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Radiation Budget Instrument

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Exhibit C
Radiation Budget Instrument (RBI) Performance Requirements Document

Langley Research Center
Hampton, Virginia

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PREFACE

This document is under RBI configuration control. Once this document is approved, RBI approved changes are handled in accordance with change control requirements as described in the RBI Configuration & Data Management Operating Procedure, and changes to this document shall be made by complete revision.

REVISION HISTORY PAGE

Revision No.	Description	Release Date
Baseline	Initial Release	06/14/2014
A	See RBI-CR-003 and JPSS 472-CCR-14-0750	11/13/2014
B	See RBI-CR-014 JPSS 472-CCR-15-0947	05/28/2015
C	See RBI-CR-015	11/09/2015
D	See RBI-CR-037	09/27/2016
E	See RBI-CR-074	10/16/2017

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Item No.	Location	Summary	Individual/ Organization	Due Date

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1 INTRODUCTION

1.1 Purpose

This Joint Polar Satellite System (JPSS) Radiation Budget Instrument (RBI) Performance Requirements Document (IPRD) specifies the Level 3 functional, design, performance, interface, integration, verification, test, and delivery requirements for the RBI.

1.2 Document Scope

The requirements in this document are applicable to the RBI, ground support equipment (GSE), and ground and flight software. The RBI flight model #1 Instrument is planned for use on the JPSS-2 Observatory.

1.3 JPSS Mission Overview

The JPSS is the National Oceanic and Atmospheric Administration (NOAA) next-generation operational low Earth orbit (LEO) observation program, which will acquire and distribute global environmental data, primarily from multiple polar-orbiting observatories. The JPSS plays a critical role in NOAA's continuing mission to understand and predict changes in weather, climate, oceans and coasts, and the space environment, which support the Nation's economy and protect lives and property. JPSS is NOAA's portion of the restructured National Polar-orbiting Operational Environmental Observatory System (NPOESS) program, which will provide operational continuity of Observatory-based observations and products from NOAA Polar-orbiting Operational Environmental Satellite (POES) observatories and the Suomi National Polar-orbiting Partnership (SNPP) mission Observatory and ground systems. The JPSS primary program objective is to sustain continuity of and enhance NOAA's Earth observing analysis, forecasting, and climate monitoring capabilities from global polar-orbiting observations. To ensure continuity of environmental data from the 1330 Local Time Ascending Node (LTAN) sun-synchronous polar orbit, the currently operational SNPP mission will be followed with similar missions, in terms of Instrument payload, with JPSS-1 and JPSS-2.

1.3.1 Mission Objectives

The JPSS mission objectives are to provide environmental sensing from a polar sun-synchronous orbit, generate calibrated/validated/geo-located data products that serve the meteorological and global climate change communities, and provide real-time broadcast of environmental data to the distributed user community.

1.3.2 Mission Success

Minimum mission success of the JPSS requires all four performance attributes identified as Key Performance Parameters (KPPs), listed below, to be met. KPPs are those polar system capabilities that, if they cannot be met, would compromise NOAA's weather mission to provide essential warnings and forecasts to protect lives and property, and would be cause for program reevaluation or cancellation. The JPSS KPPs are:

- Advanced Technology Microwave Sounder (ATMS) Sensor Data Records (SDRs)

- Cross-track Infrared Sounder (CrIS) SDRs
- Visible Infrared Imaging Radiometer Suite (VIIRS) Imagery Environmental Data Records (EDRs) at 0.64 µm (I1), 3.74 µm (I4), 11.45 µm (I5), 8.55 µm (M14),
- 10.763 µm (M15), and 12.03 µm (M16) for latitudes greater than 60 degrees North in the Alaskan region
- 96-minute data latency for the ATMS and CrIS SDRs and the VIIRS Imagery EDR channels specified above

1.3.3 Mission Architecture

The JPSS mission architecture (depicted in Figure 1.3.3-1) consists of a space segment, launch support segment, ground system, and external interfaces. The space segment includes the spacecraft and instruments, the launch support segment includes the launch vehicle and associated launch services, and the ground system includes the facilities and resources necessary to support the mission operations and data product generation. External interfaces provide resources required to support the JPSS mission objectives, but are not necessarily controlled by the JPSS program.

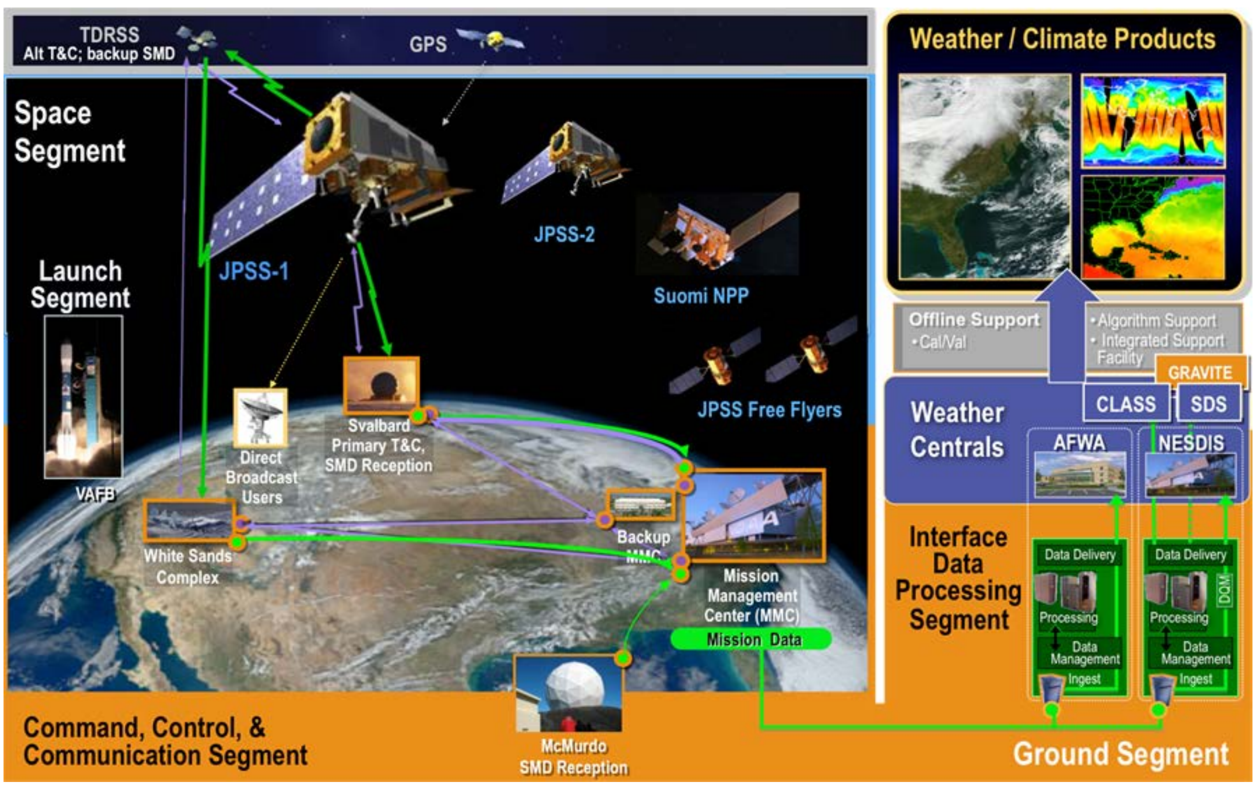


Figure 1.3.3-1 JPSS Mission Architecture.

Note: This figure intentionally does not contain the other missions that may or may not use the JPSS ground system (e.g., Defense Meteorological Satellite Program, and others), as it is intended to represent only the JPSS mission system.

1.4 RBI Instrument Overview

The RBI on-board the JPSS-2 satellite will continue NASA's long-term measurement of Earth's radiation budget. The RBI follows the successful legacy of the Clouds and the Earth's Radiant Energy System (CERES) instruments onboard NASA's Tropical Rainfall Measuring Mission satellite, NASA's Earth Observing System (EOS) Terra and Aqua satellites, and the JPSS SNPP satellite. Data produced by the RBI will facilitate production of JPSS Earth Radiation Budget (ERB) Sensor Data Records and Environmental Data Records as specified in the JPSS Level 1 Requirements Document and Supplement. JPSS data are used for short-term operational forecasting and are leveraged for maintenance of the long-term climate record. Data produced by the RBI will provide data suitable to facilitate the reprocessing and scientific analysis necessary for supporting climate applications of the JPSS data records. This will lead to a better quantification and understanding of how the Earth's climate system is changing, forcing functions for climate change, global impacts to people and property, and mitigations for climate change.

1.5 Precedence and Criticality of Requirements

The following definitions identify the weighting factors incorporated in this specification.

Shall – Compliance by the Contractor is mandatory. Any deviations from these contractually imposed mandatory requirements require the approval of the Contracting Officer.

May – At the discretion of the Contractor or Government.

Will – Designates the intent of the Government.

In this document, those paragraphs which are intended for information or clarification, but do not represent requirements, are shown in italics.

2 APPLICABLE/REFERENCE DOCUMENTS

2.1 Applicable Documents

Applicable documents in Table 2.1-1 are defined as specific documents that are called out or invoked by requirements in this document. Unless specifically noted, all requirements contained in these documents are applicable to this mission. In the event of a conflict between the following applicable documents and this document, the Contractor has the responsibility to notify the Government and seek a resolution.

Table 2.1-1 Applicable Documents.

472-00283	JPSS-2 Spacecraft to RBI Interface Control Document (ICD)
472-00287	JPSS-2 Spacecraft to Radiation Budget Instrument (RBI) Instrument Mechanical Interface Control Document (MICD)
472-00228	JPSS-2 Contamination Control Plan
AIAA S-114-2005e	Moving Mechanical Assemblies for Space and Launch Vehicles

472-00283	JPSS-2 Spacecraft to RBI Interface Control Document (ICD)
CCSDS 133.0-B-1	Space Packet Protocol
CCSDS 301.0-B-4	Time Code Format Recommended Standard
CCSDS 701.0-B-2	Advanced Orbiting Systems, Networks and Data Links: Architectural Specification
ECSS-E-ST-50-12C	SpaceWire - Links, nodes, routers and networks *(applicable to an Instrument utilizing the SpaceWire Interface)*
GSFC EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and Derating
GSFC-STD-7000A	General Environmental Verification Standard (GEVS) For GSFC Flight Programs and Projects
IEST-STD-CC1246E	Product Cleanliness Levels – Applications, Requirements, and Determination
IPC J-STD-001ES	Space Applications Electronic Hardware Addendum to Requirements for Soldered Electrical and Electronic Assemblies
ISO 14644-1	Cleanrooms and associated controlled environments - Part 1: Classification of air cleanliness
NASA-STD-5001	Structural Design and Test Factors of Safety for Spaceflight Hardware
NASA-STD-5017	Design and Development Requirements for Mechanisms
NASA-STD-5020	Requirements for Threaded Fastening Systems in Space Flight Hardware
NASA-STD-6001	Flammability, Offgassing, and Compatibility Requirements and Test Procedures
NASA-STD-8739.4	Crimping, Interconnecting Cables, Harnesses, and Wiring
NASA-STD-8719.24	NASA Expendable Launch Vehicle Payload Safety Requirements
NASM 33540	Safety Wiring, Safety Cabling, Cotter Pinning, General Practices for
NIST Handbook 152	Recommended practice; symbols, terms, units and uncertainty analysis for radiometric sensor calibration
NIST Technical Note 1297	Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results
NPR 2810.1A	Security of Information Technology
NPR 8715.6A	NASA Procedural Requirements for Limiting Orbital Debris
KSC/MMA-1985-79	Standard Test Method for Evaluating Triboelectric Charge Generation and Decay
KSC/MTB-175-88	Procedure for Casual Exposure of Materials to Hypergolic Fluids
MIL-STD-1553B	Aircraft Internal Time Division Command/Response Multiplex Data Bus (*applicable to an Instrument utilizing the MIL-STD-1553 Interface)*
MIL-STD-461C	Electromagnetic Emission and Susceptibilty Requirements for the Control of Electromagnetic Interference (EMI)
MIL-STD-461F	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-462	Measurement of Electromagnetic Interference Characteristics

472-00283	JPSS-2 Spacecraft to RBI Interface Control Document (ICD)
MIL-STD-975	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List
MIL-W-22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy
RBI-FM1-SER-001	Radiation Budget Instrument Standard Scene Spectra Document
RBI-FM1-SER-002	Radiation Budget Instrument Standard Scene Spectra Data

2.2 Reference Documents

Reference documents listed in Table 2.2-1, although not a part of this Specification, serve to amplify and clarify its contents. The reference documents are:

Table 2.2-1 Reference Documents.

470-REF-00031	JPSS Level 1 Requirements Document
470-REF-00032	JPSS Level 1 Requirements Document Supplement
470-00019	JPSS-1 Mission System Specification (MSS)
472-00020	JPSS Mission Concept of Operations
CERES-CG-BDS	CERES Collection Guide: BDS Collection Document
CERES-CG-ES-4	CERES Collection Guide: ES-4 Collection Guide
CERES-CG-ES-8	CERES Collection Guide: ES-8 Collection Guide (Draft)
CERES-CG-ES-9	CERES Collection Guide: ES-9 Collection Guide
CERES-CG-SSF	CERES Collection Guide: SSF Collection Document
GPD 7120.1A	GSFC Space Asset Protection Policy
GSFC-STD-1000E	Goddard Space Flight Center Rules for the Design, Development, Verification, and Operation of Flight Systems
NPD 7120.4D	NASA Engineering and Program/Project Management Policy
NHB 1620.3B	Physical Security Handbook
RBI-PMT-CDRL-0001-Rev-A	DRD OO-03 Instrument Command Telemetry, Science, and Engineering Data Description Document

3 GENERAL REQUIREMENTS

3.1 Interface Requirements

RB_PRD-184 The Instrument shall comply with the JPSS-2 Spacecraft to RBI Interface Control Document (ICD).

3.2 Spacecraft Body Frame and Coordinate Systems

RB_PRD-186 The instrument on-orbit coordinate system (see Figure 3.2-1) shall use a right-hand, orthogonal, body-fixed XYZ coordinate system as follows: the +Z-axis is downward towards nadir, and the X-axis is along the spacecraft velocity vector (+X toward the direction of spacecraft travel).

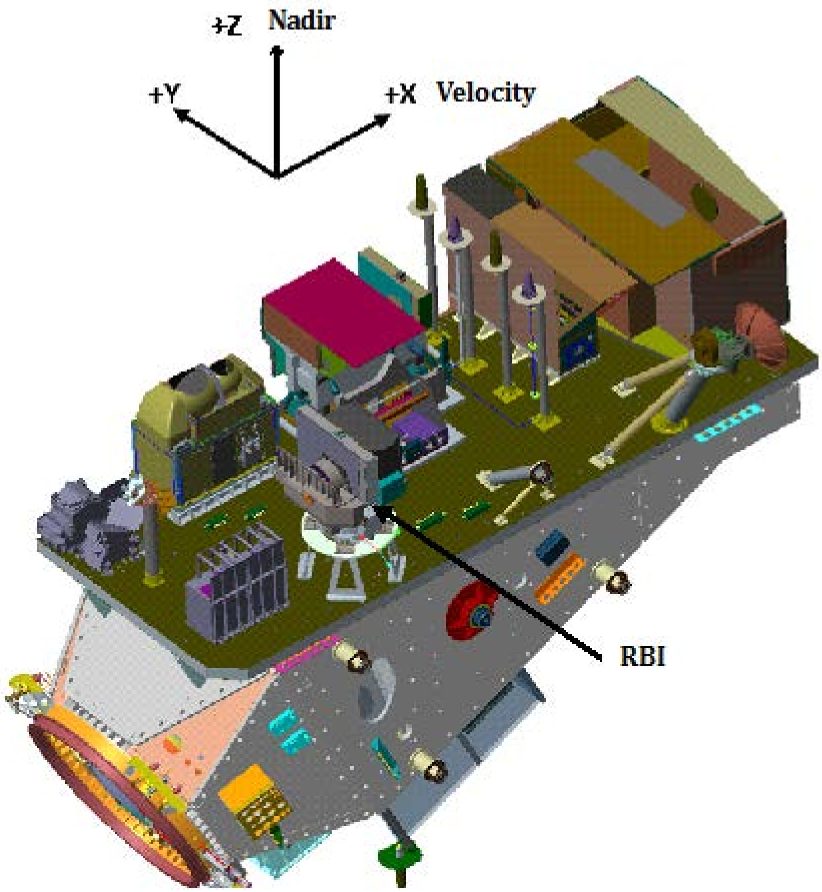


Figure 3.2-1 On-orbit coordinate system.

3.3 Environmental Test Tolerances

RB_PRD-190 The Instrument environmental testing shall comply with the Tolerances specified in Table 3.3-1, unless otherwise specified:

Table 3.3-1 Test tolerances.

Static/Steady State Load	±5%
Sinusoidal Vibration	±10% of amplitude

Static/Steady State Load	±5%
Random Vibration Overall, G rms	±10%
Random Vibration, Power Spectral Density (PSD)	20 to 500 Hz: ±1.5 dB 500 to 2000 Hz: ±3.0 dB Determined when analyzed using filters with 25 Hz or less bandwidth
Vibration Frequency	±2% or ±1 Hz, whichever is larger
Shock	Shock Response Spectrum Acceleration (Q = 10) <200 Hz: No Requirement: 200-5000 Hz: ±6 dB >5000 Hz: No Requirement Ratio of maximum spectrum level to the peak G input shall be between 2.5 and 5.0. At least 50% of the spectrum values shall be greater than the nominal test spectrum
Acoustic Sound Pressure Level	One-Third Octave Band Sound Pressure Level (SPL): <40 Hz: ±5 dB 40 to 2500 Hz: ±3 dB >2500 Hz: +3 dB, −4 dB Overall SPL: ±1.5 dB
Pressure, Altitude Vacuum	Greater than 100 mm of Hg (1.33×10^4 Pa) ± 5% 1 mm of Hg to 100 mm of Hg (1.33×10^4 Pa) ± 10% 1 micron of Hg to 1 mm of Hg (1.33×10^2 Pa) ± 25% Less than 1 micron of Hg (1.33×10^{-1} Pa) ± 80%
Relative Humidity	± 5%
Weight	Spacecraft: ±0.25%; Subsystems/instruments: ±0.1%

Static/Steady State Load	±5%
Test Temperature Sensor Accuracy	<–54 °C: ±5 °C; –54 to 177 °C: ±3 °C; >177 °C: ±5 °C; ±2 °C (on temperature control sensors)
Temperature Stabilization	Stabilization is achieved when: The largest instrumented thermal mass within the test article is within 2 °C of the specified temperature and the rate of change of its temperature is less than 2 °C/hr measured over a 30 minute time span, or The test article temperature remains constant within ±2 °C over a 2-hour period.
Temperature Change:	Change of one condition to another at an average rate greater than 1 °C/min but less than 5 °C/min for electronic units. Structural assembly temperature change rates are as specified in the procedures
Test Duration	±10%
Electromagnetic Compatibility (EMC)	Reference GSFC-STD-7000A (GEVs, section 1.13) and appropriate equipment specification for EMC tolerances.

3.4 System of Units

RB_PRD-239 The Instrument design shall use the International System of Units, Système Internationale (SI), unless design or manufacturing heritage precludes this.

RB_PRD-240 All interface documents shall provide units in SI and in United States customary unit of measure, with the primary (as-designed) units displayed above the converted units with the latter in parentheses.

3.5 Mission Time Convention

RB_PRD-242 The Instrument shall use Coordinated Universal Time (UTC), including the leap second convention.

3.6 Risk Classification

The JPSS Observatory mission risk classification is Class B, as per NPR 8705.4 Risk Classification for NASA Payloads.

3.7 Mission Assurance Requirements

RB_PRD-247 The Instrument shall comply with the RBI Mission Assurance Requirements.

3.7.1 Single Fault Tolerance Design Requirements

The instrument should be single fault tolerant to meeting the mission objectives as defined in section 4 of this document.

RB_PRD-250 The Instrument shall be designed so that there are no credible single point failures, where "credible" is defined as having a probability of greater than 0.1% at EOL.

RB_PRD-251 Instrument deployables and mechanisms or articulating appendages shall be designed without any credible single point of failure and with all elements critical to deployment and articulating drive functions redundant.

3.7.2 Reliability Design Requirements

RB_PRD-253 The Instrument shall have a minimum on-orbit operational life of 7 years with a probability of success (Ps) of 0.85 or greater.

3.7.3 Safety Requirements

Non-explosive actuators are preferred over pyrotechnic devices wherever practicable in order to minimize shock loads.

RB_PRD-256 Circuitry that resides in components due to re-use of heritage designs (e.g., unused serial interface chips) and is not utilized by the instrument shall be identified and depopulated with appropriate termination to prohibit inadvertent operation. Exceptions will be explicitly delineated in this document.

RB_PRD-257 Operational functions that reside on components due to re-use of heritage designs (e.g., Field Programmable Gate Array (FPGA) code) and are not utilized by the instrument shall be disabled from inadvertent operation. Exceptions will be explicitly delineated in this document.

3.8 Space Asset Protection/Security

RB_PRD-259 The Instrument GSE and facilities shall be designed to prevent unauthorized access to Observatory and Instrument systems, per NPR 2810.1A.

3.9 Orbital Debris

RB_PRD-261 The Instrument shall limit orbital debris generation per the U.S. National Space Policy of 2010 and NPR 8715.6 – NASA Procedural Requirements (NPR) for Limiting Orbital Debris dated May 14, 2009.

4 INSTRUMENT SCIENCE PERFORMANCE REQUIREMENTS

The objective of this Instrument development project is to continue the ERB measurements from the last two decades in support of global climate monitoring. Specifically the Instrument will extend the ERB measurements of heritage CERES instruments on the NASA EOS, SNPP, and JPSS-1 satellites.

The CERES instruments are broadband radiometers that scan Earth, observing reflected shortwave and Earth-emitted radiance at top-of-atmosphere (TOA). These observations are used to measure the time and space distribution between incoming energy from the Sun and outgoing thermal and reflected energy from Earth (known as Earth's radiation budget). They aid in the development of a quantitative understanding of the links between the radiation budget and the properties of the atmosphere and surface that define it, and improve models of Earth's climate system.

From these raw CERES measurements, the following are derived with aid of ancillary data provided by other instruments and systems through post-processing: (1) radiation data as fluxes at the TOA, at the Earth's surface, and as flux divergences within the atmosphere; and (2) cloud data in terms of measured area coverage, altitude condensed water density, and shortwave and longwave optical depths.

Critical to derivation of flux estimates from radiance measurements is the use of Angular Distribution Models (ADM). The CERES ADMs for hundreds of scene types were developed over a period of years by operating one of the two heritage CERES instruments on EOS-Terra in rotating azimuth plane (RAP) mode while the other was dedicated to systematic ERB measurements by operating in cross-track scan mode. ADMs were also developed in the same manner using the two heritage CERES instruments on EOS-Aqua.

Because ADMs depend on the point spread function (PSF) of the Instrument, significant differences in the PSF of an instrument from which ADMs were derived and the PSF of an instrument measurement to which those ADMs are applied leads to significant biases in the flux estimates.

Since an objective of the Instrument development project is to continue the ERB measurements in support of global climate monitoring, it is important that the flux estimates from the new Instrument be consistent with those of the heritage instruments. Since that entails the use of existing ADMs, it is essential that the Instrument have a PSF that yields a Ground Field of View in the range of those heritage CERES instruments on EOS, SNPP, and JPSS-1 satellites.

4.1 Radiance Measurements

RB_PRD-270 The Instrument shall provide independent measurement of broadband reflected solar radiance (Shortwave Measurement or Shortwave Channel).

RB_PRD-271 The Instrument shall provide independent measurement of Earth emitted thermal radiance (Longwave Measurement or Longwave Channel).

RB_PRD-272 The Instrument shall provide independent measurement of combined broadband reflected solar radiance and Earth emitted thermal radiance (Total Measurement or Total Channel).

4.1.1 Shortwave Measurement

4.1.1.1 Shortwave Measurement Bandpass

RB_PRD-275 The shortwave channel shall have a normalized Relative Spectral Response (RSR) between the upper and lower bounds as defined in Table 4.1.1.1-1 and shown in Figure 4.1.1.1-1.

The RSR includes detector response as well as filter and optical transmittances and reflectances.

Table 4.1.1.1-1 Shortwave Channel Relative Spectral Response Requirements

Wavelength, micron	Lower Bound	Upper Bound
0.200	0.000	1.000
0.320	0.000	1.000
0.390	0.750	1.000
3.700	0.750	1.000
4.750	0.000	1.000
5.000	0.000	1.000
5.000	0.000	0.005
50.000	0.000	0.005

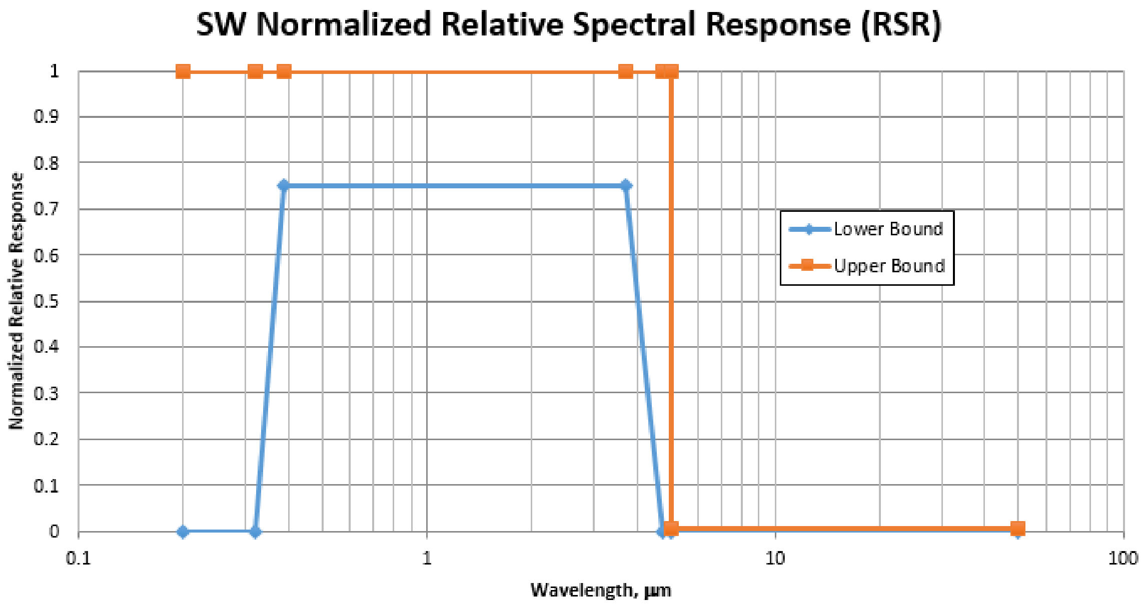


Figure 4.1.1.1-1 Shortwave Channel Relative Spectral Response Requirements

4.1.1.2 Shortwave Measurement Out-Of-Band Response

RB_PRD-318 The out-of-band spectral response of the shortwave channel shall be such that

$$\int_{5\mu m}^{100\mu m} R_{sw}(\lambda)L(\lambda)d\lambda \leq 0.005 \int_{5\mu m}^{100\mu m} L_{\lambda}(\lambda)d\lambda$$

where $L_{\lambda}(\lambda)$ is the spectral radiance (W/m^2-sr-µm) from a 300 K blackbody and $R_{sw}(\lambda)$ is the relative spectral response of the shortwave measurement.

4.1.2 Longwave Measurement

4.1.2.1 Longwave Measurement Bandpass

RB_PRD-323 The longwave channel shall have a normalized RSR between the upper and lower bounds as defined in Table 4.1.2.1-1 and shown in Figure 4.1.2.1-1.

Table 4.1.2.1-1 Longwave Channel Relative Spectral Response Requirements

Wavelength, micron	Lower Bound	Upper Bound
0.200	0.000	0.005
5.000	0.000	0.005

Wavelength, micron	Lower Bound	Upper Bound
5.000	0.000	1.000
5.250	0.000	1.000
6.500	0.750	1.000
50.000	0.750	1.000

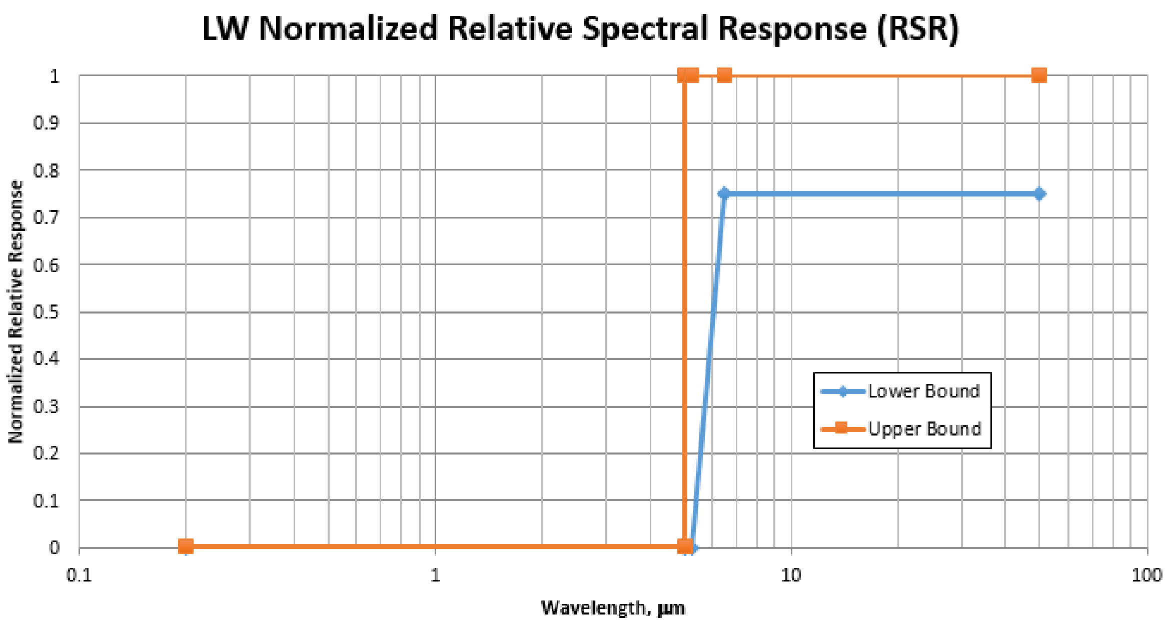


Figure 4.1.2.1-1 Longwave Channel Relative Spectral Response Requirements

4.1.2.2 Longwave Measurement Out-Of-Band Response

RB_PRD-361 The out-of-band spectral response of the longwave channel shall be such that

$$\int_{0.2\mu m}^{4.5\mu m} R_{lw}(\lambda)L(\lambda)d\lambda \leq 0.005\int_{0.2\mu m}^{4.5\mu m} L_\lambda(\lambda)d\lambda$$

where $L_\lambda(\lambda)$ is the spectral radiance (W/m^2-sr-µm) from a 2700 K blackbody and $R_{lw}(\lambda)$ is the relative spectral response of the longwave channel.

4.1.3 Total Measurement

4.1.3.1 Total Measurement RSR

RB_PRD-366 The total channel shall have a normalized RSR between the upper and lower bounds as defined in Table 4.1.3.1-1 and shown in Figure 4.1.3.1-1.

Table 4.1.3.1-1 Total Channel Relative Spectral Response Requirements

Wavelength, micron	Lower Bound	Upper Bound
0.200	0.000	1.000
0.320	0.000	1.000
0.350	0.750	1.000
60.000	0.750	1.000
100.000	0.600	1.000

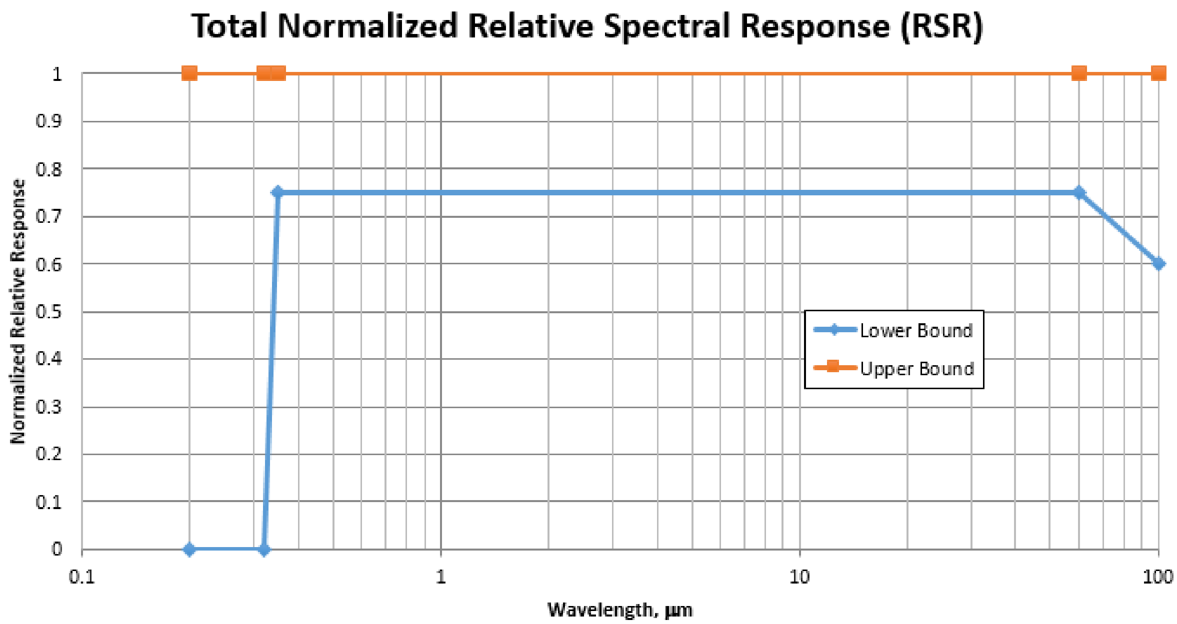


Figure 4.1.3.1-1 Total Channel Relative Spectral Response Requirements

4.1.3.2 Total Measurement In-Band RSR

Let the unfiltered total channel response be defined as:

$$U_{Li} = \int_{0.25\mu m}^{100\mu m} L_{\lambda i}(\lambda) d\lambda$$

and let the filtered total channel response be defined as:

$$F_{Li} = \int_{0.25\mu m}^{100\mu m} R(\lambda) L_{\lambda i}(\lambda) d\lambda$$

where R(λ) is the measured value of the total channel RSR at wavelength λ, and $L_{\lambda i}(\lambda)$,

i = 1, 2, 3 are the three incident spectral radiance distributions supplied in NASA Langley Research Center (LaRC) RBI Systems Engineering Reports RBI-FM1-SER-001, “Radiation Budget

Instrument Standard Scene Spectra Document", and RBI-FM1-SER-002, "Radiation Budget Instrument Standard Scene Spectra Data" titled "Clear Land", "Clear Ocean", and "Cloudy Ocean".

Linear regression is used to fit a curve of the form:

$$U_{Li} = \beta_o + \beta_1 F_{Li} + \varepsilon_i$$

where ε_i are the residuals, by determining coefficients, β_0 and β_1, that minimize the sum of the squared residuals. The standard uncertainty of the estimate is given by:

$$s = \sqrt{\frac{\sum_{i=1}^{n} \varepsilon_i^2}{n}}$$

and the mean response is:

$$\overline{U_L} = \frac{1}{n}\sum_{i=1}^{n} U_{Li}$$

RB_PRD-406 The relative standard uncertainty of the estimate shall be less than eight tenths of one percent of the mean response, i.e. $s \leq 0.008\ \overline{U}_L$, for all temperatures of the detector surface expected in flight.

RB_PRD-407 The absolute value of each residual, $|\varepsilon_i|$, shall be ≤ 2.5 W/m^2-sr for all temperatures of the detector surface expected in flight.

RB_PRD-408 The absolute value of the constant coefficient, $|\beta_0|$, shall be ≤ 10 W/m^2-sr for all temperatures of the detector surface expected in flight.

4.2 Radiometric Measurements

The definitions used in stating the instrument radiometric performance are specified in National Institute of Standards and Technology (NIST) Handbook 152 (based on Bureau International Des Poids Et Measures (BIPM): Evaluation of measurement data – Guide to the expression of uncertainty in measurement, JCGM 100:2008). Reporting of Type A and Type B evaluation of standard uncertainties, combined standard uncertainties, and expanded uncertainties as well as appropriate coverage factors (k) are specified in NIST Technical Note 1297. The measurement equation, often called the calibration equation, for the measured TOA in-band radiances, the method for reporting uncertainties in the measured radiances, and the method for propagation of uncertainties are specified in NIST Technical Note 1297.

RB_PRD-411 The Instrument shall have a total change in expanded uncertainty in each channel of less than 0.2% of that channel's maximum value of radiance given in section 4.2.1 over any 365 day period after activation is complete.

4.2.1 Radiometric Dynamic Ranges

RB_PRD-413 The Instrument shall have dynamic ranges given by:

Channel	Range (W/m^2-sr)
Total Channel (L_T)	0 to 500
Longwave Channel (L_E)	0 to 180
Shortwave Channel (L_R)	0 to 425

L_R = Earth reflected solar radiance in the Shortwave (SW) channel bandwidth within the field of view (FOV), W/m^2-sr
L_E = Earth emitted radiance in the Longwave (LW) channel bandwidth within the FOV, W/m^2-sr
L_T = Combined Earth reflected solar radiance in the Total channel bandwidth and Earth emitted radiance within the FOV, W/m^2-sr

4.2.2 Radiometric Resolution

RB_PRD-422 The Instrument shall have radiometric resolution over the full dynamic range sufficient to achieve the repeatability required in Section 4.2.5.

4.2.3 Noise Equivalent Radiance (NER)

RB_PRD-424 The Instrument shall have Noise Equivalent Radiance (NER) consistent with the overall requirement for radiance measurement noise given in Section 4.2.5.

4.2.4 Long-Term Radiance Measurement Expanded Uncertainties

RB_PRD-426 The Instrument shall have a Total channel radiance estimate of L_T, with expanded uncertainty ($k = 1$), including measurement noise, ≤ the larger of 0.575 W/m^2-sr or 0.5% of L_T for all Earth-viewing radiances as shown in Figure 4.2.4-1.

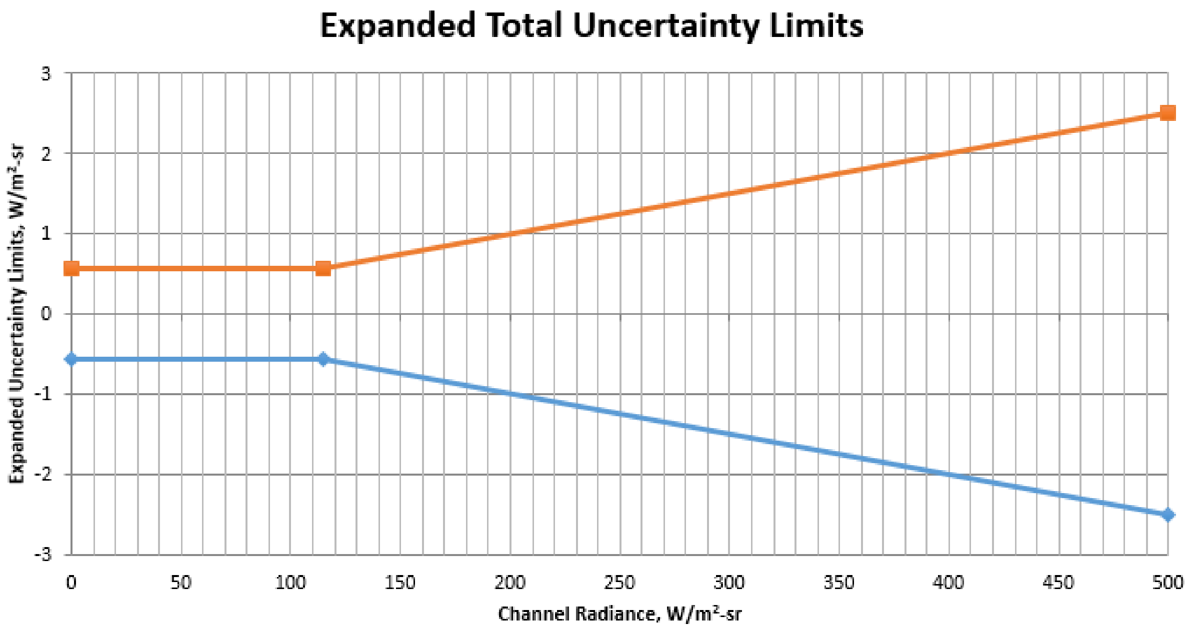


Figure 4.2.4-1 Total Channel Expanded Uncertainty Limits

RB_PRD-429 The Instrument shall have a Longwave channel radiance estimate of L_E with expanded uncertainty (k = 1), including measurement noise, ≤ the larger of 0.575 W/m^2-sr or 0.5% of L_E for all Earth-viewing radiances as shown in Figure 4.2.4-2.

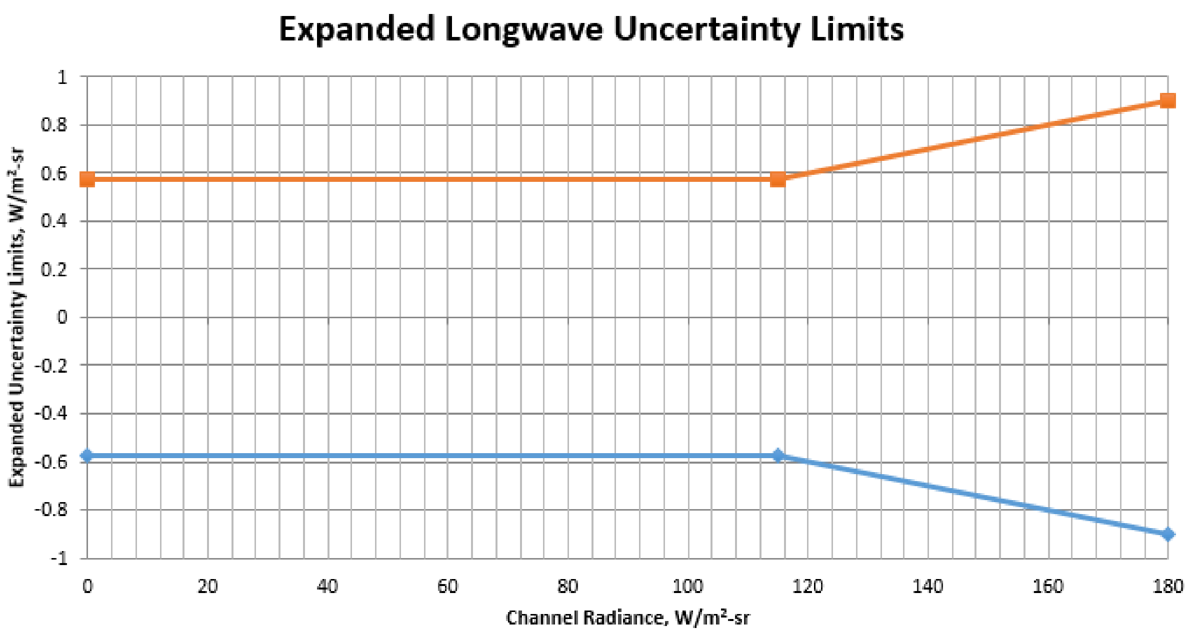


Figure 4.2.4-2 Longwave Channel Expanded Uncertainty Limits

RB_PRD-432 The Instrument shall have a Shortwave channel radiance estimate of L_R, with expanded uncertainty (k = 1) including measurement noise, ≤ the larger of 0.750 W/m^2-sr or 1.0% of L_R for all Earth-viewing radiances as shown in Figure 4.2.4-3.

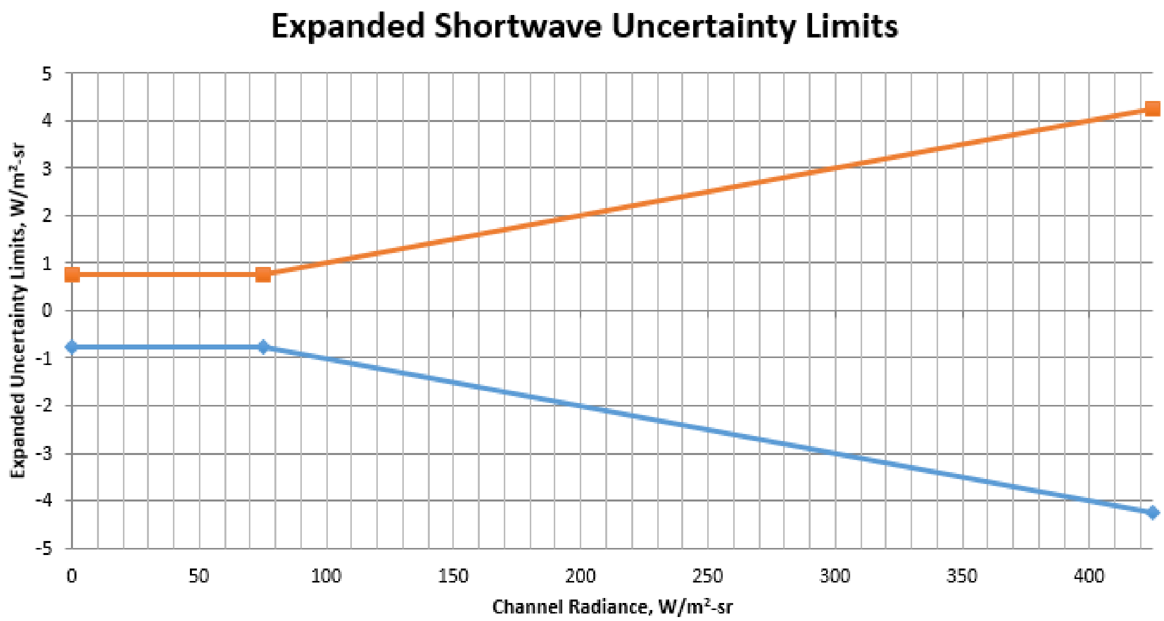


Figure 4.2.4-3 Shortwave Channel Expanded Uncertainty Limits

4.2.5 Short-Term Radiance Measurement Expanded Uncertainties

Short-Term repeatability is interpreted as measurement variation over any 1- month interval during the mission. Included are variations between measurements within an orbit, from orbit to orbit, and from day to day over a 1-month period. Any variations with time periods exceeding 1 month are considered to be Long-Term repeatability. Long-Term repeatability is to be included in the radiance measurement expanded uncertainties of paragraph 4.2.4.

RB_PRD-437 The Instrument shall have a Total channel short-term repeatability, with expanded uncertainty (k = 3), of ≤ 0.2 W/m^2-sr ± 0.1% of L_T for all Earth-viewing radiances as shown in Figure 4.2.5-1.

