention during receiving, inspection, installation, and operation, or if non-obvious characteristics require that special handling be used, the procuring activity shall be notified under separate cover, and a removable instruction tag shall be attached. Attachment shall be to the shipping container or the item, as appropriate.

5.3 Marking.

5.3.1 Marking for Shipment. Exterior shipping containers and non-carrier packages and separately shipped items shall be marked:

"FRAGILE SPACE ELECTRONICS EQUIPMENT.

DO NOT DROP.

CONTAINS ELECTROSTATIC SENSITIVE DEVICES.

WEIGHT = _____."

5.3.2 Reinspection. Articles requiring periodic reinspection shall be marked with the next inspection date.

6.0 DELIVERABLES AND TASKS

6.1 Monthly Status Reports. The Contractor shall provide a monthly status report via DD Form 1423, Contract Data Requirements List (CDRL) A001, identifying any progress to date, planned efforts for the next reporting period, and program issues and problems.

6.2 Program Support Documentation. The Contractor shall provide the necessary planning and schedule to meet the delivery requirements. The Contractor shall comment on any potential problems in the schedule and provide a detailed plan of attack for solving these problems. A detailed schedule must be prepared, maintained, and provided to the COR, with schedule changes and/or updates provided. The data shall be provided monthly starting 30 days after award of contract (DAC) via DD Form 1423, A001. The Contractor shall inform the COR within seven days of any and all events or delays at the Contractor's facility that may impact schedule, performance, quality, delivery, or cost. If any delays occur or are anticipated to occur, the Contractor shall notify the COR by phone, following up with a written notification to the Contract Negotiator (identified in Section G of the contract). The Contractor shall provide a copy of the written notification to the COR.

6.3 Interface Control Document. The ARU Interface Control Document (ICD), DD Form 1423, A009, shall provide all the electrical and mechanical interfaces for the ARU. This shall include schematics, timing diagrams, pinouts, and command and control requirements. The Contractor shall deliver a complete ICD 45 days after contract.

6.4 Design Packages.

6.4.1 Preliminary Design Review Package. A Preliminary Design Review (PDR) package, DD Form 1423, A002, consisting of engineering drawings, schematics, analyses, and schedule in accordance with this specification, shall be furnished to the COR seven days prior to the scheduled PDR. A summary of actions and action items resulting from the PDR shall be furnished to the COR within two weeks after the PDR.

6.4.2 Final Design Package. A Final Design Review (FDR) package, DD Form 1423, A003, consisting of engineering drawings, schematics, analyses, and schedule in accordance with this specification, shall be furnished to the COR seven days prior to the FDR. A summary of actions and action items resulting from the FDR shall be furnished to the COR within two weeks after the FDR.

6.4.3 Drawings.

6.4.3.1 Assembly. The Contractor shall deliver a complete set of all assembly drawings for the ARU, DD Form 1423, A004, at PDR. If changes to the drawings are required, revised drawings will be sent to the COR.

6.4.3.2 Schematics and Parts List. The Contractor shall deliver a complete parts list for the item, DD Form 1423, A005, along with annotated schematics at PDR. If any changes are required, a revised parts list and annotated schematics will be sent to the COR.

6.4.3.3 Engineering Changes. The ARU shall be fabricated and assembled in accordance with drawings, parts lists, processes, and other documents listed on Contractor drawings. These documents shall be submitted to and approved by the COR. Upon establishment of the baseline configuration between the Contractor and the COR, the Contractor shall make no changes to any of these items without written approval from the COR via a Change Control Notice (CCN). When changes need to be made to DD Form 1423, A006 will be provided.

6.5 Testing Packages.

6.5.1 Test Procedures. Test procedures, DD Form 1423, A007, shall be prepared by the Contractor and submitted for COR approval 30 days prior to testing.

6.5.2 Test Reports. Test reports, DD Form 1423, A008, shall be generated by the Contractor and submitted upon final delivery of the unit tested. Test reports shall document all test failures and anomalies. Test reports shall include assembly and test log books. A Certificate of Compliance with the specification shall be provided with the test reports.

6.6 System Effectiveness.

6.6.1 Worst Case Analysis and FMECA. The Contractor shall deliver a worst case analysis and FMECA180 days after contract via DD Form 1423, A010.

6.6.2 Stress Analysis. The Contractor shall deliver a stress analysis 180 days after contract via DD Form 1423, A011.

6.6.3 Worst Case Timing Analysis. The Contractor shall deliver a worst case timing analysis 180 days after contract via DD Form 1423, A012.

6.6.4 Reliability Analysis. The Contractor shall deliver a reliability analysis 180 days after contract via DD Form 1423, A013.

6.7 Tasks.

6.7.1 Preliminary Design Review. The Preliminary Design Review will be held at the Contractor's facility 30 days after contract.

6.7.2 Final Design Review. The Final Design Review will be held at the Contractor's facility 30 days prior to start of testing.