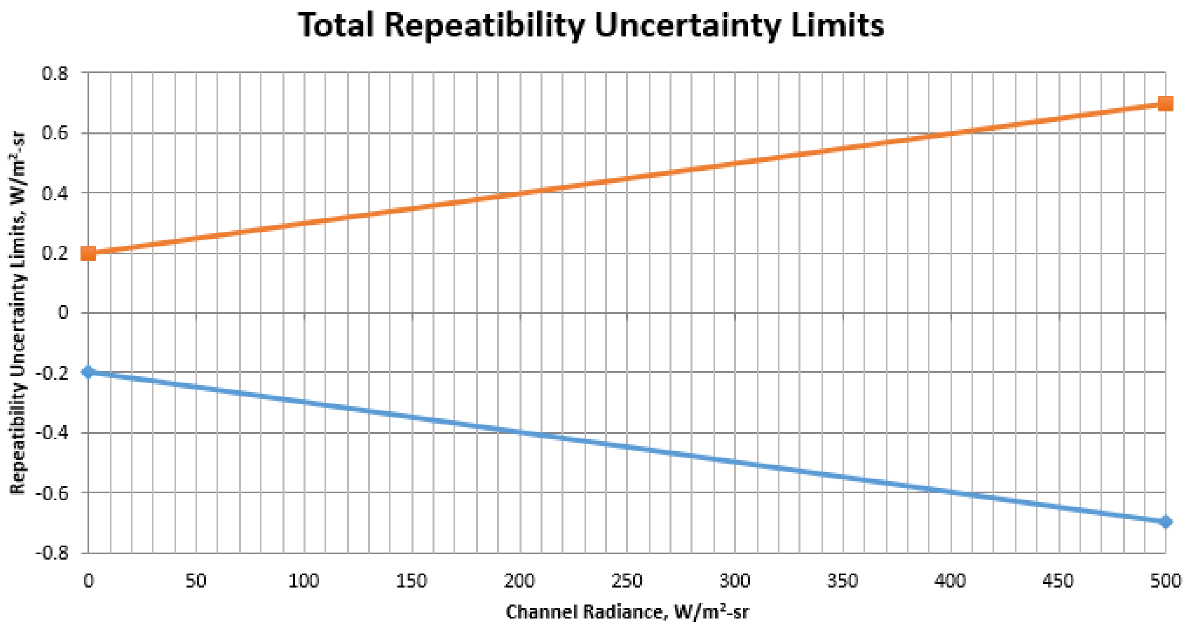


Figure 4.2.5-1 Total Channel Short-Term Repeatability Uncertainty Limits

RB_PRD-440 The Instrument shall have a Longwave channel short-term repeatability, with expanded uncertainty (k = 3), of ≤ 0.2 W/m^2-sr ± 0.1% of L_E for all Earth-viewing radiances as shown in Figure 4.2.5-2.

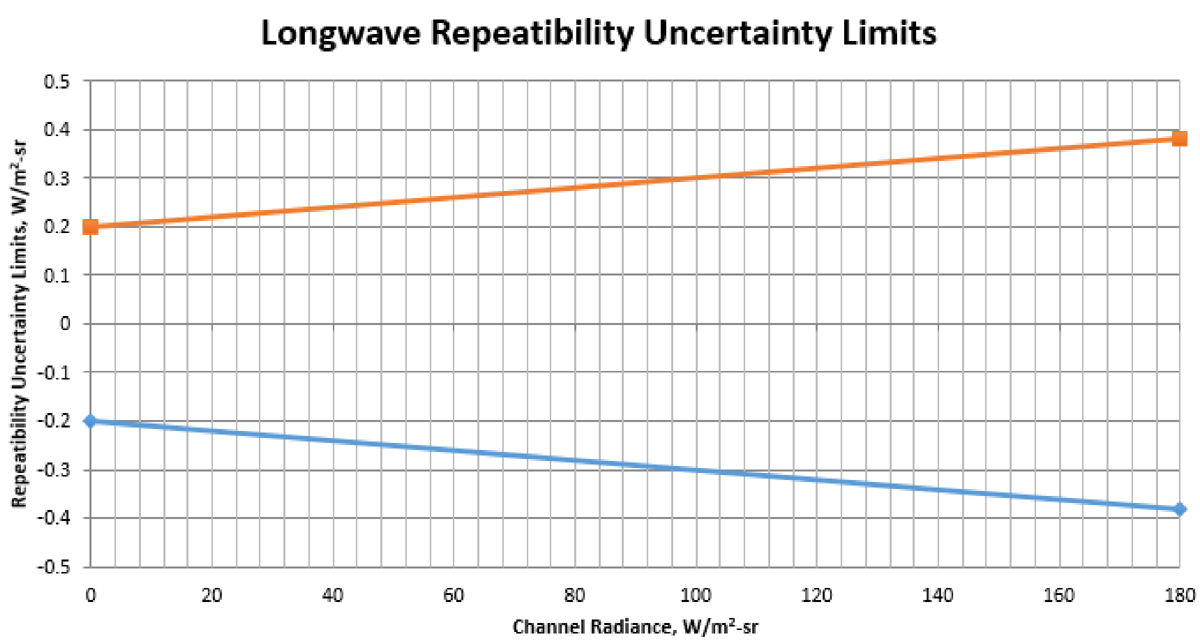


Figure 4.2.5-2 Longwave Channel Short-Term Repeatability Uncertainty Limits

RB_PRD-443 The Instrument shall have a Shortwave channel short-term repeatability, with expanded uncertainty (k = 3), of ≤ 0.2 W/m^2-sr ± 0.1% of L_R for all Earth-viewing radiances as shown in Figure 4.2.5-3.

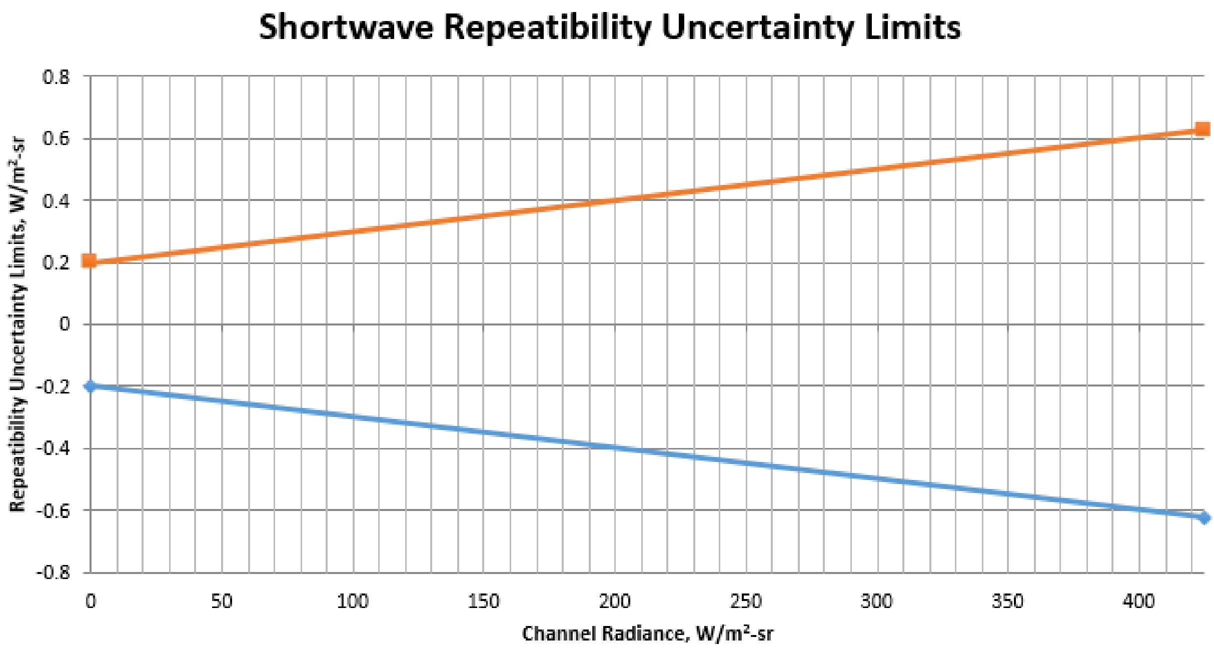


Figure 4.2.5-3 Shortwave Channel Short-Term Repeatability Uncertainty Limits

4.2.6 Linearity

RB_PRD-447 Each channel of the Instrument shall be end-to-end linear within 0.3% of that channel's maximum value of radiance given in Section 4.2.1.

4.2.7 In-Flight Calibration

RB_PRD-449 The Instrument shall utilize an on-orbit calibration system to facilitate detection of responsivity changes in each channel.

RB_PRD-450 The Instrument shall utilize the Sun and Moon as extraterrestrial calibration sources to facilitate detection of responsivity changes in each channel.

4.2.7.1 Calibration Sources

RB_PRD-452 The Instrument shall collect calibration data for the Total and Longwave channels periodically using at least one blackbody calibration target.

RB_PRD-453 The blackbodies shall have the capability to be operated at a temperature from the nominal instrument temperature to specific programmable temperatures above instrument ambient.

RB_PRD-454 The broadband radiance range covered by the blackbodies shall be at least 25 Watts/m^2-sr.

RB_PRD-455 The Instrument shall be capable of viewing the Sun indirectly with the shortwave and total channels as frequently as once per day for calibration.

RB_PRD-456 The Instrument shall include on-board shortwave calibration sources for the shortwave channel.

RB_PRD-457 The Instrument shall provide on-board shortwave calibration sources from 0.2 to ≥ 3.7 microns.

RB_PRD-458 The Instrument shall provide shortwave on-board calibration sources capable of verifying shortwave channel accuracy and stability at a minimum of three discrete levels covering a range of at least 25 W/m^2-sr to 400 W/m^2-sr.

RB_PRD-459 The Instrument shall provide in-flight calibration sources with in-flight repeatability adequate to insure that the Instrument is operating within the bounds of the Radiance Measurement Expanded Uncertainties given in Section 4.2.4.

4.2.7.2 On-Board Calibration Source Uncertainties

The Instrument calibration source uncertainties will be included in the Radiance Measurement Expanded Uncertainties described in Section 4.2.4 and reported as part of the End-to-End System Performance Analysis Report (DRD AM-21).

4.2.7.3 Calibration Frequency

RB_PRD-463 The Instrument shall have a calibration frequency adequate to meet requirements in Sections 4.2.4-4.2.5 for each measurement channel throughout the mission life.

4.3 Spatial and Temporal Response (Continuity with Heritage Earth Radiation Budget Measurement Samples)

The heritage CERES instrument spatial response, or sample size, is determined by the instrument optics (f/1.84 Cassegrain telescope with 1.8 cm entrance pupil), the size and shape of the optical field-stop (irregular hexagon 1.3° × 2.6°) defining the Instantaneous Field Of View

(IFOV), the bolometer time-constant (~0.00824 ± 0.00021 sec), the instrument scan-rate (63.14°/sec) and sample rate (100 sample/sec), and delays inherent in the electronics. The Shortwave, Longwave, and Total channels were spatially aligned and sampled simultaneously, so that measurements of radiance at TOA were spatially and temporally aligned. These factors were determined by a trade study that determined optimum design based on ground resolution, noise equivalent radiance, blur, and aliasing. The resultant sample, shown in Figure 4.3-1 by a dashed line, represents approximately 95% of the total energy contained in the PSF response. Since the PSF is defined in angular space at the instrument, the heritage CERES instrument sample is a constant in angular space at approximately 3.1° × 2.4°, but grows in surface area at the Earth from a minimum at nadir to a larger area at larger viewing zenith angles. For EOS Terra at a nominal orbital altitude of 705 km, the length and width of the sample at nadir is 37 × 28 km at TOA (30 km altitude) and grows to as much as 243 × 63 km at a viewing zenith angle of 70°. For SNPP at a nominal orbital altitude of 824 km, the length and width of the sample at nadir is 43 × 33 km at TOA (30 km altitude) and grows to as much as 286 × 74 km at a viewing zenith angle of 70°. The total bi-directional scan period of 6.6 seconds for the normal Earth scan is such that there are 3.3 seconds between successive nadir views and there is sample overlap in the cross-track and along-track directions. Refer to the CERES Collection Guides available at http://ceres.larc.nasa.gov/collect_guide.php.

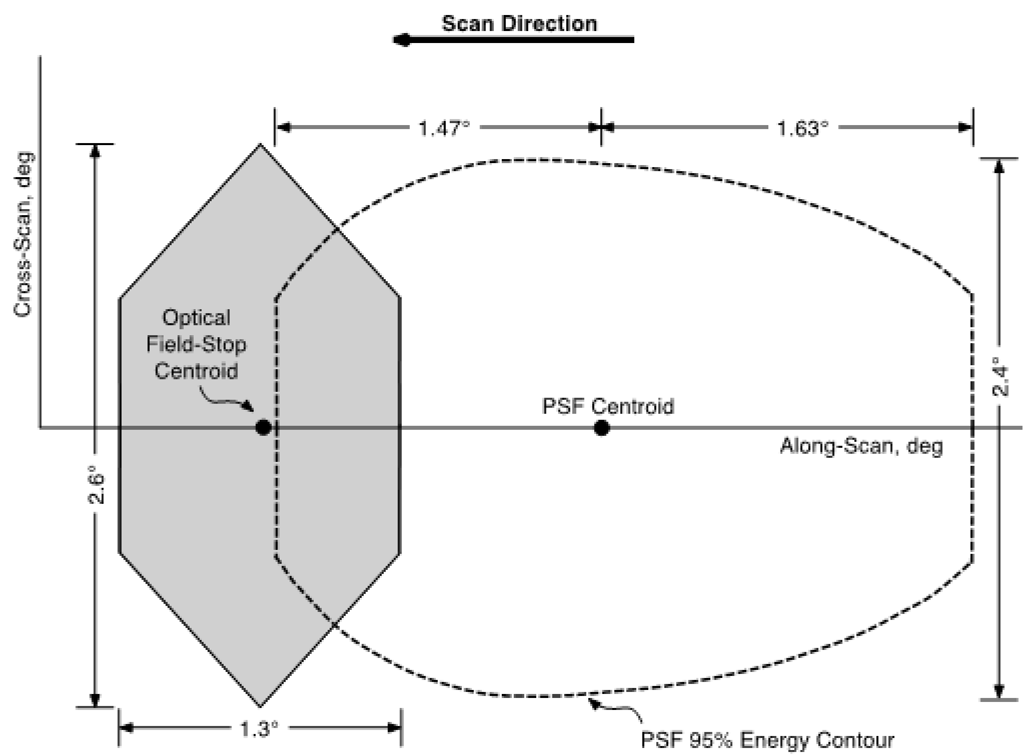


Figure 4.3-1 Shape and relative spacing of optical field-stop and the PSF 95% energy contour of a nominal heritage CERES instrument in angular space.

4.3.1 Field Of Regard (FOR)

RB_PRD-469 The Instrument shall have a field-of-regard (FOR) which includes the entire Earth disk.

4.3.2 PSF

RB_PRD-471 The Instrument optics, IFOV, detector configuration (single detector or detector array), detector time-constant(s), Instrument scan-rate, and sample rate for the Instrument channels shall be such that a sample in angular space, defined by the 95% contour of the PSF response, shall be no larger than the nominal heritage CERES PSF described in Section 4.3.

RB_PRD-473 The Instrument shall provide EHCIS overlap in the elevation scanning direction of 1/2 IFOV or greater for a nominal elevation scan rate.

RB_PRD-474 The Instrument shall provide EHCIS overlap at nadir in the along-track (±X) direction of 1/3 IFOV or greater in the Cross-track (Swath) sub-mode.

4.3.3 Spatial and Temporal Alignment

The ideal spatial and temporal alignment would ensure that each sample radiance measurement of the three spectral bands (Shortwave, Longwave, and Total) has exactly the same overlapped PSF footprint on Earth. Let $\hat{W}_{ii}(\theta, \phi)$ be the impulse response of the EHCIS of the i^{th} band, where i = 1, 2, 3; θ is the cone angle (radians) from an optical axis common to measurements in all three spectral bands; ϕ is the clock angle (radians) from any convenient axis common to measurements in all three spectral bands, and the impulse response of the EHCIS for each band is calculated on a time basis common to measurements in all three spectral bands. $\hat{W}_i(\theta, \phi)$ is the impulse response of the EHCIS of the Instrument normalized by

$$\widehat{W_i}(\theta, \phi) = W_i(\theta, \phi)/A_i$$

where

$$A_i^2 = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} W_i^2(\theta, \phi) \sin\theta d\theta d\phi$$

and i = 1, 2, 3.

RB_PRD-481 All of the quantities

$$\int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi}\widehat{W_i}(\theta,\phi)\widehat{W_j}(\theta,\phi)\sin\theta d\theta d\phi$$

(where *i*, *j* = 1, 2, 3) shall exceed or equal 0.98 over the time period required to collect the SW, Total, and LW radiance measurements.

RB_PRD-484 The scan plane shall be perpendicular to the Instrument X-Y coordinate plane per Section 3.2 to within ±0.05°.

RB_PRD-485 In the cross-track scan mode, the scan plane shall be oriented perpendicular to the Instrument X-Z coordinate plane per Section 3.2 to within ±0.05°.

RB_PRD-486 The optical boresight angular displacement of each radiometric channel from the cross-track scan plane shall be known to within ±0.05° for each channel data point (including solar calibration) in every scan cycle.

RB_PRD-487 The location of the solid angle common to the three (3) channels, relative to the Instrument's alignment cube axes, shall be known, from telemetry data, with an uncertainty ≤ ±0.05°, and have a resolution equal to or better than ±0.01° over the scan.

5 OBSERVATORY FUNCTIONAL REQUIREMENTS

5.1 Orbit Definition

The Instrument will operate throughout its mission lifetime in a polar Sun-synchronous orbit with the following characteristics:

Nominal Altitude: 824 km ± 17 km

Ground Track Repeatability Accuracy: ±20 km at the equator

Ground Track Repeat Cycle: <20 days

Nominal Ascending Equator Crossing Time: 1330 (local time) ± 10 min

5.2 Geolocation Requirements

RB_PRD-496 The geolocation knowledge of the Instrument boresight, referenced to the center of the effective FOV for any channel, shall be within 2.50 km (3 sigma) of the true location of that FOV, at nadir, on the WGS84 reference ellipsoid, at any time during nominal JPSS-2 operations.

5.3 Observatory Attitude Control Modes and Requirements

5.3.1 Instrument and Observatory Pointing Requirements

The Instrument Contractor will develop budgets and derived requirements for geolocation knowledge, pointing accuracy, pointing stability, and jitter based on the required Instrument performance and JPSS Project allocations. The budgets and allocations will be included in a future revision of this document and/or the Instrument-to-Spacecraft ICD.

5.3.2 Spacecraft Attitude and Position Knowledge

The inertial attitude knowledge of the Spacecraft Attitude Determination Frame will be less than 21 arcsec (3 sigma) per axis.

During Engineering and Science Operations Modes, the Spacecraft will be capable of providing a time-tagged orbital position estimate accurate to 75/75/75 meters (3 sigma) for radial/in-track/cross-track components with frequency of 1 Hz.

5.3.3 Nominal Observatory Attitude

RB_PRD-505 The Instrument shall meet the performance requirements defined in Section 4 while the Observatory is in the nominal mission attitude.

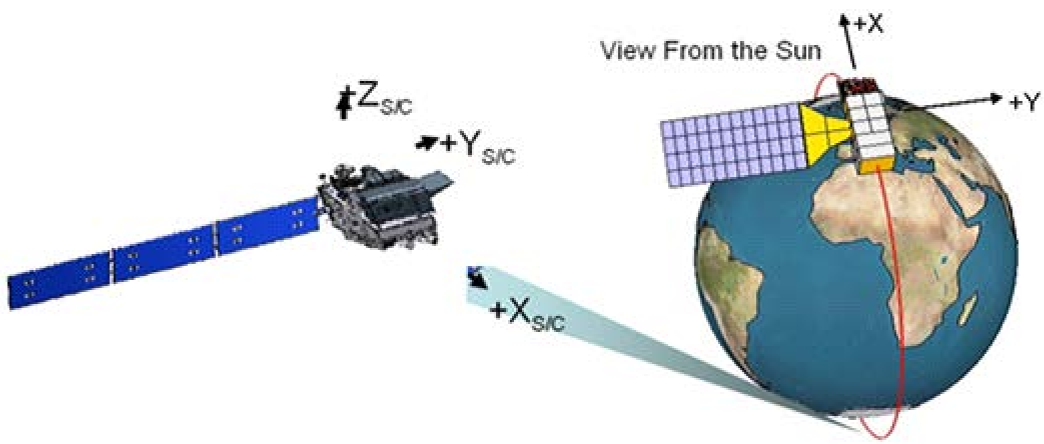


Figure 5.3.3-1 Typical Observatory configuration for the JPSS 1330 nodal crossings engineering and science operations modes.

During science operations mode (see Figure 5.3.3-1), the Spacecraft will orient the Spacecraft body frame such that the Spacecraft +Z-axis is aligned with geodetic nadir and the +X-axis is aligned with the instantaneous orbital velocity vector.

The Spacecraft Attitude Control Error during any orbit, excluding the effects due to jitter, will be less than 108 arcsec (3 sigma) per axis during all mission data collection periods.

The Spacecraft Attitude Control Rate Error during any orbit, excluding effects due to jitter, will be less than 108 arcsec/sec (3 sigma) during all mission data collection periods.

The Spacecraft will, in the absence of failure, remain oriented so as to keep direct sunlight off the "cold" side of the Instrument.

5.3.4 Observatory Attitude – Safe Mode

In the event of a failure, the Spacecraft will limit exposure of the instruments to solar input onto sensitive surfaces, to the extent that sensitive surfaces and exposure limits are defined in the individual ICDs.

5.3.4.1 Earth-Pointing Safe-Mode

RB_PRD-515 The Instrument shall survive the Observatory Earth-Pointing Safe Mode without permanent damage.

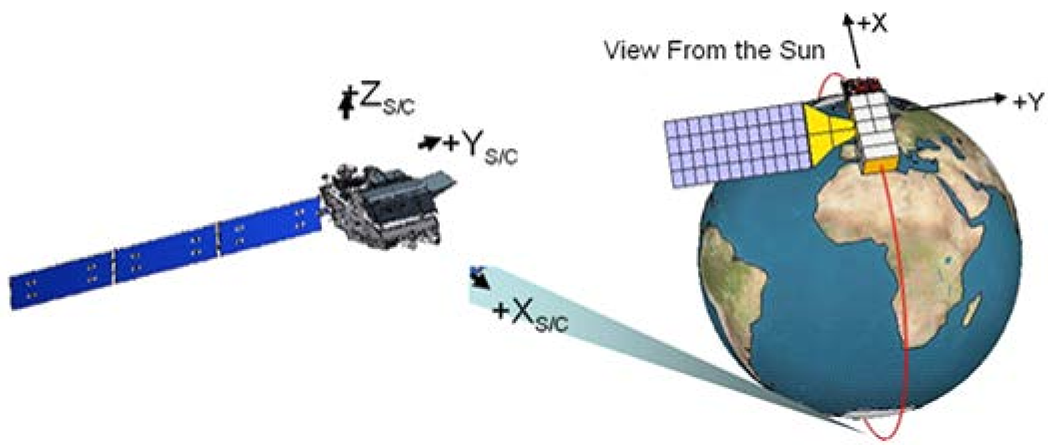


Figure 5.3.4.1-1 Typical Observatory configuration for the JPSS 1330 nodal crossings Earth-pointing safe-hold mode.

The Spacecraft will provide an Earth-pointing safe-hold capability defined as the ability to maintain the science mode attitude with three axis pointing control within 10.0 degrees or better (3 sigma) under wheel control from any starting orientation for an indefinite period of time (see Figure 5.3.4.1-1*).*

5.3.4.2 Sun-Pointing Safe-Mode

RB_PRD-520 The Instrument shall survive the Observatory Sun-Pointing Safe-Mode without permanent damage.

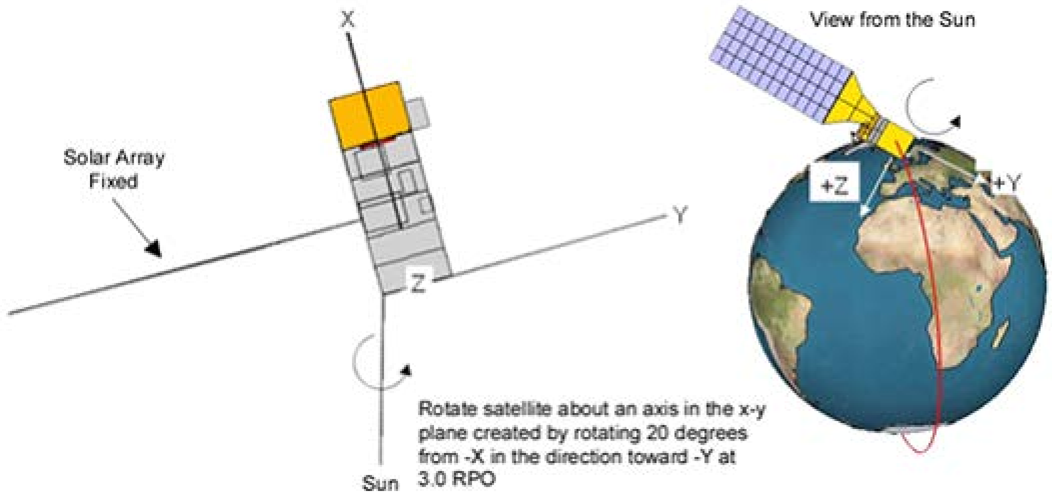


Figure 5.3.4.2-1 Typical Observatory configuration for the JPSS 1330 nodal crossings survival Sun-point mode.

The Spacecraft will provide a Sun-pointing safe-hold capability defined as the ability to transition to a rotation rate about the sun vector with control of 15.0 degrees or better (3 sigma) under wheel control from any starting orientation for an indefinite period of time (see Figure 5.3.4.2-1*).*

5.3.4.3 Special Observatory Attitudes – Science Calibration Maneuvers

RB_PRD-525 The Instrument shall have the capability to survive the calibration maneuvers listed in JPSS-2 Spacecraft to RBI Instrument Interface Control Document (ICD) Table RBI-50 and return to nominal operations upon completion of the maneuvers.

5.4 Mission Phase Requirements

The JPSS Mission Concept of Operations (472-00020) defines the following seven mission phases:

- *Assembly, Integration and Test (AI&T), and Ground Storage*
- *Pre-Launch/Launch Readiness*
- *Launch and Orbit Attainment*
- *Satellite Activation, Check-out, and Commissioning*
- *Instrument Calibration and Validation*
- *Mission Operations*
    - *Routine Operations*
    - *Non-routine Operations*

- *Contingency Operations*
- *EOL Decommissioning*

5.4.1 AI&T, and Ground Storage Phase

RB_PRD-576 The Instrument shall be designed for a 2-year ground storage period at Observatory level, which includes routine maintenance and monitoring activities to ensure no loss of functional capabilities.

RB_PRD-577 The Instrument shall be designed for a total of 8 years of ground storage. For reliability calculation purposes, the Instrument ground storage duration equates to 5000 equivalent hours of powered testing.

Note: The 2-year JPSS-2 Observatory ground storage period is included within the total 8-year Instrument storage period.

RB_PRD-579 The Instrument shall be designed for a total of 3 years of ground storage, under routine maintenance and monitoring activities, without the need for thermal vacuum testing or other temperature dependent calibration to maintain functional capabilities.

5.4.2 Pre-Launch/Launch Site Processing Phase

RB_PRD-581 The Instrument shall have the capability of being tested, while in storage and on the launch pad, to verify limited functionality.

RB_PRD-582 The Instrument shall have clearly identifiable and readily accessible red tag/green tag items.

5.4.3 Launch and Orbit Insertion Phase

As per requirement RB_PRD-658 in Section 5.5.1.2 the Instrument will be in "OFF" mode during launch. Therefore there is no requirement on the Instrument to store and forward telemetry during the launch and orbit insertion phase.

5.4.4 Satellite Activation, Checkout, and Commissioning Phase

RB_PRD-586 The Instrument shall complete outgassing, initial checkout, and be able to support initial science collection and evaluation within 45 days of launch.

RB_PRD-587 The Instrument shall complete commissioning within 90 days of nominal spacecraft operations after activation.

5.4.5 Intensive Instrument Calibration and Validation Phase

The Government will complete initial on-orbit calibration and validation within 1 year following launch.

5.4.6 Mission Operations Phase

5.4.6.1 Availability

RB_PRD-593 The Instrument shall be capable of continuous operation over the on-orbit life.

RB_PRD-594 The Instrument shall collect and enable transmit of ≥99% of the sensor data to the Spacecraft averaged over any 30-day period.

RB_PRD-595 The total time spent in outages that prevent acquisition of operational data shall not exceed 4 hours per month over the full operational lifetime of the Instrument.

5.4.7 EOL Decommissioning Phase

The Instrument will be passivated by removing instrument power prior to conducting the controlled reentry of the Observatory in accordance with NPR 8715.6A Requirement 56866. No additional passivation is required.

5.5 Mission Modes

5.5.1 Spacecraft Modes

Section 4.2-1 of the JPSS-2 Spacecraft to RBI Instrument ICD defines the Spacecraft mode and sub-mode configurations and Spacecraft mode transitions.

5.5.1.1 Observatory OFF-Mode Functional Requirement

RB_PRD-655 The Instrument shall be able to be remotely commanded into OFF mode during ground operations.

5.5.1.2 Launch Mode Functional Requirements

The JPSS Observatory will be in Launch Mode from pre-launch processing through separation from the launch vehicle.

RB_PRD-658 The Instrument mode at the time of launch shall be OFF.

Following orbit insertion and initial deployments, the Observatory will transition into SUN-POINTING SAFE-HOLD mode with the Instruments in their applicable SURVIVAL mode.

RB_PRD-660 The Instrument shall meet all requirements after being unpowered (no survival and no operational power) for ≤ 120 minutes after launch.

5.5.1.3 Spacecraft Safe Mode

As part of the process of entering a complete SPACECRAFT SAFE mode, the Spacecraft will initiate the INSTRUMENT SAFE mode described below, and may also turn off the Instrument, while ensuring the survival heater bus is enabled (see SURVIVAL Mode).

5.5.1.4 Engineering Modes

Engineering modes are a collection of modes where the Observatory initially performs Spacecraft check-out, Instrument outgassing, and other Observatory commissioning activities, as well as performs routine maintenance activities such as orbit adjust maneuvers and Instrument sensor calibration maneuvers.

5.5.1.4.1 Orbit Adjust/Collision Avoidance Sub-Mode

The Spacecraft will be capable of performing orbit adjust maneuvers necessary to support the mission orbit acquisition, maintenance, collision avoidance, and controlled reentry requirements defined in this specification.

5.5.1.4.2 Science Calibration Sub-Mode

In science calibration mode, the Spacecraft will perform the calibration maneuvers upon ground command, and return to nominal Observatory operations (including Earth-pointing orientation) upon completion.

5.5.1.5 Science Operations Mode

Science Operations mode is the predominant operating mode during the JPSS mission. All time spent in the Science Operations Mode counts towards the satisfaction of the mission availability requirements defined in Section 5.4.6.1.

The Spacecraft will be capable of performing Instrument data collection, including Instrument pointing, and mission data collection, storage and transmission.

5.5.1.6 Controlled Reentry Mode

Controlled Reentry mode is the final operating mode during the JPSS mission. During this mode the Spacecraft autonomously performs the deorbit maneuver to satisfy the requirements of the controlled reentry as well as passivates the Observatory in the event of maneuver failure. The Instrument will be commanded to OFF mode for passivation prior to reentry.

5.5.2 Instrument Modes

This section defines requirements associated with the five individual operating modes of the JPSS Instruments. The five main Instrument operating modes are:

- *Instrument OFF Mode*
- *Instrument SURVIVAL Mode*

- *Instrument SAFE Mode*
- *Instrument Engineering Modes: ACTIVATION, DIAGNOSTIC, and OUTGAS*
- *Instrument OPERATIONAL Mode*

While the modes can be dependent on the Spacecraft, when the Spacecraft is in science operations mode, the instruments can be in any of the above modes.

RB_PRD-685 The Instrument shall implement the following modes and functionalities, as appropriate, with the mode characterizations shown in Table 5.5.2-1.

Table 5.5.2-1 Instrument mode characterization.

Instrument Mode	Survival Power	Operational Power	Command and Telemetry	Meet Science Performance
OFF	OFF	OFF	No	No
Survival	Enabled	OFF	No	No
Instrument Safe	Enabled	ON	Yes	No
Engineering - Activation - Diagnostic - Outgas	Enabled*	ON	Yes	No**
Operational	Enabled*	ON	Yes	Yes

Yes or No = capability pertains to that mode/functionality

* = Survival heater bus enabled in Survival Mode. May or may not be remain enabled when on Operational Power.

** = Functional performance in Diagnostic Mode is not precluded, but is not required.

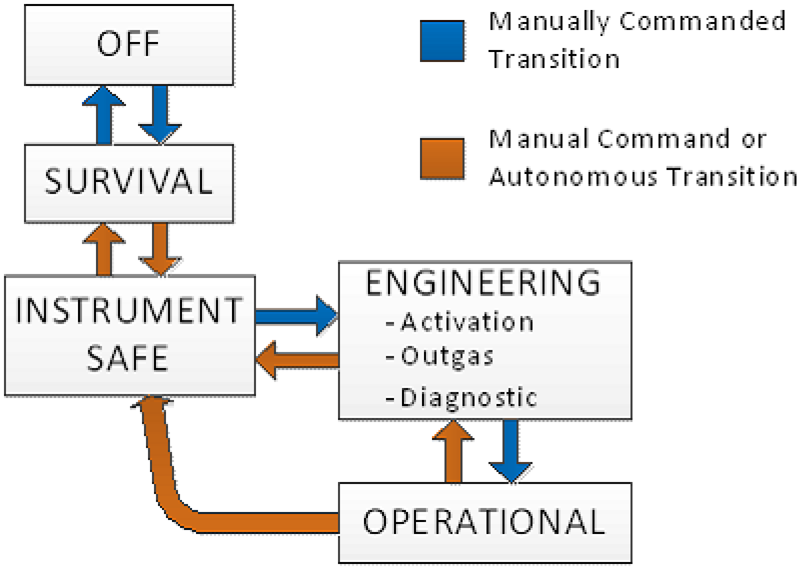


Figure 5.5.2-1 Instrument mode transition diagram.

RB_PRD-741 The Instrument shall be commandable into any of the modes shown in Figure 5.5.2-1.

RB_PRD-742 The Instrument shall cause no damage to any other Instrument or the Spacecraft when transitioning from any mode to any other mode.

5.5.2.1 Instrument OFF Mode

Instrument OFF mode may be used for ground storage & transportation, launch, and Spacecraft power crisis situations.

RB_PRD-745 The Instrument shall receive no external power, including survival heater power and operational power in OFF mode.

RB_PRD-746 The Instrument shall be capable of accepting, without damage, the sudden unplanned entry into the OFF mode from any other mode. This refers specifically to the sudden removal of operational power without first going through an orderly shutdown sequence.

5.5.2.2 Instrument Survival Mode

SURVIVAL mode is a low power mode from which the Observatory can eventually recover to full operational status. Only those functions required for Observatory safety, diagnostics and recovery will be powered.

RB_PRD-749 In SURVIVAL mode, the Instrument shall be able to survive indefinitely while the Spacecraft is in a Sun-pointing attitude.

RB_PRD-750 Initiation of Survival Mode shall not require commands to the instrument.

The Spacecraft will place the Instrument into SURVIVAL mode in the event of a severe Spacecraft emergency.

The Spacecraft will remove Instrument operational power during SURVIVAL mode.

The Spacecraft will ensure Instrument survival heater power is enabled during SURVIVAL mode.

The Spacecraft will ensure that both the primary and redundant survival heater circuits are normally enabled on-orbit when an Instrument is off.

RB_PRD-755 In those cases where an agreed-upon sequence of commands is sent to the Instrument prior to removing Instrument operational power, the Instrument shall transition into its SURVIVAL mode within 45 seconds after initiation of that command sequence.

In SURVIVAL mode, the Spacecraft will be responsible for sampling critical Instrument temperatures via the Instrument passive analog temperature sensors (normal Instrument telemetry is not available with operational power off).

5.5.2.3 Instrument SAFE Mode

RB_PRD-758 The Instrument shall enter SAFE mode upon detection of any on-orbit fault condition where failure to take prompt corrective action could result in damage to the instrument.

RB_PRD-759 The Instrument shall collect and transmit health and status data while in SAFE mode, but not science or calibration data.

RB_PRD-761 The Instrument shall autonomously configure to its SAFE mode within 45 seconds after receipt of a Spacecraft SAFE mode command.

RB_PRD-762 The Instrument shall configure itself such that no damage will occur if the next action from the Spacecraft is to command the Instrument to OFF mode.

RB_PRD-763 The command from the spacecraft for the Instrument to enter SAFE mode (i.e., "forcing" instrument safe mode) shall not be inhibitable by the Instrument.

RB_PRD-764 The Instrument shall remain in SAFE mode unless commanded by the Spacecraft to any other mode.

RB_PRD-664 The Instrument shall enter SAFE mode upon failing to receive a configurable number of consecutive time-code data packets from the Spacecraft.

RB_PRD-665 The Instrument shall accept configuration commands setting the number of missed consecutive time-code packets causing SAFE mode to range from 8 up to a maximum of 63 consecutive time-code-packets with 12 being the default.

5.5.2.4 Instrument Engineering Modes

Instrument engineering modes are the collection of modes where the Instrument initially performs the post-launch check-out and commissioning activities such as activation, outgassing, and calibrations, as well as performs routine maintenance activities such as software updates, outgassing and sensor calibrations. While the science performance requirements may be the same as science operations, time spent in engineering modes is NOT counted towards satisfaction of the mission availability requirements defined in Section 5.4.6.

5.5.2.4.1 Instrument Activation Mode

ACTIVATION refers to Instrument turn-on and stabilization within, and subsequent Instrument component warm-up, or cool-down, to the operating temperature, biases, and current ranges. ACTIVATION terminates when all Instrument temperatures, biases, and currents have stabilized within specified operational limits. For some instruments, this may refer to a period of time, rather than a different state of the Instrument. ACTIVATION also includes any deployments and opening of covers or shutters.

RB_PRD-769 The Instrument ACTIVATION mode shall enable the command and telemetry functions.

RB_PRD-770 The Instrument ACTIVATION mode shall enable scheduling of power-on events.

RB_PRD-771 The Instrument shall be functional without requiring software or data upload after receipt of an ACTIVATION mode command.

5.5.2.4.2 Instrument Diagnostic Mode

RB_PRD-773 The Instrument DIAGNOSTIC mode shall support housekeeping and software updates.

RB_PRD-774 The Instrument shall provide the capability to selectively disable any on-orbit processing operation that combines or compresses raw data in any manner.

5.5.2.4.3 Instrument Outgassing Mode

Instrument outgassing mode refers to any specialized mode that the Instrument must be in to ensure sufficient outgassing on-orbit prior to opening Instrument aperture covers. Time spent in the Outgassing Mode does not count towards the satisfaction of the mission availability requirements defined in Section 5.4.6. Details of the RBI outgassing mode, if implemented, will be included in a future revision of this document.

5.5.2.5 Instrument Operational Mode

Science Operations mode is the predominant operating mode during the JPSS mission. All time spent in the Science Operations Mode counts towards the satisfaction of the mission availability requirements defined in Section 5.4.6. All allocated Spacecraft resources will be available to the Instrument in OPERATIONAL mode.

RB_PRD-779 The Instrument shall provide all data necessary to produce the raw data records used to create the Level 0 data while in OPERATIONAL mode.

RB_PRD-780 The Instrument shall be capable of remaining in OPERATIONAL mode without damage while the Spacecraft performs orbit correction.

Instrument data collection is based on pointing the IFOV of the three channels in the Instrument scan plane (RB_PRD-484) at the Earth, Sun, Moon, deep-space, and internal calibration sources.

Generally the Instrument scan plane is fixed parallel to the Spacecraft Y-Z plane. This orientation facilitates heritage CERES cross-track (swath) collection. However to maintain additional heritage CERES collection capabilities the scan plan will be rotated about the Instrument azimuth (+Z) axis. This change in orientation puts the Instrument scan plane at arbitrary angles with respect to the Spacecraft Y-Z plane and allows collection of data from purely cross-track to purely in-track directions.

The Instrument will be operated primarily in five data collection sub-modes under control of ground commands:

1) "Cross-track" (Swath) where the scan plane is fixed parallel to the Spacecraft Y-Z plane (AZ = 0) while the IFOV is scanned continuously across the Earth to viewing zenith angles (VZA) of 90 degrees on both the Spacecraft +Y and –Y sides of the ground track.

2) "Bi-axial" (ADM) where the scan plane is rotated at various rates in both the positive and negative directions about the Instrument azimuth (Z-axis) while the IFOV is scanned continuously across the Earth.

3) "Earth Target" where predetermined ground locations, deep-space, and calibration sources are viewed by commanding the Instrument via uploaded command sequences chosen by the Instrument Operations Center (IOC).

4) "Calibration" where a calibration of any of the three channels is performed using any appropriate and available internal and external calibration sources.

5) "User defined" where predetermined arbitrary angles, rates, and durations within the Instrument pointing capability are uploaded command sequences chosen by the Instrument Operations Center (IOC).

RB_PRD-786 The Instrument shall prevent inadvertent exposure of the optics and detectors to direct sunlight.

5.5.2.5.1 Cross-Track Sub-Mode

RB_PRD-789 The Instrument shall have an elevation scan plane that is parallel to the Instrument Y-Z plane defined in RB_PRD-186 to within ±0.05° and move the IFOV at a constant rate between a viewing zenith angle (VZA) of 90° on the Spacecraft +Y and -Y side of the ground track while in Cross-track (Swath) sub-mode.

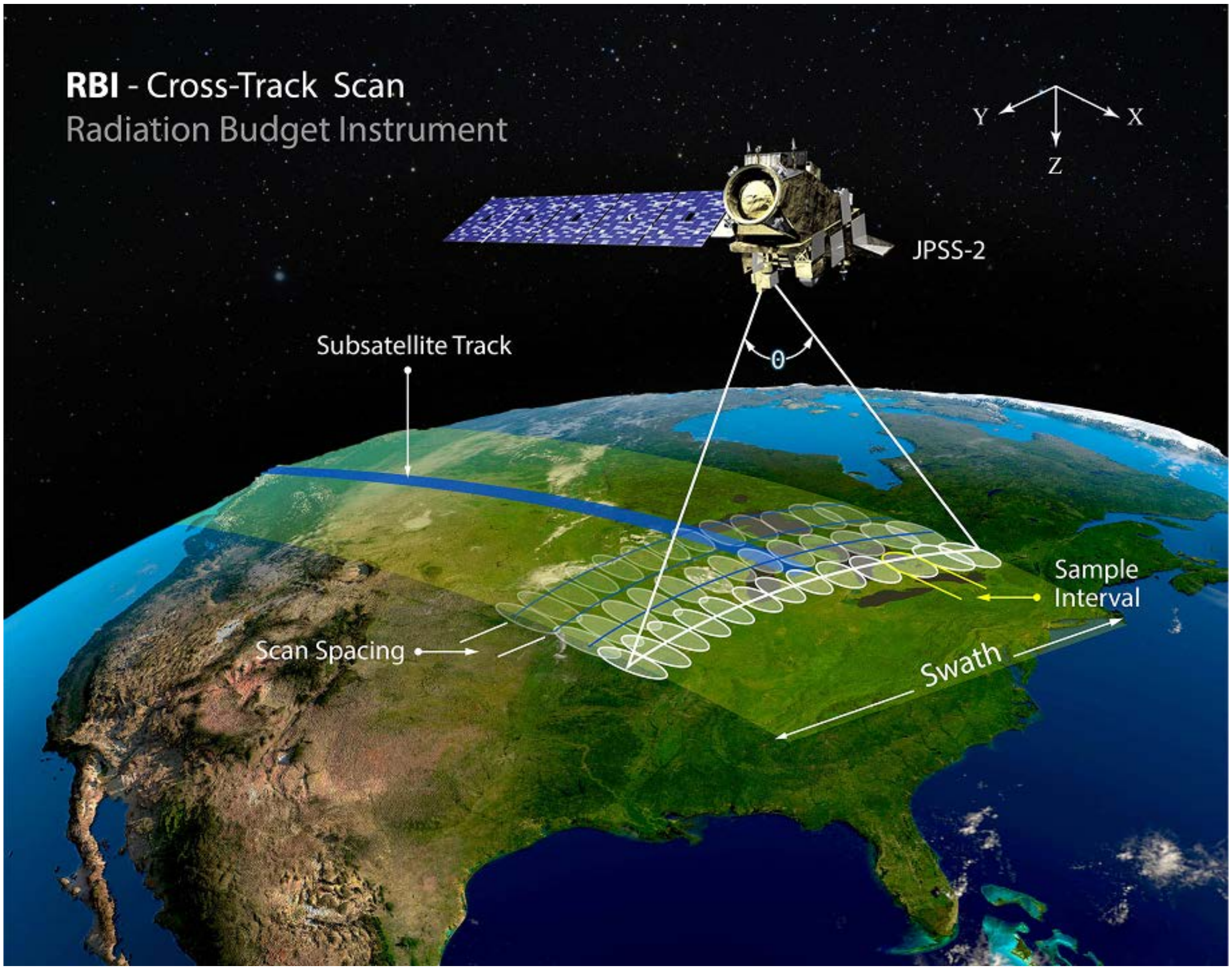


Figure 5.5.2.5.1-1 Cross-Track Scan

5.5.2.5.2 Bi-Axial Sub-Mode

RB_PRD-791 The Instrument shall simultaneously rotate the elevation scan plane about the Instrument +Z axis and move the IFOV at a constant rate between a viewing zenith angle (VZA) of 90° on the Instrument +Y and -Y side of Nadir while in Bi-axial sub-mode.

RB_PRD-792 The Instrument shall rotate the elevation scan plane ± 90 degrees with respect to the Instrument +X axis about the Instrument +Z axis (azimuth) while in the Bi-axial sub-mode.

RB_PRD-793 The Instrument shall rotate the elevation scan plane about the Instrument +Z axis (azimuth) at variable rates from 0.5 to 6 degrees per second in both the positive and negative directions at a maximum rate increment of 0.1 degrees per second as set by command while in the Bi-axial sub-mode.

RB_PRD-6358 The Instrument shall be capable of Azimuth motion (rotation of the elevation scan plane about the Instrument +Z axis) in both the positive and negative directions over the full angular range a minimum of 1.1×10^6 complete cycles while in Bi-axial sub-mode.

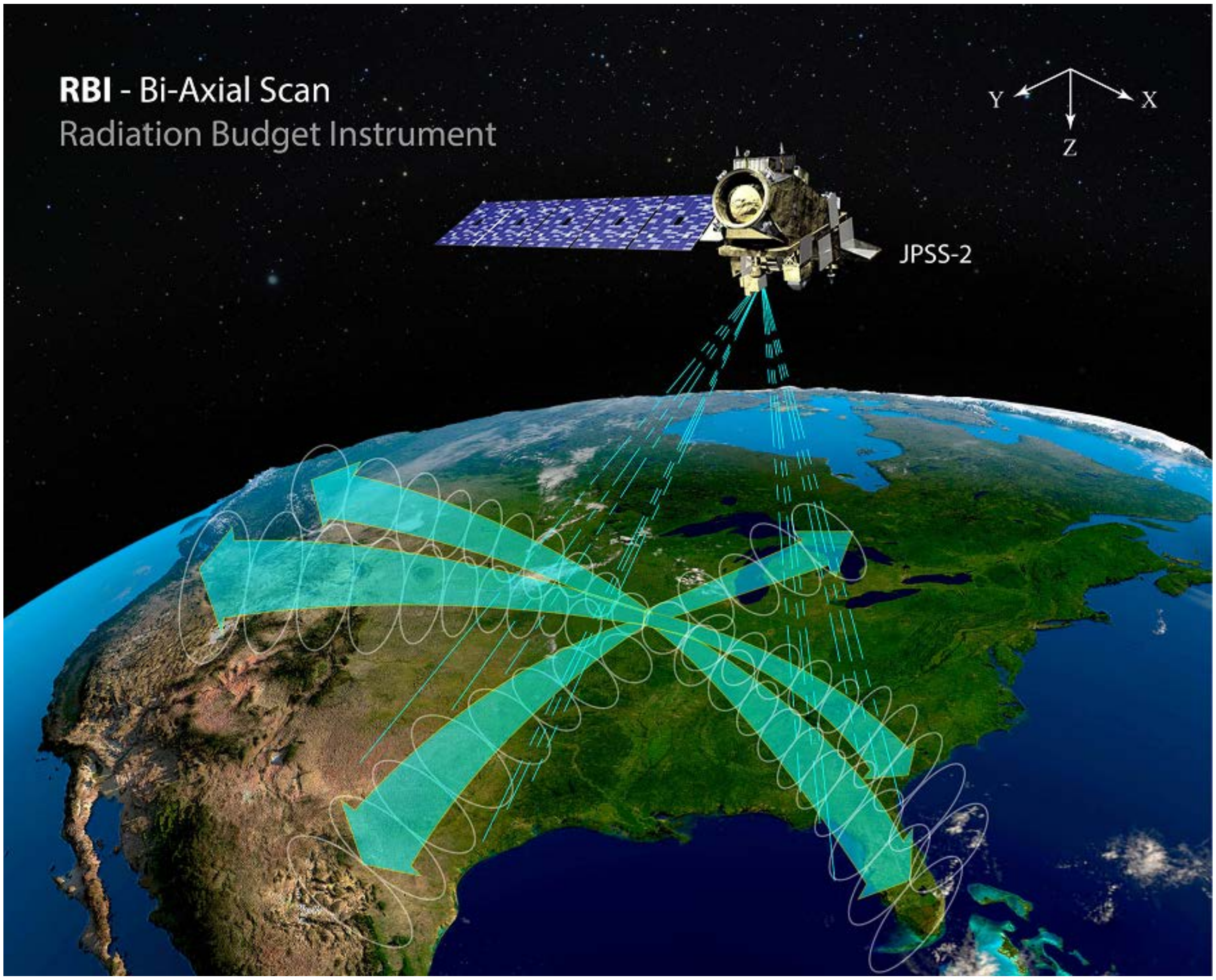


Figure 5.5.2.5.2-1 Bi-Axial Scan

5.5.2.5.3 Earth Target Sub-Mode

RB_PRD-795 The Instrument shall operate in an Earth Target mode in which the IFOV is pointed to, is centered on, and tracks a fixed ground target on the Earth's surface in accordance with uploaded commands at any time during normal operations.

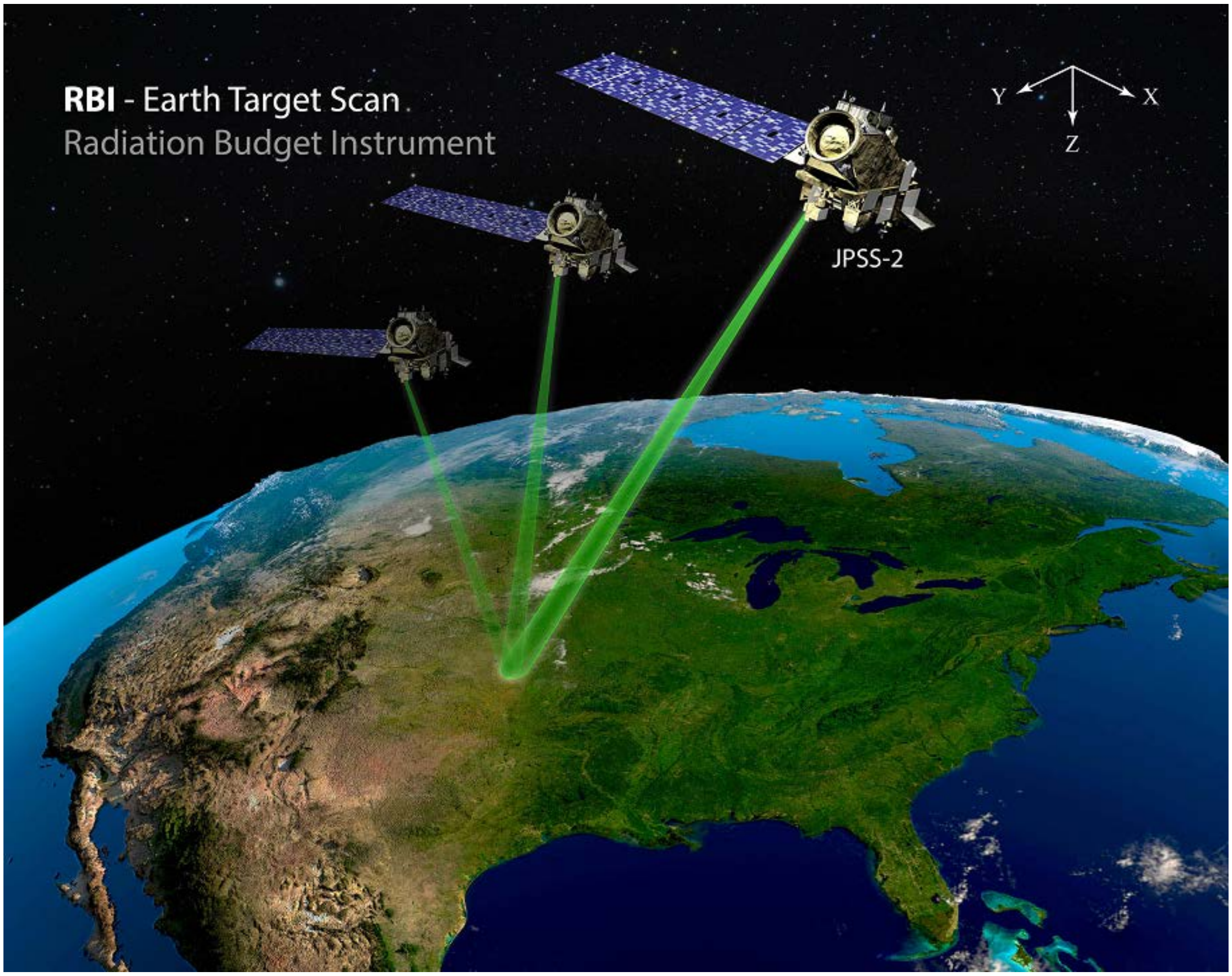


Figure 5.5.2.5.3-1 Earth Target Scan

5.5.2.5.4 Calibration Sub-Mode

RB_PRD-797 The Instrument shall collect calibration data of the three channels using appropriate and available internal and external calibration sources in accordance with uploaded commands.

5.5.2.5.5 User-Defined Sub-Mode

RB_PRD-6360 The Instrument shall allow an elevation scan angle range between two VZA of up to 90° on the Instrument +Y and -Y side of Nadir, while in the User-Defined Sub-Mode.

RB_PRD-6395 The Instrument shall allow an elevation scan rate between 0.00 deg/sec and 70.00 deg/sec in increments of 0.01 deg/sec and resolution of less than 1.1 deg/sec, while in the User-Defined Sub-Mode.

Note: The scan rate resolution is calculated as a 1-bit change in the encoder position over a 10 msec period.

RB_PRD-6397 The Instrument shall allow an elevation scan plane angle about the Instrument +Z axis (azimuth) between ± 90 degrees with respect to the Instrument +X axis with rotation rate equal to zero, while in the User-Defined Sub-Mode.

RB_PRD-6398 The Instrument shall allow an elevation scan plane angle rotation rate and direction, rates from 0.5 to 6 degrees per second in both the positive and negative directions with a maximum rate increment of 0.1 degrees per second, while in the User-Defined Sub-Mode.

RB_PRD-6361 The Instrument shall be capable of Azimuth motion (rotation of the elevation scan plane about the Instrument +Z axis) in both the positive and negative directions over the full angular range a minimum of $1.1x10^6$ complete cycles while in User-defined sub-mode.

6 DESIGN REQUIREMENTS

6.1 Mechanical Requirements

RB_PRD-800 All mechanical requirements specified shall be met at the mechanical interface, the surface(s) of the Spacecraft where the Instrument is in contact with the Spacecraft, unless otherwise specifically indicated.

RB_PRD-801 The Instrument shall comply with the Instrument to Spacecraft Mechanical Interface Control Document (MICD).

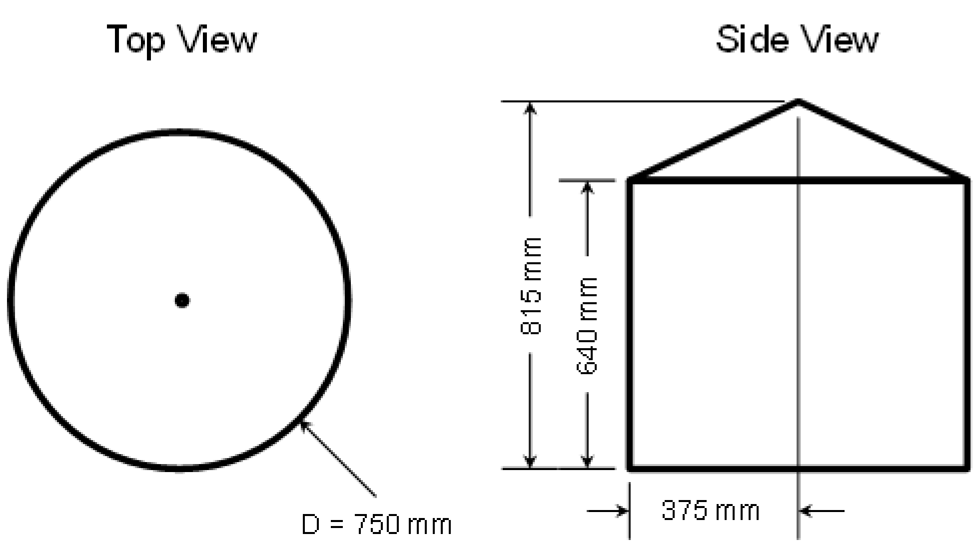


Figure 6.1-1 Instrument Dimensional Envelope

RB_PRD-803 The Instrument shall maintain static and dynamic clearances to the dimensional envelope shown in the Spacecraft to RBI Instrument Mechanical Interface Control Document (MICD).

6.1.1 Mounting Provisions

RB_PRD-805 The Instrument shall use a stable, positive location system as the primary means of attachment.

RB_PRD-807 The Instrument shall be mounted using kinematic mounts unless the Instrument contractor determines that kinematic mounts are not required.

RB_PRD-808 The Instrument mounting method shall accommodate manufacturing tolerance, structural distortion, thermal distortions, and alignment requirements.

RB_PRD-809 The Instrument coordinate axes shall be defined to be in the same orientation as the Spacecraft axes (refer to Section 3.2), but not necessarily the same origin.

RB_PRD-810 The Instrument shall be designed to have adequate clearance(s) for any mounting/attachment hardware and the tools necessary for their installation and removal.

6.1.2 Mass Properties

RB_PRD-812 The Instrument total mass shall not exceed 90 kg.

RB_PRD-813 The Instrument mass shall be known to ±0.1 kg.

RB_PRD-814 The actual stowed (launch configuration) and deployed (on-orbit configuration) centers of mass of each separately mounted component shall be known to ±6 mm (not-to-exceed).

RB_PRD-815 The moments and products of inertia shall be measured or calculated for each separately mounted component; using coordinates based on the Spacecraft axes but passing through the component center of mass.

RB_PRD-816 Moments and products of inertia values shall be accurate to within ±5% for calculated values, and the greater of 5% or 300 kg-cm^2 for measured values.

6.1.3 Venting and Purge

Final Instrument multilayer insulation (MLI) vent locations will be determined in consultation with the Instrument Contractor, NASA LaRC, and JPSS contamination control engineers so as to prevent venting onto other instruments or Spacecraft sensitive surfaces. Instrument venting sources and MLI vent locations will be documented in a future release of the ICD and/or MICD.

RB_PRD-819 The Instrument shall not contain any propulsive device or component that would impart force or momentum on the Spacecraft during on-orbit operations.

6.1.4 Pointing and Alignment Reference

RB_PRD-821 The Instrument Alignment References shall be viewable from two orthogonal directions when integrated to the Observatory.

RB_PRD-822 Optical targets or cubes shall have a per-face surface area of at least 360 mm^2.

RB_PRD-823 The angular position knowledge of the optical alignment target or cube shall be known to within ±3 arcsec, 3-sigma.

RB_PRD-824 All optical targets or cubes shall have a minimum reflectance of 80%, surface figure of 1/4 wave peak value at 0.63 microns, and a surface quality of 80/50 scratch/dig or better.

RB_PRD-825 Each optical target or cube shall be covered with a flight quality (and flight capable) cover, provided by the Instrument contractor.

RB_PRD-826 The optical target or cube cover shall be removable during I&T.

RB_PRD-827 While on orbit, the optical target or cube cover shall provide protection against optical reflections onto any light-sensitive surface.

RB_PRD-828 The optical target or cube cover shall be able to capture loose pieces if the target or cube and associated hardware become loose.

6.1.5 Fastening Systems

For additional guidance on the design and analysis of threaded fastening systems in NASA spaceflight hardware consult NASA-STD-5020: Requirements for Threaded Fastening Systems in Spaceflight Hardware.

6.1.5.1 Fastener Performance Analysis

6.1.5.1.1 Strength

RB_PRD-833 Factors of safety for fastener analysis shall be as specified in Section 6.2, Table 6.2.1-1.

RB_PRD-834 A supplemental factor, referred to as a fitting factor (greater than or equal to 1.0), shall be applied.

The guidelines within NASA-STD-5020, Section A.12 should be followed for implementation of a fitting factor.

6.1.5.1.2 Ultimate Design Loads

RB_PRD-837 All threaded fastening systems shall withstand ultimate design loads in conjunction with the applicable maximum expected range of environmental conditions without rupture.

6.1.5.1.3 Yield Design Loads

RB_PRD-839 All threaded fastening systems shall withstand yield design loads in conjunction with the applicable maximum expected range of environmental conditions without detrimental yielding.

6.1.5.1.4 Joint Separation

RB_PRD-841 Mechanical joints using threaded fastening system hardware shall withstand the design separation load in conjunction with applicable maximum or minimum temperatures without separation, using the minimum separation factor of safety of 1.0 for non-separation critical joints.

6.1.5.2 Fastener Locking and Retention

6.1.5.2.1 Fastener Retention

RB_PRD-844 All items to be installed, removed, or replaced at the Instrument or Observatory level of integration shall utilize captive hardware, except Instrument mounting hardware.

6.1.5.2.2 Locking Features

RB_PRD-846 Regardless of the magnitude of preload, each threaded fastening system in spaceflight hardware shall incorporate a minimum of one locking feature that does not depend upon preload to function.

RB_PRD-847 Locking features shall be verifiable per Section 7.6 of NASA-STD-5020.

RB_PRD-848 A mechanical locking feature shall be used on any bolt subject to rotation in operation.

RB_PRD-849 Snap rings and cotter pins shall not be used where other acceptable retention methods are possible.

RB_PRD-850 Where use of snap rings or cotter pins cannot be avoided, new snap rings or cotter pins shall be used once the previous snap ring or cotter pin is removed.

RB_PRD-851 Liquid Locking Compounds (LLC), if used, shall be applied using a formal validated process that addresses: (1) Quantity and coverage of LLC, (2) Fastener and joint material, (3) Thread size, (4) Fastener preload, (5) All environmental conditions, (6) Specified process for cleaning threads, (7) Specified process for application of primer to threads, (8) Specified process for applying LLC to threads, and (9) Break-torque strength in comparison with LLC's manufacturer-stated capability.

6.1.5.2.3 Locking Features Verification

RB_PRD-853 Mechanical locking features such as cotter pins, safety wire, and safety cable, shall be installed per National Aerospace Standard NASM 33540, "Safety Wiring, Safety Cabling, Cotter Pinning, General Practices for".

RB_PRD-854 Mechanical locking features, such as cotter pins, safety wire, and safety cable, shall be verified by visual inspection after installation.

RB_PRD-855 Prevailing torque features, such as deformed thread features, pellets, strips, or patches, shall be verified by torque measurement during the installation process.

RB_PRD-856 Adhesive locking features dependent upon substrate and/or configuration for cure, such as anaerobic liquid locking compounds, shall be verified by torque measurements on witness coupons that are representative of and processed with the hardware being verified.

RB_PRD-857 All other adhesive locking features shall be verified using cure samples processed at the time of application/processing.

6.1.5.2.4 Locking Features Installation

RB_PRD-859 Locking features and their installation processes, including verification methods, shall be specified in the engineering documentation.

RB_PRD-860 When using locking adhesives, whether as thread-locking compounds or staking materials, installation processes shall be developed and validated prior to implementation to ensure adhesives cure, adhere, and function as expected.

6.1.5.2.4.1 Thread Engagement, Dimensions, and Tolerances

RB_PRD-862 Dimensions, tolerances, and fastening system hardware shall be specified in the engineering documentation to control the features and issues described in the following subsections.

6.1.5.2.4.1.1 Fastener Length Selection for Thread Engagement

RB_PRD-864 When the threaded fastening system incorporates a prevailing torque-locking feature, the fastener length shall be sufficient for fully formed threads to engage the locking feature.

RB_PRD-865 The length of each fastener used with a nut, nut plate, or insert shall be selected to extend a distance of at least two (2) full threads past the outboard end of the nut, nut plate, or insert.

RB_PRD-866 Thread engagement in an internally threaded part other than a nut, nut plate, or insert shall be selected to ensure the minimum number of engaged complete threads such that the fastener would fail in tension before threads would strip.

Figure 6.1.5.2.4.1.1-1 *highlights common methods of addressing dimensional issues in hardware selection for a fastener used with a nut.*

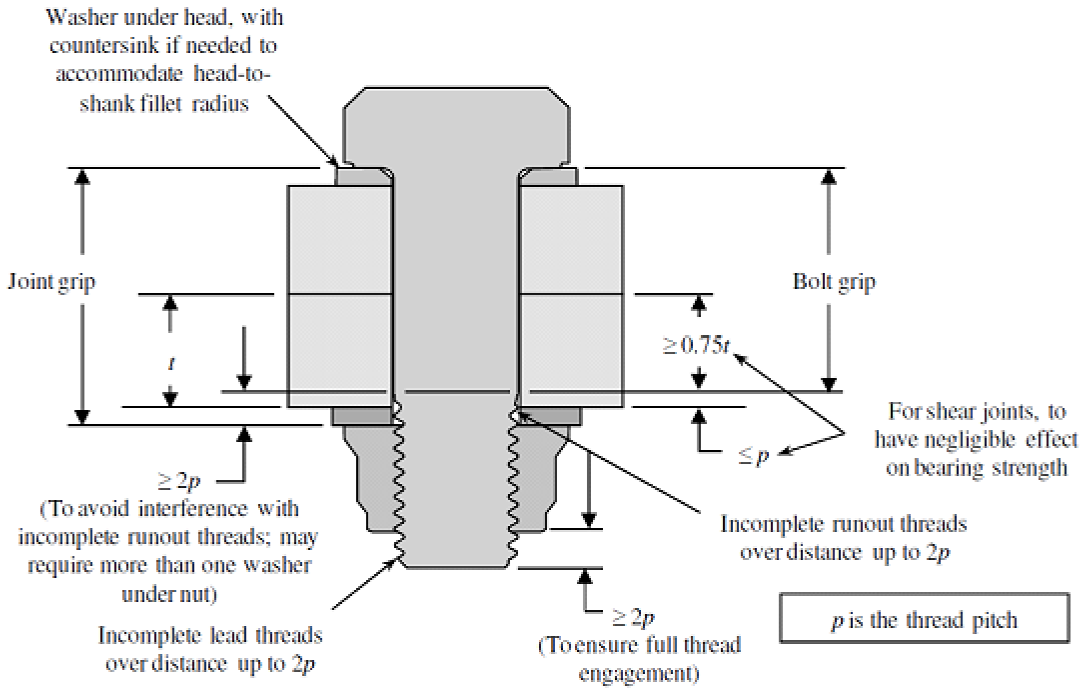


Figure 6.1.5.2.4.1.1-1 Dimensional considerations in selecting fastening hardware.

6.1.5.2.4.1.2 Bolt Grip Selection to Prevent Interference

RB_PRD-871 For a fastener with a full diameter body, the bolt grip and the number and type of washers shall be selected to ensure the internal threads do not encroach on the incomplete runout threads of the fastener.

RB_PRD-872 Fasteners threaded into blind holes shall be selected to prevent contacting the bottom of the hole or interfering with incomplete internal threads.

6.1.5.2.4.2 Fastener Installation Specification and Control

RB_PRD-874 The engineering drawings and assembly procedures shall specify and control installation methods and parameters for achieving preload.

6.1.5.2.4.3 Installation Torque Specification and Control

RB_PRD-876 The engineering documentation shall specify the installation torque range or specify an applicable standard that defines the installation torque range.

RB_PRD-877 The engineering documentation shall clearly identify when the installation torque is the torque above running torque.

6.1.5.3 Fastened Joints Criteria

RB_PRD-879 Analysis of threaded fastening systems shall address maximum and minimum preloads per NASA-STD-5020, Section 6.1.

6.1.5.4 Strength Under Ultimate Design Loads

RB_PRD-881 Analysis for ultimate design loads shall address potential rupture in all elements of the threaded fastening system, including the fastener, the internally threaded part, such as a nut or an insert, and the clamped parts.

6.1.5.4.1 Ultimate Strength Analysis for Tensile Loading

RB_PRD-883 Ultimate strength analysis of a fastening system under applied tensile loading shall be performed per NASA-STD-5020, Section 6.2.1.

6.1.5.4.2 Ultimate Strength Analysis for Shear Loading

RB_PRD-885 Ultimate strength analysis of a fastening system under applied shear loading shall be performed per NASA-STD-5020, Section 6.2.2.

RB_PRD-886 Ultimate strength analysis of bolts under shear loading shall be based on the assumption that no shear load is carried by friction between the faying surfaces.

6.1.5.4.3 Ultimate Strength Analysis for Combined Loading

RB_PRD-888 For fasteners under simultaneous applied tensile and shear loads, along with any applicable bending, analysis shall account for interaction of the combined loading.

6.1.5.4.4 Strength Under Yield Design Loads

RB_PRD-890 If one or more of the following applies:
Fastener yielding causes the joint to separate under an applied tensile load that is less than the design separation load;
Fastener yielding causes the joint to suffer detrimental slip under an applied shear load that is less than the applicable design shear load;
Some other design-specific reason exists for why fastener yielding is detrimental (e.g., any fastener yielding that adversely affects the form, fit, or function of the design);
then fastener yielding is detrimental and analysis shall be performed per NASA-STD-5020, Section 6.3 to show the fastener's total tensile load, when accounting for maximum preload and the yield design tensile load, does not exceed the allowable yield tensile load.

6.1.5.4.5 Joint Separation Analysis

RB_PRD-895 Analysis shall be performed per NASA-STD-5020, Section 6.5 showing no separation for each threaded fastening system that is subject to applied tensile loading, with the assumption of minimum preload.

RB_PRD-896 For a joint that maintains a seal (e.g., to maintain pressure or contain a fluid), analysis shall show that the seal meets its requirements at the design separation load when assuming minimum preload for all fasteners in the joint.

6.1.6 Mechanism Design

For additional guidance on the design and analysis of mechanisms used in NASA spaceflight hardware consult NASA-STD-5017, "Design and Development Requirements for Mechanisms" and AIAA S-114-2005e, "Moving Mechanical Assemblies for Space and Launch Vehicles".

6.1.6.1 Torque/Force Margins

RB_PRD-900 The minimum torque at the motor shaft shall never be less than 7.06E-3 N-m (1 oz-in) for gear-driven systems.

RB_PRD-901 Instrument mechanism torque and force margins shall be determined using worst-case conditions and include all flight drive electronics effects and limitations.

RB_PRD-902 Instrument mechanism torque margin shall be verified using data acquired from unit qualification or acceptance level operational testing.

RB_PRD-903 The torque margin shall be verified by testing the qualification (or protoflight) unit both before and after exposure to qualification level environmental testing.

RB_PRD-904 The torque margin on all flight units shall be verified by testing (without breaking the flight hardware configuration), both before and after exposure to acceptance level environmental testing.

RB_PRD-905 Instrument mechanism torque margins shall be greater than zero as calculated per GSFC-STD-7000A, Section 2.4.5.3.

RB_PRD-906 The minimum available driving torque for the mechanism shall be determined based on the factor of safety (FS) listed in Table 6.1.6.1-1.

Table 6.1.6.1-1 Mechanism factor of safety

Program Phase	**Known Torque Factor of Safety (FSk)**	**Variable Torque Factor of Safety (FSv)**
Preliminary Design Review	2.00	4.0
Critical Design Review	1.50	3.0
Acceptance/Qualification Test	1.50	2.0

RB_PRD-925 Where mechanisms are driven by electric motors, a torque-versus-current relationship for each motor under minimum, maximum, and ambient thermal conditions shall be established.

RB_PRD-926 Where mechanisms are driven by stepper motors, the torque margin shall be calculated one of two ways: using motor available torque (pull-in torque) and comparing to friction loads or performing a step stability analysis.

RB_PRD-927 Designs shall avoid brush-type motors for critical applications with very low relative humidity, or vacuum operations. Intentionally excluded from this rule are contacting sensory and signal power transfer devices such as potentiometers and electrical contact ring assemblies (slip rings, roll rings), etc.

6.1.6.2 Binding/Jamming/Seizing

RB_PRD-929 Designs shall include provisions to prevent binding, jamming, or seizing.

6.1.6.2.1 Clearances

RB_PRD-931 Static and dynamic clearances between the mechanism and any other structure, component, thermal covering, and FOV shall be established and maintained during all phases of the mission.

RB_PRD-932 The established clearance requirements shall account for the following: (1) Manufacturing, assembly, and alignment tolerances, (2) Temperature, (3) Temperature gradients, (4) Vibration, (5) Distortion and relaxation due to the acceleration field, (6) Distortion and relaxation due to depressurization, (7) Ascent loads, (8) Operational loads, and (9) Other internally and externally applied loads.

6.1.6.2.2 Tolerancing

RB_PRD-934 Dimensional tolerances on all moving parts and intentional interference-fit parts shall be established and documented via a tolerance stack-up/clearance analysis to ensure that proper functional performance is maintained under all natural and induced environmental conditions and configurations.

6.1.6.2.3 Lubrication

6.1.6.2.3.1 Lubricant Compatibility

RB_PRD-937 Lubricants used in the mechanism shall be compatible with the following:

a. Interfacing materials (including components and fluids),
b. Other lubricants used in the mechanism,
c. All natural and induced environments encountered by the mechanism,
d. Outgassing/creep requirements (e.g., for nearby optical surfaces), if applicable, and
e. Hydroscopic requirements, if applicable.

6.1.6.2.3.2 Lubricant Life

RB_PRD-944 The selection of lubricant for use in the mechanism shall be based upon development tests of the lubricant that demonstrate its ability to provide adequate lubrication under all specified operating conditions over the design lifetime.

RB_PRD-945 An analysis shall be performed for any liquid lubricant application, subject to depletion, to show that there is an adequate amount of lubricant in the system (not including degradation) for the duration of the mechanism's operational life with a margin greater than 10.

6.1.6.2.3.3 Bearing Lubrication

RB_PRD-947 The selection of lubricant for use in critical moving mechanical assemblies shall be based upon development tests or flight heritage of the lubricant that demonstrate its ability to provide adequate lubrication under all specified operating conditions over the design lifetime.

RB_PRD-948 If solid lubrications are used, specific written procedures shall control the method of application, subsequent handling and ground testing of the components and assemblies to avoid exposure to moisture or humidity

6.1.6.3 Deployables

6.1.6.3.1 Caging of Deployables

RB_PRD-951 Mechanisms that require restraint during launch shall be caged during launch without requiring power to maintain the caged condition.

RB_PRD-952 Mechanisms that require caging and/or uncaging during test and launch site operations shall be capable of being caged or uncaged by command and by manual actuation of accessible locking/unlocking devices.

RB_PRD-953 Mechanisms that require uncaging and/or caging on-orbit shall be capable of being caged and uncaged by command.

RB_PRD-954 All mechanisms requiring restraint shall be designed with a positive indication of the caged position.

6.1.6.3.2 Indication of Deployment/Release Status

RB_PRD-956 All movable/deployable mechanisms shall include in telemetry a positive indication that the mechanism has achieved its desired position or else it shall be possible to directly ascertain from telemetry that the mechanisms has released and deployed adequately.

6.1.6.4 Springs

RB_PRD-958 In applications where spring failure would result in a hazard, or partial or complete loss of mission, the springs shall be redundant or designed, evaluated, and used under an acceptable fracture control program.

RB_PRD-959 In spring-driven mechanisms where redundant springs are used instead of a backup deployment mechanism, the mechanism shall have a positive torque or force margin for a one-spring-out case based on combining worst-case conditions.

6.1.6.5 Dampers

RB_PRD-961 All viscous dampers shall be vacuum filled to preclude entrapment of air.

RB_PRD-962 All viscous dampers shall allow changes in fluid volume and viscosity with temperature.

RB_PRD-963 Viscous dampers shall not leak fluid during the design life of the mechanism in which they are used.

6.1.6.6 Harmonic Drives

RB_PRD-965 Harmonic Drives shall be designed per AIAA S-114-2005, Section 6.13.2.

RB_PRD-966 Harmonic drives used for precision pointing applications shall undergo full functional testing at each level of assembly to verify the harmonic drive characteristics.

6.1.6.7 Bearings

RB_PRD-968 Bearings shall not be used for ground current return paths or to carry electrical current.

RB_PRD-969 Bearings shall meet Annular Bearing Engineering Council (ABEC) 7, 7P, or 7T tolerances (or better) in accordance with Anti-Friction Bearing Manufacturing Association (AFBMA) standards. Nonstandard bearings or thin sectioned bearings where AFBMA tolerances do not apply shall have the manufacturer's precision level most nearly equivalent to ABEC 7.

RB_PRD-970 The mean Hertzian contact stress in a bearing shall not exceed the appropriate values in Table 6.1.6.7-1 when subjected to the yield load.

Table 6.1.6.7-1 Mean Hertzian contact stress.

Bearing Material	Mean Hertzian Contact Stress	
	Quiet Running	Non-Quiet Running
440C Steel	335 ksi (2310 MPa)	400 ksi (2760 MPa)
52100, M50 Steels	360 ksi (2480 MPa)	430 ksi (2960 MPa)
M62 Steel	550 ksi (3790 MPa)	590 ksi (4070 MPa)

RB_PRD-973 Rolling element bearings shall have a minimum hardness of Rockwell C58.

RB_PRD-974 Bearing fatigue life analysis shall be based on a minimum survival probability of 99.95% when subjected to maximum time varying operational loads under worst-case environmental conditions.

6.1.6.8 Mechanical Stops

RB_PRD-976 End-of-travel stops shall be incorporated into mechanisms to prevent mechanism motion beyond design travel limit.

RB_PRD-977 Mechanical stops or shoulders and associated attachments shall be designed to a structural yield factor of safety of at least 2.0 and an ultimate factor of safety of 3.0 based on static analysis for maximum impact loads that occur upon full extension, actuation, or stopping of the Moving Mechanical Assembly.

RB_PRD-978 Impact loads shall account for uncertainties in model parameters, analysis methodology, and any other effects, such as amplified inertia loads that may be transmitted through gear trains.

RB_PRD-979 The design shall ensure that the stop transients do not overstress gear teeth or drive mechanisms. A snubbing arrangement that dissipates energy may be provided where necessary to reduce the impact forces.

RB_PRD-980 Adjustments shall be provided in linkages and stops to ensure that the travel of the Moving Mechanical Assembly is not restricted before contact with the stop by tolerance buildups, thermal distortions, and other uncertainties.

6.1.6.9 Switches

RB_PRD-982 When switches are used as indicating devices for mechanisms, the design of the switch mounting and the switch orientation shall be such that maladjustment of the switch shall not physically impede mechanism travel.

RB_PRD-983 Switch actuation shall be accomplished such that the switch is capable of being actuated only within its acceptable operating range (e.g., cam-operated switches using ramps that level off, or use of indirect switch-release levers).

RB_PRD-984 The use of micro switches in the Instrument design shall be limited to the indication of status conditions in telemetry and is prohibited in logic or command circuits.

6.1.6.10 Mechanism Performance and Strength Analysis

RB_PRD-986 Mechanism components and linkages shall have sufficient strength to tolerate an actuation force/torque stall condition at any point of travel and still maintain a positive margin of safety with the ultimate factor of safety applied.

RB_PRD-987 Bearings shall have analysis demonstrating acceptable material, mounting, preload, performance, and structural integrity, accounting for the following conditions:

1) Maximum combined axial, radial, and moment loads sustained during ground handling, launch, on-orbit, or other operational modes
2) System stiffness requirements
3) Effects of temperature, temperature gradients, fits, tolerances and initial preload on torque, stiffness, and life
4) Lubrication
5) Wear
6) Smoothness of operation
7) Friction torque, considering breakaway and running, in the installed state
8) Reliability and life
9) Effects of alignments, fits, tolerances, thermal, and load-induced distortions on preload, stress, and bearing shoulder height requirements

6.1.6.11 Mechanism Installation

RB_PRD-998 Mechanisms shall either be designed to preclude installation in an incorrect orientation or else be clearly labeled in a manner that indicates proper installation orientation and prevents improper installation.

6.2 Structural Requirements

6.2.1 Strength and Stiffness

RB_PRD-1001 Limit loads shall be applied through the center of mass (CM) of the Instrument, configured for launch, to design the mounting interface.

RB_PRD-1002 Limit loads shall be applied simultaneously using combination of ± loads in such a way as to produce the maximum stresses.

RB_PRD-1003 The Instrument structure shall be designed to have sufficient strength to withstand simultaneously the yield loads, applied temperature, and other accompanying environmental phenomena for each design condition without experiencing yielding or detrimental deformation.

RB_PRD-1004 The Instrument structure shall be designed to withstand simultaneously the ultimate loads, applied temperature, and other accompanying environmental phenomena without failure.

RB_PRD-1005 Special stowage provisions shall be used, if required, to prevent excessive dynamic amplification during transient flight events.

RB_PRD-1006 The Instrument shall be capable of withstanding all worst-case load conditions to which it may be exposed, without requiring additional recalibration or realignment. This includes handling and transportation, test, pre-launch operations, launch, and on-orbit operations.

RB_PRD-1007 Positive structural margins of safety shall be maintained so that the Instrument can meet all design requirements after being subjected to the worst-case load combinations.

RB_PRD-1008 The factors of safety shown in Table 6.2.1-1, or those defined in the notes to the table, as applicable to the type of calculation listed in the table, shall be applied to limit loads to calculate structural margins.

RB_PRD-1009 A fracture control program (FCP), which may include specific loads tests, shall be established to prevent structural failure due to the initiation or propagation of flaws or crack-like defects, which may occur during fabrication, testing, and service life.

Table 6.2.1-1 Flight hardware design/analysis factors of safety applied to limit loads1, 2

Type	Static	Sine	Random/Acoustic[4]
Metallic Yield	1.25[3]	1.25	1.6
Metallic Ultimate	1.4[3]	1.4	1.8
Stability Ultimate	1.4	1.4	1.8
Beryllium Yield	1.4	1.4	1.8
Beryllium Ultimate	1.6	1.6	2.0
Composite Ultimate	1.5	1.5	1.9
Bonded Inserts/Joints Ultimate	1.5	1.5	1.9

1) Factors of safety for pressurized systems to be compliant with NASA-STD 8719.24 (Range safety).

2) Factors of safety for glass and structural glass bonds specified in NASA-STD-5001.

3) If qualified by analysis only, positive margin shall be shown for factors of safety of 2.0 on yield and 2.6 on ultimate.

4) Factors shown shall be applied to statistically derived peak response based on root mean squared (RMS) level. As a minimum, the peak response will be calculated as a 3-sigma value.

6.2.2 Launch and Ascent Loads

6.2.2.1 Static Liftoff Loads (Flight Limit Loads)

RB_PRD-1058 The load factors given in the mass-acceleration curve shown in Figure 6.2.2.1-1 shall be applied in each individual axis.

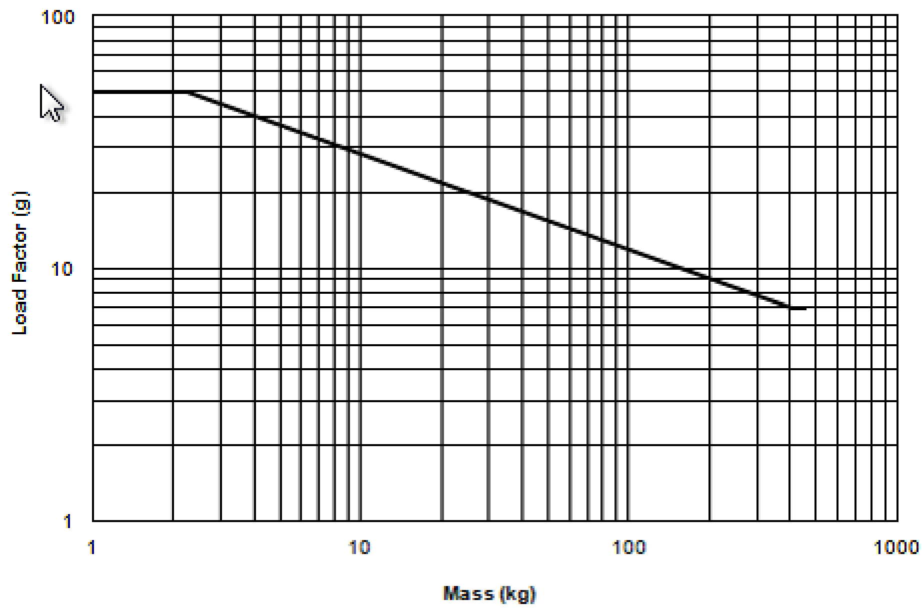


Figure 6.2.2.1-1 Acceleration load factors (limit).

6.2.2.2 Dynamic Environment

Until such time as Launch Vehicle and Spacecraft-specific information is provided, Instrument design is to be performed using an envelope of Expendable Evolved Launch Vehicles (EELV) maximum predicted environments.

6.2.2.2.1 Acoustic Loads

RB_PRD-1064 The Instrument shall be designed to survive a launch acoustic environment specified in Table 6.2.2.2.1-1.

Table 6.2.2.2.1-1 Maximum predicted acoustic environment (P95/50).

JPSS-2 Acoustic Envelope			
Frequency (Hz)	SPL (dB)	Frequency (Hz)	SPL (dB)
20	126.5	500	128.0
25	127.7	630	125.0
31.5	127.0	800	123.0
40	128.5	1000	121.0
50	128.5	1250	119.5
63	131.1	1600	118.0
80	131.4	2000	116.5
100	133.0	2500	115.0
125	133.8	3150	113.5
160	133.7	4000	112.0
200	131.9	5000	110.5
250	130.0	6300	109.0
315	130.0	8000	107.5
400	129.5	10000	106.0
Overall SPL (dB)		142.6	

6.2.2.2.2 Random Mechanical Vibration

The random vibration test levels are dependent on the payload fairing internal acoustic environment and design of the spacecraft bus.

RB_PRD-1069 The Instrument shall be designed to survive the acceptance and protoflight launch random vibration levels defined in Section 8.4.3 and meet all operational requirements thereafter.

6.2.2.2.3 Mechanical Shock

JPSS-2 Spacecraft to RBI Instrument Interface Control Document (ICD) Table RBI-462 *presents an envelope of the maximum predicted environments (P95/50 resonant amplification factor, Q = 10) at the Spacecraft to Instrument interface. This environment includes Launch Vehicle Stage and Payload Fairing Separations events. Location of the Instrument on the Spacecraft, as well as Spacecraft structure design will affect the shock level seen at the Instrument mounting location.*

RB_PRD-6371 The Instrument shall be designed to withstand shock levels 3 dB above the values listed in JPSS-2 Spacecraft to RBI Instrument Interface Control Document (ICD) Table RBI-462 without performance degradation.

RB_PRD-1088 The Instrument shall be capable of surviving, without degradation, shock resulting from self-induced events, such as deployments and other pyrotechnic devices initiated during its life.

6.2.2.2.4 Resonant Frequency Constraints

RB_PRD-1090 Each separately-mounted Instrument component, configured for launch, shall have a fixed-base fundamental resonant mode frequency of greater than 60 Hz.

RB_PRD-1091 The Instrument on-orbit configuration shall have fundamental non-rigid body modes 6 Hz or greater.

6.2.3 On-Orbit Loads

6.2.3.1 Uncompensated Momentum

RB_PRD-1094 Each Instrument having movable components shall not exceed an uncompensated momentum contribution of ±0.5 N-m-sec per axis.

6.2.3.2 Instrument Disturbance Allocations

6.2.3.2.1 Periodic Disturbance Torque Limits

RB_PRD-1097 The magnitude of the periodic disturbance torque, including the torque resulting from linear forces reacting from the Instrument to the Spacecraft shall be in the acceptable range of Figure 6.2.3.2.1-1 for all frequencies. The transition points for Figure 6.2.3.2.1-1 are shown in Table 6.2.3.2.1-1 for clarity.

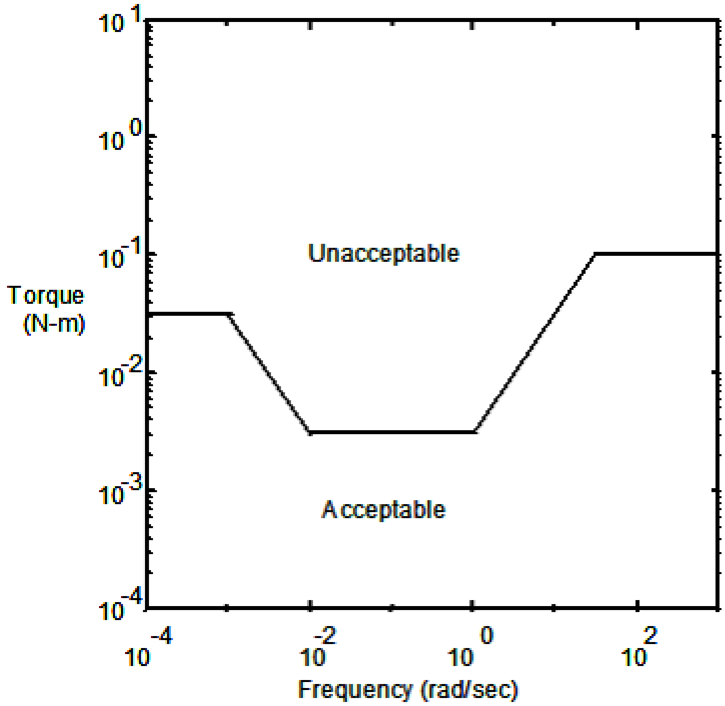


Figure 6.2.3.2.1-1 Allowed transmitted torque.

Table 6.2.3.2.1-1 Allowable transmitted torque transition points.

Frequency (rad/sec)	Torque (N-m)
< 0.001	0.03
0.01	0.003
1.0	0.003
> 33.3	0.1

6.2.3.2.2 Constant Disturbance Torque Limits

RB_PRD-1118 Instrument-induced constant disturbances of the same polarity, separated by more than 200 seconds, shall not exceed the torque limit defined in Figure 6.2.3.2.2-1 if the duration of application is in excess of 10 seconds. For constant torques of 10 seconds duration or less, the impulse limit is 0.04 N-m-s. For constant torques of 400 seconds duration or more, the torque limit is maintained at the 400-second limit shown in Figure 6.2.3.2.2-1.

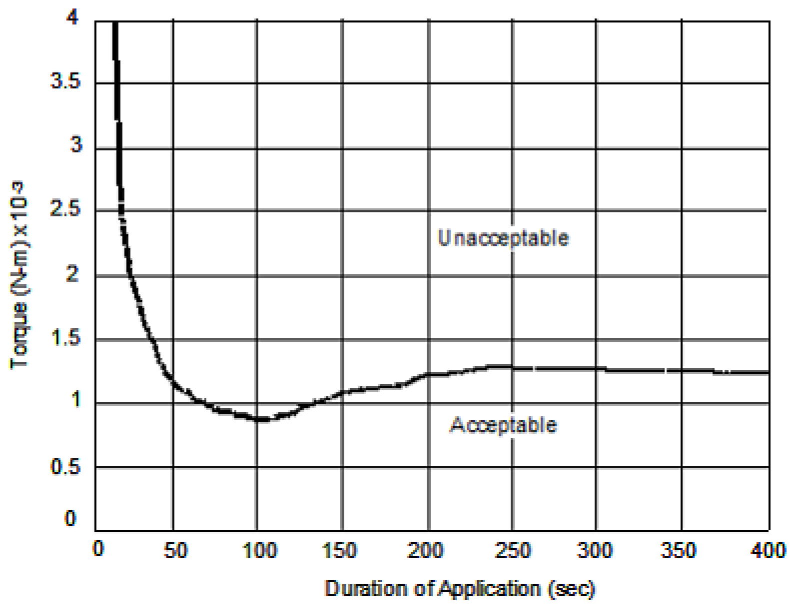


Figure 6.2.3.2.2-1 Constant torque vs. duration of application.

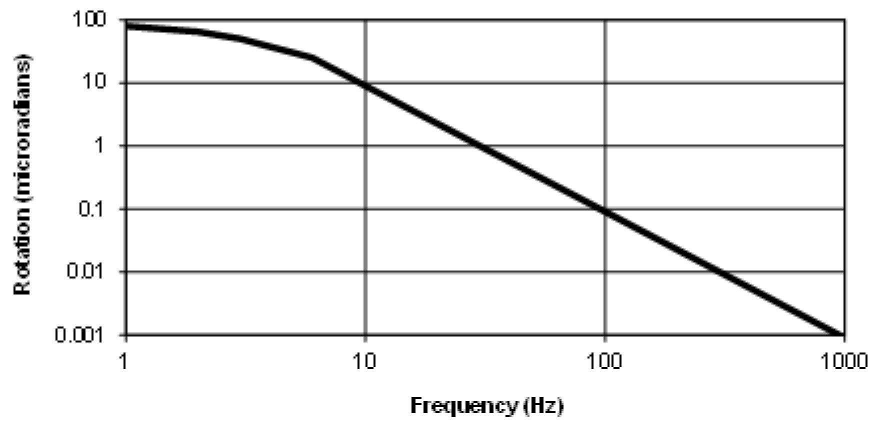
RB_PRD-1121 The same requirements specified above for constant and periodic torques shall apply when linear forces are converted to torques, assuming a moment arm of 2 m for motion along the pitch or yaw axes and 3 m for motion along the roll axis.

6.2.3.3 Acceleration

The Instrument will meet all performance requirements on-orbit when operating at the maximum accelerations (per axis at the Instrument Interface) listed in JPSS-2 Spacecraft to RBI Instrument Interface Control Document (ICD) Table RBI-160 and Figure RBI-565.

6.2.3.4 Rotation

RB_PRD-1142 The Instrument shall meet all performance requirements on-orbit when operating at the maximum zero-to-peak rotation of the Instrument interface, defined as follows for an Instrument attached directly to the spacecraft structure: The maximum zero-to-peak rotation of the Instrument Interface due to jitter shall be less than 20 arcsec (3-sigma) per axis over any orbit and be less than the values specified in Figure 6.2.3.4-1 per axis (3-sigma) for any given frequency.



The breakpoints are:

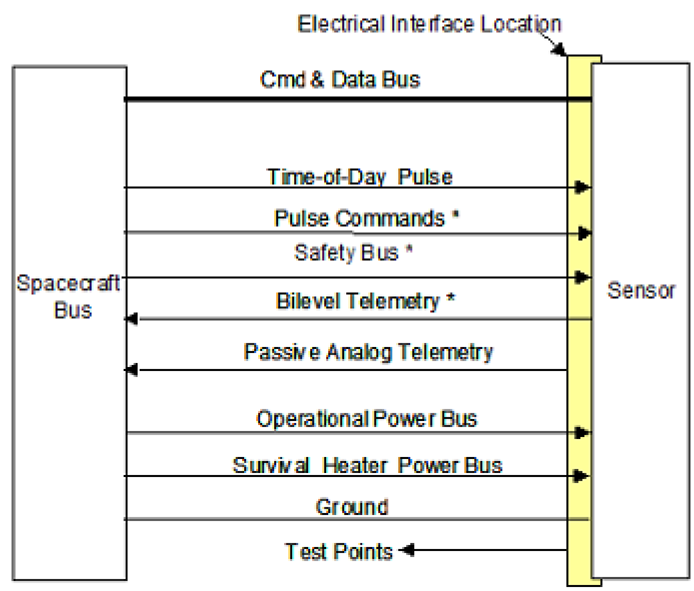
Frequency (Hz)	Rotation (μradians)
1	80
2	65
3	50
4	37.5
5	30
6	25
>6	falls off as $1/f^2$

Note that in the graph above the rotation amplitude is specified as zero-to-peak.

Figure 6.2.3.4-1 Zero-to-peak rotations at the Instrument Interface.

6.3 Electrical Systems Requirements

Figure 6.3-1 illustrates the Spacecraft - instrument electrical interfaces.



* = minimalusage

* = minimal usage

Figure 6.3-1 Spacecraft-Instrument electrical interfaces.

6.3.1 Power

6.3.1.1 Instrument Power Requirements

RB_PRD-1151 The Instrument shall not exceed an orbital average operational power load of 90.0 W.

RB_PRD-1152 The Instrument shall not exceed an orbital peak operational power load of 195.0 W over any single orbit.

RB_PRD-1153 The Instrument shall return to orbital average power load within 6 orbits of exceeding orbital average.

RB_PRD-1154 The Instrument shall not exceed an orbital average survival power load of 70.0 W.

As a design goal Survival orbit average power required by the Instrument should be no more than 30% of the lowest-power operational mode orbit average power.

6.3.1.1.1 Power Services

The Spacecraft will provide two, functionally redundant power services for the Instrument, to be implemented in a block-redundant or cross-strapped configuration, as defined in the Spacecraft to Instrument ICD.

RB_PRD-1158 Any interface requiring steady state current of 250 mA or greater shall be treated as a power service.

RB_PRD-1159 Instrument operational heaters shall be powered from Instrument internal power.

RB_PRD-1160 Redundant power services shall be routed through separate connectors at both the source and the load.

RB_PRD-1161 All Main Bus power shall be routed with power returns in twisted groups with an integral or overwrap shield terminated per NASA-STD-8739.4.

RB_PRD-1162 For cross-strapped redundant power services, where the redundant services may share return lines, all wires from both power services shall be twisted within the same twist group. *Group twist should be maintained over the maximum length possible, given the physical restriction of connector separation for the two power services.*

RB_PRD-1163 At least four wires shall be provided for each Main Bus power service (excepting those for redundant heater circuits), with equal numbers of wires dedicated to power and power return.

RB_PRD-1164 Power services shall be sized such that, voltage drop and steady-state current derating requirements of GSFC EEE-INST-002 are met, with any single wire failed open. Reference Table 6.3.1.1.1-1.

Table 6.3.1.1.1-1 GSFC EEE-INST-002 Current Derating for Contacts and Wire (reference).

Wire Size (AWG)	Max Current (A)
26	1.4
24	2.0
22	2.5
20	3.7
16	6.5
12	11.5

RB_PRD-1188 The Instrument shall telemeter the ON/OFF state and voltage of all Instrument secondary power supplies.

RB_PRD-1189 The Instrument shall telemeter the ON/OFF state of all Main Bus power services for which switching capability exists internal to the Instrument.

6.3.1.1.1.1 Survival Heater Power Services

The Spacecraft will provide redundant, dedicated power services for Instrument survival heaters.

RB_PRD-1192 Individual Instrument survival heater services shall be electrically isolated from each other, and shall have independent power returns.

RB_PRD-1193 Survival power shall be used within the Instrument only for resistive heaters (and associated thermal control device).

6.3.1.2 Power Fault Tolerance

RB_PRD-1195 The Instrument shall prevent a fault on any main bus power service from propagating to, damaging, or degrading the alternate redundant power service to the Instrument.

RB_PRD-1196 The Instrument shall survive the sudden, unannounced removal of Main Bus operational power at any time in any configuration.

RB_PRD-1198 The Instrument shall survive overvoltage conditions of up to 68 VDC for 10 microseconds.

RB_PRD-1199 The Instrument shall survive, without permanent degradation, voltage conditions of up to 50 VDC for 100 milliseconds.

RB_PRD-1200 The Instrument shall survive when subjected to operational power input voltage of 0 to 40 VDC.

Note: Survive means the Instrument will meet all performance requirements after subjected to power input voltages of 0 to 40 VDC for any duration of time.

RB_PRD-1202 If the Instrument employs overcurrent fault protection, the Instrument shall reset autonomously upon removal of the fault or be able to be reset by command.

6.3.1.3 Observatory Load Requirements

6.3.1.3.1 Operational Voltage

RB_PRD-1205 The Instrument shall be designed to operate, and achieve all performance parameters, over the main bus power voltage range from 26 VDC to 34 VDC.

RB_PRD-6354 The nominal operating voltage for all instrument testing shall be 30.0 VDC.

RB_PRD-6355 Unless otherwise specified, the reference operating voltage for Instrument shall be 30 VDC. All current draws and power consumption requirements will be based on this reference voltage.

6.3.1.3.2 Transients

6.3.1.3.2.1 Current Transients

RB_PRD-1208 The Instrument shall not generate net negative back current into the Spacecraft during any operating mode.

6.3.1.3.2.1.1 Turn-on Transients (In-Rush Current). Retired - covered in ICD.

6.3.1.3.2.1.2 Turn-off Transients

RB_PRD-1217 The Instrument shall use suppression devices, such as diodes, located at the source of the inductive transient, across all filter inductors, relay coils, or other energy sources, which could induce transients on the power lines during turn-off.

RB_PRD-1218 In remote solenoid valve applications, where diode suppression components cannot be applied directly across the solenoid coil or transient source, the suppression components shall be applied at the valve driving signal source.

RB_PRD-1219 The Instrument shall limit the absolute range of peak voltage of transients generated on the Instrument side of the power relay caused by inductive effects of the load to the range of -2 VDC to +45 VDC differentially between power and return.

6.3.1.3.2.1.3 Operational Transients

RB_PRD-1221 The Instrument shall limit operational bus transients to less than 125% of the maximum operational current during any nominal mode of operation (non-fault).

RB_PRD-1222 The Instrument shall limit current operational transient rate of change to no greater than 20 milliamps per microsecond.

6.3.1.3.3 Component Load Ripple

RB_PRD-1225 The Instrument shall operate within specified performance under nominal conditions (no fault clearing) when the differential voltage ripple between the power and return lines on the operational power buses (not the survival heater bus), including repetitive spikes, does not exceed 1.0 V peak-to-peak as measured over the frequency interval of 30 Hz to 1.0 kHz, decreasing log-linearly to 0.5 V peak-to-peak at 10 kHz and continuing at 0.5 V peak to peak from 10.0 kHz to 10 MHz when the power system is delivering the nominal Operational Mode current into the instrument.

Note: This requirement may be satisfied with a combination of analyses of RB_PRD-1278, 1281, and RB_PRD-1305 data.

6.3.1.3.3.1 Reflected Ripple

RB_PRD-1227 The Instrument shall not produce reflected ripple greater than the CE101 limits from 30 Hz to 50 MHz shown in Figure 6.3.1.3.3.1-1 when tested to a modified MIL-STD-461F (extended frequency range) procedure.

The CE101 low frequency plateau limit from 30 Hz to 2 kHz is for loads with a steady-state current of 1 Amp rms or less.

RB_PRD-1229 The CE101 low frequency plateau limit from 30 Hz to 2 kHz shall be increased by adding a factor of 20*log (load current in Amperes) to the base 100 dB µA.

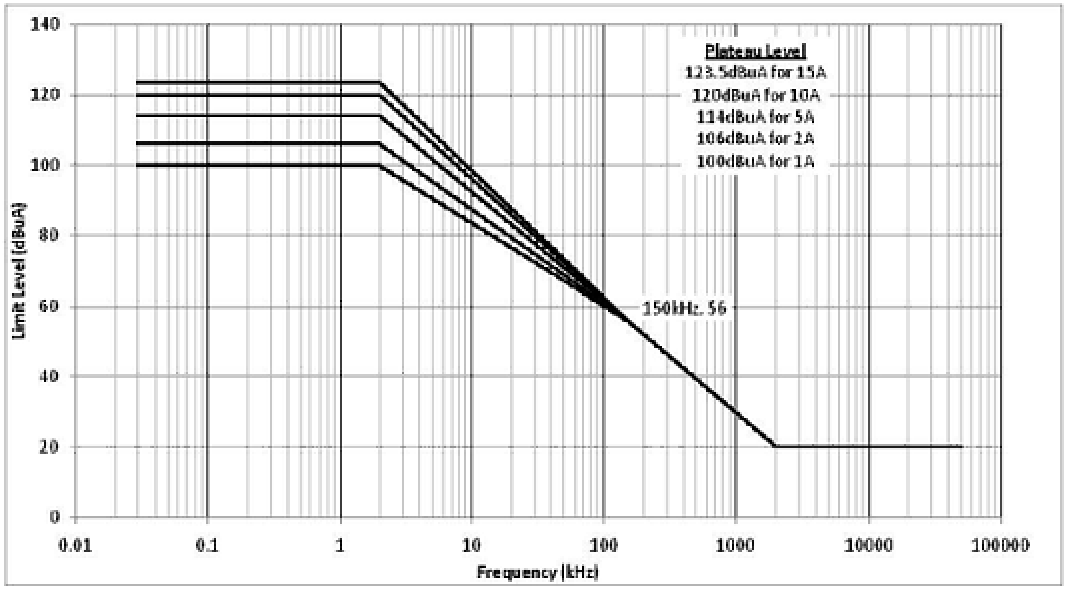


Figure 6.3.1.3.3.1-1 Power lead conducted emissions (CE101).

RB_PRD-1230 A Common Mode Bulk Current Emissions (CMBCE) Test shall be performed from 150 kHz to 200 MHz on the instrument power and signal cable(s) using an absorbing clamp per GSFC-STD-7000A Section 2.5.2.1.2 except that the LISN specified in RB_PRD-3988 may be used in place of the capacitor network.

RB_PRD-1231 Common Mode Bulk Cable Emissions (CMBCE) from component power and signal cables shall not exceed 50 dBµA.

6.3.1.3.4 Bus Impedance

RB_PRD-1236 The Instrument Main Bus power interface shall be designed to meet the requirements specified herein, with a Spacecraft power bus impedance, at the interface between the Instrument and the Spacecraft harness, looking back toward the Spacecraft source, equivalent to a resistance of 100 milliohms in series with a 5 microHenry inductance.

6.3.1.4 Instrument High-Voltage Restriction

RB_PRD-1238 Instrument high-voltage power supply (HVPS) shall be capable of operating at atmospheric pressure without damage or degradation to the Instrument.

RB_PRD-1239 Output of any Instrument power supply of 50 V or greater shall be double insulated from the ground plane and current limited to prevent discharge damage to Spacecraft interfaces or other instruments in the event of single point failures within the Instrument.

6.3.2 System Grounding

The Observatory will employ a SPG configuration, with Main Bus power returns, Solar Array (SA) returns, battery grounds and the Chassis Ground Plane having independent paths to the SPG located at a definitive point in the Power Subsystem.

6.3.2.1 Main Bus Power Return Ground

RB_PRD-1246 Instrument Main (Primary) Bus returns shall be isolated from Chassis Ground and Secondary Power returns by >1 MOhm.

RB_PRD-1247 The Instrument Main Bus Power shall be isolated from Chassis Ground by >1 MOhm.

RB_PRD-1248 Discrete Pulse Commands, using Main Bus power to supply the pulse, shall have returns isolated from Chassis Ground and Secondary Power returns by >1 MOhm.

RB_PRD-1249 Bi-level telemetry returns shall have their returns referenced to the associated secondary power supply return at the telemetry source side of the interface.

6.3.2.2 Secondary Power Return Ground

RB_PRD-1251 Components and Subsystems shall employ a “Star” Ground configuration with secondary power supply returns and signal references having independent paths to the related digital or analog Secondary Ground.

RB_PRD-1252 Each Secondary Power supply shall have a single Secondary Power Ground within the same physical component as the power supply.

RB_PRD-1253 All power and signal returns from a secondary power supply shall be referenced to the Secondary Ground referencing the secondary power supply from which they are generated.

RB_PRD-1254 All Secondary Grounds shall be referenced (connected directly) to Chassis Ground of the component in which the Secondary Power supply resides. When necessary to meet Instrument performance requirements, the Instrument contractor may request the use of floating local voltage references by formal written waiver request to the Government.

RB_PRD-1255 No digital or analog circuit shall be designed with the intent of returning current over Chassis Ground.

RB_PRD-1256 Loads supplied by a HVPS shall be isolated from the Chassis Ground Plane by >1 MΩ and referenced to ground only via the HVPS return lines.

6.3.2.3 RF Ground Bonding

RB_PRD-1262 For mechanical interfaces forming part of the RBI Instrument Chassis Ground Plane, each joint between conductive surfaces shall be electrically bonded with a resistance not to exceed 2.5 mΩ.

RB_PRD-1263 Where a mechanical interface, forming part of the RBI Instrument Chassis Ground Plane, is spanned using groundstraps, total bonding resistance, as measured from one side of the interface to the other, shall not exceed 10 mΩ. Fasteners shall NOT to be used as a measurement point.

RB_PRD-1264 All electrical connector shells shall be designed to achieve an electrical bond to the mating component chassis of less than 2.5 mΩ.

6.3.3 Electromagnetic Interference (EMI) and EMC

EMC is necessary in each of the following areas:

- *Self-compatibility of an instrument to itself;*
- *Compatibility between an instrument and all internal sources and receivers on the observatory (other instruments and the spacecraft bus);*

- *Compatibility between an instrument and all external sources and receivers "visible" on the ground, on the launch vehicle, and on-orbit.*

The electromagnetic radiation environment on each JPSS observatory could differ from the environment on any other due to changes in the proposed instrument complements. The RBI must satisfy overall JPSS EMI requirements, although waivers can be granted for non-compliance under conditions where the non-compliance is against requirements for an instrument not present on that flight.

6.3.3.1 EMI Filtering of Spacecraft Power

RB_PRD-1272 The Instrument EMI input filters, if required, shall be installed on the Instrument side of the power interface.

6.3.3.2 EMI/EMC General Requirements

The EMC performance requirements are a tailored version of the MIL-STD-461F requirements.

RB_PRD-1275 While operating in the configurations necessary for transport, test, launch, separation, and on-orbit mission activities, the Spacecraft bus, instruments, GSE, and test equipment shall operate together without performance degradation due to EMI from each other, or the external environment, and without interfering with equipment in the external environment. However, see Section 7.6.1.

6.3.3.2.1 Conducted Susceptibility (CS)

RB_PRD-1278 The Instrument shall not exhibit any malfunction, degradation of performance, or deviation from the specified indications beyond the tolerances indicated in the individual equipment or subsystem specification, when power leads are subjected to the voltage levels shown in Figure 6.3.3.2.1-1 from 30 Hz to 150 kHz per the MIL-STD-461F CS101 test method. The requirement is also met when the power source is adjusted to dissipate the power level shown in Figure 6.3.3.2.1-2 in a 0.5 ohm load and the instrument is not susceptible.

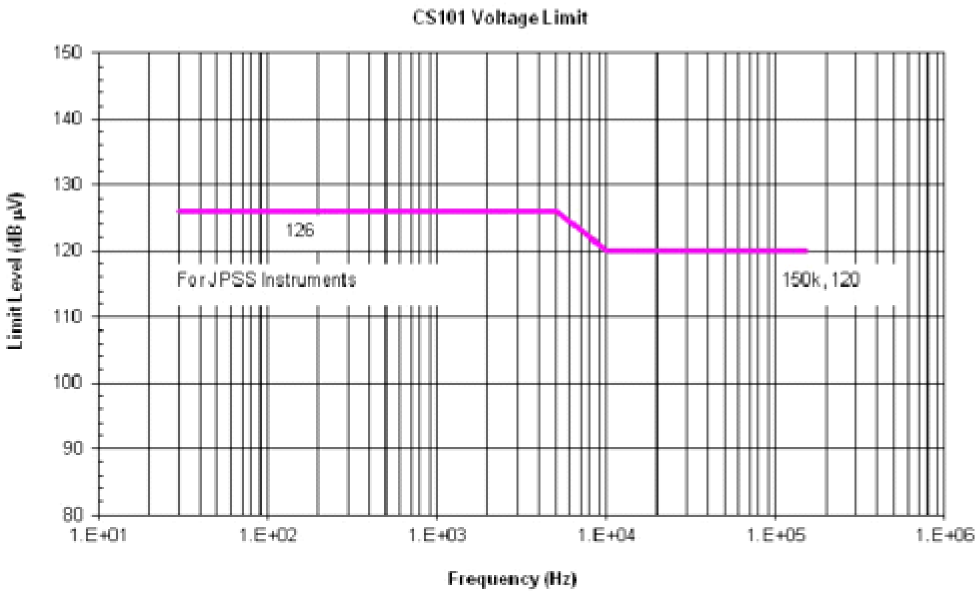


Figure 6.3.3.2.1-1 Instrument power lead CS (CS101).

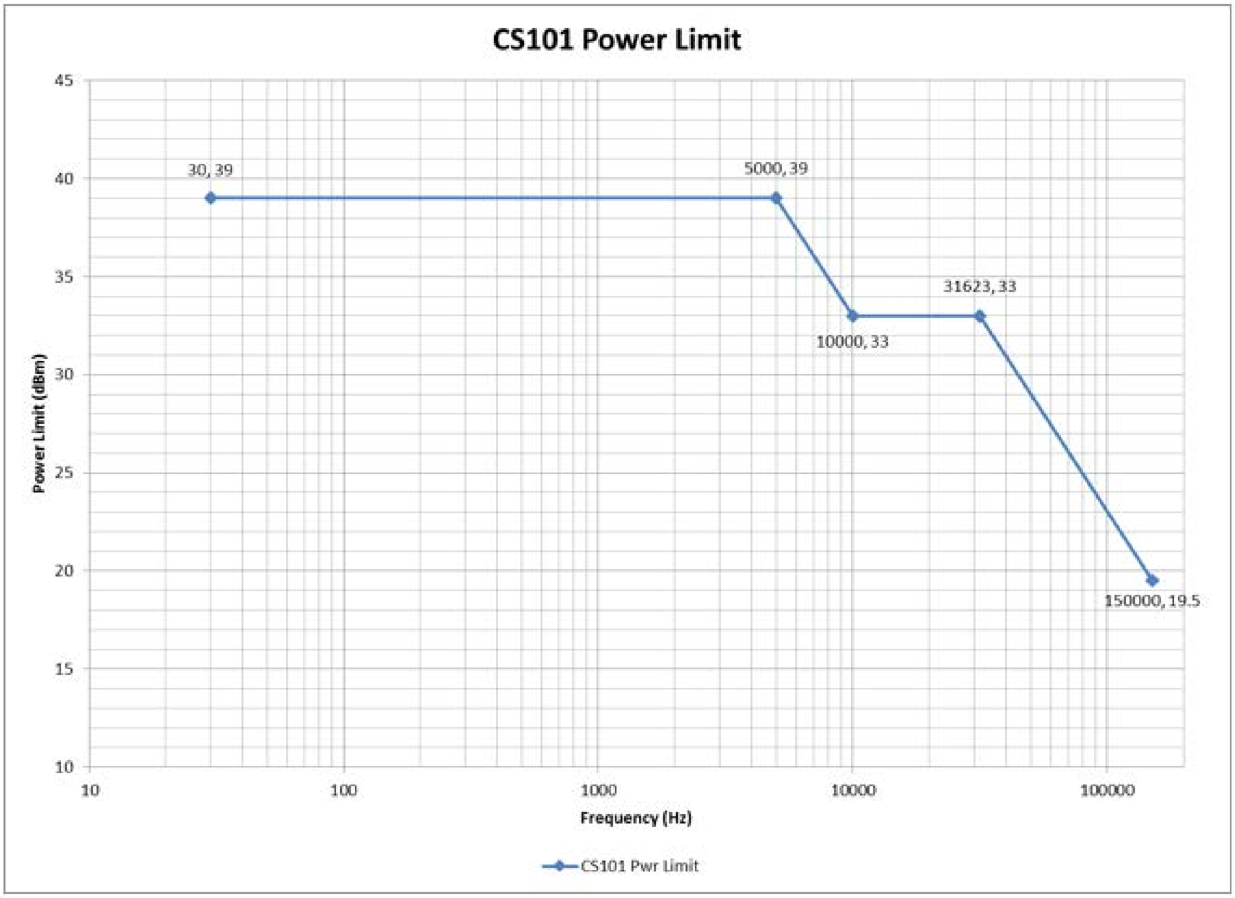


Figure 6.3.3.2.1-2   Instrument Power Lead Conducted Susceptibility (CS101) Power Limit

RB_PRD-1281   The Instrument shall not exhibit any malfunction, degradation of performance, or deviation from the specified indications beyond the tolerances indicated in the individual equipment or subsystem specification, when power and signal leads are subjected to the limits shown in Figure 6.3.3.2.1-3 from 10 kHz to 200 MHz per the MIL-STD-461F CS114 test method.

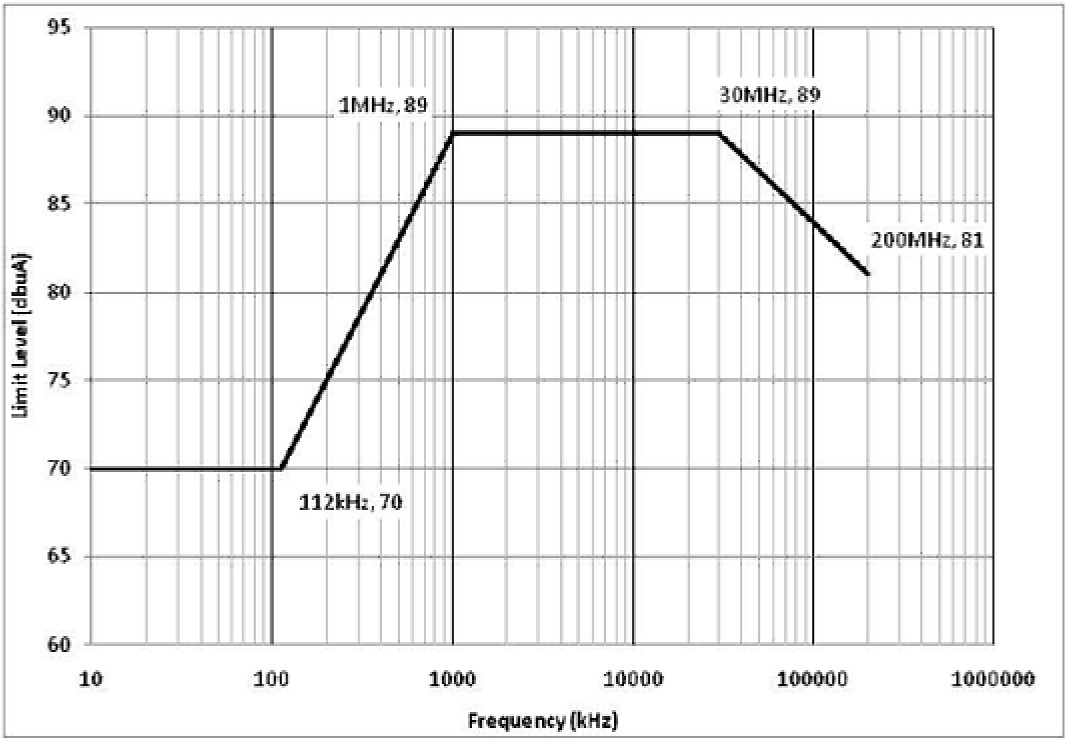
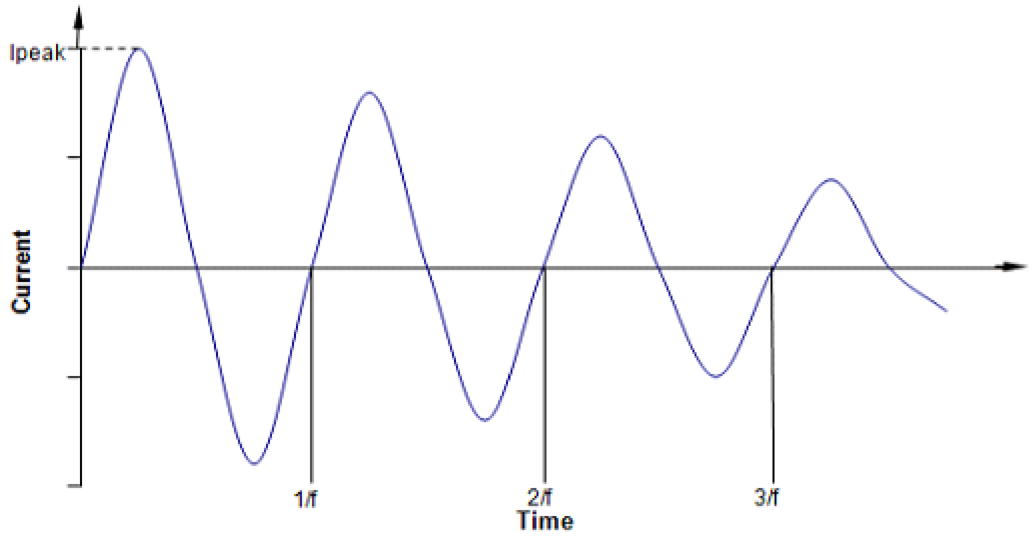


Figure 6.3.3.2.1-3 CS, bulk cable injection (CS114).

RB_PRD-1284 The Instrument using primary power shall not exhibit any malfunction, degradation of performance, or deviation from the specified indications beyond the tolerances indicated in the individual equipment or subsystem specification, when power leads are subjected to a signal having the waveform shown in Figure 6.3.3.2.1-4 and the amplitude for the curve shown in Figure 6.3.3.2.1-5 where Ipeak is 5 A using the MIL-STD-461F CS116 test method.



NOTES:

1. Normalized waveform: $e^{-(\pi ft)/Q}\sin(2\pi ft)$

Where:

f = *Frequency (Hz)*

t = *Time (sec)*

Q = *Damping factor, 15* $\pm$ *5*

2. Damping factor (Q) is determined as follows:

$$Q = \frac{\pi(N-1)}{\ln(I_P/I_N)}$$

Where:

Q = *Damping factor*

N = *Cycle number (i.e., N = 2, 3, 4, 5, ...)*

I_P = *Peak current at 1st cycle*

I_N = *Peak current at cycle closest to 50% decay*

ln = *Natural log*

3. I_P *as specified in the graph above*

Figure 6.3.3.2.1-4 CS, damped sinusoidal transient limit (CS116).

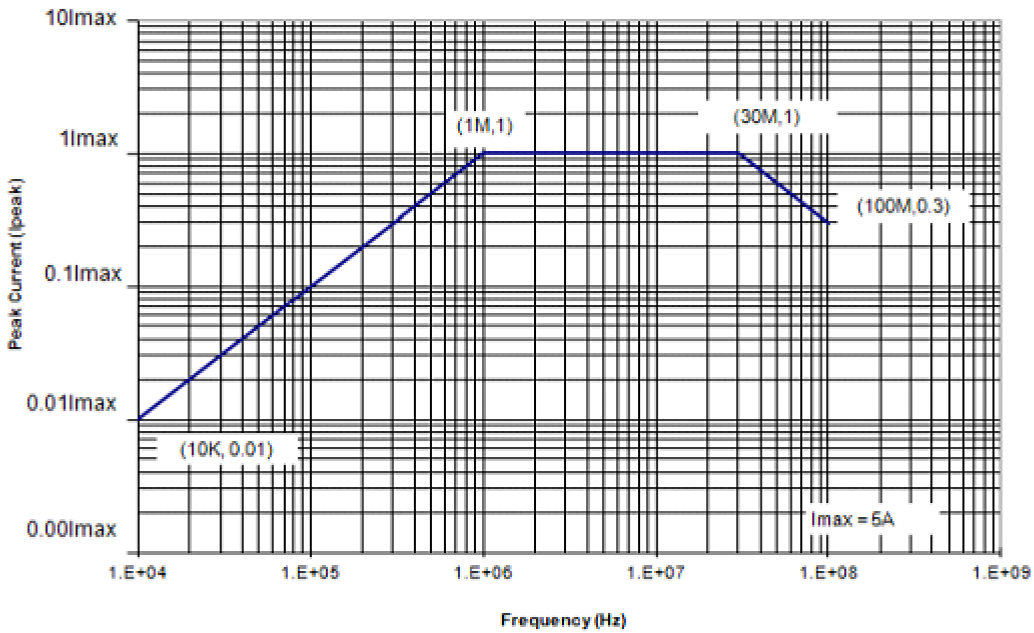


Figure 6.3.3.2.1-5 Instrument conducted transient susceptibility (CS116).

RB_PRD-1305 The Instrument shall not exhibit any malfunction, degradation of performance, or deviation from specified indications, beyond the tolerances indicated in the individual equipment or subsystem specification, when subjected to 1 Vrms from a 50-ohm source over a frequency range of 150 kHz to 50 MHz per the MIL-STD-462/461C CS02 test method.

RB_PRD-1306 The Instrument shall not exhibit any malfunction, degradation of performance, or deviation from specified indications, beyond the tolerances indicated in the individual equipment or subsystems specification, when spacecraft interface power and signal cables are subjected to a pre-calibrated signal having rise and fall times, pulse width, and amplitude as specified in Figure 6.3.3.2.1-6 at a 30-Hz rate for one minute per the MIL-STD-461F CS115 test method.

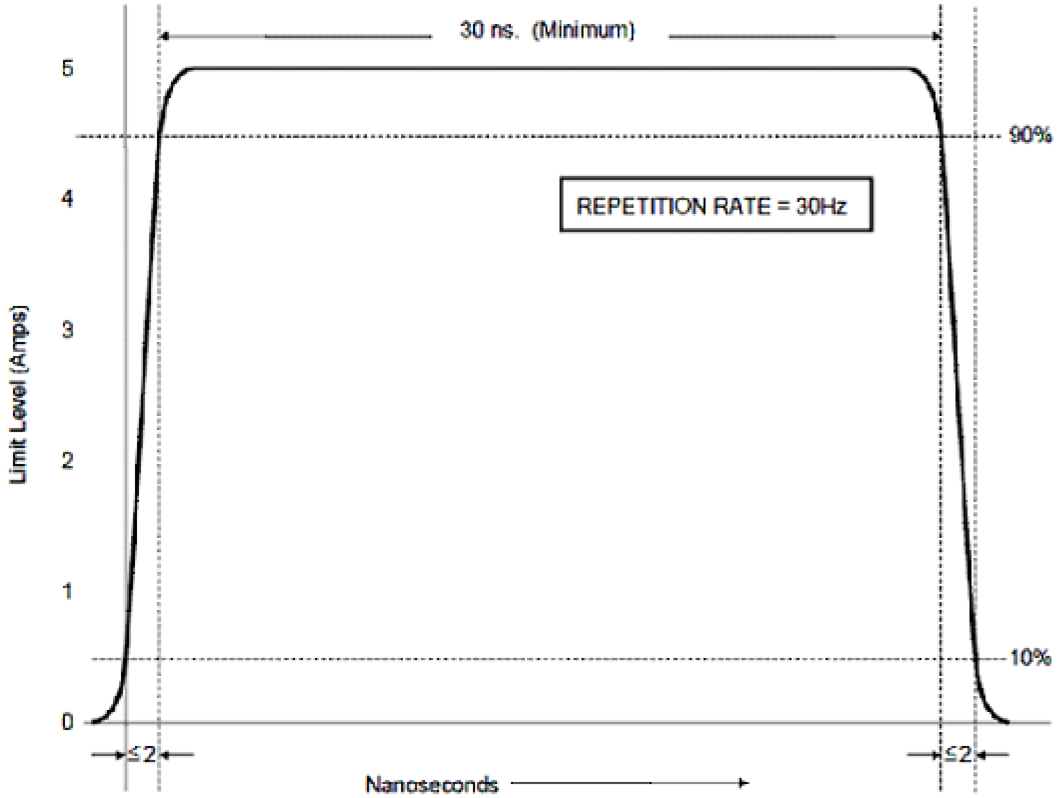


Figure 6.3.3.2.1-6 CS115 signal characteristics.

RB_PRD-1309 The Instrument shall have no intentional RF Receivers.

RB_PRD-1310 The Instrument shall not exhibit any undesired response or degrading of operational performance beyond requirements, due to negative transient signals, beyond specified tolerances when the test spikes having the waveform shown on Figure 6.3.3.2.1-7 are applied to the power input leads once per second, and for a total test period of 1 minute in duration (in lieu of the values in MIL-STD-462). The values to use for E( ) is 0 V with a tolerance of +3.0V/–0V, t( ) is 10 µS, and initial voltage is 30 V. Each spike shall be superimposed on the power line voltage waveform.

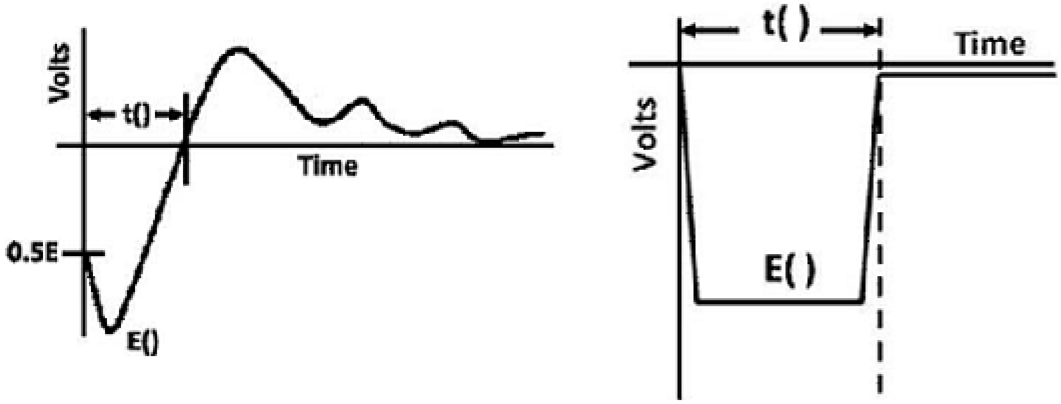


Figure 6.3.3.2.1-7 Acceptable wave shapes for CS06.

6.3.3.2.2 Radiated Susceptibility

6.3.3.2.2.1 Radiated Susceptibility, RS101

RB_PRD-1315 The Instrument shall not exhibit any malfunction, degradation of performance or deviation from the specified indications beyond the tolerances indicated in their individual specifications as a result of being irradiated with the magnetic field levels shown in Figure 6.3.3.2.2.1-1 per MIL-STD-461F RS101 testing (Navy parameters).

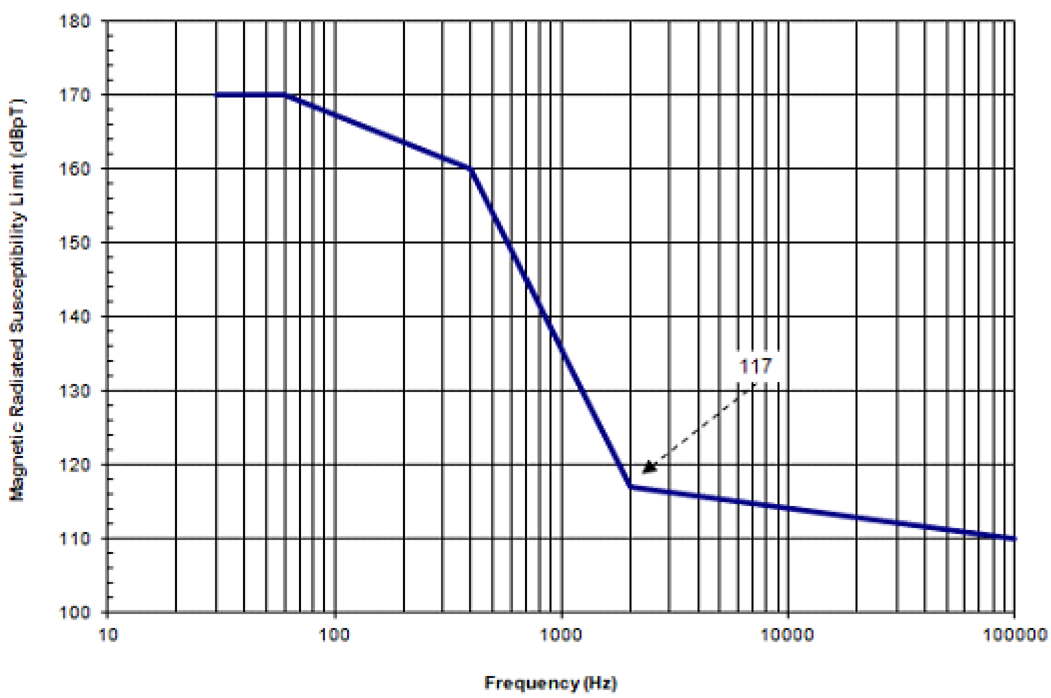


Figure 6.3.3.2.2.1-1 Alternating current (AC) magnetic field radiated susceptibility limit (RS101).

6.3.3.2.2.2 Radiated Susceptibility RS103

RB_PRD-1319 RS103 testing shall be performed per MIL-STD-461F as tailored by the requirements stated in Section 7.6.1.

6.3.3.2.3 Radiated Emissions

6.3.3.2.3.1 Magnetic Field Radiated Emissions, RE101

RB_PRD-1322 Radiated AC magnetic field emissions from the Instrument shall not exceed the levels shown in Figure 6.3.3.2.3.1-1 at a distance of 7 cm per MIL-STD-461F, RE101.

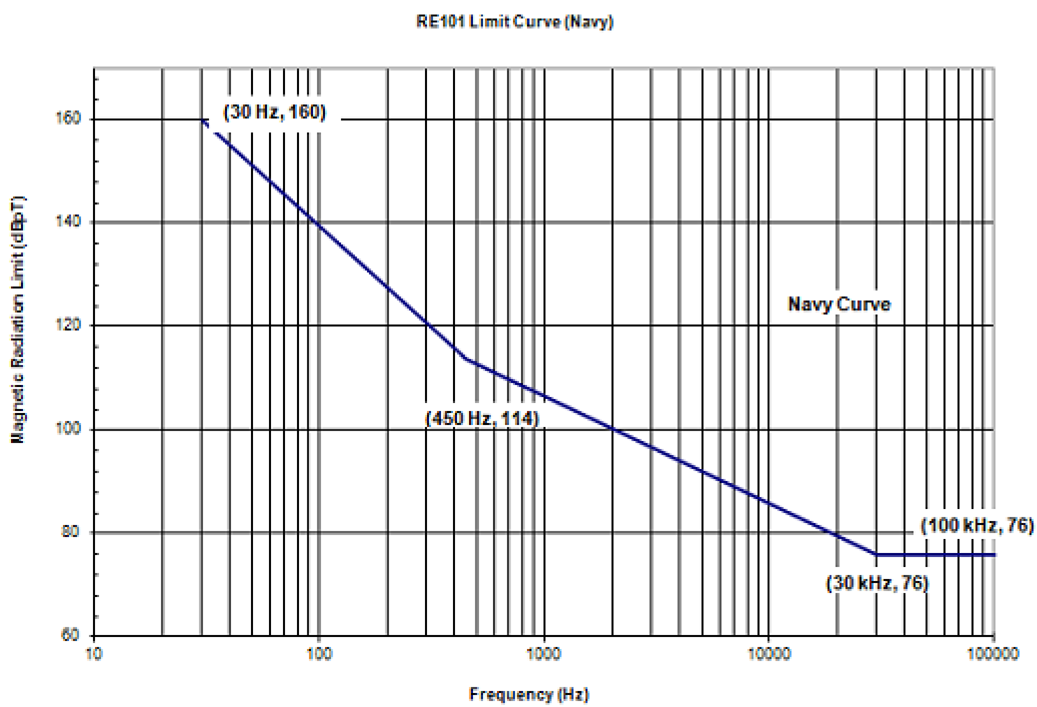


Figure 6.3.3.2.3.1-1 Radiated emissions, magnetic field (RE101).

6.3.3.2.3.2 Electric Field Radiated Emissions, RE102

RB_PRD-1326 Radiated emissions testing, RE102, shall be from 2 MHz to 18 GHz.

Note: RE102 testing in the frequency range of 10 kHz to 200 MHz is not required if the Instrument complies with the limits specified for the CMBCE Test (RB_PRD-1231).

RB_PRD-1327 The Instrument shall have no RF transmitters.

RB_PRD-1328 The Instrument shall have no intentional radiated emissions.

RB_PRD-1329 Unintentional radiated electric field emissions from the instruments shall not exceed the levels shown in Tables 6.3.3.2.3.2-1 and 6.3.3.2.3.2-2.
The test method is as defined in MIL-STD-461F RE102 except for the modified bandwidths shown in Table 6.3.3.2.3.2-2.

The test method is as defined in a modified MIL-STD-461F RE102 test.

Table 6.3.3.2.3.2-1 Unintentional Radiated Electric Field Emissions, 2 MHz to 18 GHz, Standard MIL-STD-461F Bandwidths

Frequency (MHz)	Limit Level (dBμV/m)	6dB Resolution Bandwidth (Hz)	Receiver Protected
2	56	10K	
30	56	10K	
30	56	100K	
1000	56	100K	
1000	56	1M	
1201	56	1M	
1201	35	1M	GPS-L2
1253	35	1M	GPS-L2
1253	56	1M	
1550	56	1M	
1550	37	1M	GPS-L1
1600	37	1M	GPS-L1
1600	56	1M	
2025	56	1M	
2025	40	1M	CMD
2110	40	1M	CMD
2110	56	1M	
4000	56	1M	
4000-18000	+20 dB per decade	1M	
18000	69	1M	

Table 6.3.3.2.3.2-2 Unintentional Radiated Electric Field Emissions, Receiver Frequencies, Narrowband MIL-STD-461F Scans (Modified Bandwidths)

Frequency (MHz)	Limit Level (dBμV/m)	6dB Resolution Bandwidth (Hz)	Receiver Protected
1208	12	1000	GPS-L2
1244	12	1000	GPS-L2
1556	14	1000	GPS-L1
1592	14	1000	GPS-L1
2025	15	1000	CMD
2110	15	1000	CMD

RB_PRD-1330 The Instrument shall meet the radiated emissions requirements shown in Table 6.3.3.2.3.2-3 if the Instrument contains noise sources above 5 GHz.

Table 6.3.3.2.3.2-3 Unintentional Radiated Electric Field Emissions, 18 to 200 GHz

Frequency Range		Emission Limits	Susceptible Receiver
From (MHz)	To (MHz)	(dBμV/m) [1]	
18000	200000	69-90	General Requirement [1]
23567.25	24032.75	46	ATMS Channel 1
31241.5	31558.5	69	ATMS Channel 2
50141.5	50458.5	57	ATMS Channel 3
51425	52095	58	ATMS Channel 4
52465	53135	62	ATMS Channel 5
53316	53446	62	ATMS Channel 6
53746	53876	62	ATMS Channel 6
54065	55782.25	61	ATMS Channels 7-9
56889.22	57691.46	47	ATMS Channels 10-15
86665	92235	71	ATMS Channel 16
163665	167335	67	ATMS Channel 17
176028.1	176157.9	66	ATMS Channel 18
178489.3	178495.3	66	ATMS Channel 19
179989.3	179995.3	66	ATMS Channel 20
181190.7	181204.9	66	ATMS Channel 21
181990.7	182004.9	66	ATMS Channel 22
184615.1	184629.3	66	ATMS Channel 22
185415.1	185429.3	66	ATMS Channel 21
186624.7	186630.7	66	ATMS Channel 20
188124.7	188130.7	67	ATMS Channel 19
190462.2	190591.9	67	ATMS Channel 18

[1] General requirement for Unintentional Emissions is 69 dBμV/m at 18 GHz and increases +20 dB/decade. Limits apply at a distance of 1 meter from the instrument.

6.3.3.3 Magnetic Requirements

RB_PRD-1341 The remnant uncompensated magnetic moment of an Instrument shall not exceed 0.031 ampere-turn-meter-square (31 pole-cm) per kilogram of Instrument mass. *An alternate method of allocation can be used by the Spacecraft contractor, if the allocation is documented in the individual Instrument ICDs.*

RB_PRD-1342 The stray uncompensated magnetic moment of the Instrument shall not exceed 0.0106 ampere-turn-meter-square (10.6 pole-cm) per watt of Instrument average operational power. *An alternate method of allocation can be used by the Spacecraft contractor, if the allocation is documented in the individual Instrument ICDs.*

6.3.4 Data and Signal Interfaces

RB_PRD-1344 All electrical interfaces except test point interfaces shall be functionally redundant.

6.3.4.1 Spacecraft/Instrument Data Bus

RB_PRD-1346 The Instrument shall utilize either the MIL-STD-1553B or SpaceWire communication protocol and data bus.

6.3.4.1.1 Instrument 1553 Data Bus

The requirements below are applicable to RBI only if the Instrument utilizes the MIL-STD-1553 data bus.

RB_PRD-1349 All 1553 Bus Controller (BC), Remote Terminal (RT), and coupling transformer devices shall comply with MIL-STD-1553B requirements.

RB_PRD-1350 All RTs shall be transformer-coupled, as specified in MIL-STD-1553B.

A typical subsystem RT interface to the data bus is shown in Figure 6.3.4.1.1-1.

RB_PRD-1352 The Instrument RT address shall be configurable.

RB_PRD-1353 The 1553 bus shall use transformer coupling as defined in Section 4.5.1.5.1 of MIL-STD-1553B.

RB_PRD-1354 1553 bus cabling shall be twin-ax cable with a characteristic impedance of 78 ohms (MIL-C-17/176-00002 or equivalent).

RB_PRD-1355 The 1553 bus coupling transformer shall have a turn ratio of 1:1.41 ± 3%.

RB_PRD-1358 RT isolation transformers shall be designed to provide an output signal level of 18 to 27 V p-p at the component output interface.

RB_PRD-1359 A dual, standby-redundant bus as defined in MIL-STD-1553B shall be used.

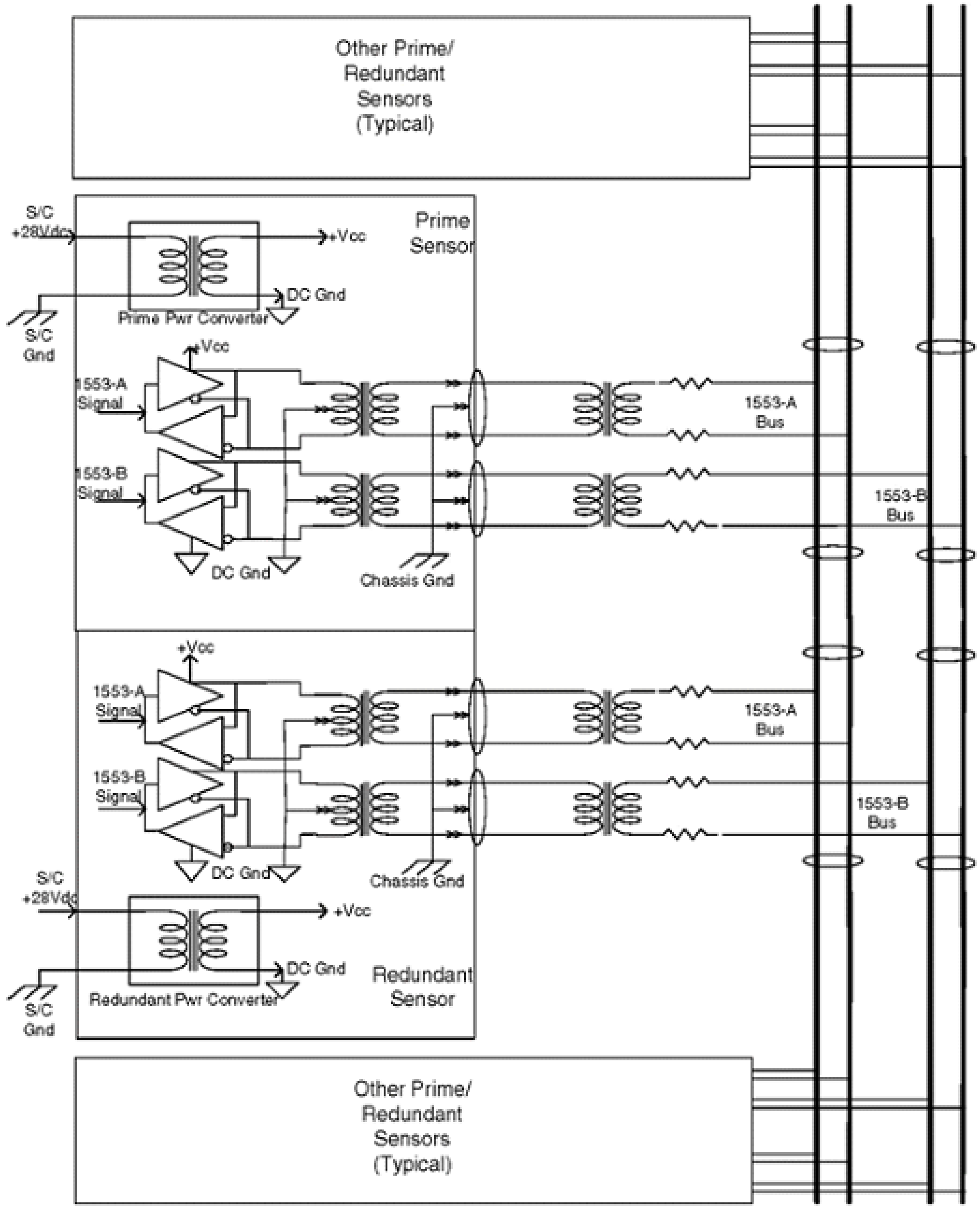


Figure 6.3.4.1.1-1 1553 detailed system topology.

6.3.4.1.2 Instrument SpaceWire Link

The requirements below are applicable to RBI only if the Instrument utilizes the SpaceWire data bus.

RB_PRD-1364 The SpaceWire link shall comply with ECSS-E-ST-50-12C, except where tailored by this document.

RB_PRD-1365 All SpaceWire interfaces shall use a unique physical PHY for the signal layer transmission and reception between A and B links of the powered Instrument and Spacecraft.

RB_PRD-1366 Each SpaceWire interface to the Instrument, and the corresponding redundant link, shall be capable of operating independently, such that commands and telemetry can flow concurrently to all other SpaceWire instruments on the bus and changes to a single interface do not affect the other.

RB_PRD-1367 Each SpaceWire link to the Instrument shall be capable of being re-initialized without impacting another Instrument's SpaceWire link.

RB_PRD-1368 Each SpaceWire link's transmit or receive buffer shall be capable of being reset/re-initialized without impacting another Instrument's SpaceWire link's transmit and receive buffers.

6.3.4.2 Passive Analog Telemetry

RB_PRD-1370 The Instrument shall provide functionally redundant passive analog temperature sensors sufficient to determine the thermal state of the Instrument in all operational modes, including Off Mode. Use of more than five redundant pairs requires approval by NASA LaRC.

RB_PRD-1373 Passive Analog Telemetry returns shall be isolated from Chassis Ground and Secondary Power returns by >1 MOhm.

6.3.4.3 Passive Bi-level Telemetry

RB_PRD-1375 Passive Bi-level Telemetry shall be implemented as an open circuit or closed circuit, having the following characteristics:

- Open contact resistance shall be >100 K ohms
- Closed contact resistance shall be <100 ohms

6.3.4.4 Discrete Command Interfaces

RB_PRD-1379 All Instrument discrete pulse commands shall be redundant.

RB_PRD-1380 Instrument discrete pulse commands shall return current over a dedicated return line in a twisted shielded pair (TS2) with the command line.

RB_PRD-1381 The pulse command characteristics shall be as follows:
Inactive:
Amplitude:

- –2.0 to 4.0 VDC @ 4 microamps load source current

Active:
Amplitude:

- 22 VDC to bus voltage @ 350 ma load sink current
- Load Impedance: 97 ohms minimum
- Pulse Width: 70 ± 10 milliseconds
- Voltage Rise Time: 4 msec maximum
- Voltage Fall Time: 6 msec maximum

RB_PRD-1392 The Instrument shall provide series redundant suppression diodes in parallel with all inductive loads interfacing to Pulse Commands.

RB_PRD-1393 The minimum time between the leading edges of consecutive Pulse Commands shall be 160 msec.

6.3.4.5 Synchronization Pulses Electrical Characteristics. Retired - covered in ICD.

6.3.4.6 Deployment Device Release Electronics

6.3.4.6.1 Electro Explosive Devices (EED)

RB_PRD-1402 Electrical circuits used to activate EEDs shall be at least dual fault tolerant.

RB_PRD-1403 Electrical circuits used to activate EEDs, shall be properly protected from inadvertent charging, by means of charge bleed resistance to ground for each circuit.

RB_PRD-1404 Electrical circuits used to activate EEDs shall be fused and current limited to protect against EED bridgewire failure to clear.

RB_PRD-1405 The Distinction between an installed Safe Plug and an installed Arm Plug for EEDs, or the absence of any installed plug, shall be telemetered.

RB_PRD-1406 Electrical circuits used to activate EEDs shall meet the Detail Design Criteria (requirements) of MIL-STD-1576.

6.3.4.6.2 Non-Explosive Devices (NED)

RB_PRD-1408 Electrical circuits used to activate NEDs, used for release or deployment mechanisms, shall be at least single fault tolerant.

RB_PRD-1409 Electrical circuits used to activate NEDs, used for release or deployment mechanisms, where inadvertent activation is hazardous (may cause personnel injury or damage to high-value hardware) shall be at least dual fault tolerant.

RB_PRD-1410 Instrument non-explosive release mechanisms shall meet range safety requirements of NASA-STD-8719.24.

6.3.4.7 External Test Point Interfaces

RB_PRD-1412 Captive, EMI tight, flight quality, and flight capable test connector covers shall be installed whenever the test connector is not in use.

RB_PRD-1413 Credible test point failures, or misapplication of voltage to a test point, shall not cause damage or degradation.

RB_PRD-1414 Test points shall be designed such that a short circuit to ground, or any conductor on the same connecter, will not compromise performance.

RB_PRD-1415 Test point interface circuitry and GSE shall not violate the Observatory grounding scheme.

6.3.5 Multipaction and Corona

RB_PRD-1417 Components with high-voltage circuits shall be immune to corona and arcing while in a nominal orbital vacuum environment.

6.3.6 Flight Electronics Design and Development

RB_PRD-1419 The Instrument shall maintain electrical isolation of greater than 100 kOhm between the primary and redundant interface circuitry to the Spacecraft per the JPSS-2 Spacecraft to RBI Instrument ICD.

6.3.7 Electrical Harness Design and Development

6.3.7.1 Connector Identification

RB_PRD-1422 Connectors on components and harnesses shall have clearly marked, permanent and unique identifiers.

6.3.7.2 Connector Keying

RB_PRD-1424 Connectors of the same type and gender, where accidental mismate is possible AND could cause damage to the hardware, or pose a safety hazard, shall be keyed differently or appropriate warnings included in test and/or assembly documentation.

6.3.7.3 Connector Design Selection

RB_PRD-1426 Multi-contact connectors shall be selected in accordance with MIL-STD-975M, GSFC EEE-INST-002 or MSFC-40M39569.

Multi-contact connectors should be sized, by design, to have 10% spare (unused) contacts. (See "Spare" contact definition in Section 6.3.7.4).

RB_PRD-1428 For any connector pair providing Main Bus or Secondary Power, the connector at the source side shall not have exposed contacts.

RB_PRD-1429 For any connector that cannot be deadfaced (power removed by command) a scoop-proof connector pair shall be used, selected in accordance with MIL-STD-975 and/or GSFC EEE-INST-002.

RB_PRD-1430 Connectors providing HVPS power shall be qualified, rated high-voltage connectors, selected in accordance with MIL-STD-975 and/or GSFC EEE-INST-002.

RB_PRD-1431 Multi-contact connectors shall not be used for high-voltage applications (250 VAC P-P, or 300 VDC).

RB_PRD-1432 All coaxial, tri-axial and twin-axial connectors shall be selected in accordance with MIL-STD-975, GSFC EEE-INST-002 or MIL-C-17/176-00002.

RB_PRD-1433 Connectors used as test points shall not have exposed contacts.

6.3.7.4 Unused Connector Contacts

RB_PRD-1435 Contacts shall be designated as "Spare" in the harness documentation if they require no termination on either side of the interface.

RB_PRD-1436 Contacts shall be designated as "No-Connect (NC)" in harness documentation if they require no termination at the harness side of the interface, but are connected to circuits at the opposite side of the interface. The nomenclature NC should be appended with the signal name in these instances.

RB_PRD-1437 Contact requiring terminations in the harness (whether for EMI or biasing purposes) shall not be designated as “Spare” or “NC” and the component/subsystem provider shall specify the required terminations for such signals.

6.3.7.5 Connector Accessibility

RB_PRD-1439 Connectors shall be capable of being mated and demated without the use of special tools.

RB_PRD-1440 Connector location and mounting of components, subsystems, and brackets shall be such that sufficient clearance is provided for the mating and demating of connectors without the removal of affected or adjacent mounted hardware.

RB_PRD-1441 Connector location and mounting of components, subsystems, and brackets shall be such that blind mating of connectors is not necessary.

RB_PRD-1442 Connectors used as test connectors, safe/arm plug interfaces, fuse plugs and/or final closeout items shall be located so as to be accessible, without the removal of mounted hardware, at a level of assembly and processing consistent with the need for access throughout the I&T and Launch campaigns.

6.3.7.6 Harness Wiring Requirements

RB_PRD-1444 Except as noted herein, all harness wiring shall be in accordance with MIL-W-22759 and MIL-C-27500, per EEE-INST-002.

RB_PRD-1445 All 26 American Wire Gage (AWG) and smaller gauge wire shall be high tensile strength wire.

RB_PRD-1446 All wire insulation shall be in accordance with GSFC EEE-INST-002 or equivalents approved by the RBI Parts & Materials Control Board.

RB_PRD-1447 All wire insulation shall be rated at 500 MΩ (min).

Wire splicing in the harness should be minimized to the greatest extent practical.

RB_PRD-1449 Where transitions are necessary from one AWG to another or single conductor to multiple conductors, GSFC EEE-INST-002 approved termination devices shall be used.

RB_PRD-1450 Where splicing is required for rework or repair, splices shall be in accordance with IPC J-STD-001ES and NASA-STD-8739.4.

6.3.7.7 Harness Grouping, Routing and Shielding

RB_PRD-1452 All Twist Groups shall have a twist ratio compliant with the requirements as specified in NASA-STD-8739.4.

RB_PRD-1453 Main Bus Power shall interface using dedicated harness bundles and connectors and not be routed with signals.

RB_PRD-1454 RF signals shall be transmitted on coax cable and terminated using EMI tight RF connectors as per NASA-STD-8739.4.

RB_PRD-1455 All EED signals shall be routed in dedicated harness bundles and through dedicated connectors.

RB_PRD-1456 Where EED signals pass through in-line interface connectors, shields shall be carried through the connectors on dedicated contacts.

RB_PRD-1457 EED signals shall be routed using 20 AWG, double insulated, twisted, shielded wire.

RB_PRD-1458 Shielding of all EED circuitry and interface cabling up to an EED, including safe/arm EED cabling shall be designed to provide maximum continuous shielding effectiveness in order to ensure compliance with the 20-dB EMI Safety Margin (EMISM) requirements of MIL-STD-1576.

RB_PRD-1459 For multi-pin connectors, harness overwrap shields shall be terminated, with 360° circumferential contact, to the connector backshell at both ends of the harness interface.

RB_PRD-1460 Harnesses shall be designed and fabricated to achieve an RF ground bonding resistance of less than 2.5 milliohms between a connector shell and the connector mounting panel.

6.4 Thermal Control Requirements

6.4.1 General

RB_PRD-1464 The operating and survival temperatures, as well as the thermal isolation requirements specified in this section shall be met at the mechanical interface between the Spacecraft and the Instrument.

The Spacecraft will monitor and report the temperatures of the Spacecraft at the Instrument mechanical mounting interfaces in the Spacecraft telemetry.

RB_PRD-1466 The Instrument shall achieve thermal control, once the operational power bus is activated, without use of the survival heaters.

Note: The survival heater bus may be powered during the initial phase of warm-up upon exit from SURVIVAL mode.

6.4.2 Operational Temperature and Heat Transfer Limits

In normal operational mode, the Spacecraft will maintain the temperature of the mechanical Instrument-to-Spacecraft mounting surface within the range of −10 °C and +40 °C so long as the Instrument does not exceed the allowed heat transfer between the Instrument and the Spacecraft. This temperature range includes analytical uncertainty in the Spacecraft prediction.

RB_PRD-1469 The Instrument shall meet all specified performance requirements when the temperature of the mechanical Instrument-to-Spacecraft mounting surface is in the normal operating range of −10 °C and +40 °C.

RB_PRD-1472 Each Instrument module total orbit average heat transfer rate (conducted and radiated) between the Instrument and the Observatory, divided by the footprint area, shall not exceed 15 watts per square meter into or out of the Instrument. This includes heat conducted through the harness and ground straps. The term “footprint area” as used in this requirement means the area under the Instrument module, projected onto the Spacecraft. It does not refer to the area of the footprint of the kinematic mounts.

6.4.3 Survival Temperature Limits

In survival mode, the Spacecraft will maintain the temperature of the mechanical Instrument-to-Spacecraft mounting surface within the range of −20 °C and +50 °C so long as the Instrument does not exceed the allowed heat transfer between the Instrument and the Spacecraft. This temperature range includes analytical uncertainty in the Spacecraft prediction.

RB_PRD-1475 The Instrument temperatures shall stay within the survival limits when the temperature of the mechanical Instrument-to-Spacecraft mounting surface is in the survival range –20 °C and +50 °C and return to normal operations after the Instrument temperature returns to the normal operating range.

6.4.4 Thermal Margins

RB_PRD-1477 The maximum expected temperature range shall be defined as the analytically determined extreme temperatures predicted from thermal models with an additional 5 °C margin.

Analytically determined extreme temperatures are the peak temperatures predicted by a transient orbital analysis performed under worst case hot and worst case cold environmental conditions. Component orbit average temperatures should not be used to define extreme temperature ranges.

RB_PRD-1479 Acceptance ranges shall be calculated by adding a thermal margin of ±5 °C to the maximum expected temperature range per Figure 6.4.4-1.

RB_PRD-1480 Protoflight and/or qualification ranges shall be calculated by adding ±10 °C to the maximum expected temperature range per Figure 6.4.4-1.

RB_PRD-1481 Operational heater duty cycle shall be less than 70% in worst cold case, at minimum bus voltage.

RB_PRD-1482 Survival temperatures shall be defined as the maximum expected temperature range for non-operating or unpowered components that can be experienced without damage or loss of performance when the unit is returned to within the specified operating temperature range.

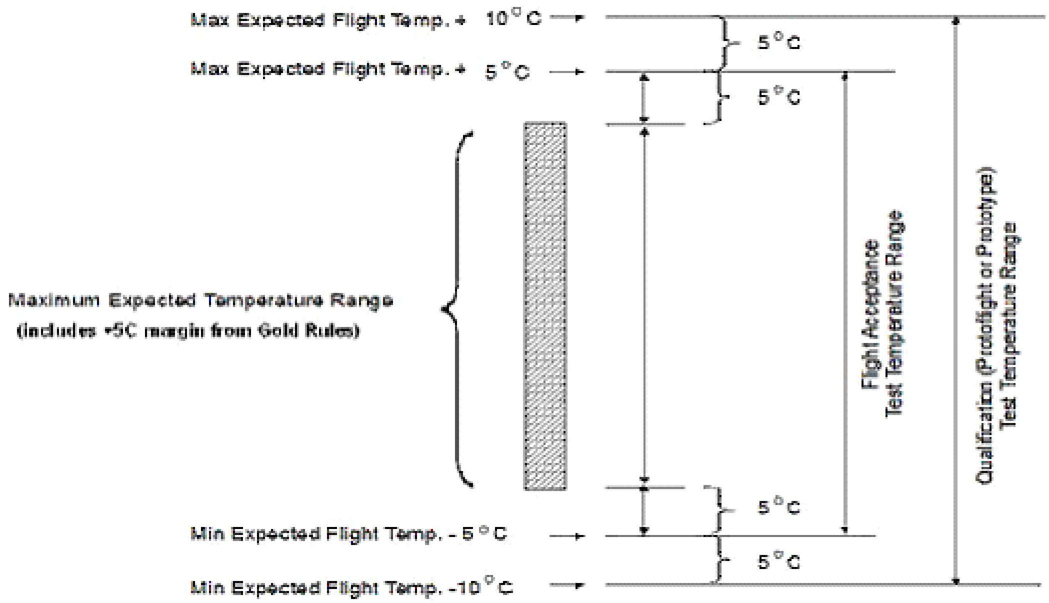


Figure 6.4.4-1 Protoflight and flight acceptance thermal-vacuum temperatures.

6.4.5 Survival Heater Sizing

RB_PRD-1486 The Instrument shall employ survival heaters that are sized to maintain the Instrument at or above the minimum survival temperature when the spacecraft enables survival heater power.

RB_PRD-1487 Instrument design shall be such that having both primary and redundant survival heater circuits enabled does not violate any thermal or power requirement.

RB_PRD-1488 The Instrument shall provide thermal control of the survival heaters, which is single-fault tolerant against excessive application of power.

RB_PRD-1489 Instrument survival heaters shall be sized for a minimum applied voltage of 25 V, at the heater interface.

6.4.6 Contamination Control

RB_PRD-1491 The Instrument shall be designed to function in the Spacecraft contamination environment.

The Spacecraft Contractor will place the Instrument such that the contamination products from the vents of one Instrument will not directly impinge on another Instrument's contamination-sensitive surface nor directly enter another Instrument's aperture unless it can be shown by *analysis (by the Spacecraft contractor or JPSS project) that the performance of the Instrument will not be degraded.*

The Spacecraft contractor will perform a total Spacecraft contamination analysis of all contributing deployment devices on all sensitive surfaces and document the results to the Instrument contractor.

6.4.6.1 Instrument Cleanliness Requirements

The requirements below constitute a minimum set of Instrument cleanliness requirements for JPSS instruments at the Observatory-level. Specific cleanliness requirements for RBI will be determined by the RBI Contractor based on instrument design and contamination budget. Any additional cleanliness requirements specific to the Instrument will be included in a future revision of this document.

Contamination levels specified herein are defined per IEST-STD-1246D.

RB_PRD-1497 The Instrument external surface cleanliness shall be maintained to meet the levels specified in Table 6.4.6.1-1.

Table 6.4.6.1-1 Instrument External Surface Cleanliness Levels

Surface	Ship	S/C Integration	Launch Activities	BOL	EOL
	Particulate Percent Area Coverage (PAC) per Assembly Phase [Cleanliness Level per IEST-STD-CC1246]				
OM Apertures	0.024 [310]	0.083 [400]	0.087 [410]	0.102 [420]	0.607 [600]
Exterior Surfaces	0.241 [500]	0.241 [500]	0.486 [525]	0.918 [650]	1.118 [675]
	Molecular Cleanliness Level per Assembly Phase (NVR Level µg/cm^2) [Cleanliness Level per IEST-STD-CC1246]				
OM Apertures	0.7 [A]	1.00 [A]	1.00 [A]	1.00 [A]	1.50 [1.5A]
Exterior Surfaces	1.0 [A]	1.0 [A]	1.0 [A]	1.75 [1.75A]	4.00 [D]

6.4.6.2 Contamination Control Detailed Requirements

RB_PRD-1528 Contamination control processes are detailed in the JPSS Project Contamination Control Plan (472-00228). Should there be any conflicts between the requirements listed below and the contents of the Contamination Control Plan, this document shall have precedence.

RB_PRD-1529 The Instrument shall not require any sanding/scribing/shaving/machining of any beryllium material after delivery.

RB_PRD-1530 Non-metallic materials used in the construction of the Instrument shall not suffer a total mass loss of greater than 1.0% and a volatile condensable material mass gain of greater than 0.1% when tested in accordance with the Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment, ASTM E595-93.

RB_PRD-1531 If percent total mass loss (%TML) and percent collected volatile condensable material (%CVCM) data is unavailable, the material shall be tested, per ASTM E -1559, or ASTM E 595.

RB_PRD-1532 Vents and outgassing paths shall be controlled to minimize the extent to which molecular outgassing products have access to exterior surfaces.

RB_PRD-1533 Items that might otherwise produce deleterious outgassing while on-orbit, such as composite structures, shall be baked for a sufficient time to drive out all but an acceptable level of outgassing products prior to installation within or on the Instrument.

The acceptable outgassing level for each item will be determined by the Instrument contractor in consideration of the Instrument contamination budget defined within the contractor's Instrument Contamination Control Plan.

RB_PRD-1535 Instrument materials selection shall minimize the generation of particulate and molecular film contamination via interaction with atomic oxygen (AO).

RB_PRD-1536 Thermal control surfaces shall be cleanable to visibly clean level VC-0.5-1000 (per IEST-STD-CC1246E) or better.

RB_PRD-1537 Thermal blankets shall be cleaned and baked prior to installation.

RB_PRD-1538 Tubing design shall incorporate provisions for cleaning and to allow proof testing.

RB_PRD-1539 Separable fittings shall not be designed or assembled with lubricants or fluids that could cause contamination or could mask leakage of a poor assembly.

RB_PRD-1540 The Instrument materials shall be selected for low outgassing, using "Outgassing Data for Selecting Spacecraft Materials" [http://outgassing.nasa.gov] as a guide, and for resistance to the effects of incident radiation.

RB_PRD-1542 The Instrument shall be bagged or covered with contamination and Electrostatic Discharge (ESD) acceptable film whenever possible while in the cleanroom facility.

6.4.6.2.1 Optical Witness Samples

RB_PRD-1544 The Instrument shall have two optical witness samples installable on the Instrument exterior.

RB_PRD-1545 Optical witness samples shall be flight-like and representative of the most contamination-sensitive optical component within the Instrument.

RB_PRD-1546 Optical witness samples shall be from the same optical coating run as the flight components.

RB_PRD-1547 The optical witness sample size (each sample) shall be 25.4 ± 6.4 mm (1.00 ± 0.25 inches) diameter.

RB_PRD-1548 The optical witness sample thickness (each sample) shall be less than or equal to 6.4 mm (0.25 inch).

RB_PRD-1549 Each optical witness sample shall be labeled with a unique and permanent serial number or other identifying mark.

RB_PRD-1550 Optical witness samples shall be identical to each other with exception of the unique identification marking.

RB_PRD-1551 Optical witness samples and associated mounting hardware shall be designed for periodic removal, contamination measurement, and replacement.

The typical remove-measure-replace period is every 3 months, or after each environmental test, or after Instrument/Spacecraft transportation.

RB_PRD-1553 Access for periodic removal and replacement of the optical witness samples and associated mounting hardware shall be from the Instrument exterior only.

RB_PRD-1554 Optical witness samples and associated mounting hardware shall be removable from/installable to the Instrument with the use of standard cleanroom compatible hand tools.

RB_PRD-1555 Optical witness samples shall be fully removable from all associated mounting hardware.

RB_PRD-1556 Optical witness samples and associated mounting hardware shall be remove-before-flight items.

RB_PRD-1557 The Instrument shall be operable with no risk of damage to Instrument hardware with optical witness samples and associated mounting hardware installed.

RB_PRD-1558 The Instrument shall be operable at full functionality with the optical witness samples and associated mounting hardware removed.

6.4.6.2.2 Instrument Purge Equipment

The requirements below are applicable if the Instrument requires a gaseous purge to maintain Instrument cleanliness or prevent hardware deterioration. The Instrument Contractor will identify Instrument purge requirements, if any, and describe purge procedures within the Instrument Contamination Control Plan.

A nitrogen purge will be available to the instruments during Observatory integration, test (except during thermal vacuum testing), and storage.

RB_PRD-1562 Instrument purge gas shall be gaseous nitrogen (GN2) per MIL-PRF-27401 (Grade B or better) or equivalent.

RB_PRD-1563 Instrument purge covers and/or bagging shall remain within the diameter of the Instrument mechanical envelope defined in Section 6.1 of this document.

RB_PRD-1564 Instrument purge covers and/or bagging shall have a contact point for attachment of an electrical grounding strap.

RB_PRD-1565 Instrument purge covers and/or bagging shall be remove-before-flight items.

RB_PRD-1566 Instrument purge covers and/or bagging shall be designed for periodic removal and replacement.

RB_PRD-1567 The Instrument purge control unit shall contain all necessary devices to deliver GN2 to the Instrument at the required gas flow rate and purity.

RB_PRD-1568 The Instrument purge control unit shall meet launch site safety requirements.

6.4.7 Observatory Thermal Environment Maintenance

6.4.7.1 Thermal Recovery

RB_PRD-1571 The Instrument shall take no more than 60 minutes to return from SAFE mode to a temperature condition capable of normal operation, assuming no anomalies. This time limitation does not include passive radiative detector coolers.

RB_PRD-1572 The Instrument shall take no more than 102 minutes to return from SURVIVAL mode to a temperature condition capable of normal operation, after Spacecraft application of operational power. This time limitation does not include passive radiative detector coolers.

6.4.7.2 Integrated Instrument Thermal Environments

6.4.7.2.1 Environmental Heat Flux

The thermal environment parameters for worst hot and cold cases are shown in Table 6.4.7.2.1-1.

Table 6.4.7.2.1-1 Worst-case hot and cold thermal environment parameters.

Parameter	Hot Case	Cold Case
Solar Constant, W/m^2	1400	1308
Earth IR Constant, W/m^2	262	222
Albedo (ratio)	0.387	0.275

6.4.7.2.2 Spacecraft IR Backload Heat Flux

RB_PRD-1595 The Instrument Contractor shall estimate backloads on the Instrument by the Observatory. The integrated Spacecraft IR backload heat fluxes absorbed on Instrument external surfaces for the cold, hot, and survival cases are defined as a result of the integrated overall Observatory thermal analysis. The Observatory thermal model, or an appropriate surrogate, may be provided to the Instrument teams by GSFC to support such assessments.

The total IR backload on an Instrument external surface, *i*, is given by

$$Q_{IR-Backload,i} = \sum_{j=1}^{J} \sigma A_i \Im_{ij} T_j^4$$

where $j = 1 \rightarrow J$ represents all surfaces radiatively coupled to surface *i*.

The IR backload can be segregated into Spacecraft and Instrument contributions

$$Q_{IR-Backload,i} = \sum_{n=1}^{N} \sigma A_i \Im_{in} T_n^4 + \sum_{k=1}^{K} \sigma A_i \Im_{ik} T_k^4$$

where $n = 1 \rightarrow N$ represents all non-Instrument surfaces (Spacecraft and other instruments), and $k = 1 \rightarrow K$ represents all surfaces of the Instrument.

6.5 Command and Data Handling Requirements

Unless specified otherwise, the requirements in this section will apply to all Command and Data Handling (C&DH) interfaces.

The following functions (see Figure 6.5-1), where appropriate, are to be provided between the Spacecraft and the instruments.

1) Spacecraft to Instrument transfers consisting of:

a. real-time ground commands

b. stored commands

c. memory loads

d. state of health indications

e. auxiliary data (e.g., time code, Observatory ephemeris)

2) Instrument to Spacecraft transfers consisting of:

a. mission data, including auxiliary data received from Spacecraft

b. Instrument health and status telemetry

c. Instrument transition to safe mode indicator

d. Instrument diagnostic data

e. memory dumps

f. survival mode temperatures (not part of the data bus)

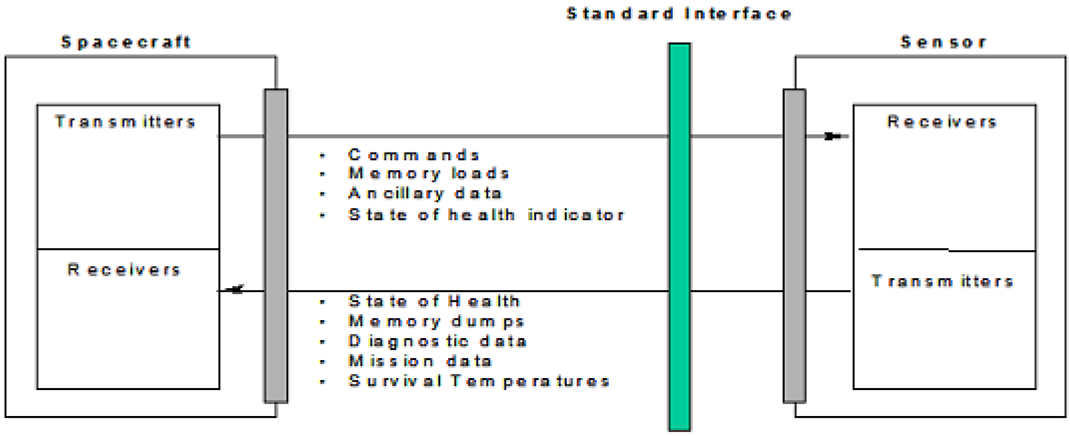


Figure 6.5-1 Data transfer interface.

6.5.1 General Command and Telemetry (Consultative Committee for Space Data Systems (CCSDS)/Packets)

RB_PRD-1624 The Instrument shall accept Instrument data bus command packets from the Spacecraft in unencrypted, cleartext format.

RB_PRD-1625 The Instrument shall accept Instrument memory load source packets from the Spacecraft in unencrypted, clear text format.

RB_PRD-1626 The Instrument shall accept data packets from the Spacecraft with a data bus command packet APID (Application Process Identifier).

RB_PRD-1627 This Instrument shall accept data packets from the Spacecraft with a memory load source packet APID.

RB_PRD-1628 The Instrument shall be capable of functional operation while having no more than one upload per day.

RB_PRD-1634 The Time-of-Day shall employ the Day Segmented Time Code format defined in CCSDS Blue Book 301.0-B-4.

6.5.1.1 Mission Data

RB_PRD-1636 The Instrument shall transfer Mission Data to the Spacecraft C&DH via the Command & Data Interface.

6.5.1.2 Data Packetization

The Spacecraft C&DH Subsystem collects Instrument Health & Status Telemetry, Instrument Memory Dump, and Mission Data packets through the Command & Data interface. The C&DH

Subsystem multiplexes these packets and attaches appropriate protocol for downlink and storage.

RB_PRD-1639 The Instrument shall be capable of selecting which application packets are transmitted.

RB_PRD-1640 The Instrument shall produce Health & Status telemetry source packets (CP_PDU) that contain the appropriate APID.

RB_PRD-1641 The Instrument shall produce Instrument Memory dump packets (CP_PDU) that contain the appropriate APID.

RB_PRD-1642 The Instrument shall produce Mission Data source packets (CP_PDU) that contain the appropriate APID.

RB_PRD-1643 The Instrument shall provide the capability, through APID assignment, to support the selection of source packets, as necessary, by the Spacecraft.

RB_PRD-1645 APIDs not used for a specific Spacecraft configuration shall not be reassigned to another use unless the original assignment is permanently retired.

All “spare” bits within a CCSDS packet data should be permanently set to value “zero”.

6.5.1.3 Instrument Data Types and Packet Formats

All packet formats will be defined in the Spacecraft to Instrument ICD.

6.5.1.3.1 Test Packets

RB_PRD-1659 The Instrument shall be capable of generating and transmitting, on command, a continuous sequence of packets.

RB_PRD-1660 The data pattern shall be repeated within each packet or repeated over an integral number of packets.

RB_PRD-1661 The test packet(s) shall consist of a fixed packet header and a known data pattern within the data zone.

RB_PRD-1662 The packet header “type” bit shall be set to logical zero.

RB_PRD-1663 Each test packet type shall be identified with a unique APID.

RB_PRD-1664 The Instrument shall be capable of producing a test packet in each mode in which operational power is enabled.

RB_PRD-1665 Test packets shall be at science data packet frequency, not to exceed the peak data rate for the Instrument.

6.5.1.3.2 Memory Dump Packets

RB_PRD-1667 Memory dump packets shall consist of the contents of the commanded range of memory or processor register dump.

RB_PRD-1668 Memory dump packets shall be implemented for any unit that contains processor functionality.

RB_PRD-1669 Memory dump packets shall consist of a range of memory not to include computer register, which could lock up the central processing unit (CPU) upon register access.

6.5.1.3.3 Engineering Packets

RB_PRD-1671 The Instrument shall produce engineering packets consisting of all engineering data required to meet specified science data processing performance such that the combination of science data and engineering data is, without excess, sufficient to achieve specified performance.

6.5.1.3.4 Housekeeping Telemetry Packets

RB_PRD-1674 The Instrument shall produce health and status telemetry packets that include housekeeping data required for Instrument status and health monitoring.

RB_PRD-1675 Instrument health and status telemetry shall include, as applicable:

a. Instrument mode and configuration,
b. Instrument temperatures,
c. Instrument internal (converter) power supply voltage and currents,
d. Relay status, scan mirror rotation, and other rotating mechanism rates,
e. Verification of commands received and commands executed,
f. Other telemetry data required to support Instrument performance evaluation.

RB_PRD-1682 Instrument housekeeping data shall be generated continuously in all modes except when operational power has been turned off by the spacecraft.

RB_PRD-1683 The delay between housekeeping data generation and availability for transmission onto the data bus shall not exceed 2 seconds plus the fundamental Instrument scan or data production cycle.

6.5.1.3.5 Dwell Packets

RB_PRD-1685 Dwell packets shall consist of the resulting data of commanded housekeeping or engineering data over-sampling to obtain increased bandwidth knowledge for diagnostic purposes.

RB_PRD-1686 Dwell data shall be a specific set of data, as defined in the unique Spacecraft-to-Instrument ICD, requested by command to be repetitively sampled for diagnostic purposes.

6.5.1.3.6 Calibration Packets

RB_PRD-1688 Calibration packets shall consist of resulting data from Instrument calibration, alignment or other precision enhancing actions, used to compensate or otherwise reduce science and/or engineering data uncertainties.

RB_PRD-1689 Calibration data required for Instrument calibration, alignment, and data processing shall be documented in the unique Spacecraft-to-Instrument ICD.

6.5.1.3.7 LEO&A Packets

RB_PRD-1691 LEO&A packets shall contain the bare minimum housekeeping data necessary for management of the Instrument when the Spacecraft normal telemetry stream is not functioning due to emergency conditions.

RB_PRD-1692 A pre-defined critical subset of Instrument Engineering and Housekeeping data shall be extracted by the Instrument and sent to the Spacecraft using a dedicated APID.

RB_PRD-1693 Critical Instrument engineering and housekeeping data shall be documented in the unique Spacecraft-to-Instrument ICD.

6.5.1.3.8 Diagnostic Packets

RB_PRD-1696 The diagnostic telemetry shall be placed within selected packets, identified with a unique packet APID.

RB_PRD-1697 Diagnostic data shall be any data other than normal engineering data and science data that are downlinked to support ground diagnosis of Instrument anomalies.

RB_PRD-1698 Diagnostic data shall be transferred to the Spacecraft in the same way science data is transferred.

6.5.1.3.9 Science Packets

RB_PRD-1700 Science data shall be broken into multiple APID such that the data is capable of being sorted by APID at the lowest useful level.

RB_PRD-1701 Science packets shall consist of Instrument measurement and observation data, whether processed or raw, such that the combination of science data and engineering data is, without excess, sufficient to achieve specified performance as determined by the supplier of the associated mathematical algorithms.

6.5.1.3.10 Telemetry Monitoring Packets

The Spacecraft TMON function performs limit checking on specific data items and is capable of activating a stored command sequence when errors are detected. Group and Logic Tables are used to define the data thresholds. The ground is capable of modifying any of the TMON tables via a Memory Load operation. The TMON function compares the collected data with the predefined limits defined in the tables.

Any payload telemetry parameter that requires monitoring by the Spacecraft must be placed in a TMON packet message. Payload telemetry sent in LEO&A and Housekeeping packets simply goes to the ground without Spacecraft monitoring.

If an Instrument requires an action by the Spacecraft, the algorithm associated with each data item within a telemetry monitor packet will be documented in the unique Instrument-to-Spacecraft ICD.

RB_PRD-1707 TMON packets shall contain only the information required for the specified action by the supplied algorithm.

6.5.1.4 Telecommand Formatting

All packet maximum sizes will be defined in the Spacecraft to Instrument ICD.

6.5.2 Commanding

RB_PRD-1735 The Instrument shall be capable of supporting all routine science operations with no more than 12 minutes of command uplink contact every 24 hours.

RB_PRD-1736 The Instrument shall be capable of continuous operations without receiving ground commands for a minimum of 48 hours. The Spacecraft will be capable of accommodating commands required for at least 48 hours of operations in addition to any safing commands required in the event of extended loss of ground contact.

6.5.2.1 Command Verification

RB_PRD-1738 Receipt of individual commands via the Command & Data bus shall be verifiable via Instrument Health and Status telemetry.

RB_PRD-1739 Execution of serial commands (data bus) shall be verifiable via Instrument Health and Status telemetry.

RB_PRD-1740 Execution of discrete commands shall be verified via discrete Instrument telemetry points sampled by the Spacecraft.

RB_PRD-1741 The Instrument shall execute all valid commands.

RB_PRD-1742 Invalid commands shall be reported in telemetry.

6.5.2.2 Real-time Ground Commands

RB_PRD-1744 The Instrument shall accept and execute all valid commands issued to the Instrument.

The Spacecraft will execute real-time commands within one second of receipt by the Spacecraft.

6.5.2.3 Stored Commands

RB_PRD-1747 The Instrument shall be capable of supporting absolute time commands and relative time sequences.

RB_PRD-1748 The Instrument shall accommodate stored commands with a maximum time resolution of one second or finer.

RB_PRD-1749 The Instrument shall tag for stored commands will have a resolution of 1 second or finer.

RB_PRD-1750 The Instrument shall execute absolute time commands within 1 second of their time tag.

RB_PRD-1751 The Instrument shall execute relative time commands within 1 second of their designated delay of issue.

RB_PRD-1752 The Instrument shall provide a means to modify (e.g., add, delete, replace) the contents of the stored command buffers.

RB_PRD-1753 The Instrument shall provide a mechanism to manage (e.g., enable, disable, cancel) individual relative time sequences.

RB_PRD-6362 The Instrument shall allow the user to store at least 32 user defined command sequences, each consisting of at least 64 commands, which can be selected from all available profiles.

RB_PRD-6363 The Instrument shall have a command to execute any user defined command sequence.

RB_PRD-6364 The Instrument shall allow the user to store at least 16 user defined elevation scan profiles, each consisting of at least 36 inflection points, which control elevation angle and rate over time.

RB_PRD-6365 The Instrument shall include a command to execute user defined elevation scan profiles.

6.5.2.4 Command Restraints

RB_PRD-1755 The Instrument commands shall be explicitly defined to cause the same effects when executed without a dependence on the previous state.

RB_PRD-1756 Each command shall be unique and have the same effect in all Instrument modes for which the command is applicable.

RB_PRD-1757 The Instrument shall execute valid commands in any sequence without damage.

RB_PRD-1758 For any command, the command format shall be identical for every mission phase and every Instrument mode for which the command is applicable.

RB_PRD-1759 Within commands that control multiple discrete conditions, each controlled function shall have an enabling bit (or a unique code) which shall be able to be changed individually or in any combination.

RB_PRD-1761 The Instrument shall execute commands that disable or override all automatically triggered Instrument functions that change configuration or operational state of the Instrument, including Instrument induced transition to SAFE mode.

6.5.2.5 Critical Command

RB_PRD-1763 The Instrument shall utilize separate enable and execution sequences for critical or hazardous functions.

RB_PRD-1764 Enables shall be disabled by the Instrument after the critical function is commanded, or after 30 seconds have elapsed following receipt of the enable, if the command itself has not been received.

6.5.3 Telemetry

RB_PRD-1766 The Instrument shall provide for transmission to the ground system the Instrument Raw Data Records (RDRs), Calibration Data, and Instrument Housekeeping Data per the unique Instrument-to-Spacecraft ICD.

RB_PRD-1767 The Instrument shall report all critical Instrument temperatures in the health and status telemetry data.

RB_PRD-1768 The Instrument shall use lossless compression techniques when compression is required.

6.5.3.1 Instrument Health and Status Telemetry

RB_PRD-1770 The Instrument shall use the same telemetry stream format for ground activities and on-orbit operation.

RB_PRD-1771 All telemetry used for determining Instrument configuration shall be invariant to Instrument mode.

6.5.3.1.1 Telemetry Diagnostic Data

RB_PRD-1773 The Instrument shall provide sufficient telemetry to diagnose failures to the lowest switchable level, and to track variations in performance of critical functions.

RB_PRD-1774 During Instrument anomaly resolution, the Instrument shall have the capability to dwell (multiple samples per second) on particular telemetry measurands, as required to support ground diagnostic investigations.

RB_PRD-1775 Telemetry dwell shall be in response to a ground-initiated process.

6.5.4 Timing

The Spacecraft will provide a 1-Hz Time-of-Day pulse to indicate the point in time at which to apply the time code which was previously transmitted over the data bus.

The Observatory on-board absolute correlation of time will be no greater than 1 millisecond to UTC.

RB_PRD-1782 The Instrument shall time stamp all CCSDS packets with the UTC time of the event measured.

RB_PRD-1783 The Instrument shall utilize the rising edge of the Time-of-Day pulse, together with the time code data, in order to establish the time reference for Instrument data within 1 millisecond of UTC.

The Spacecraft will issue the Time of Day pulse rising edge (non-inverting side of differential interface) within 5 microseconds of each Spacecraft 1-second time occurrence.

RB_PRD-1785 The Instrument shall correlate the time code, contained within packets generated by the Instrument, to the time of sampling data with sufficient accuracy to enable the government to produce the desired Environmental Data Record performance.

RB_PRD-1786 The Instrument additional Time-of-Day uncertainty as included in their packet headers shall be less than 500 microseconds.

6.5.4.1 Time Code Data and Format

RB_PRD-1789 The broadcast time shall become effective upon receipt of the Time-of-Day pulse that follows.

6.5.4.2 Time Code Data Transfer

RB_PRD-1794 The Instrument shall accommodate the arrival of the broadcast Time-of-Day between 100 ms and 900 ms prior to the arrival of the next Time-of-Day pulse per Figure RBI-336 in the JPSS-2 Spacecraft to RBI Instrument Interface Control Document (472-00283).

Note: This allows RBI to perform its operations given these timing characteristics from the Spacecraft.

6.5.4.3 Missing Time Code Data

RB_PRD-1798 Instruments shall go into Safe Mode should the number of consecutive Time-of-Day pulses missed exceeds the safe mode Time-of-Day counter threshold.

6.5.5 Internal Observatory Data Communications

The RBI communications protocol will be standard 1553 protocol and C&DH implementation will be developed as necessary for instrument performance and to accommodate instrument design. C&DH details are documented in DRD OO-03 Instrument Command Telemetry, Science, and Engineering Data Description document, RBI-PMT-CDRL-0001-Rev-A.

The Spacecraft will provide discrete commands for Instrument operational and survival heater power switching, fault recovery, and squib functions as necessary. The Spacecraft will provide time synchronization and Time-of-day pulses. The Spacecraft will provide auxiliary data and Spacecraft ephemeris, where appropriate.

RB_PRD-1802 The standard means of transmitting commands and data loads from the Spacecraft to the Instrument shall be via the data bus.

6.5.5.1 Instrument Data Rates

RB_PRD-1807 All telecommand and memory load data rate or other operational constraints shall be documented in the unique Spacecraft-to-Instrument ICD.

RB_PRD-1808 The Instrument shall provide buffering for those periods of time where the data rate of transfer is above the average.

6.6 Flight Software Requirements

6.6.1 Instrument Fault Detection and Response

RB_PRD-1825 The Instrument software shall perform fault detection on all commands and operations, and reject any function which could cause Instrument damage, loss of communication, or loss of data.

RB_PRD-1826 The Instrument shall prevent the propagation of unsafe conditions to Spacecraft subsystems and other instruments due to Instrument failures in operational and survival power feeds, data lines, and passive and active discrete electrical signals.

RB_PRD-1827 The Instrument, with use of the Spacecraft TMON capability, shall be capable of maintaining its health and safety without ground support.

6.6.1.1 Monitoring of Housekeeping Data

The Spacecraft will be capable of continuously monitoring Instrument Housekeeping Data, detecting out-of-limit conditions, and responding to these out of limit conditions by configuring an appropriate safe state for the Instrument.

6.6.1.2 Ground Override of Autonomous Functions

RB_PRD-1831 All autonomous Instrument safing functions shall be capable of being overridden by ground command.

Not intended to include one-time protective hardware devices, such as electrical fuses, battery cell bypass switches, etc.

6.6.2 Flight Processor

RB_PRD-1834 During development, flight processors providing computing resources shall be sized for worst case utilization not to exceed the capacity shown in Table 6.6.2-1 (measured as a percentage of total available resource capacity).

Table 6.6.2-1 Flight processor resource utilization limits.

Mission Phase	**SRS Review**	**Software PDR**	**Software CDR**	**Ship/Flight**
Method	Estimate	Analysis	Analysis/Measured	Measured
RAM	50%	50%	60%	70%
PROM	50%	70%	80%	100%
EEPROM	50%	50%	60%	70%
CPU	50%	50%	60%	70%

RB_PRD-1873 The Instrument shall be reset on execution of a discrete hardware command, or on execution of a flight software initiated instruction or instruction set.

RB_PRD-1874 Flight software shall preserve the contents of selected memory regions (e.g., event log, parameter data tables) following a soft reset.

RB_PRD-1875 The flight software shall be deterministic in terms of scheduling and prioritization of critical processing tasks to ensure their timely completion.

RB_PRD-1876 All software data that are modifiable and examinable by ground operators shall be organized into tables that can be referenced by table number so table data can be loaded and dumped by the ground without reference to memory address.

6.6.3 Flight Software Detailed Requirements

RB_PRD-1878 Instrument flight software shall be developed in a high-level language compliant with an ANSI standard.

Minimal use of processor-specific assembly language is permitted for certain low-level program functions such as interrupt service routines and device drivers.

6.6.3.1 Software Revision Number Identification

RB_PRD-1881 All Instrument software shall be implemented with an internal revision number embedded in the executable program and accessible by the C3 Segment.

RB_PRD-1882 The current flight software revision number shall be included in the Instrument housekeeping data.

RB_PRD-1883 Memory loads which modify the behavior of Instrument flight software code shall include a new software revision number. This does not apply to updated data tables, constants, or scan tables.

RB_PRD-1884 Upon receipt of a memory load that affects executable code, the Instrument software shall update its revision number to the new revision number included in the memory load. This does not apply to updated data tables, constants, or scan tables.

6.6.3.2 Software Cyclic Redundancy Check

RB_PRD-1886 The Instrument shall perform a cyclic redundancy check of software code instructions, constants, and static tables startup to be made accessible to the ground.

RB_PRD-1887 The instrument shall be configurable such that if the stored Cyclic Redundancy Check (CRC) does not match the computed CRC, the CRC failure will be flagged in telemetry.

6.6.3.3 Event Log

RB_PRD-1889 Each onboard processor shall maintain a log of errors and anomalous conditions to facilitate troubleshooting of onboard anomalies.

RB_PRD-1890 All flight software components shall utilize a common format for event messages.

6.6.3.3.1 Fault Frame Reporting

6.6.3.4 Processor Watchdog

RB_PRD-1893 The Instrument shall provide processor watchdog hardware to protect against software failure.

RB_PRD-1894 The Instrument shall provide capability to enable and disable processor watchdog hardware.

RB_PRD-1895 The Instrument watchdog hardware shall be enabled and operational by default upon Instrument power-up or reset.

RB_PRD-1896 Once enabled, the Instrument watchdog hardware shall remain enabled and continuously operational until disabled.

6.6.3.5 Memory Integrity

6.6.3.5.1 Volatile Memory Error Correction

RB_PRD-1899 Error detection and reporting of all programmed onboard volatile memory shall be implemented and performed on a frequency of every 24 hours or less.

6.6.3.5.2 Memory Cyclic Redundancy Check

RB_PRD-1901 The Instrument shall perform a CRC on code instructions, constants, and static tables stored in non-volatile memory with a frequency of every 24 hours or less.

6.6.3.5.3 Flight Software Integrity

6.6.3.6 Instrument Memory Dump Capability

RB_PRD-1904 The Instrument shall have the capability to perform memory dumps.

RB_PRD-1905 The Instrument Memory Dumps shall be initiated by ground command.

RB_PRD-1906 The Instrument shall have the capability to dump any portion of its memory, according to the memory location boundaries specified in the ground command.

Memory dumps should be allowed for specified subsections of the Instrument memory, rather than dumping the entire Instrument memory map.

RB_PRD-1908 The Instrument shall be capable of performing memory dumps in any operational mode except SURVIVAL and OFF.

RB_PRD-1909 Memory dumps shall not be performed when the Instrument is operating in a mode in which memory locations are being actively changed.

RB_PRD-1910 Instrument Memory Dump data shall be transferred to the Spacecraft C&DH via the data bus.

RB_PRD-1911 Instrument Memory Dump packetization shall be as specified in Section 6.5.1.3.2.

6.6.3.7 Memory Load Capability

RB_PRD-1913 Instrument memory loads shall be capable of being loaded in segments.

RB_PRD-1915 Instrument memory loads shall be performed only by ground command.

RB_PRD-1916 Instrument memory load commands shall only be accepted in any mode except SURVIVAL and OFF.

RB_PRD-1918 Instrument memory load commands shall be formatted as specified in Section 6.5.1.

RB_PRD-1919 Instrument memory load commands shall span one or more command packets.

6.6.3.7.1 Instrument Software and Table Upload Protections

RB_PRD-1921 Flight software shall be designed so that complete or partial revisions can be installed and verified on-orbit, consistent with operations constraints.

This means, for example, that loads may occur over multiple ground contacts. As such, active memory must not be altered until the complete load is received and verified, at which time the newly uplinked information can be utilized.

RB_PRD-1923 The Instrument software upload shall contain a checksum to be used for onboard error checking upon receipt.

RB_PRD-1924 The Instrument table uploads shall contain a checksum to be used for onboard error checking upon receipt.

RB_PRD-1925 The Instrument shall verify memory load format upon receipt and report acceptance status via telemetry.

6.6.3.8 Bootstrap and Application Code Environment

RB_PRD-1927 The Instrument shall start up into a selectable state, ready to receive and execute commands from and provide telemetry to the Spacecraft.

RB_PRD-1928 The Instrument shall store in non-volatile memory a selectable, protected, pre-launch defined flight software and diagnostics capabilities that cannot be modified or replaced on orbit. This will be referred to as the "default version".

RB_PRD-1929 The Instrument shall store in non-volatile memory at least one selectable flight software version that can be modified or replaced on orbit using memory load commands.

7 SPACE ENVIRONMENT REQUIREMENTS

Specified below are natural environment characteristics in the presence of which the Spacecraft and the instruments must meet all other requirements.

7.1 Pressure

RB_PRD-1933 The Instrument shall be designed to withstand a payload fairing internal pressure decay rate of 0.4 psi/second (2.76 kPa/second), with a single brief excursion (not exceeding 5 seconds) to 0.9 psi/second (6.21 kPa/second).

7.2 Magnetic

RB_PRD-1935 The Instrument shall not exhibit any malfunction, degradation of performance or deviation from the specified indications beyond the tolerances indicated in their individual equipment specifications as a result of being exposed to the DC levels not exceeding 0.001 T.

7.3 Meteoroids and Manmade Orbital Debris

RB_PRD-1937 Equipment and materials that are directly exposed to free space, such as cables, propulsion lines, pressurized tanks, and sensor optics, shall be designed to meet reliability requirements to remain operable within their performance specifications over the mission lifetime in the meteoroid and space debris environments defined in Figure 7.3-1, Table 7.3-1, Figure 7.3-2, and Table 7.3-2 respectively.

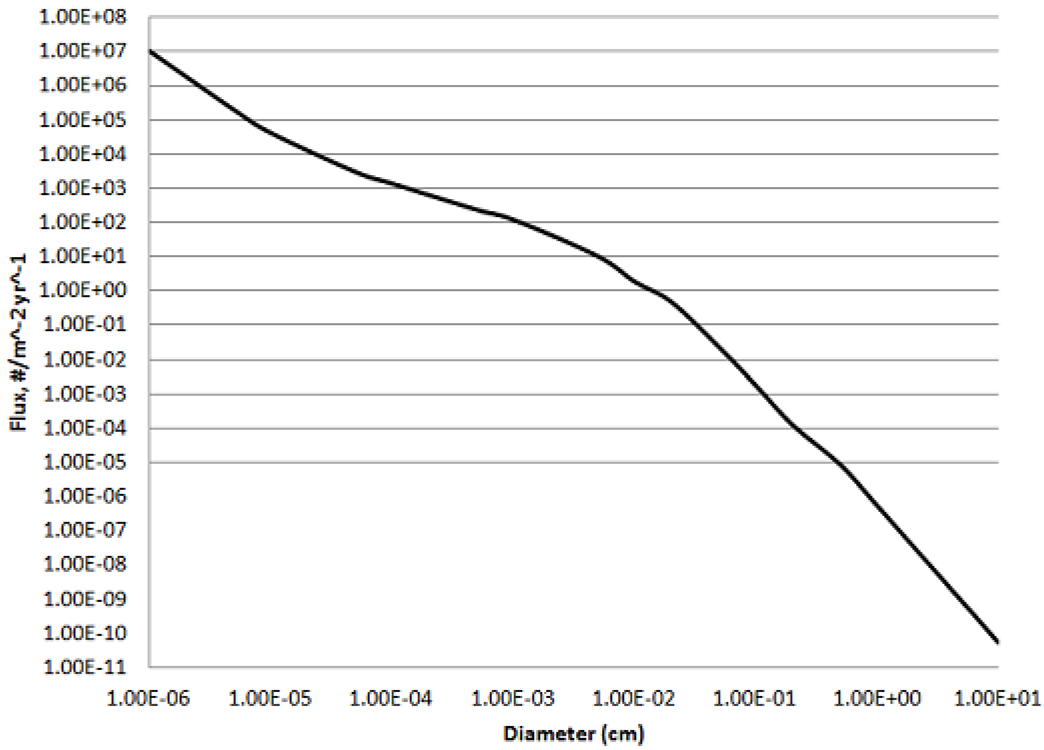


Figure 7.3-1 Meteoroid flux vs. size.

Table 7.3-1 Meteoroid flux environment.

Mass (g)	Diameter (cm)	Density (g/cm^3)	Flux ($\#/m^2/yr$)	Mass (g)	Diameter (cm)	Density (g/cm^3)	Flux ($\#/m^2/yr$)
1.05E-18	1.00E-06	2	1.09E+07	4.16E-06	2.00E-02	1	5.06E-01
1.32E-16	5.01E-06	2	2.06E+05	6.59E-05	5.01E-02	1	2.32E-02
1.05E-15	1.00E-05	2	4.44E+04	5.24E-04	1.00E-01	1	1.84E-03
1.32E-13	5.01E-05	2	3.19E+03	4.16E-03	2.00E-01	1	1.31E-04

Mass (g)	Diameter (cm)	Density (g/cm³)	Flux (#/m²/yr)	Mass (g)	Diameter (cm)	Density (g/cm³)	Flux (#/m²/yr)
1.05E-12	1.00E-04	2	1.46E+03	3.30E-02	5.01E-01	0.5	8.79E-06
1.32E-10	5.01E-04	2	2.51E+02	2.62E-01	1.00E+00	0.5	5.69E-07
1.05E-09	1.00E-03	2	1.28E+02	3.30E+01	5.01E+00	0.5	9.02E-10
1.32E-07	5.01E-03	2	1.07E+01	2.62E+02	1.00E+01	0.5	5.64E-11
1.05E-06	1.00E-02	2	1.95E+00				

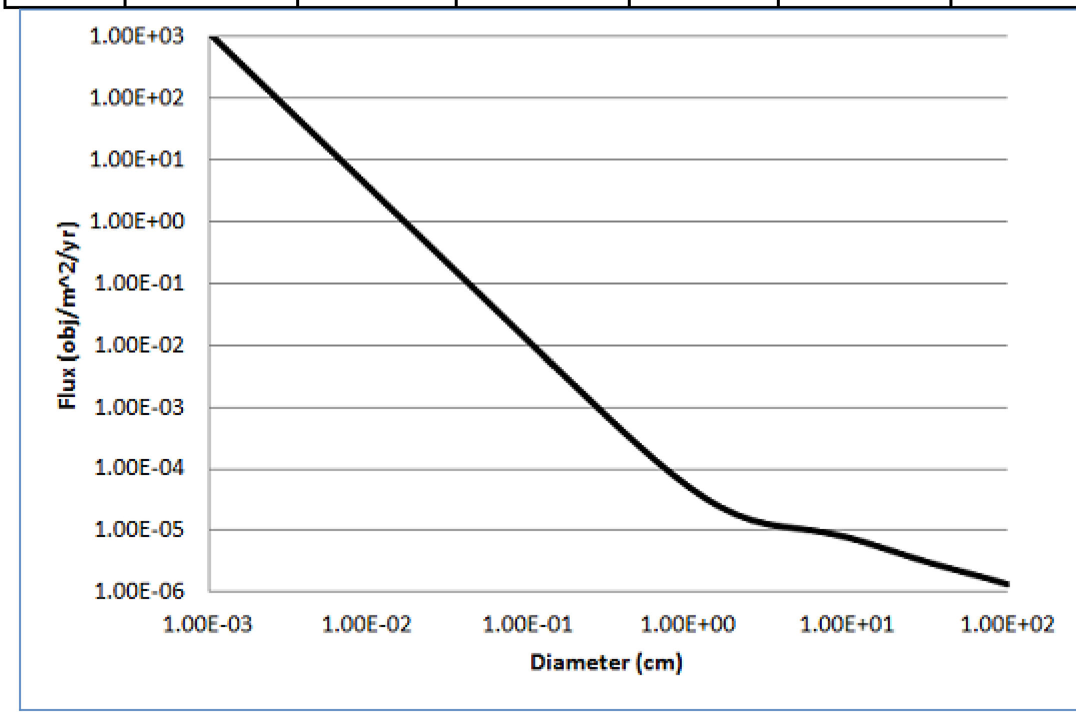


Figure 7.3-2 Debris flux vs. size.

Table 7.3-2 Debris flux environment.

Mass	Diameter (cm)	Flux (m^2 yr^{-1})	Mass	Diameter (cm)	Flux (m^2 yr^{-1})
1.59E-10	1.00E-03	1.16E+03	1.00E-02	3.98E-01	3.82E-04
3.17E-10	1.26E-03	6.50E+02	2.00E-02	5.01E-01	2.22E-04
6.32E-10	1.58E-03	3.65E+02	3.99E-02	6.31E-01	1.32E-04
1.26E-09	2.00E-03	2.05E+02	7.96E-02	7.94E-01	8.04E-05
2.52E-09	2.51E-03	1.16E+02	1.59E-01	1.00E+00	5.09E-05

Mass	**Diameter (cm)**	**Flux (m^2 yr^{-1})**	**Mass**	**Diameter (cm)**	**Flux (m^2 yr^{-1})**
5.02E-09	3.16E-03	6.50E+01	3.17E-01	1.26E+00	3.38E-05
1.00E-08	3.98E-03	3.65E+01	6.32E-01	1.58E+00	2.37E-05
2.00E-08	5.01E-03	2.05E+01	1.26E+00	2.00E+00	1.79E-05
3.99E-08	6.31E-03	1.16E+01	2.52E+00	2.51E+00	1.44E-05
7.96E-08	7.94E-03	6.50E+00	5.02E+00	3.16E+00	1.25E-05
1.59E-07	1.00E-02	3.65E+00	1.00E+01	3.98E+00	1.13E-05
3.17E-07	1.26E-02	2.05E+00	2.00E+01	5.01E+00	1.05E-05
6.32E-07	1.58E-02	1.16E+00	3.99E+01	6.31E+00	9.67E-06
1.26E-06	2.00E-02	6.50E-01	7.96E+01	7.94E+00	8.70E-06
2.52E-06	2.51E-02	3.65E-01	1.59E+02	1.00E+01	7.58E-06
5.02E-06	3.16E-02	2.05E-01	3.17E+02	1.26E+01	6.41E-06
1.00E-05	3.98E-02	1.16E-01	6.32E+02	1.58E+01	5.32E-06
2.00E-05	5.01E-02	6.50E-02	1.26E+03	2.00E+01	4.38E-06
3.99E-05	6.31E-02	3.65E-02	2.52E+03	2.51E+01	3.62E-06
7.96E-05	7.94E-02	2.06E-02	5.02E+03	3.16E+01	3.02E-06
1.59E-04	1.00E-01	1.16E-02	1.00E+04	3.98E+01	2.55E-06
3.17E-04	1.26E-01	6.51E-03	2.00E+04	5.01E+01	2.17E-06
6.32E-04	1.58E-01	3.67E-03	3.99E+04	6.31E+01	1.85E-06
1.26E-03	2.00E-01	2.07E-03	7.96E+04	7.94E+01	1.57E-06
2.52E-03	2.51E-01	1.17E-03	1.59E+05	1.00E+02	1.32E-06
5.02E-03	3.16E-01	6.66E-04			

7.4 General Radiation

RB_PRD-2226 The Instrument shall be compatible with the natural radiation environments for the operational orbits.

7.4.1 Total Ionizing Dose Environment

RB_PRD-2228 The Instrument shall be designed to meet all performance requirements at the total ionizing dose (TID) levels given in Figure 7.4.1-1 (data provided in Table 7.4.1) and the trapped proton and electron fluxes provided in Figure 7.4.1-2 (Table 7.4.1-2) and Figure 7.4.1-3 (Table 7.4.1-3).

RB_PRD-2229 Linear bipolar and BiCMOS device types that are known to be, or potentially susceptible to Enhanced Low Dose Rate Sensitivity (ELDRS) for TID shall be evaluated using test data at a low dose rate not to exceed 0.01 rad/sec in accordance with Test Method 1019.6 (Condition D) in Notice 5 of MIL-STD-883E for all bias cases to be used in the Spacecraft equipment (i.e., biased and unbiased), unless existing data shows that a lower dose rate is required to manifest the ELDRS effect. However, testing at TID levels above 35 krads may use a higher dose rate (e.g., >10 rads/sec) for the irradiation steps above 35 krads.

RB_PRD-2230 In cases where it is not possible to perform the test at a low dose rate, a ratio of the degradation from low dose rate to high dose rate (MIL standard specified dose rates) shall be calculated based on published literature and used to further derate the parts that are tested at the MIL standard dose rates. (This approach is only acceptable for devices that have been previously characterized at low dose rates.)

Radiation design margin (RDM) is defined as the ratio of the derated hardness capability of the part to the estimated dose at the part location.

RB_PRD-2232 Parts with a radiation design margin (RDM) of 3 or greater shall not require radiation lot acceptance testing (RLAT).

RB_PRD-2233 Parts with a RDM less than 3 but greater than or equal to 2 are of marginal hardness and shall require RLAT.

RB_PRD-2234 Parts with a RDM less than 2 shall not be used.

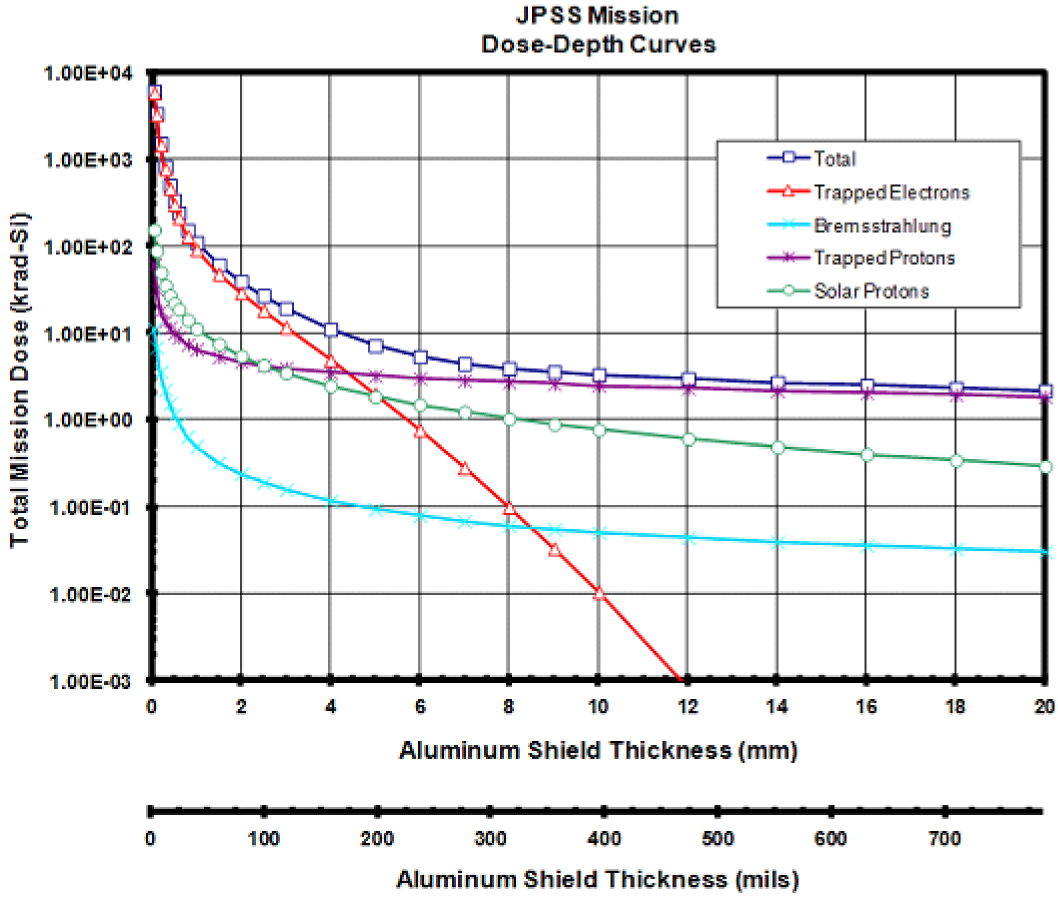


Figure 7.4.1-1 JPSS TID.

Table 7.4.1-1 JPSS TID.

Aluminum Shield Thickness			**Mission Dose (krad (Si))**				
(mm):	**(mils):**	**(g/cm²):**	**Total:**	**Trapped electrons:**	**Bremsstrahlung:**	**Trapped protons:**	**Solar protons:**
0.05	1.97E+00	1.40E-02	6.04E+03	5.82E+03	1.11E+01	6.07E+01	1.53E+02
0.10	3.94E+00	2.70E-02	3.36E+03	3.23E+03	6.73E+00	3.18E+01	8.76E+01
0.20	7.87E+00	5.40E-02	1.52E+03	1.45E+03	3.55E+00	1.80E+01	4.95E+01
0.30	1.18E+01	8.10E-02	8.23E+02	7.72E+02	2.21E+00	1.37E+01	3.50E+01
0.40	1.57E+01	1.08E-01	5.00E+02	4.61E+02	1.52E+00	1.13E+01	2.68E+01
0.50	1.97E+01	1.35E-01	3.33E+02	3.00E+02	1.14E+00	9.85E+00	2.18E+01
0.60	2.36E+01	1.62E-01	2.40E+02	2.12E+02	8.99E-01	8.80E+00	1.85E+01
0.80	3.15E+01	2.16E-01	1.51E+02	1.29E+02	6.36E-01	7.34E+00	1.40E+01
1.00	3.94E+01	2.70E-01	1.09E+02	9.08E+01	4.96E-01	6.44E+00	1.11E+01
1.50	5.91E+01	4.05E-01	6.07E+01	4.77E+01	3.24E-01	5.26E+00	7.40E+00

Aluminum Shield Thickness	Mission Dose (krad (Si))						
2.00	7.87E+01	5.40E-01	3.90E+01	2.88E+01	2.40E-01	4.61E+00	5.40E+00
2.50	9.84E+01	6.75E-01	2.67E+01	1.81E+01	1.89E-01	4.19E+00	4.22E+00
3.00	1.18E+02	8.10E-01	1.90E+01	1.16E+01	1.57E-01	3.89E+00	3.43E+00
4.00	1.57E+02	1.08E+00	1.09E+01	4.85E+00	1.17E-01	3.47E+00	2.43E+00
5.00	1.97E+02	1.35E+00	7.09E+00	1.98E+00	9.35E-02	3.18E+00	1.84E+00
6.00	2.36E+02	1.62E+00	5.31E+00	7.61E-01	7.86E-02	2.99E+00	1.48E+00
7.00	2.76E+02	1.89E+00	4.38E+00	2.81E-01	6.82E-02	2.82E+00	1.22E+00
8.00	3.15E+02	2.16E+00	3.86E+00	9.90E-02	6.05E-02	2.68E+00	1.02E+00
9.00	3.54E+02	2.43E+00	3.54E+00	3.30E-02	5.48E-02	2.57E+00	8.80E-01
10.00	3.94E+02	2.70E+00	3.28E+00	1.04E-02	5.03E-02	2.46E+00	7.60E-01
12.00	4.72E+02	3.24E+00	2.94E+00	8.10E-04	4.37E-02	2.29E+00	6.00E-01
14.00	5.51E+02	3.78E+00	2.67E+00	2.12E-05	3.91E-02	2.14E+00	4.84E-01
16.00	6.30E+02	4.32E+00	2.46E+00	1.63E-07	3.55E-02	2.02E+00	4.02E-01
18.00	7.09E+02	4.86E+00	2.30E+00	1.78E-09	3.26E-02	1.93E+00	3.42E-01
20.00	7.87E+02	5.40E+00	2.15E+00	0.00E+00	3.01E-02	1.83E+00	2.92E-01

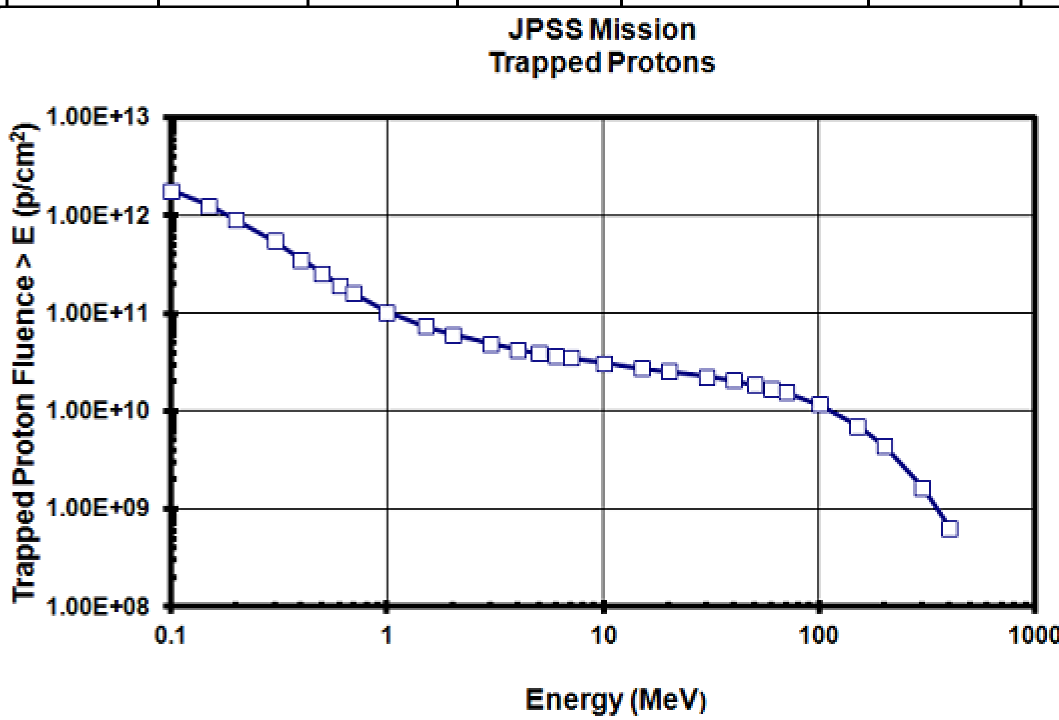


Figure 7.4.1-2 JPSS trapped proton fluence.

Table 7.4.1-2 JPSS trapped proton fluence.

Integral Proton Spectrum - Total Mission	Integral Proton Spectrum - Total Mission

Integral Proton Spectrum - Total Mission		Integral Proton Spectrum - Total Mission	
Energy	Fluence	Energy	Fluence
(>MeV):	(p/cm2):	(>MeV):	(p/cm^2):
0.1	1.80E+12	7	3.48E+10
0.15	1.26E+12	10	3.09E+10
0.2	9.07E+11	15	2.76E+10
0.3	5.50E+11	20	2.55E+10
0.4	3.54E+11	30	2.27E+10
0.5	2.57E+11	40	2.06E+10
0.6	1.94E+11	50	1.87E+10
0.7	1.59E+11	60	1.70E+10
1	1.04E+11	70	1.55E+10
1.5	7.42E+10	100	1.17E+10
2	6.02E+10	150	7.09E+09
3	4.91E+10	200	4.39E+09
4	4.27E+10	300	1.66E+09
5	3.93E+10	400	6.41E+08
6	3.67E+10		

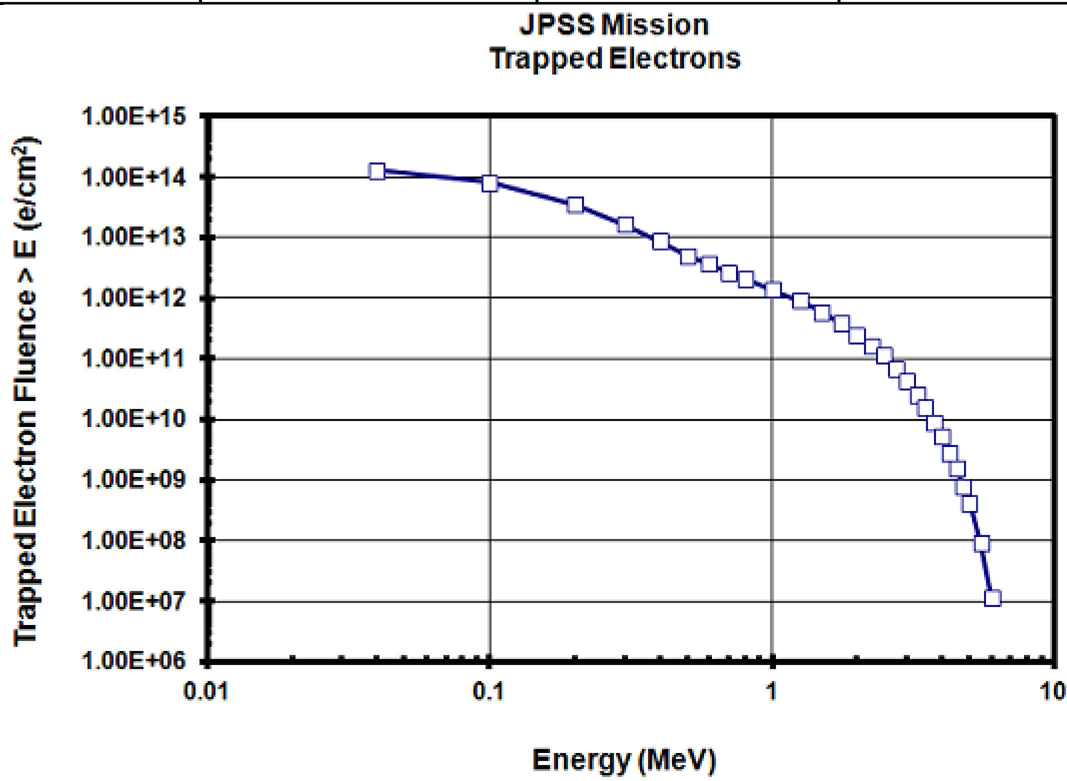


Figure 7.4.1-3 Integral electron flux.

Table 7.4.1-3 Integral electron flux.

Integral Electron Spectrum - Total Mission		Integral Electron Spectrum - Total Mission	
Energy	Fluence	Energy	Fluence
(>MeV):	(e/cm^2):	(>MeV):	(e/cm^2):
0.04	1.27E+14	2.5	1.11E+11
0.1	8.03E+13	2.75	6.78E+10
0.2	3.51E+13	3	4.20E+10
0.3	1.65E+13	3.25	2.56E+10
0.4	8.67E+12	3.5	1.58E+10
0.5	5.02E+12	3.75	9.09E+09
0.6	3.63E+12	4	5.26E+09
0.7	2.68E+12	4.25	2.85E+09
0.8	2.08E+12	4.5	1.55E+09
1	1.38E+12	4.75	8.01E+08
1.25	8.94E+11	5	4.17E+08
1.5	5.84E+11	5.5	9.02E+07
1.75	3.81E+11	6	1.14E+07
2	2.49E+11		
2.25	1.66E+11		

7.4.2 Cosmic Ray and High Energy Proton Environment

7.4.2.1 Single Events Radiation Environment

RB_PRD-2658 The Instrument shall be designed to meet all performance requirements in the heavy ion and proton environments specified in Sections 7.4.2.1.1 and 7.4.2.1.2.

RB_PRD-2659 Predictions of single events (i.e., single-event latch-up (SEL), single-event upset, single-event functional interrupt, single-event gate rupture (SEGR), and single-event burnout (SEB)) induced by heavy ions and high energy protons shall be performed separately and the results combined.

RB_PRD-2660 The Instrument design shall be such that single event phenomena associated with the specified cosmic particle and proton environment does not result in damage or non-recoverable upset.

RB_PRD-2661 Part types that are susceptible to destructive SEL shall not be used.

RB_PRD-2662 For nondestructive latchup, the probability of SEL occurrence shall be sufficiently low that Instrument reliability or availability is not adversely impacted.

RB_PRD-2663 Part types that are susceptible to SEGR shall not be used at a level higher than 75% of the maximum survivable voltage as determined by SEGR testing.

RB_PRD-2664 Power Metal Oxide Semiconductor Field Effect Transistor (MOSFETs) shall be derated to 75% of their maximum survival voltage as determined by SEGR testing at the worst-case circuit-application gate-source turnoff voltage, unless the worst-case application drain-source voltage is no more than 30 V, and the device is rated to at least 100 V.

RB_PRD-2665 The survival voltage (VDS) shall be established from exposure to a minimum fluence of 1E6 ions/cm^2 with a minimum LET of 37 MeV-cm^2/mg throughout the sensitive charge-collection region of the device.

RB_PRD-2666 Table 7.4.2.1-1 provides the ion range requirements that shall be met as a function of device voltage rating for SEGR testing.

RB_PRD-2667 Testing shall be performed at normal beam incidence and at room ambient temperature.

RB_PRD-2668 Part types that are susceptible to SEB shall not be used at a level higher than 75% of the maximum survivable voltage as determined in SEB testing.

RB_PRD-2669 The survival voltage (VCE or VDS) shall be established from exposure (at normal beam incidence) to a minimum fluence of 1E6 ions/cm^2 of an ion with a minimum or average linear energy transfer (LET) of 37 MeV-cm^2/mg throughout the depletion depth of the device at its maximum voltage.

Table 7.4.2.1-1 Ion range requirements for SEGR testing.

Maximum Rated Drain-Source Voltage	Minimum Ion Range (microns)
≤100	30
100 to 250	40
250 to 400	80
400 to 1000	200

7.4.2.1.1 Galactic Cosmic Ray (GCR) LET Spectrum

RB_PRD-2688 The integral GCR and solar heavy ion LET spectrum in Figure 7.4.2.1.1-1 (Table 7.4.2.1.1-1) and Figure 7.4.2.1.1-2 (Table 7.4.2.1.1-2), respectively, shall be used for prediction of heavy ion-induced single-event effects.

RB_PRD-2689 Fluxes in Figure 7.4.2.1.1-1 and Table 7.4.2.1.1-1 shall be used to determine the proton-induced single-event rates for the background environment (trapped protons plus galactic cosmic ray protons) and during a flare.

RB_PRD-2690 The Instrument shall be designed to meet all performance requirements from the Solar Min and Solar Max for the background environments.

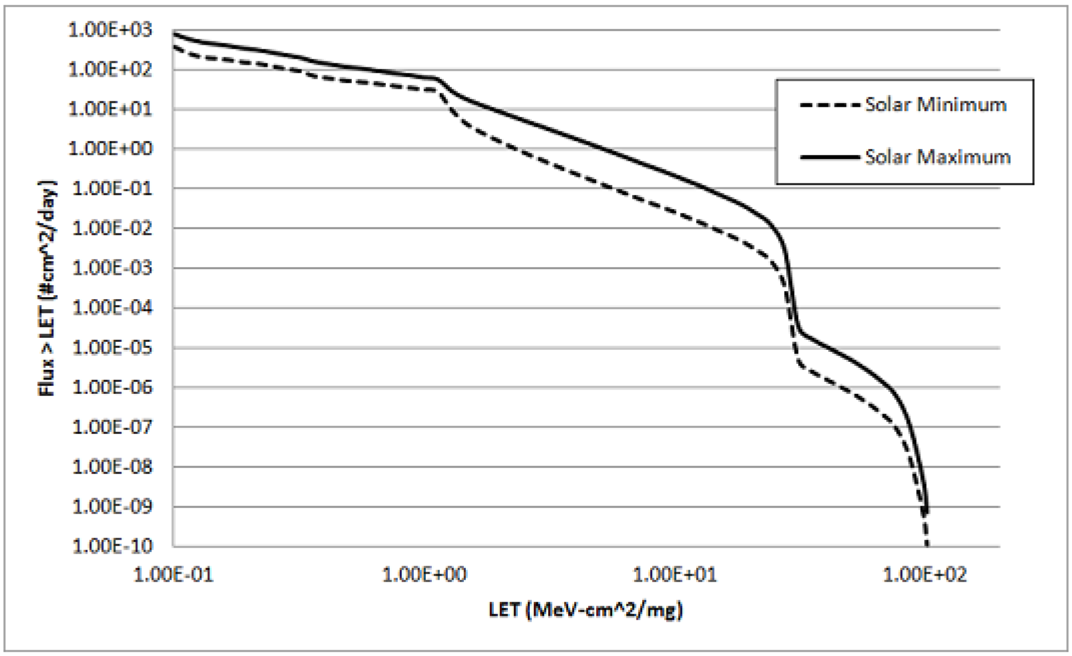


Figure 7.4.2.1.1-1 Integral LET spectra for galactic cosmic ray ions.

Table 7.4.2.1.1-1 Integral LET spectra for galactic cosmic ray ions.

LET (MeV-cm²/mg):	Flux > LET (#/cm²/day):		LET (MeV-cm²/mg):	Flux > LET (#/cm²/day):	
	Solar Maximum	Solar Minimum		Solar Maximum	Solar Minimum
1.01E-01	3.78E+02	7.96E+02	3.59E+00	3.25E-01	2.38E+00
1.15E-01	2.58E+02	5.97E+02	4.08E+00	2.35E-01	1.78E+00
1.30E-01	2.11E+02	5.00E+02	4.64E+00	1.71E-01	1.33E+00
1.48E-01	1.92E+02	4.45E+02	5.27E+00	1.24E-01	9.84E-01

LET (MeV-cm²/mg):	**Flux > LET (#/cm²/day):**		**LET (MeV-cm²/mg):**	**Flux > LET (#/cm²/day):**	
1.68E-01	1.77E+02	4.00E+02	5.99E+00	9.08E-02	7.29E-01
1.91E-01	1.55E+02	3.50E+02	6.80E+00	6.66E-02	5.39E-01
2.17E-01	1.44E+02	3.17E+02	7.73E+00	4.88E-02	3.96E-01
2.47E-01	1.25E+02	2.76E+02	8.78E+00	3.63E-02	2.96E-01
2.80E-01	1.06E+02	2.36E+02	9.97E+00	2.68E-02	2.18E-01
3.18E-01	9.45E+01	2.08E+02	1.13E+01	1.95E-02	1.59E-01
3.62E-01	7.07E+01	1.64E+02	1.29E+01	1.39E-02	1.14E-01
4.11E-01	6.24E+01	1.43E+02	1.46E+01	9.77E-03	7.95E-02
4.67E-01	5.53E+01	1.25E+02	1.66E+01	6.85E-03	5.57E-02
5.30E-01	5.13E+01	1.13E+02	1.89E+01	4.64E-03	3.77E-02
6.03E-01	4.75E+01	1.02E+02	2.14E+01	2.87E-03	2.33E-02
6.85E-01	4.30E+01	9.07E+01	2.44E+01	1.53E-03	1.23E-02
7.78E-01	3.89E+01	8.11E+01	2.77E+01	3.53E-04	2.85E-03
8.84E-01	3.55E+01	7.29E+01	3.14E+01	5.12E-06	3.37E-05
1.00E+00	3.17E+01	6.47E+01	3.57E+01	2.56E-06	1.65E-05
1.14E+00	2.81E+01	5.72E+01	4.06E+01	1.65E-06	1.06E-05
1.30E+00	9.43E+00	2.86E+01	4.61E+01	1.09E-06	6.95E-06
1.47E+00	4.57E+00	1.87E+01	5.24E+01	7.02E-07	4.48E-06
1.67E+00	2.81E+00	1.35E+01	5.95E+01	4.18E-07	2.64E-06
1.90E+00	1.87E+00	1.00E+01	6.76E+01	2.27E-07	1.42E-06
2.16E+00	1.28E+00	7.50E+00	7.68E+01	1.03E-07	6.45E-07
2.45E+00	8.90E-01	5.62E+00	8.72E+01	1.96E-08	1.22E-07
2.79E+00	6.29E-01	4.22E+00	9.91E+01	7.51E-10	4.71E-09
3.16E+00	4.49E-01	3.17E+00	1.03E+02	1.10E-10	6.87E-10

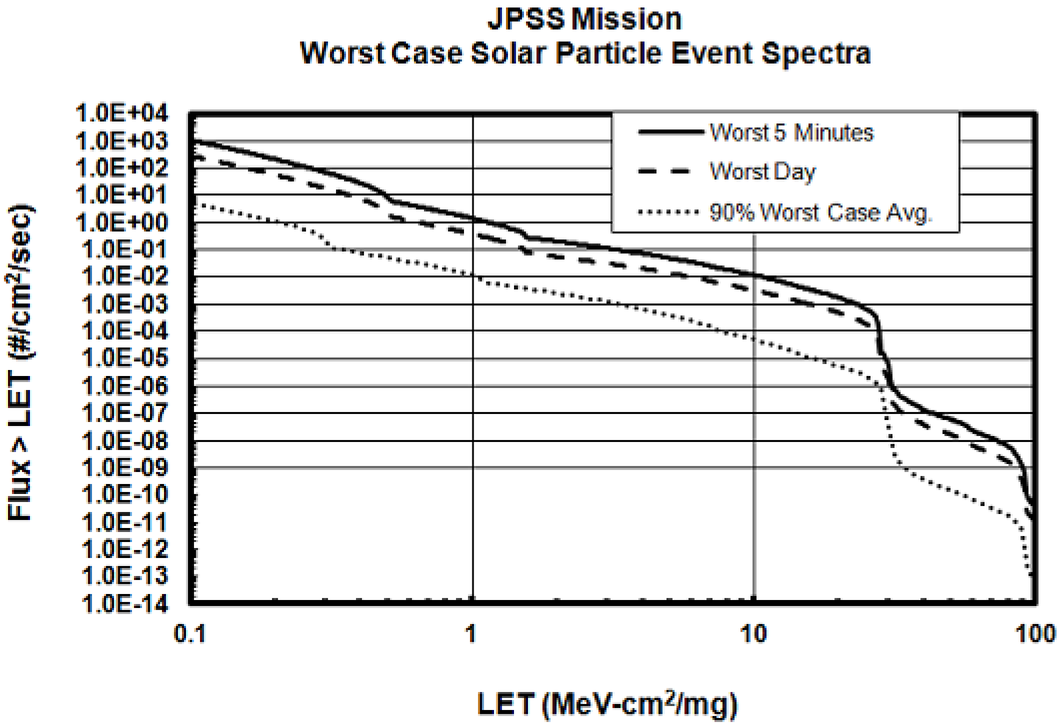


Figure 7.4.2.1.1-2 Solar heavy ion linear energy transfer spectrum.

Table 7.4.2.1.1-2 Solar heavy ion linear energy transfer spectrum.

LET (MeV-cm^2/mg):	Flux> LET (#/cm^2/sec):		LET (MeV-cm^2/mg):	Flux> LET (#/cm^2/sec):	
	Worst 5 Minutes	Worst Day		Worst 5 Minutes	Worst Day
1.01E-01	1.05E+03	2.78E+02	5.27E+00	4.48E-02	1.24E-02
1.15E-01	7.94E+02	2.10E+02	5.99E+00	3.54E-02	9.81E-03
1.30E-01	5.95E+02	1.57E+02	4.64E+00	5.70E-02	1.58E-02
1.48E-01	4.43E+02	1.17E+02	5.27E+00	4.48E-02	1.24E-02
1.68E-01	3.27E+02	8.64E+01	5.99E+00	3.54E-02	9.81E-03
1.91E-01	2.37E+02	6.26E+01	6.80E+00	2.72E-02	7.54E-03
2.17E-01	1.71E+02	4.52E+01	7.73E+00	1.99E-02	5.53E-03
2.47E-01	1.22E+02	3.22E+01	8.78E+00	1.55E-02	4.30E-03
2.80E-01	8.55E+01	2.26E+01	9.97E+00	1.17E-02	3.24E-03
3.18E-01	5.92E+01	1.57E+01	1.13E+01	8.71E-03	2.42E-03
3.62E-01	4.02E+01	1.06E+01	1.29E+01	6.24E-03	1.73E-03
4.11E-01	2.59E+01	6.84E+00	1.46E+01	4.23E-03	1.17E-03
4.67E-01	1.46E+01	3.87E+00	1.66E+01	2.98E-03	8.30E-04

LET (MeV-cm^2/mg):	Flux> LET (#/cm^2/sec):		LET (MeV-cm^2/mg):	Flux> LET (#/cm^2/sec):	
5.30E-01	5.76E+00	1.53E+00	1.89E+01	2.10E-03	5.83E-04
6.03E-01	4.41E+00	1.17E+00	2.14E+01	1.36E-03	3.78E-04
6.85E-01	3.36E+00	8.95E-01	2.44E+01	7.97E-04	2.22E-04
7.78E-01	2.55E+00	6.78E-01	2.77E+01	2.11E-04	5.87E-05
8.84E-01	1.91E+00	5.11E-01	3.14E+01	7.99E-07	2.22E-07
1.00E+00	1.42E+00	3.80E-01	3.57E+01	2.69E-07	7.50E-08
1.14E+00	1.03E+00	2.77E-01	4.06E+01	1.31E-07	3.65E-08
1.30E+00	7.27E-01	1.96E-01	4.61E+01	7.99E-08	2.22E-08
1.47E+00	4.71E-01	1.28E-01	5.24E+01	5.11E-08	1.42E-08
1.67E+00	2.56E-01	7.04E-02	5.95E+01	2.57E-08	7.14E-09
1.90E+00	2.16E-01	5.95E-02	6.76E+01	1.40E-08	3.90E-09
2.16E+00	1.82E-01	5.00E-02	7.68E+01	7.89E-09	2.19E-09
2.45E+00	1.52E-01	4.18E-02	8.72E+01	2.15E-09	5.99E-10
2.79E+00	1.26E-01	3.48E-02	9.91E+01	3.91E-11	1.09E-11
3.16E+00	1.05E-01	2.89E-02	1.03E+02	5.76E-12	1.60E-12
3.59E+00	8.62E-02	2.38E-02	6.80E+00	2.72E-02	7.54E-03
4.08E+00	7.06E-02	1.95E-02	7.73E+00	1.99E-02	5.53E-03

7.4.2.1.2 High Energy Proton Fluence

RB_PRD-3130 The proton fluxes in Figure 7.4.2.1.2-1 and Table 7.4.2.1.2-1 shall be used to determine the proton-induced single-event rates for the background environment (trapped protons) and during a flare.

RB_PRD-3131 The Instrument shall be designed to meet all performance requirements for the background environment.

RB_PRD-3132 The total number of proton-induced single events shall be determined from the background environment and the worst-case proton fluxes. The background proton fluxes are shown in Figure 7.4.2.1.2-1 and Table 7.4.2.1.2-1. The worst case proton fluxes, which include the trapped proton fluxes during solar maximum and the proton fluxes averaged over the peak 5 minutes during solar flare, are provided in Figure 7.4.2.1.2-2 and Table 7.4.2.1.2-2.

RB_PRD-3133 The Instrument shall survive the peak proton flux of the solar flare.

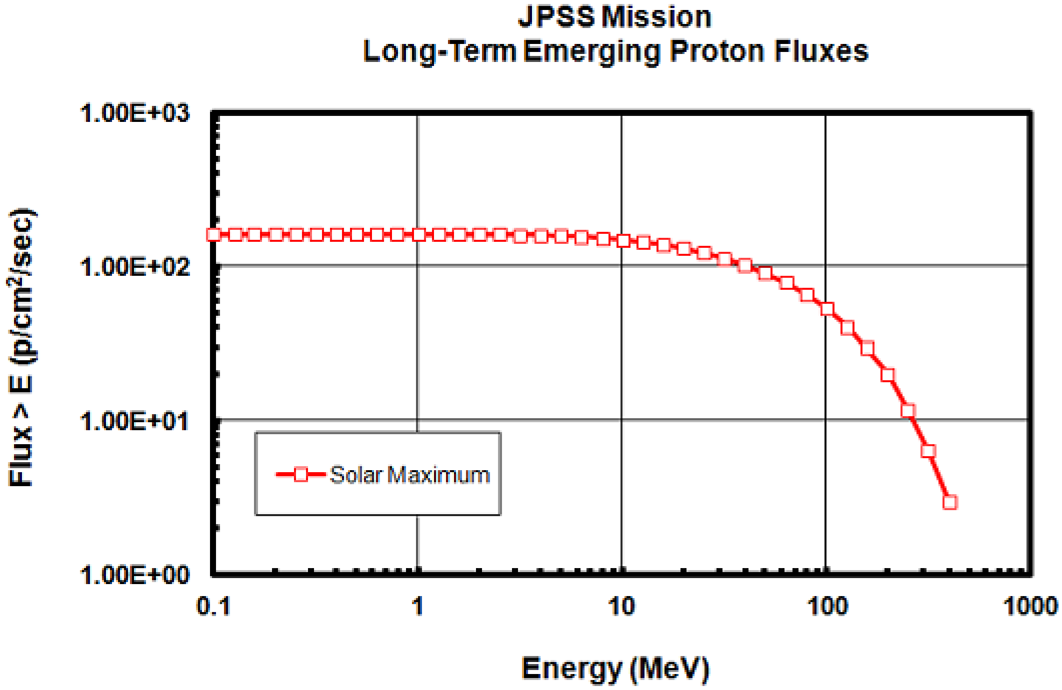


Figure 7.4.2.1.2-1 Long-term integral proton fluxes for single event effects evaluation. (Included are the trapped proton and solar proton fluxes behind 100 mils of aluminum shielding).

Table 7.4.2.1.2-1 Long-term integral proton fluxes.

Energy, E (MeV):	Flux > E ($p/cm^2/sec$):
	Solar Maximum
0.1	1.62E+02
0.126	1.62E+02
0.158	1.62E+02
0.2	1.62E+02
0.251	1.62E+02
0.316	1.62E+02
0.398	1.62E+02
0.501	1.62E+02
0.631	1.62E+02
0.794	1.62E+02
1	1.62E+02
1.26	1.61E+02
1.58	1.61E+02
2	1.61E+02

Energy, E (MeV):	**Flux > E ($p/cm^2/sec$):**
2.51	1.61E+02
3.16	1.59E+02
3.98	1.59E+02
5.01	1.58E+02
6.31	1.56E+02
7.94	1.53E+02
10	1.50E+02
12.6	1.45E+02
15.8	1.39E+02
20	1.31E+02
25.1	1.23E+02
31.6	1.13E+02
39.8	1.02E+02
50.1	9.08E+01
63.1	7.88E+01
79.4	6.59E+01
100	5.37E+01
126	4.07E+01
158	2.96E+01
200	2.01E+01
251	1.16E+01
316	6.37E+00
398	2.99E+00

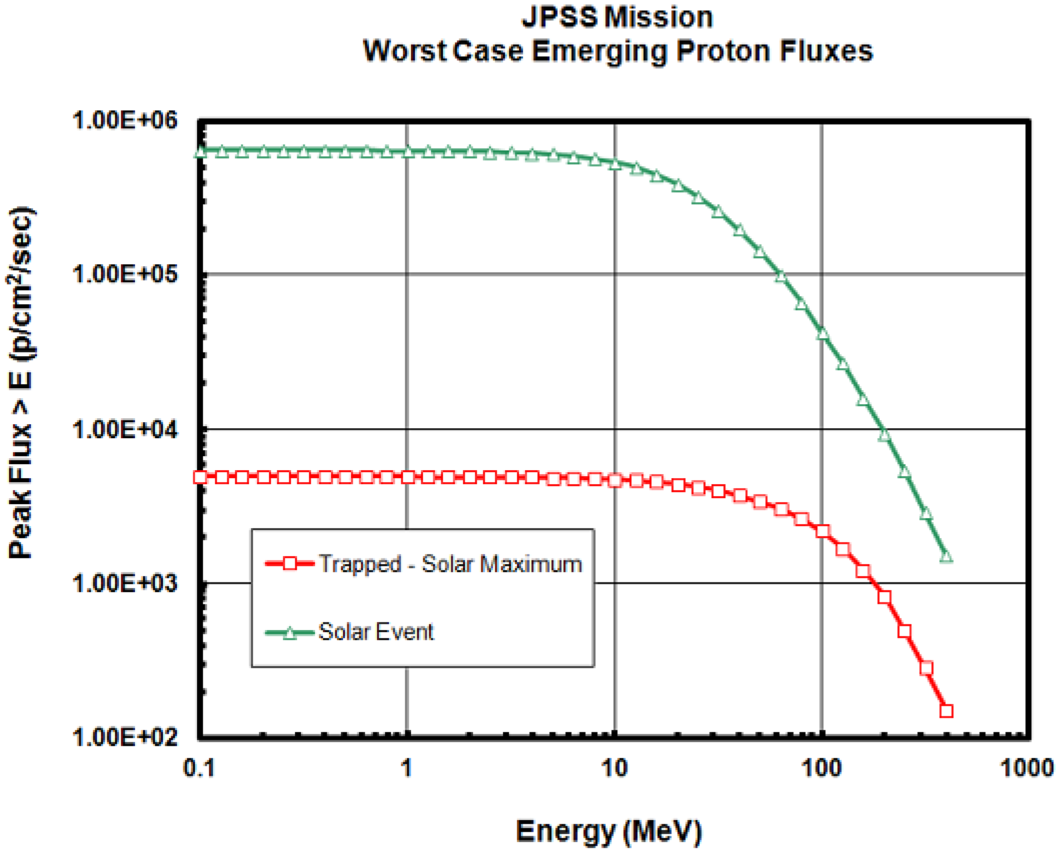


Figure 7.4.2.1.2-2 Worst-case emerging proton fluxes.

Table 7.4.2.1.2-2 Worst-case emerging proton fluxes.

Energy, E (MeV):	Flux > E ($p/cm^2/sec$):	Flux > E ($p/cm^2/sec$):
	Trapped - Solar Maximum	**Solar Particle Event**
0.1	5.46E+03	6.42E+05
0.126	5.46E+03	6.42E+05
0.158	5.46E+03	6.42E+05
0.2	5.46E+03	6.42E+05
0.251	5.46E+03	6.42E+05
0.316	5.46E+03	6.42E+05
0.398	5.46E+03	6.42E+05
0.501	5.46E+03	6.41E+05
0.631	5.46E+03	6.41E+05
0.794	5.46E+03	6.40E+05
1	5.46E+03	6.39E+05
1.26	5.45E+03	6.38E+05

Energy, E (MeV):	Flux > E ($p/cm^2/sec$):	Flux > E ($p/cm^2/sec$):
1.58	5.45E+03	6.36E+05
2	5.45E+03	6.34E+05
2.51	5.44E+03	6.30E+05
3.16	5.43E+03	6.25E+05
3.98	5.41E+03	6.17E+05
5.01	5.39E+03	6.06E+05
6.31	5.36E+03	5.90E+05
7.94	5.31E+03	5.68E+05
10	5.24E+03	5.38E+05
12.6	5.15E+03	4.98E+05
15.8	5.03E+03	4.48E+05
20	4.88E+03	3.89E+05
25.1	4.68E+03	3.25E+05
31.6	4.44E+03	2.59E+05
39.8	4.12E+03	1.97E+05
50.1	3.77E+03	1.44E+05
63.1	3.38E+03	1.00E+05
79.4	2.90E+03	6.65E+04
100	2.43E+03	4.26E+04
126	1.86E+03	2.67E+04
158	1.37E+03	1.60E+04
200	9.29E+02	9.41E+03
251	5.41E+02	5.36E+03
316	3.04E+02	2.89E+03
398	1.55E+02	1.52E+03

7.4.2.2 Displacement Damage

Displacement damage for electronics due to protons and electrons is defined here in terms of an equivalent fluence of 1 MeV neutrons.

RB_PRD-3417 Part types sensitive to displacement damage degradation (e.g., linear integrated circuits (ICs), bipolar technologies, crystal oscillators, and power devices), shall be selected such that the assembly meets all performance requirements at the RDM specified in Section 7.4.1. The 1-MeV-equivalent neutron fluence as a function of shielding due to the trapped protons, trapped electrons, and solar flare protons is shown in Figure 7.4.2.2-1 and Table 7.4.2.2-1

RB_PRD-3418 When optical detectors are used, the design shall incorporate features that minimize the effects of displacement damage. The displacement damage dose as a function of shielding thickness is provided in Table 7.4.2.2-1.

RB_PRD-3419 The RDM and RLAT requirements given in Section 7.4.1 shall also apply to displacement damage.

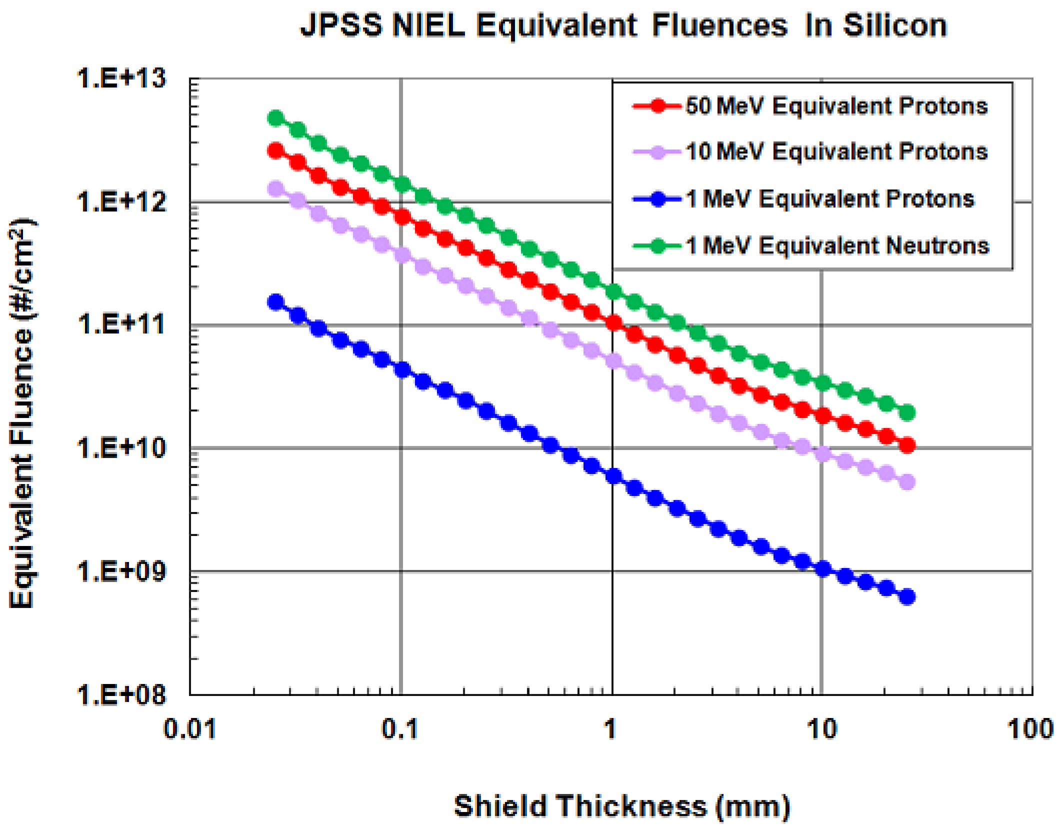


Figure 7.4.2.2-1 JPSS NIEL equivalent fluences in silicon.

Table 7.4.2.2-1 JPSS NIEL equivalent fluences in silicon.

Aluminum Shield Thickness			**NIEL Equivalent Proton Fluences In Silicon**				**Equivalent Neutron Fluence**
(mm):	**(mils):**	**(g/cm²):**	**1 MeV (#/cm²):**	**10 MeV (#/cm²):**	**50 MeV (#/cm²):**	**63 MeV (#/cm²):**	**1 MeV (#/cm²):**
0.025	0.98	0.007	1.53E+11	1.31E+12	2.66E+12	3.06E+12	4.87E+12
0.032	1.26	0.009	1.23E+11	1.05E+12	2.13E+12	2.45E+12	3.89E+12
0.040	1.57	0.011	9.51E+10	8.11E+11	1.65E+12	1.90E+12	3.02E+12
0.051	2.01	0.014	7.65E+10	6.53E+11	1.33E+12	1.53E+12	2.43E+12
0.064	2.52	0.017	6.52E+10	5.56E+11	1.13E+12	1.30E+12	2.07E+12

Aluminum Shield Thickness			**NIEL Equivalent Proton Fluences In Silicon**				**Equivalent Neutron Fluence**
0.080	3.15	0.022	5.36E+10	4.57E+11	9.29E+11	1.07E+12	1.70E+12
0.101	3.98	0.027	4.44E+10	3.79E+11	7.70E+11	8.87E+11	1.41E+12
0.127	5.00	0.034	3.56E+10	3.04E+11	6.17E+11	7.11E+11	1.13E+12
0.160	6.30	0.043	2.96E+10	2.53E+11	5.14E+11	5.91E+11	9.40E+11
0.202	7.95	0.054	2.46E+10	2.10E+11	4.27E+11	4.92E+11	7.82E+11
0.254	10.00	0.069	2.02E+10	1.72E+11	3.50E+11	4.03E+11	6.41E+11
0.320	12.60	0.086	1.64E+10	1.40E+11	2.85E+11	3.28E+11	5.22E+11
0.403	15.87	0.109	1.34E+10	1.14E+11	2.32E+11	2.67E+11	4.24E+11
0.507	19.96	0.137	1.09E+10	9.30E+10	1.89E+11	2.18E+11	3.46E+11
0.638	25.12	0.172	8.95E+09	7.63E+10	1.55E+11	1.79E+11	2.84E+11
0.803	31.61	0.217	7.37E+09	6.29E+10	1.28E+11	1.47E+11	2.34E+11
1.011	39.80	0.273	6.02E+09	5.13E+10	1.04E+11	1.20E+11	1.91E+11
1.273	50.12	0.344	4.91E+09	4.19E+10	8.52E+10	9.81E+10	1.56E+11
1.603	63.11	0.433	4.06E+09	3.47E+10	7.05E+10	8.12E+10	1.29E+11
2.018	79.45	0.545	3.34E+09	2.85E+10	5.79E+10	6.67E+10	1.06E+11
2.540	100.00	0.686	2.74E+09	2.33E+10	4.75E+10	5.47E+10	8.69E+10
3.198	125.91	0.863	2.26E+09	1.93E+10	3.92E+10	4.51E+10	7.17E+10
4.026	158.50	1.086	1.89E+09	1.61E+10	3.28E+10	3.77E+10	6.00E+10
5.068	199.53	1.368	1.60E+09	1.37E+10	2.78E+10	3.20E+10	5.09E+10
6.380	251.18	1.722	1.38E+09	1.18E+10	2.40E+10	2.76E+10	4.39E+10
8.032	316.22	2.168	1.22E+09	1.04E+10	2.11E+10	2.43E+10	3.87E+10
10.112	398.11	2.729	1.07E+09	9.11E+09	1.85E+10	2.13E+10	3.39E+10
12.730	501.18	3.436	9.45E+08	8.06E+09	1.64E+10	1.89E+10	3.00E+10
16.026	630.94	4.325	8.35E+08	7.12E+09	1.45E+10	1.67E+10	2.65E+10
20.176	794.33	5.445	7.40E+08	6.31E+09	1.28E+10	1.48E+10	2.35E+10
25.400	1000.00	6.855	6.30E+08	5.37E+09	1.09E+10	1.26E+10	2.00E+10

7.4.3 Spacecraft Charging from All Sources

RB_PRD-3717 Instrument external surfaces, if required, shall have special coatings for electrostatic discharge suppression in the plasma environment (except where such coatings degrade performance).

RB_PRD-3718 The Instrument shall operate without performance degradation due to the surface charging, bulk charging, and deep charging environment. The plasma environment is shown in Table 7.4.3-1.

Table 7.4.3-1 Plasma environment.

Particle	Density	Temperature
Ambient electrons	1E3 to 2E6 cm^{-3}	0.1 - 0.39 eV
Ambient positive ions	1E3 to 2E6 cm^{-3}	0.07 - 0.34 eV
High energy electron flux*	1E8 to 1E10 cm^{-2} sec^{-1} sr^{-1}	14 - 30 keV
* Note: This occurs during periods of auroral arcs. The Spacecraft is exposed to auroral environments for < 30 seconds per encounter		

RB_PRD-3739 No floating wires shall be allowed greater than 25 cm length.

RB_PRD-3740 The design shall provide electrostatic grounding connections between all conductive elements greater than 3 square cm and exposed to an orbit average electron flux greater than 10 femtoamps/sq. cm.

RB_PRD-3741 Metallized tapes of surface area >25 cm^2 shall be grounded to the ground plane with a resistance not to exceed 100 ohms DC.

RB_PRD-3742 The DC resistance between any point on the metallized layer and the ground plane shall not exceed 100 ohm DC.

RB_PRD-3743 Electrical continuity of less than 100 ohm DC shall exist between the joints of glass fiber-reinforced polymer (GFRP) components.

RB_PRD-3744 The resistance of the farthest point on a GFRP structure and the ground plane shall not exceed 1000 ohm DC.

RB_PRD-3745 GFRP surface areas >25cm^2 shall be grounded.

RB_PRD-3746 Instrument thermal blankets with exposed areas exceeding 25 cm^2 shall use dielectric films, which are metallized on the back side and grounded.

RB_PRD-3747 Instrument thermal insulation blankets shall be connected to chassis ground with a resistance of less than 100 ohm DC.

RB_PRD-3748 All Instrument thermal insulation blankets shall be designed with metallized and conductive layers electrically interconnected such that the resistance between layers is less than 100 ohm DC.

RB_PRD-3749 The number of required ground straps for Instrument thermal blankets shall be as shown in Table 7.4.3-2.

Table 7.4.3-2 Thermal blanket ground straps requirement.

Blanket Surface Area (cm^2)	Number of Required Straps
< 25	0
25 - 100	2
100 - 900	2
900 - 8000	3
8000 - 16000	4
Each additional 8000	1 additional strap

The ground straps should be spaced evenly (approximately) around the perimeter of the blanket.

7.5 Atomic Oxygen

RB_PRD-3775 The Instrument shall be able to survive an AO fluence of 6.705E19 atoms/cm2 without loss of structural integrity or loss of critical performance criteria.

The specified AO fluence is at unblocked surfaces in the spacecraft ram-facing direction over a 7-year mission life. This is equivalent to 0.08 mils of Kapton erosion using +2 sigma values of Schatten's solar activity predictions.

7.6 Electromagnetic Interference/Electromagnetic Compatibility

7.6.1 External RF Environment

"External" means external to the Observatory, hence, from another source, either on the earth, in space, or from the launch vehicle.

RB_PRD-3780 For the Instrument, if the irradiated RF electric field frequency is within the passband of an Instrument, the Instrument shall automatically recover from, and operate without performance degradation after experiencing the field while in the intended operational mode for the On-Orbit External and On-Orbit Steady State environments defined in Table 7.6.1-1.

Table 7.6.1-1 Radiated susceptibility levels due to factory/transport, launch site, launch vehicle, ascent, and on-orbit phases.

Frequency (Hz)	Factory/Transport (V/m) [2,3]	Launch Site (V/m) [2,3]	Ascent (V/m) [2,3]	On Orbit External (V/m) [2]	On Orbit Steady State (V/m) [1, 5]
2 M - 100 M	20	20	20	20	20
100 M - 1 G	20	20	100	20	20
1 G - 1.67 G	100	100	200	30	20
1.67 G - 1.71 G	100	100	200	30	30
1.71 G - 2.2 G	100	100	200	30	20
2.2 G - 2.29 G	100	100	200	30	30
2.29 G - 2.5 G	100	100	200	45	20
2.5 G - 5 G	100	100	200	30	20
5 G – 7.4 G	100	100	200	110	20
7.4 G – 8.5 G	100	100	200	110	40
8.5 G - 10 G	100	100	200	110	20
10 G - 18 G	20	20	20	20	20
18 G - 26.4 G [4]	20	20	20	20	20
26.4 G – 27.1G	20	20	20	20	40
27.1 G - 40 G [4]	20	20	20	20	20

Note [1]: The On Orbit Steady State (RS103) values are the maximum levels at any instrument and include 6 dB EMI susceptibility margin. Values that exceed 20 V/m are due to the local transmitters. Individual instrument environments may be lower. See the respective ICDs.

Note [2]: the large values (100-200 V/m) do not apply across the entire frequency ranges shown, but at discrete frequencies within those bands. The specific frequencies are classified and can be requested via NASA JPSS. The ‘Factory/Transport’ and ‘Launch Site’ environments may be reduced by any combination of procedures, facility shielding, or shipping container shielding.

Note [3]: The following survival test ranges are to be analyzed for compliance but not tested on the JPSS Flight Units: "Factory/Transport/Launch Site” 100 V/m from 1 GHz to 5 GHz, "Ascent" 100 V/m from 100 MHz to 1 GHz, and "Ascent" 200 V/m from 1 GHz to 10 GHz.

Note [4]: Frequencies above 18 GHz may be analyzed for compliance in lieu of testing (exception: 26.4 to 27.1 GHz On-Orbit Steady State will be tested).

Note [5]: Maximum scan rates/step sizes and/or minimum dwell times for identified spacecraft RF transmitter frequencies (as determined by the applicable Instrument to Spacecraft ICD) will be adjusted such that the total sweep time across each transmitter bandwidth is at least 180 seconds.

RB_PRD-3890 If the irradiated RF electric field frequency is outside the passbands of an Instrument, the Instrument shall operate without performance degradation while exposed to the field while in the intended operational mode for the On-Orbit External and On-Orbit Steady State environments defined in Table 7.6.1-1.

RB_PRD-3891 The Instrument shall survive after being exposed to the field while in the intended operational mode for the Factory/Transport, Launch Site, and Ascent environments defined in Table 7.6.1-1.

The Instrument will be in the OFF mode during Factory/Transport, Launch Site, and Ascent phases. Therefore there is no RS103 testing required for the Flight Instrument in OFF mode for Factory/Transport, Launch Site, and Ascent phases shown in Table 7.6.1-1.

7.7 Launch and Ascent Thermal

7.7.1 Temperatures

The worst case effective internal environment in the Observatory compartment within the fairing during ascent is defined in Figure 7.7.1-1. *The surfaces seen by the Observatory will generally fall into one of two categories: surfaces with low emissivity ($\varepsilon \leq 0.3$) and those of higher emissivity ($\varepsilon \leq 0.9$). Maximum temperatures as a function of the time from launch, 150 °C for a surface emissivity of 0.3 and 93 °C for a surface emissivity of 0.9, are shown in the plot. The exact configuration and percentages of each type of surface is both mission specific and Launch Vehicle specific.*

RB_PRD-3896 Temperatures may exceed those shown below, but in no case shall the total integrated thermal energy imparted to the Spacecraft exceed the maximum total integrated energy indicated by the temperature profile shown in Figure 7.7.1-1.

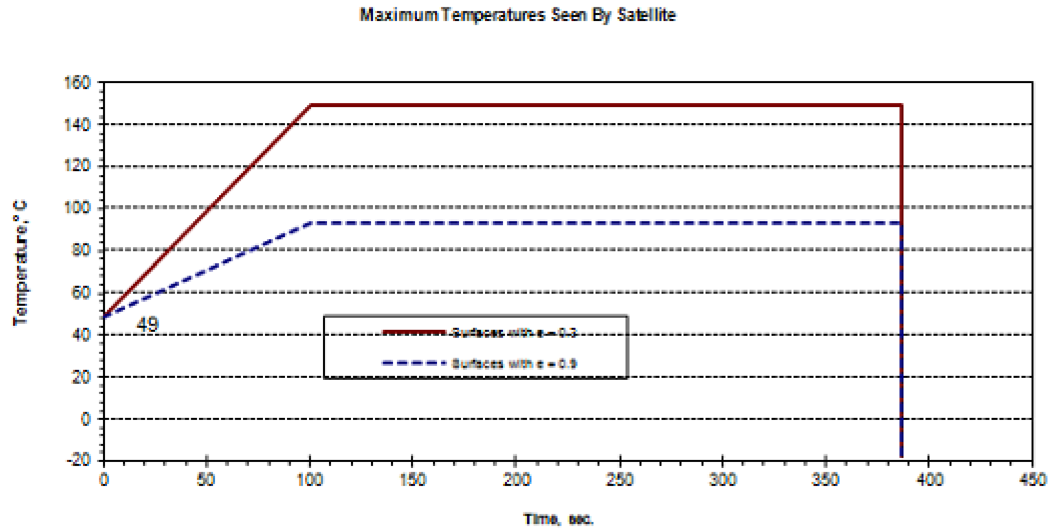


Figure 7.7.1-1 Maximum payload fairing (PLF) inner temperature.

7.7.2 Free Molecular Heating

RB_PRD-3900 The Instrument shall be designed to withstand a maximum, instantaneous, 3-sigma free molecular heating on Instrument surfaces perpendicular to the velocity vector at the time of fairing separation of 1135 watts/m2 (360 Btu/hr-ft^2).

8 VERIFICATION REQUIREMENTS

The following paragraphs delineate the functional performance tests and demonstrations to be conducted on the Instrument and its components and subsystems.

8.1 Mission Requirements Verification

The following requirements delineate the baseline verification testing sequence for the JPSS Instruments and, while cannot be deleted, the sequence of tests can be tailored as needed to optimize schedule or workflow considerations.

RB_PRD-3905 The baseline Instrument verification test set, prior to shipment of the Instrument to the Observatory, shall be the following:

1) Electrical Interface Tests (per Section 8.2.1)
2) Comprehensive Performance Test (CPT) (per Section 8.2.2)
   a. Including Limited Performance Testing (Per Section 8.2.3)
   b. Including Mechanical Deployments (per Section 8.5)
3) EMI/EMC Characterization and Verification tests (per Section 8.3)
4) Limited Performance Testing (Per Section 8.2.3)
5) Structural and Dynamic Testing (Per Section 8.4)
   a. Pre-Test Mechanical Alignment Verifications (Section 8.4)

b. Vibroacoustic Testing (Sections 8.4.2 and 8.4.3)
c. Sinusoidal Vibration Testing (Section 8.4.4)
d. Shock Testing (per Section 8.4.5)
e. Post-Test Mechanical Alignment Verifications (Section 8.4)
f. Limited Performance Test (LPTs) or other functional testing tailored as appropriate shall be performed between each Structural Test sequence (each axis or sequence where appropriate).

6) Comprehensive Performance Test (Pre-thermal vacuum (TV))
7) Thermal Vacuum and Thermal Balance Testing (per Sections 8.6.1 and 8.6.2)
   a. Includes Plateau CPT and LPT (per Section 8.2.2 and 8.2.3)
   b. Includes Performance Verification Testing (Per Section 8.2.5)
   c. Includes Contamination/Bake-out Testing (per Section 8.6.3)
8) Comprehensive Performance Test (Post-TV)
   a. Including Mechanical Deployments
   b. Including Final Mechanical Alignment Verifications
9) Mass Properties

RB_PRD-3928 All Instrument protoflight and acceptance testing shall be done in accordance with GSFC-STD-7000A as specified in this document.

RB_PRD-3929 All Instrument protoflight tests shall be conducted with hardware of the final design that has passed the in-process production screens.

RB_PRD-3930 Test levels including any requests for tailoring or notching shall be submitted to NASA LaRC for approval prior to testing.

The following requirement identifies the testing that JPSS instruments will undergo following delivery of the Instrument to the Spacecraft integration facility. JPSS Observatory I&T activities for the Instrument are the responsibility of NASA LaRC and not the RBI Instrument Contractor.

The baseline Instrument verification test sequence, after delivery to the Observatory, will be the following:

1) Electrical Interface Tests (per Section 8.2.1)
2) CPT (per Section 8.2.2)
   a. Including Mechanical Deployments (per Section 8.5)
3) EMI/EMC Characterization and Verification tests (per Section 8.3)
4) Limited Performance Testing (Per Section 8.2.3)

5) Structural and Dynamic Testing (Per Section 8.4)

   a. Pre-Test Mechanical Alignment Verifications (Section 8.4)

   b. Vibroacoustic Testing (Sections 8.4.2 and 8.4.3)

   c. Sinusoidal Vibration Testing (Section 8.4.4)

   d. Shock Testing (per Section 8.4.5)

   e. Post-Test Mechanical Alignment Verifications (Section 8.4)

   f. NOTE: LPT's should be performed between each Structural Test sequence (each axis or sequence) where appropriate.

6) CPT (Pre-spacecraft thermal vacuum (SCTV))

7) Thermal Vacuum and Thermal Balance Testing (per Sections 8.6.1 and 8.6.2)

   a. Includes Plateau CPT and LPT Testing (per Sections 8.2.2 and 8.2.3)

   b. Includes Performance Verification Testing (per Section 8.2.5)

   c. Includes Contamination/Bake-out Testing (per Section 8.6.3)

8) CPT (Post-SCTV)

   a. Including Mechanical Deployments

   b. Including Final Mechanical Alignment Verifications

9) Mass Properties

8.2 Electrical Functional Test Requirements

The following paragraphs delineate the functional performance tests and demonstrations to be conducted on the JPSS Observatory and its components, subsystems, and instruments.

8.2.1 Electrical Interface Testing

RB_PRD-3957 As a part of the integration of a component or subsystem into the next higher level of assembly, electrical tests shall be performed to verify the interface configuration (power, grounds, commands, telemetry, signals, timing, etc.).

RB_PRD-3958 Prior to mating with other hardware, electrical harnessing shall be tested to verify the wire routing, isolation, impedance, and overall workmanship. The following parameters shall be verified as a minimum:

- Accuracy (signals on correct pins and nowhere else)
- Inputs and outputs (unloaded and loaded)
- Specified range (high/low extremes as well as nominal)
- Range impacts (how range extremes of one signal affect related signals)

8.2.2 Comprehensive Performance Tests (CPT's)

RB_PRD-3964 CPTs shall be conducted at the subsystem, Spacecraft, Instrument, and Observatory levels of assembly to demonstrate that the hardware and software meet their performance requirements within allowable tolerances.

RB_PRD-3965 CPTs shall demonstrate:

1) With the application of known stimuli and appropriate inputs, the test article will produce the expected responses and outputs within acceptable limits.
2) The operation of redundant circuitry and satisfactory performance in all operational modes.
3) When compared to the initial baseline CPT, performance of the test article has been unaffected by the environmental testing program.

8.2.3 Limited Performance Tests (LPT's)

RB_PRD-3970 LPTs shall be conducted at the subsystem, Spacecraft, Instrument, and Observatory levels of assembly, where CPTs are not warranted, to demonstrate that the hardware and software performance has not been degraded by environmental testing/exposure.

RB_PRD-3971 LPTs shall demonstrate:

1) With the application of known stimuli and appropriate inputs, the test article will produce the expected responses and outputs within allowable tolerances.
2) The operation of redundant circuitry, and satisfactory performance in selected operational modes.
3) When compared to the initial baseline LPT, performance of the test article has been unaffected by the environmental testing program.

8.2.4 End-to-End Performance Tests (ETEs)

The following requirements address ETE JPSS Observatory performance testing. JPSS Observatory I&T activities for the Instrument are the responsibility of NASA LaRC and not the RBI Instrument Contractor.

At the Observatory level, ETE compatibility tests will be performed to demonstrate the ground system capability to communicate with the Observatory (up-link and down-link) via the ground to space network.

ETEs will demonstrate:

1) Simulated normal orbital mission scenarios encompassing launch, systems turn-on, housekeeping, command/control, and stabilization/pointing, including the collecting, processing, and archiving of science data.

2) That the Observatory is immune to erroneous commands, autonomous safe-hold, and simulated anomaly recovery operations.

8.2.5 Flight Hardware Operating Time (Burn-In) and Failure Free Performance

One thousand (1000) hours of operating/power-on time will be accumulated on the Instrument (including all redundant hardware) prior to launch, of which at least 200 hours shall be in vacuum. The last 350 hours of operating/power-on time will be failure-free.

The 200 vacuum hours will be 100 at hot dwell and 100 at cold dwell.

RB_PRD-3984 The Instrument shall accumulate operating/power-on time of 500 hours on primary and an additional 500 hours on secondary on all flight electronic hardware prior to instrument delivery of which at least 100 hours shall be in vacuum on primary and at least 100 hours on secondary. The 100 vacuum hours shall be 50 at hot dwell and 50 at cold dwell. The last 200 hours of operating/power-on time shall be failure-free.

8.3 EMC/EMI Testing

RB_PRD-3987 EMI/EMC tests CE101, CMBCE, CS06, CS101, CS02, CS114, CS115, RE101, RE102, RS101 (Magnetically Sensitive Components), and RS103 shall be conducted for all electrical flight hardware, as applicable based on test specifications per MIL-STD-461F, MIL-STD-461C/462 (for CS02 and CS06 only), and GSFC-STD-7000A (CMBCE, CS06).

RB_PRD-3988 For all MIL-STD-461F EMI/EMC testing, the LISN in MIL-STD-461F shall be tailored, as necessary, to be more representative of the Spacecraft power bus impedance. When not otherwise specified, the 5uH LISN specified in Section A.4.3.6, Figures A-2 & A-3 of MIL-STD-461F will be utilized in place of the standard 50 uH LISN.

RB_PRD-6372 Flight-like cables (constructed with expected flight wire groupings, twisting, shielding, and shield terminations per the applicable Satellite to Instrument ICD) shall be used for all EMC testing.

8.3.1 Radiated Emissions

RB_PRD-3991 The radiated emission measurement bandwidths and frequency steps in MIL-STD-461F shall be reduced as specified in Table 6.3.3.2.3.2-2 to show compliance with the receiver notches.

RB_PRD-3993 Unintentional radiated emission measurements in the specified Table 6.3.3.2.3.2-2 receiver bands shall be made in accordance with MIL-STD-461F RE102 with the EMI receiver preceded by a low-noise preamplifier such that the test system noise figure is < 3 dB.

8.3.2 Reserved

8.3.3 Radiated Susceptibility

RB_PRD-3998 Modulation of the applied susceptibility signal is required, simulating as closely as possible the modulation characteristics of the known emitter. If the appropriate modulation has not been established by hardware design or mission scenario, the test method of MIL-STD-461F RS103 shall be used.

8.3.4 Charging Verification

RB_PRD-4000 Instrument charging verification shall be conducted in accordance with NASA-STD-4002A, as tailored.

8.4 Structural and Mechanical Verification Requirements

RB_PRD-4002 The Instrument shall experience no unintentional change of state when subjected to the specified dynamic environments specified herein.

RB_PRD-4003 Structural and Mechanical Verification activities shall be performed per Table 8.4-1 and associated notes.

Table 8.4-1 Structural and mechanical verification test requirements.

Requirement	Satellite	Instrument
Structural Loads		
Modal Survey	*	T[2]
Design Qualification	*	A,T/A[1]
Structural Reliability		
Primary & Secondary Structure	*	(A,T)[1]
Vibroacoustics		
Acoustics	T	T[2]
Random Vibration	T[2]	T[2]
Sine Vibration	T[3] ,T[4]	T[3],T[5]
Mechanical Shock	T	T[7]
Mechanical Function	A,T	A,T

Requirement	Satellite	Instrument
Pressure Profile	-	A,T^2
Mass Properties	A/T	A,T^2

* = May be performed at payload or component level of assembly if appropriate.

A = Analysis required.

T = Test required.

A/T = Analysis and/or Test.

A,T/A1 = Analysis and Test or Analysis only, using no-test factors of safety of 2.0 on yield and 2.6 on ultimate (with NASA concurrence).

$(A,T)^1$ = Combination of fracture analysis and proof tests on selected elements, with special attention given to beryllium, composites, and bonded joints.

T^2 = Test must be performed unless assessment justifies deletion.

T^3 = Test performed to simulate any sustained periodic mission environment, or to satisfy other requirement (loads, low frequency transient vibration).

T^4 = Test must be performed for ELV payloads, if practicable, to simulate transient and any sustained periodic vibration mission environment.

T^5 = Test must be performed for ELV payload instruments and for ELV payload subsystems if not performed at payload level of assembly due to test facility limitations; to simulate sine transient and any sustained periodic vibration mission environment.

T^6 = Test must be performed for ELV payload, instruments, and components to simulate sine transient and any sustained periodic vibration mission environment.

T^7 = Test required for self-induced shocks, but may be performed at payload level of assembly for externally induced shocks.

8.4.1 Structural Loads Qualification

RB_PRD-4075 The strength qualification test shall be accompanied by a stress analysis that demonstrates a positive margin on ultimate at loads equal to 1.4 times the limit load for all ultimate failure modes such as fracture or buckling.

RB_PRD-4076 Acceptance structural loads test profile shall be the limit load for 5 cycles at full level per axis if using the sine burst technique, or a sustained 30 seconds of loading at full level otherwise (centrifuge or static load).

RB_PRD-4077 Protoflight structural loads test profile shall be 1.25 × limit load for 5 cycles at full level per axis if using the sine burst technique, or a sustained 30 seconds of loading at full level otherwise (centrifuge or static load).

RB_PRD-4078 All composite and Beryllium structures and structural bonded joints shall be proof tested, regardless of safety factor.

RB_PRD-4079 Test levels for Beryllium structure shall be 1.4 × limit level for both qualification and acceptance testing.

RB_PRD-4080 Test levels for composite structure, including metal matrix, shall be 1.25 × limit level for acceptance testing.

RB_PRD-4081 Analysis-only strength verification plans shall require NASA LaRC concurrence.

RB_PRD-4082 If qualified by analysis only, positive margins shall be shown for factors of safety of 2.0 on yield and 2.6 on ultimate.

8.4.2 Acoustic Testing

RB_PRD-4084 An acoustic test shall be performed on instruments and components unless an assessment of the hardware indicates that they are not susceptible to the expected acoustic environment, or responses are enveloped by random vibration testing, or that testing at higher levels of assembly provides sufficient exposure at an acceptable level of risk to the program.

8.4.2.1 Acceptance Level Acoustic Testing

RB_PRD-4086 The acceptance acoustic test levels and durations shall be in accordance with Table 6.2.2.2.1-1.

RB_PRD-4087 The acceptance test duration shall be one minute.

8.4.2.2 Protoflight Level Acoustic Testing

RB_PRD-4089 The protoflight acoustic test levels and durations shall be in accordance with Table 6.2.2.2.1-1, increased by 3 dB.

RB_PRD-4090 The protoflight test duration shall be one minute.

8.4.3 Random Vibration Testing

RB_PRD-4092 The Instrument shall survive the acceptance and protoflight launch random vibration levels defined in Table 8.4.3-2 and meet all operational requirements thereafter.

RB_PRD-4093 Acceptance and protoflight random vibration testing shall be conducted for 1 minute per axis with a spectrum that is based on levels measured at the component mounting locations during previous subsystem or payload testing.

RB_PRD-4094 When previous test measurements are not available, the vibration levels shall be based on statistically estimated responses of similar components on similar structures or on analysis of the payload. Actual measurements should then be used if and when they become available.

Table 8.4.3-2 Protoflight and acceptance random vibration test levels.

Frequency (Hz)	ASD Level (g^2/Hz)	
	Qualification	Acceptance
20	0.026	0.013
20-50	+6 dB/oct	+6 dB/oct
50-800	0.16	0.08
800-2000	-6 dB/oct	-6 dB/oct
2000	0.026	0.013
Overall	14.1 G_{rms}	10.0 G_{rms}

RB_PRD-4100 The slopes shall be maintained at + and – 6dB/oct for components weighing up to 59-kg (130-lb).

RB_PRD-4101 Above that weight, the slopes shall be adjusted to maintain an ASD level of 0.01 g2/Hz at 20 and 2000 Hz.

For components weighing over 182-kg (400-lb), the test specification will be maintained at the level for 182-kg (400 pounds).

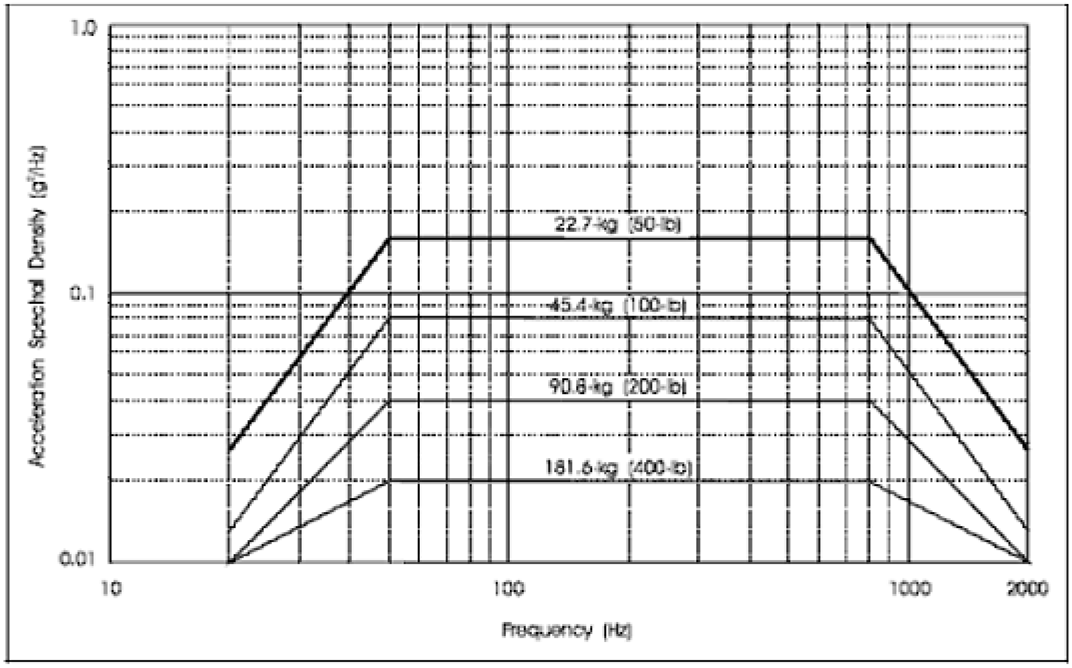


Figure 8.4.3-1 Protoflight and acceptance random vibration test levels.

8.4.3.1 Random Vibration After Rework

RB_PRD-4106 As a minimum, reworked components shall be subjected to a single axis workmanship random vibration test to the Minimum Workmanship Test Levels specified in Table 8.4.3.1-1 and Figure 8.4.3.1-1, where the actual levels to be used have NASA LaRC concurrence.

The determination of axis is to be made based on the direction necessary to provide the highest excitation of the reworked area. Testing may be required in more than one axis if a single axis test cannot be shown to adequately test all of the reworked area. If the amount of rework or disassembly required is significant, then 3-axis testing to acceptance levels may be necessary if they are higher than workmanship levels.

Table 8.4.3.1-1 Component minimum workmanship random vibration test levels.

Frequency (Hz)	ASD Level (g^2/Hz)
20	0.01
20-80	+3 dB/oct
80-500	0.04
500-2000	-3 dB/oct
2000	0.01
Overall	6.8 g_{rms}

The plateau acceleration spectral density level (ASD) may be reduced for components weighing between 45.4 and 182 kg, or 100 and 400 pounds according to the component weight (W) up to a maximum of 6 dB as shown in Table 8.4.3.1-2:

Table 8.4.3.1-2 dB reduction for ASD.

	Weight in kg	Weight in lb
dB reduction =	10 log(W/45.4)	10 log(W/100)
ASD(plateau) level =	0.04•(45.4/W)	0.04•(100/W)

RB_PRD-4113 The sloped portions of the spectrum shall be maintained at plus and minus 3 dB/oct. Therefore, the lower and upper break points, or frequencies at the ends of the plateau become:

FL = 80 (45.4/W) [kg] FL = frequency break point low end of plateau

= 80 (100/W) [lb]

FH = 500 (W/45.4) [kg] FH = frequency break point high end of plateau

= 500 (W/100) [lb]

RB_PRD-4116 The test spectrum shall not go below 0.01 g^2/Hz. For components whose weight is greater than 182-kg or 400 pounds, the workmanship test spectrum is 0.01 g^2/Hz from 20 to 2000 Hz with an overall level of 4.4 grms.

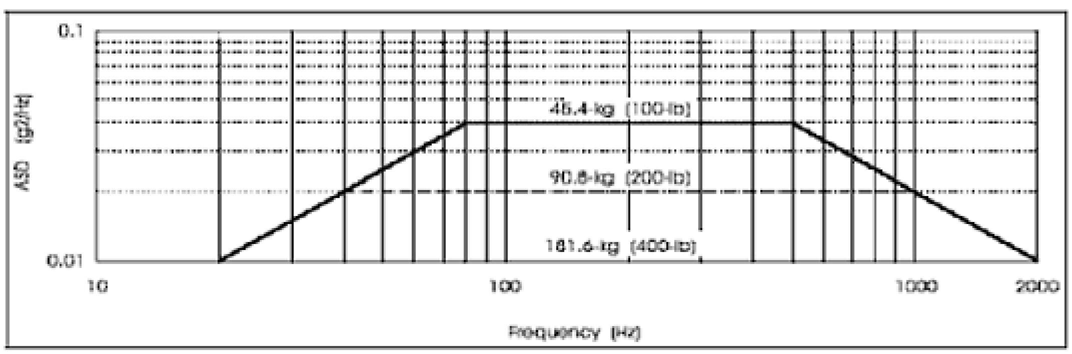


Figure 8.4.3.1-1 Minimum workmanship random vibration test levels.

8.4.4 Sine Vibration Testing

RB_PRD-4120 This test shall be conducted with the Instrument in the launch configuration.

RB_PRD-4121 There shall be one sweep from 5 Hz to 60 Hz for each axis.

RB_PRD-4122 The test sweep rate shall be 4 oct/min.

The Instrument will be tested to the sine vibration test levels specified in JPSS-2 Spacecraft to RBI Instrument Interface Control Document (ICD) Table RBI-457 and in Figure RBI-458.

RB_PRD-4124 Requests for tailoring/notching shall be submitted to NASA LaRC for approval prior to testing.

8.4.5 Shock Testing

Testing for externally induced shocks (Spacecraft separation, solar array deployment, etc.) is typically accomplished at the Spacecraft level based on an assessment of the shock susceptibility of the component and the expected shock levels. If there is low potential for damage due to the shock environment, then the project may choose to defer shock testing to the payload level of assembly.

8.4.5.1 General

Shock testing will be performed at the Spacecraft level for payload attach fitting separation shocks, solar array deployment shocks, appendage deployment shocks, and Instrument-induced shocks – if any.

RB_PRD-4142 The Instrument shall be shock tested at Instrument-level prior to delivery if the instrument contains pyrotechnics or shock-sensitive parts.

The Instrument will be designed to withstand shock level values listed in JPSS-2 Spacecraft to RBI Instrument Interface Control Document (ICD) Table RBI-462 without performance degradation.

8.4.5.2 Instrument Level Self-Induced Shock Testing

RB_PRD-4147 Instrument self-induced shock testing shall be accomplished by two actuations at the Instrument level for each self-induced shock source (in order to account for the scatter associated with the actuation of the device), for the first flight unit, and a single actuation on subsequent units.

8.5 Mechanism Verification

RB_PRD-4149 All Mechanisms, including deployment and latching devices shall be tested to demonstrate adequate functioning following exposure to the environments in this document, following NASA-STD-5017.

8.5.1 Mechanism Qualification Testing

RB_PRD-4151 Each mechanism shall undergo qualification testing to assure that its design margin meets all performance and safety requirements in all environments and situations that the mechanism may reasonably expect to encounter during its service life.

RB_PRD-4152 The mechanisms shall be qualification tested in their launch, on-orbit, landing, and other operational configurations at the appropriate corresponding environmental extremes and in their appropriate passive or operating state during the launch or on-orbit operational phases.

RB_PRD-4153 Qualification testing of mechanical systems shall be conducted with the appropriate mounting interface, boundary conditions, including stiffness/flexibility, mounting alignment tolerances, thermal and load-induced distortions to ensure mechanical system structural integrity and performance.

RB_PRD-4154 Inspection and functional tests shall be performed both before and after qualification tests. The inspection and pass-fail criteria for the functional tests shall be established prior to the qualification test.

8.5.2 Mechanism Acceptance Testing

RB_PRD-4156 All mechanisms shall be subjected to acceptance testing, which incorporates functional, run-in, and environmental testing structured to detect workmanship defects that could affect operational performance.

RB_PRD-4157 All testing for Moving Mechanical Assemblies that are part of deployable or movable systems shall, where practical, be conducted with the Moving Mechanical Assemblies attached to the movable system.

RB_PRD-4158 Mechanical Stops shall be tested by intentionally running the Moving Mechanical Assembly into the stops whether or not the Moving Mechanical Assembly has limit switches or other design features to prevent contacting the stops in normal operation.

RB_PRD-4159 The Mechanical Stops shall be tested for at least twice the number of duty cycles expected in operational use, plus twice the number of duty cycles expected during component and vehicle functional and environmental tests. For Moving Mechanical Assembly that employ limit switches or other design feature and do not normally contact the stops, the qualification tests of the Mechanical Stops may be conducted as a separate subassembly level test with the switch inactive.

8.5.2.1 Functional Test Structuring

RB_PRD-4161 Functional tests shall be structured to demonstrate that the mechanism is operating correctly in order to verify all performance requirements.

RB_PRD-4162 All mechanism functions shall be exercised during mechanism functional testing.

RB_PRD-4163 Each mechanism designated as a flight or qualification test article shall undergo an initial functional test prior to undergoing any other acceptance testing.

RB_PRD-4164 Functional tests that exercise all mechanism functions shall be performed both before and after environmental tests in order to establish whether damage or degradation in performance has occurred.

8.5.2.2 Run-In Testing

Consult NASA-STD-5017 Section 5.9 for descriptive information on Run-In testing.

RB_PRD-4167 A run-in test shall be performed on each mechanism after initial functional testing and prior to being subjected to further acceptance testing unless both of the following are true: (a) It can be shown that this procedure is detrimental to performance and would result in reduced reliability, and (b) The appropriate technical authority of the governing program grants a waiver for the run-in test prior to the start of acceptance testing.

RB_PRD-4168 The run-in test shall be conducted for a minimum of 50 hours except for items where the number of cycles of operation, rather than hours of operation, is a more appropriate measure of the capability to perform in a consistent and controlled manner. For these mechanisms, the run-in test shall be for at least 15 cycles or 5% of the total expected life cycles; whichever is greater for these mechanisms.

RB_PRD-4169 The run-in test conditions shall be representative of the operational loads, speed, and environment.

RB_PRD-4170 During the run-in test, periodic measurements shall be made to indicate what conditions may be changing with time and what wear rate characteristics exist.

8.5.2.3 Motor Characterization Testing

RB_PRD-4172 For applications where the motor performance is critical to the mission success, the design shall be based on a complete motor characterization at the minimum and maximum voltages from the Spacecraft bus and motor driver.

RB_PRD-4173 The motor characterization shall include:

- rotor inertia,
- friction and damping parameters,
- back-electromotive force (EMF) constant or torque constant,
- time constant,
- torque characteristics,
- speed versus torque curves,
- thermal dissipation,
- temperature effects,
- and analysis to demonstrate adequate margin against back driving.

RB_PRD-4183 For applications where the motor is integrated into a higher assembly the motor characterization shall be performed at the motor level prior to the integration.

8.5.3 Life Test

Consult GSFC-STD-7000A Section 2.4.5.1 for guidance on Life Testing.

RB_PRD-4186 A life test program shall be implemented for mechanical elements that move repetitively as part of their normal function and whose useful life must be determined in order to verify their adequacy for the mission.

8.5.3.1 Design Life Verification Tests

RB_PRD-4188 Design life verification testing shall be performed on all mechanism functions to verify that all design life requirements have been met. Typical design life concerns include cycle life, endurance or fatigue limits, potential deterioration of lubrication, excessive wear, storage times, etc.

RB_PRD-4189 Design life verification of the mechanisms shall be tested in their on-orbit configurations with applicable environment extremes.

RB_PRD-4190 Prior to the start of life testing, consideration shall be given to subjecting the mechanisms to the same ground testing environments, both structural and thermal, that are anticipated for the flight units (protoflight or acceptance levels, as appropriate). These environments may have a significant influence on the life test performance of the mechanism.

RB_PRD-4191 For life-limited items, Instrument design, qualification, and verification shall account for multiple activations during Spacecraft level tests.

RB_PRD-4192 The thermal environment of the mechanism during the life test shall be representative of the on-orbit environment.

RB_PRD-4193 If expected bulk temperature changes are significant, then the life test shall include a number of transitions from the hot on-orbit predictions to the cold on-orbit predictions, and vice versa.

RB_PRD-4194 Significant temperature gradients shall be factored into the thermal profile for the life test.

RB_PRD-4195 The life tests shall consider the effects of vacuum on the performance of the mechanism with particular attention to its effects on the thermal environment (i.e., no convective heat transfer) and potentially adverse effects on lubrication and materials.

RB_PRD-4196 Life testing shall include testing of mechanical stops by intentionally running the mechanism into the stops, whether or not the mechanism has limit switches to prevent contracting the stops in normal operations.

RB_PRD-4197 Inspection and functional tests shall be performed both before and after design life verification tests.

RB_PRD-4198 Mechanical system’s components that are subject to wear shall be disassembled and inspected for degradation or other anomalies.

RB_PRD-4199 Upon completion of the life test, proper inspections shall be conducted to identify any anomalous conditions such as abnormal wear, significant lubrication breakdown, or excessive debris generation. These or other anomalous conditions may be cause for declaring the life test a failure despite completion of the required test spectrum. A thorough investigation of all moving components and wear surfaces should be conducted. This may include physical dimensional inspection of components, high magnification photography, lubricant analysis, Scanning Electron Microscope (SEM) analysis, etc.

8.5.3.2 Life Test Unit

RB_PRD-4201 The life test mechanism shall be fabricated and assembled such that it is representative of the actual flight mechanism.

RB_PRD-4202 Any differences between the test items and the flight items shall not jeopardize the validity of the life tests.

8.5.3.3 Life Test Instrumentations

RB_PRD-4204 Sufficient test instrumentation shall be incorporated into the mechanism, test fixture, and test set-up to allow characterization and verification of the mechanism performance requirements.

RB_PRD-4205 Physical parameters that are an indication of the health of the mechanism shall be closely monitored and trended during the life test.

RB_PRD-4206 The life test shall be designed to “fail safe” in the event of any failure of the test setup, GSE, or test article.

8.5.3.4 Life Test Setup

RB_PRD-4208 Significant interface masses, loads, stiffnesses, electrical interface, and cables shall be flight-like.

RB_PRD-4209 Interfacing equipment subject to motion, such as thermal blankets, cabling, or hoses, shall be included.

RB_PRD-4210 Consideration shall be given to the geometry of the test set-up and the effects of gravity on the performance of the life test mechanism, including the effects on lubrication. For example, gravity may cause lubrication to puddle at the bottom of a bearing race or run out of the bearing. In some cases, the effects of gravity may cause abnormally high loads on the mechanism.

RB_PRD-4211 System dynamics effects due to inertial loads shall be considered.

8.5.3.5 Life Test Considerations

RB_PRD-4214 The test spectrum for the life test shall represent the required mission life for the flight mechanism, including both ground and on-orbit mechanism operations.

RB_PRD-4215 The minimum requirement for demonstrated life test operation without failure shall be 2.0 times the mission life and 4.0 times the ground cycles (includes assembly, installation, run-in, functional, environmental, etc.).

RB_PRD-4216 Pre and post-life test baseline performance tests shall be conducted with clear requirements established for determining minimum acceptable performance at EOL.

RB_PRD-4217 A mechanism that normally operates in "boundary lubrication" and "mixed lubrication" shall never be accelerated in a life test to a level where the lubrication system moves into the elastohydrodynamic (EHD) regime for the test.

RB_PRD-4218 For stepper motor, it shall be shown that the rotor oscillations damp out to less than 10% of the peak overshoot amplitude prior to initiating the next accelerated step.

RB_PRD-4219 Where lubrication is used, consideration shall be given to measuring lubricant loss, degradation, distribution, quantity, and outgassing constituents over the duration of the test.

8.6 Thermal Vacuum Environmental Testing

8.6.1 Thermal Vacuum Cycling

RB_PRD-4222 Thermal vacuum testing shall be performed in accordance with the environmental temperature ranges specified in Section 6.4.4 using GSFC-STD-7000A as a guideline.

RB_PRD-4223 All space hardware shall be subjected to a minimum of eight (8) thermal-vacuum temperature cycles before being delivered to the Spacecraft, of which a minimum of four (4) thermal-vacuum cycles shall be performed at the integrated Instrument-level.

RB_PRD-4224 To verify survival performance thermal-vacuum testing shall include a minimum of one plateau at each survival temperature extreme. Following each survival plateau the unit shall be returned to within its operating temperature limits to verify performance.

RB_PRD-4225 During the thermal-vacuum cycling with exception to the survival plateaus, the hardware shall be operating and its performance evaluated against specifications during transitions and temperature plateaus.

RB_PRD-4226 Temperature dwell (plateau) periods at the Instrument level of assembly shall not be less than twelve (12) hours at each plateau.

RB_PRD-4227 Temperature dwell (plateau) periods at the unit/component level of assembly shall not be less than four (4) hours at each plateau.

RB_PRD-4228 The temperature tolerances for thermal testing shall be ±2 °C.

RB_PRD-4229 The chamber pressure after the electrical discharge checks are conducted shall be less than 1.33×10^{-3} Pa. (1×10^{-5} torr).

RB_PRD-4230 The Instrument shall demonstrate satisfactory operation during thermal vacuum testing over the range of possible flight voltages.

RB_PRD-4231 The Instrument shall demonstrate satisfactory operation of the Instrument primary and redundant side electronics during thermal vacuum testing.

RB_PRD-4232 The Instrument shall demonstrate satisfactory operation in all modes including SAFE and SURVIVAL during thermal vacuum testing.

RB_PRD-4233 The Instrument shall demonstrate a minimum of two hot and cold turn-ons during thermal vacuum tests at qualification or expected survival temperature whichever is greater.

RB_PRD-4234 For actively controlled systems such as Heaters, thermo-electric coolers (TECs), loop heat pipes (LHPs), capillary pumped loops (CPLs), or other devices with selectable/variable set points, a test temperature margin of no less than 5 °C shall be imposed on the respective set point band that is under control.

RB_PRD-4235 For components/subsystems/payloads with operational heater circuits with fixed temperature set points, the test temperature margin shall be reduced from 10 °C to 5 °C.

RB_PRD-4236 If a component/subsystem/payload has an active control whose range is not selectable/ variable such that the control system will not allow the hardware to be stressed via temperature, then the active temperature control hardware shall maintain control when stressing is induced by the increase or decrease of a heat load (internal or external) of at least 30%.

RB_PRD-4237 Instrument heat pipes shall function with a 1-g field in a direction compatible with Spacecraft thermal vacuum testing.

8.6.2 Thermal Design Margin (Thermal Balance) Testing

RB_PRD-4239 Thermal balance testing shall be performed at worst case hot, worst case cold, and nominal temperature for operational mode, using the interface temperature ranges specified in Table 8.6.2-1 using GSFC-STD-7000A.

Table 8.6.2-1 RBI to Spacecraft Interface Temperature and Heat Transfer Rates

Instrument Mode	Interface Temperature		Interface Heat Transfer Rate (+ Transfer into Spacecraft)*	
	Min (deg C)	Max (deg C)	Min (Watts)	Max (Watts)
OPERATIONAL	-10	+40	-10	+10
SAFE	-10	+40	-10	+10
SURVIVAL	-20	+50	-10	+10
OFF	-20	+50	-10	+10

* This includes heat conducted through the harness and ground straps.

RB_PRD-4240 Thermal design margins shall be verified under worst-case hot and cold, survival, and, if tested, safe mode conditions.

RB_PRD-4241 Stabilization shall be considered to have been achieved either when the control sensors change less than 0.05 °C per hour, for a period of not less than 6 hours, and exhibit a decreasing temperature slope over that period, or is considered to have been achieved when the amount of energy represented by the time rate of temperature change (and the thermal mass of the test article) is 5% or less than the total energy of the test article.

8.6.3 Contamination/Bake-Out Requirements

RB_PRD-4243 MLI blankets, harnesses and cables, and electronic boxes/modules to be included in thermal-vacuum testing shall be baked out separately from the Instrument.

RB_PRD-4244 Verification of Instrument outgassing levels shall occur during the last hot temperature plateau of Instrument-level thermal vacuum testing, after completion of Instrument thermal cycling and functional tests.

RB_PRD-4245 The Instrument temperature during outgassing verification shall be the Instrument hot protoflight temperature or 30 °C, whichever is higher.

RB_PRD-4246 The thermal vacuum chamber pressure shall be less than 1E-5 Torr during Instrument outgassing verification.

RB_PRD-4247 The Instrument outgassing rate shall be measured using a Temperature-Controlled Quartz Crystal Microbalance (TQCM) maintained at -20 oC.

RB_PRD-4248 The TQCM shall be positioned at a location representative of the effluent flux.

RB_PRD-4249 The Instrument outgassing rate shall be less than 1.2 E-8 g/s.

RB_PRD-4250 The required Instrument outgassing level shall be obtained for at least 5 consecutive hours.

RB_PRD-4251 Data shall be recorded at least once every 30 minutes during outgassing certification and include, at a minimum, TQCM data, temperature of hardware, chamber/shroud temperature, TQCM temperature, and chamber pressure.

RB_PRD-4252 A cold finger or scavenger plate shall be used to provide a qualitative assessment of the instrument outgassing effluent at the end of the certification test.

9 INTEGRATION, TEST, AND GSE REQUIREMENTS

9.1 General I&T Design Requirements

RB_PRD-4255 The Instrument designs shall include maintainability features, if applicable, to ensure timely replacement or test of Instrument subsystems or modules prior to launch.

Only remove-and-replace maintenance actions will be performed on the Observatory and instruments after delivery.

RB_PRD-4257 Except for software updates, the Instrument shall not require maintenance or repair on-orbit.

RB_PRD-4258 The Instrument shall be capable of undergoing testing at periodic intervals (e.g., 6-month periods) while remaining integrated during AI&T and Ground Storage.

RB_PRD-4259 All items to be installed, removed, or replaced on the Instrument shall be accessible without disassembly of the unit.

RB_PRD-4260 Access for and installation of Instrument mounting hardware shall be exclusively from the Instrument side of the Spacecraft - Instrument mechanical interface.

RB_PRD-4261 Installation/removal of any separately mountable Instrument component shall not require rotation of the Instrument or the Spacecraft during installation/removal.

RB_PRD-4262 Each separately mountable Instrument component shall be capable of being installed and removed in any order.

RB_PRD-4263 The Instrument shall be capable of undergoing the periodic testing described above while oriented with gravity in any direction.

RB_PRD-4264 Instrument design shall be such that the Instrument is capable of being mounted to the Observatory with the Spacecraft interface in the horizontal position.

9.2 Ground Support Equipment

GSE is defined as those items which are required for the assembly, handling, functional evaluation, design verification, performance testing, transportation shipping and storage of the Instrument.

RB_PRD-4267 GSE, which is used in a cleanroom, shall be ISO Class 7 (per ISO 14644-1) cleanroom compatible.

RB_PRD-4268 GSE shall be designed for a seismic loading of 0.5 g lateral.

RB_PRD-4275 Instrument Ground Support Equipment (IGSE) shall be capable of providing quick look determination on Instrument state of health and performance data.

RB_PRD-4277 Shipping containers for the sensors and GSE shall have features that permit the use of a forklift.

9.2.1 Electrical Ground Support Equipment (EGSE)

RB_PRD-4279 All Instrument electrical ground support equipment (IEGSE) shall have separate and isolated grounds for DC power, telemetry, and facility AC power.

Note: Isolated grounds is to prevent A/C signal crosstalk onto data transmission lines.

This requirement only applies to GSE that is used post-shipment of the Instrument.

RB_PRD-4281 EGSE chassis shall be grounded to facility AC power ground.

RB_PRD-4282 If the Instrument or IGSE employs high voltage (>50 VDC), kill (emergency off) switches on the GSE shall be provided.

RB_PRD-1356 1553 bus stub length shall not exceed 20 feet (6.1 meters).

RB_PRD-1357 The MIL-STD-1553B data bus for EGSE shall be terminated at both ends with Zo = 78 ohms ± 2%, in accordance with Section 4.5.1.4 of MIL-STD-1553B.

9.2.1.1 Instrument GSE to Spacecraft I&T GSE Interface

RB_PRD-4285 The Instrument EGSE shall have a configurable IP address.

RB_PRD-4286 The Instrument EGSE shall be capable of receiving the Instrument SMD packets at least 20 times the average data rate of the Instrument.

RB_PRD-4287 The Instrument EGSE shall be capable of receiving and displaying the Instrument real-time science data (HRD and/or low rate data (LRD) packets).

RB_PRD-4288 The deliverable Instrument EGSE shall be capable of archiving and processing science telemetry (SMD, HRD, and/or LRD packets).

RB_PRD-4289 The Instrument shall not require the Instrument EGSE for commanding or loads after the Instrument is integrated to the Spacecraft. This means that all Instrument commands may only be sent or received by the Spacecraft EGSE.

9.2.1.2 Instrument GSE Requirements

RB_PRD-4291 The Instrument EGSE shall allow up to ten individual telemetry data signals to be plotted in real time simultaneously as data is received from the Spacecraft GSE.

RB_PRD-4292 The Instrument EGSE shall include the capability to perform real time trending on up to ten individual telemetry data signals simultaneously as data is received from the Spacecraft GSE.

RB_PRD-4293 The Instrument EGSE shall record all data received from the Spacecraft EGSE in a file to be used for later playback and analysis.

RB_PRD-4294 The Instrument EGSE shall include the capability to play back recorded Instrument data for offline analysis.

9.2.2 Mechanical Ground Support Equipment (MGSE)

9.2.2.1 MGSE Functional Requirements

RB_PRD-4298 The fixture attaches to the Instrument and permits Instrument lifting/lowering operations along the Spacecraft +Z-axis; when the lifting fixture is used, the Spacecraft +Z-axis shall be vertical and up.

9.2.2.2 MGSE Design Requirements

The requirements in this section apply to any GSE that accompanies the Instrument into a cleanroom area or vacuum chamber.

RB_PRD-4302 MGSE shall be designed to eliminate/mitigate contamination (i.e., use low outgassing, non-shedding materials, enclose moving parts to prevent particulate release into the environment surrounding the Spacecraft, use labyrinth seals to isolate lubricated surfaces).

RB_PRD-4303 MGSE used over the Spacecraft shall be bagged to prevent contaminants from falling onto the Spacecraft.

RB_PRD-4304 MGSE used within the thermal vacuum test chamber shall be vacuum baked out prior to use.

RB_PRD-4305 Mating gas and liquid lines as well as electrical connectors shall be pre-cleaned and packaged to ensure that contaminants are not transferred to the payload hardware.

RB_PRD-4306 MGSE shall be fabricated out of open cross section structural members (i.e., I-beams or C-channels).

RB_PRD-4307 No polyvinyl chloride (PVC) or tygon tubing shall be utilized in the GSE fabrication.

RB_PRD-4308 No highly volatile compounds (lubricants, greases, cutting fluids) shall be utilized in GSE fabrication.

RB_PRD-4309 MGSE shall use only low outgassing, durable (chip & solvent resistant) paint.

RB_PRD-4310 No cadmium, zinc plating, or tin plating (unless it is re-flowed) shall be utilized in GSE fabrication.

RB_PRD-4311 Any GSE, which does not meet the above requirements shall be bagged and sealed to be used in the clean room.

RB_PRD-4312 Electronic test equipment employing blowers or fans shall be compatible with ISO Class 7 (per 14644-1) cleanroom environments.

RB_PRD-4313 All GSE, including cables, used inside thermal/vacuum chambers shall be cleaned and verified as vacuum compatible.

10 PACKAGING, HANDLING, STORAGE, AND TRANSPORTATION REQUIREMENTS

10.1 Ambient Environment Requirements

RB_PRD-4317 The Instrument shall be designed to withstand exposure to ambient temperatures between 5 °C and 35 °C without degradation to subsequent performance.

RB_PRD-4318 The Instrument shall be designed to withstand exposure to ambient relative humidity (RH) levels between 10% and 60% without degradation to subsequent performance.

RB_PRD-4319 The Instrument shall be designed to withstand exposure to ambient pressures of up to 2 standard atmospheres without degradation to subsequent performance.

10.2 Packaging Requirements

RB_PRD-4321 Packaging/cover materials to be used for launch site activities shall have passed the tests for ESD per KSC/MMA-1985-79; Flammability per NASA-STD-6001 and Hypergolic Ignition (for hydrazine only) per KSC/MTB-175-88.

RB_PRD-4322 Packaging/cover materials to be used during Spacecraft I&T activities shall have passed the tests for ESD per KSC/MMA-1985-79; and Flammability per NASA-STD-6001.

10.3 Observatory Handling

RB_PRD-4324 The Instrument shall not be damaged by being stored in any position, with the deployables stowed.

RB_PRD-4325 All deliverable items with sensitivity to shock, temperature, and moisture shall include positive means to verify compliance with shock, temperature, and moisture requirements during shipping/handling.

10.4 Transportation Requirements

RB_PRD-4327 Deliverable items shall be packed and handled by the Instrument contractor to protect them against vibrations, shocks, moisture, electrostatic charge, and contamination associated with ground or air transport such that calibrations, alignment and performance are not degraded.

During Spacecraft transportation, the ambient air temperature will be maintained and monitored at 20 ± 4 °C and the relative humidity at <50%.

RB_PRD-4329 The cleanliness shall be a Class 7 or better per ISO 14644-1 during transport.

RB_PRD-4330 Instrument contamination witness samples shall be in place during the move.

RB_PRD-4331 The interior of the shipping container shall be designed and fabricated out of low outgassing, low shedding materials compatible with Class 7 requirements.

RB_PRD-4332 The interior of the shipping container shall be cleaned to a level 500A or better per IEST-STD-CC1246 prior to its use.

RB_PRD-4333 The payload instruments and support equipment that is to be transported with the instruments shall be designed for ground and air transportation in accordance with best commercial or military practices, as applicable to the mode(s) of transportation to be implemented.

10.5 Environment for Storage

RB_PRD-4335 The Instrument shall be configurable such that it can be stored, integrated with the Spacecraft, and operated in a Class 7 or better (per ISO 14644-1) cleanroom environment for extended periods of time.

11 REQUIREMENTS VERIFICATION MATRIX (RVM)

11.1 Verification Cross Reference

RB_PRD-4338 Each requirement of this specification shall be verified by the method (or, combination of methods) specified in the Verification Matrix (Appendix C).

11.2 Definition of Verification Methods

There are four acceptable requirement verification methods as defined below: Analysis, Inspection, Demonstration, and Test.

Verification by Design is not an acceptable verification method. Generally requirements that contained verification by design should be defined as Inspection of configuration controlled design documentation, such as drawings or software.

11.2.1 Verification by Analysis

The interpretation, interpolation or extrapolation of analytical, empirical, or test data, to show theoretical compliance with stated requirement. This method also applies to requirements to perform an analysis, or that specify how an analysis is to be performed.

11.2.2 Verification by Inspection

An observation or examination of the item that does not require the item to be powered or operating. This includes:

1) *Certain requirements verified by simple mechanical measurements that do not require the item to be powered or operated.*
2) *Hardware implementation constraints (such as required or prohibited materials or processes)*
3) *Software implementation constraints (such as coding standards) – verified by examination of source code.*
4) *Requirements for documentation and other requirements that are verified by the examination of documentation. The documentation must be configuration controlled at time of inspection.*

11.2.3 Verification by Demonstration

An exhibition of the operability or supportability of an item under either controlled or intended service-use conditions. These verifications are oriented almost exclusively toward acquisition of qualitative data, not requiring use of special test equipment or processing of data outputs from the hardware.

11.2.4 Verification by Test

An action that verifies an item's operability, supportability, performance capability, or other specified qualities when subjected to controlled conditions that are real or simulated. These verifications require use of special test equipment and sensors to obtain quantitative data for analysis as well as qualitative data derived from displays and indicators inherent in the item(s) for monitor and control. The Test method includes examination of output data from the unit under test that has been collected and/or processed by special test equipment. This also applies to requirements to perform a test, or that specify how a test is to be performed.

APPENDIX A - ACRONYMS/ABBREVIATIONS

Acronym	Definition
A	AMP
ABEC	Annular Bearing Engineering Council
AC	Alternating Current
ADCS	Attitude Determination and Control Subsystem
ADM	Angular Distribution Models
AFBMA	Anti-Friction Bearing Manufacturing Association
AI&T	Assembly, Integration and Test
ANSI	American National Standards Institute
AO	Atomic Oxygen

Acronym	Definition
AOS	Advanced Orbiting System
APID	Application Process Identifier
ASD	Acceleration Spectral Density
ASTM	American Society for Testing and Materials
ATMS	Advanced Technology Microwave Sounder
AWG	American Wire Gage
BC	Bus Controller
BIPM	Bureau International Des Poids Et Measures
bps	Bits per second
C&DH	Command and Data Handling
CCSDS	Consultative Committee for Space Data Systems
CERES	Clouds and the Earth's Radiant Energy System
CM	Center of Mass
CMBCE	Common Mode Bulk Current Emissions
CPL	Capillary Pumped Loop
CPT	Comprehensive Performance Test
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CrIS	Cross-track Infrared Sounder
CS	Conducted Susceptibility
CVCM	Collected Volatile Condensable Material
ECI	Earth Centered Inertial
EDR	Environmental Data Records
EED	Electronic Explosive Devices
EELV	Expendable Evolved Launch Vehicles
EEPROM	Electrically Erasable Programmable Read-Only Memory
EGSE	Electrical Ground Support Equipment
EHCIS	Equivalent Heritage CERES Instrument Sample
EHD	Elastohydrodynamic
EIA	Electronic Industries Alliance
ELDRS	Enhanced Low Dose Rate Sensitivity
EMC	Electromagnetic Compatibility
EMF	Electromotive Force
EMI	Electromagnetic Interference
EMISM	Electromagnetic Interference Safety Margin
EOL	End of Life
EOS	Earth Observing System
ERB	Earth Radiation Budget
ESD	Electrostatic Discharge
ETE	End-to-End
ETFE	Ethylene Tetrafluoroethylene

Acronym	Definition
FCP	Fracture Control Program
FOR	Field of Regard
FOV	Field of View
FPGA	Field Programmable Gate Array
FS	Factor of Safety
GCR	Galactic Cosmic Ray
GFRP	Glass Fiber-Reinforced Polymer
GN2	Gaseous Nitrogen
GPSOS	Global Positioning System Occultation Sensor
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HRD	High Rate Data
HVPS	High Voltage Power Supply
I&T	Integration and Test
IAR	Instrument Attitude Reference
IC	Integrated Circuit
ICD	Interface Control Document
IEGSE	Instrument Electrical Ground Support Equipment
IFOV	Instantaneous Field of View
IGSE	Instrument Ground Support Equipment
IPRD	Instrument Performance Requirements Document
IR	Inrfared
ISO	International Organization for Standardization
JPSS	Joint Polar Satellite System
KPP	Key Performance Parameters
KSC	Kennedy Space Center
LaRC	Langley Research Center
LaRC	Langley Research Center
LEO	Low Earth Orbit
LET	Linear Energy Transfer
LHP	Loop Heat Pipe
LISN	Line Impedance Stabilization Network
LLC	Liquid Locking Compounds
LPT	Limited Performance Test
LRD	Low Rate Data
LTAN	Local Time Ascending Node
MGSE	Mechanical Ground Support Equipment
MICD	Mechanical Interface Control Document
MLI	Multilayer Insulation
MMC	Mission Management Center
MOSFET	Metal Oxide Semiconductor Field Effect Transistor

Acronym	Definition
NASA	National Aeronautics and Space Administration
NC	No-Connect
NED	Non-Explosive Devices
NEIL	Non-Ionizing Energy Loss
NER	Noise Equivalent Radiance
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Observatory System
NPR	NASA Procedural Requirement
PDR	Preliminary Design Review
PLF	Payload Fairing
POES	Polar-orbiting Operational Environmental Satellite
PROM	Programmable Read-Only Memory
Ps	Probability of Success
PSD	Power Spectral Density
PSF	Point Spread Function
PVC	Polyvinyl Chloride
RAM	Random Access Memory
RAP	Rotating Azimuth Plane
RBI	Radiation Budget Instrument
RDM	Radiation Design Margin
RDR	Raw Data Records
RF	Radio Frequency
rms	Root Mean Squared
RMS	Root Mean Squared
RPO	Revolutions per Orbit.
RSR	Relative Spectral Response
RT	Remote Terminal
S/C	Spacecraft
SA	Solar Array
SADF	Spacecraft Attitude Determination Frame
SADR	Spacecraft Attitude Determination Reference
SAR	Spacecraft Attitude Reference
SARP	Software Assurance Research Program
SARR	Search and Rescue Repeater
SBF	Spacecraft Body Frame
SC	Spacecraft
SCTV	Spacecraft Thermal Vacuum
SDR	Sensor Data Records
SEB	Single-Event Burnout
SEGR	Single-Event Gate Rupture

Acronym	Definition
SEL	Single-Event Latch-up
SI	Système Internationale
SMD	Science Mission Data
SNPP	Suomi National Polar-orbiting Partnership
SPG	Single-Point Ground
SPL	Sound Pressure Level
SRS	Shock Response Spectrum
STF	Spacecraft Target Frame
TBD	To Be Determined
TEC	Thermoelectric Cooling
TID	Total Ionizing Dose
TML	Total Mass Loss
TMON	Telemetry Monitor
TOA	Top-of-Atmosphere
TQCM	Temperature-controlled Quartz Crystal Microbalance
TV	Thermal Vacuum
UTC	Coordinated Universal Time
V	Volt
V&V	Verification and Validation
VCE	Collector-to-Emitter Voltage
VCRM	Verification Cross Reference Matrix
VDC	Voltage Direct Current
VDS	Drain-to-Source Voltage
VIIRS	Visible Infrared Imaging Radiometer Suite

APPENDIX B - DEFINITIONS

Term	Definition
3 Sigma	A set of values is considered to meet a 3 sigma requirement if no fewer than 99.73% of the values are within the specified limits of the requirement.
Actual	Refers to values which apply to a given serial number. As indicated below, these are generally provided in a data package associated with delivery of each individual serial numbered instrument.
Alignment	The relative orientation of 2 reference frames.
Alignment Control	The process of controlling the maximum difference between the actual orientation of a reference frame and its nominal orientation.

Term	Definition
Alignment Control Error	The maximum difference between the actual orientation of a reference frame and its nominal orientation.
Alignment Drift	Changes in the alignment between 2 reference frames that occur during normal on-orbit operations, excluding effects due to jitter. For the alignment of instruments relative to the spacecraft, one source of drift is structural distortions arising from orbital and seasonal changes in thermal conditions.
Alignment Knowledge	The estimate of the relative orientation between 2 reference frames.
Alignment Knowledge Uncertainty	The uncertainty in the knowledge of the relative orientation between 2 reference frames.
Alignment Shift	A change in the alignment between 2 reference frames that occurs over one finite, defined, period of time, typically prior to and not changing significantly during normal on-orbit operations. For the alignment of the instruments relative to the spacecraft, alignment shifts arise from structural distortion effects such as launch loads, moisture out-gassing and the relief of gravity loads.
Allowable	An A-basis allowable material is defined as having an attribute value where 99 percent of a population of values is expected to equal or exceed the allowable, with a confidence of 95 percent. A B-basis allowable materiel is defined as having an attribute value where 90 % of a population of values is expected to equal or exceed the allowable, with a confidence of 95%.
Altitude	Height above mean sea level
Average Operational Power	The one-orbit average power is the average power utilized by an instrument over any one-orbit period commencing with the crossing of the night-to-day terminator. The two- orbit average power is the average power utilized by an instrument over any two-orbit period commencing with the crossing of the night-to-day terminator.
Bond	A low-impedance electrical connection between two conductive elements
Boresight	The nominal line-of-sight (LOS) of the instrument radiometric sensor(s) at a point in time.

Term	Definition
Boresight Alignment Control Error	For a specific instrument, the maximum difference between the actual and the nominal orientation of its Instrument Boresight relative to the Spacecraft Attitude Determination Frame. This error will be considered to be composed of the following factors: (1) Static factors: a) Measurement uncertainty during installation alignment b) Limitations associated with fabrication and installation c) Alignment Shifts (2) Dynamic factors: a) Alignment Drifts b) Jitter See Figure B-3 for more details
Boresight Alignment Knowledge Uncertainty	For a specific instrument, the uncertainty in the knowledge of the relative orientation between its Instrument Boresight and the Spacecraft Attitude Determination Frame. This uncertainty will be considered to be composed of the following factors: (1) Static factors: a) Measurement uncertainty during installation alignment b) Alignment Shifts (2) Dynamic factors: a) Alignment Drifts b) Jitter See Figure B-2 for more details

Term	Definition
Calibration and Characterization Uncertainty	Calibration and Characterization Uncertainty are figures of merit that apply to sensor parameters that are measured in the course of sensor test or characterization. These uncertainties quantify how close the measured value of a sensor parameter is believed to be to the true value based on estimation techniques described below. Measurement Uncertainty (MU) as defined elsewhere in this glossary is a figure of merit that applies to JPSS data products that are derived from on-orbit sensor measurements using algorithmic processing. MU quantifies how close the measured data product value is believed to be to the true value based on simulations in which true values are known or post-launch validation campaigns in which data product estimates are independently measured with higher confidence than that provided by JPSS. MU is not an appropriate figure of merit for sensor parameters because the true value of a sensor parameter is never available, and sensor parameters are not independently validated in the sense in which JPSS data products are validated. Calibration and Characterization uncertainty as defined herein provide appropriate figures of merit for sensor parameters that are not defined in terms of true value but in terms of evaluation techniques and analyses commonly used in the sensor community and, in the case of calibration uncertainty, are standardized by NIST guidelines. In what follows “measurement” refers to sensor parameter measurement, not data product estimation by JPSS. Also, “uncertainty” refers to either calibration or characterization uncertainty, if not explicitly stated otherwise, and not to Measurement Uncertainty. The result of a measurement is only an approximation or estimate of the value of the specific quantity subject to measurement and thus the result is complete only when accompanied by a quantitative statement of its uncertainty. The uncertainty of the result of a measurement generally consists of several components, which may be grouped into two categories according to the method used to estimate their numerical values: Type A. those that are evaluated by statistical methods, Type B. those that are evaluated by other means. Type A evaluation of uncertainty may be based on any valid statistical method for treating data. Examples are calculating the standard deviation of the mean of a series of independent observations. Typically the method of least squares is used to fit a curve to data in order to estimate the parameters of the curve and their standard deviations. Analysis of variance is used to identify and quantify random effects in certain kinds of measurements. Type B evaluation of uncertainty is usually based on scientific judgment using all the relevant information available. Information sources includes previous measurement data, experience with, or general

Term	Definition
CE101	Conducted emissions, power leads, 30 Hz to 10 kHz [50 MHz, modified, extended range]
CE102	Conducted emissions, power leads, 10 kHz to 10 MHz [50 MHz, modified, extended range]
CE106	Conducted emissions, antenna terminals 10 kHz to 40 GHz
Centrals Element	The Centrals element will be that equipment and software necessary to ingest and store (temporarily) the RDRs, and process them as necessary into SDRs and EDRs. The currently defined Centrals are AFGWC, NOAA/NESDIS, FNMOC, NAVOCEANO, and 55 SWXS.
Charge Transfer Efficiency (CTE)	In a Charge-coupled Device (CCD) operated to transfer a packet of electrical charge from one location to an adjacent or overlapping location, the fraction of the charge that is actually moved by each transfer cycle. In a CCD using 2 or 3 phase clocks, 2 or 3 transfer cycles respectively are required to move the charge packet a distance equal to the size of the area in which the packet is nominally constrained. Thus the number of transfer cycles that take place in operating a CCD is generally 2 or 3 times the number of pixel positions in the charge transfer path. In this case, charge transfer efficiency refers to the efficiency of each single transfer, and not to the resulting efficiency of moving the charge an entire pixel.
Chassis	The metal enclosure which shields electronic circuits
Chassis Ground Plane	The low impedance, low inductance ground plane used as the RF Ground reference and Secondary Power Ground reference for the observatory. The Chassis Ground Plane is terminated the SPG at the S/C Power Subsystem.
Chassis reference	The point within a component at which signal reference and secondary power return leads are referenced to the component chassis
CMBCE/CMCE	Common Mode Bulk Current Emissions, 150kHz to 200MHz
Component	A generic term used to describe independently packaged electronics
Computational Equipment	Includes processing units; special-purpose computational devices; main storage; peripheral data storage; input and output units.

Term	Definition
Computer Resources	Include all computer software and the associated computational equipment included within the instrument.
Co-Registration of Spectral Bands	Co-registration of spectral bands is measured by the displacement of corresponding pixels in two different bands from their ideal relative location. Two pixels are "corresponding" if their footprints should ideally coincide or if the footprint of one should ideally lie within a specific region of the footprint of the other. If co-registration is specified by a single value, this value is the upper bound on the magnitude of the displacement of the locations of corresponding pixels in any direction.
CS02	Conducted Susceptibility, power and interconnecting control leads, 150kHz to 400MHz
CS06	Conducted Susceptibility, sine and square wave powerline transient, 10 microseconds
CS101	Conducted susceptibility, power leads, 30 Hz to 150 kHz
CS103	Conducted susceptibility, antenna port, intermodulation, 15 kHz to 10 GHz
CS104	Conducted susceptibility, antenna port, rejection of undesired signals, 30 Hz to 20 GHz
CS105	Conducted susceptibility, antenna port, cross modulation, 30 Hz to 20 GHz
CS114	Conducted susceptibility, bulk cable injection, 10 kHz to 200 MHz
CS115	Conducted susceptibility, bulk cable injection, impulse excitation, 30 nS
CS116	Conducted susceptibility, damped sinusoidal transients, cables and power leads, 10 kHz to 100 MHz
Damage	When any article has been compromised to the point that it no longer meets performance specifications.
Degradation	When an article has been compromised to the point that it has lost some margin over the specified performance requirements, though it may still meet the performance requirements.

Term	Definition
Detectable Cloud	An aqueous aerosol having a vertical extinction optical depth exceeding 0.03 in the visible or a contrast with the background exceeding 0.02 in the visible (0.64 um region). Contrast with the background is defined as the difference between the cloud and adjacent background radiance divided by the sum of these two radiances. In this specification “cloud” is always to be interpreted to mean “detectable cloud.”
Detector	The smallest independent sensing region on a detector chip that produces photo-current proportional to the radiant energy (exposure) it receives.
Differential Nonlinearity of the Quantizer	For an ideal quantizer, all quantization steps are separated by the analog input voltage corresponding to exactly one least-significant bit. Differential nonlinearity of the quantizer is defined as the maximum deviation from this ideal step size.
Detrimental Yielding	Yielding that affects the fit, form, function or integrity of the structure.
Dynamic	Changing significantly during normal on orbit operations
Electrical Interface Location	All requirements apply at the electrical interface, which is at the instrument end of the instrument-to-spacecraft bus harness connector mating surfaces.
Electrostatic Charge Bleed Ground	A moderate resistance termination, to the Chassis Ground Plane, of the various observatory surfaces that are subject to external charge. The Charge Bleed Ground ensures that charge does not build on these surfaces to potential that could cause a sudden arc of discharge.
EMC	Electromagnetic Compatibility
EMCWG	EMC Working Group
EMI/EMS	Electromagnetic interference/electromagnetic susceptibility
Environmental Data Records (EDRs)	Data records that contain the environmental parameters or imagery required to be generated as user products as well as any ancillary data required to identify or interpret these parameters or images. EDRs are generally produced by applying an appropriate set of algorithms to Raw Data Records (RDRs)
Equipment Chassis	The metal enclosure which shields the equipment's electronics
Equipment Panel Ground Plane	The spacecraft conducting plate or other structure to which all ground planes are connected

Term	Definition
Equipment/Unit	A generic term used to describe independently packaged components and subsystems. A group of components which work together and whose operation is interrelated are also categorized as equipment
Factor of Safety (of a structure)	The ratio of the maximum stress that a structural part or other piece of material can withstand to the maximum stress estimated for it in the use for which it is designed (limit load).
Fields of View	The angular extent in object space over which a detector is able to receive scene radiance.
Fixed-base	Each mounting point is constrained in those translational degrees of freedom which are rigidly attached to the spacecraft and is free in those translational degrees of freedom for which kinematic mounts or flexures provide flexibility.
Ground Plane	The local electrically conductive surface to which a component is bonded
Horizontal Reporting Interval	The spacing between nearest neighbor points in the horizontal direction at which an environmental parameter is estimated and reported. For atmospheric profiles, the horizontal reporting interval applies to the lowest altitude samples.
Horizontal Spatial Resolution	For a scanning imager on a space-based platform, a specified band, and a specified nadir angle, one half of the wavelength corresponding to the earth surface spatial frequency at which the end-to-end system modulation transfer function (MTF) equals 0.5 on the in- track spatial frequency axis or cross-track spatial frequency axis, whichever is greater. The in-track (cross-track) spatial frequency is the earth surface spatial frequency associated with the in-track (cross-track) direction. “End-to-end” in this definition means from photons collected by the sensor to calibrated radiances provided as part of the explicit Imagery EDR or within SDRs used to generate other EDRs. The effects of all signal and data processing functions performed in the course of generating these calibrated radiances, e.g., sample aggregation, re-sampling, image enhancement, image restoration, etc., are included in the HSR. (See definition of Modulation Transfer Function.)

Term	Definition
Housekeeping	Functions such as orbit and attitude maintenance, navigation, power, command, telemetry and data handling, structure, rigidity, alignment, heater power, temperature measurements, etc.
Imagery	Two-dimensional array of numbers, in digital format, each representing the brightness of a small elemental area.
Installation Alignment	The process of setting, measuring and/or adjusting the relative orientation of an instrument or hardware reference frame with respect to another reference frame in order to satisfy required alignment criteria.
Instrument Chassis	The metal enclosure which shields the instrument's electronics
Instrument Interface	The mechanical interface and associated datum(s) at the location where the instrument attaches to the spacecraft.
Internal Emissions	The signal or spectrum of emitted energy which is the fundamental purpose of operation. Example: the RF output of a transmitter is an intentional emissions at the transmitting antenna, while leakage of the transmitter output from the case of the transmitter is an unintentional emission (see unintentional emission)
Jitter	Rotations due to elastic as well as rigid body vibrations caused by disturbance sources such as reaction wheels, solar array drive assemblies and instrument mechanisms.
Launch-Phase Power	Launch-phase power is the power required by the instrument in launch phase.
Limit load	The highest expected load, including environmental effects
Linearity	The maximum difference in output between a calibration curve over the complete range and a straight line through the end points, and applies to the entire Instrument from input to the optics to the digital output of that channel.
Line of sight (LOS)	The extension of the telescope principal ray to the scene. The principal ray is the ray that passes through the center of the telescope entrance aperture and also through a predetermined point on the visible focal plane. This point is approximately at the center of the rectangle encompassing the sensitive areas of the VIS/NIR focal plane and the DNB focal plane.

Term	Definition
Line Spread Function (LSF)	Line Spread Function (LSF) is the cross-track (along-track) sensor response to an along-track (cross-track) line slit source. The cross-track (along-track) Modulation Transfer Function (MTF) is the normalized one-dimensional Fourier Transform of the cross-track (along-track) LSF. The MTF would include optical diffraction, aberration, detector GIFOV, integration drag, CCD charge transfer inefficiency because the LSF is a Sensor level measurement.

Term	Definition
Long Term Stability	The difference between the maximum and minimum short-term mean of an estimated parameter over the JPSS life cycle. This estimate may be the result of a direct measurement, an indirect measurement, or an algorithmic derivation. The short-term mean is defined as the mean of a set of estimates of the parameter satisfying the following three conditions: 1) The physical measurements on which the estimates are based, at least in part, are performed within a time period not exceeding 70 days. (This time limit does not apply to data bases or other ancillary data sources which may be used to generate the estimate.) 2) The set is large enough so that the sample size error (see definition) in the short- term mean is much smaller than the specified long term stability value. 3) The true value of the parameter is the same for all estimates in the set The third condition is imposed because a long term stability requirement must be met for any true value of the parameter within the measurement range (see definition), not in an average sense over the measurement range. In practice, such as in the analysis of simulation results or measured calibration/validation data, it is understood that measurements will be binned into sets for which the true value of the parameters falls into a narrow range, preferably a range much smaller than the required measurement range. Corrections for known temporal changes in sensor performance characteristics and for differences in sensor performance characteristics from satellite to satellite are considered to be part of the parameter estimation process. Retrospective processing and re-analysis of data is allowed for the purpose of meeting a long-term stability requirement. The long-term stability r is given by the following formula: ρ = max{mN(t)}0≤t≤T-T‶ - min{mN(t)}0≤t≤T-T‶ where mN(t) is the short-term mean at time t, T is the JPSS life cycle, T‶ is the maximum duration of the period during which measurements contributing to the short-term mean are performed, and the minimum and maximum are taken over the time period from t = 0, which is defined to be the beginning of the JPSS life cycle, to t = T - T‶. The short-term mean mN(t) is given by the following formula: mN(t) = (Si=1,N xi(t‶))/N , 0 ≤ t ≤ T - T‶, where xi(t‶) is the value obtained in the i‶th estimate of the parameter at time t‶. Si=1,N denotes summation from i = 1 to i = N, and t ≤ t‶ ≤ t + T‶. The value of N is large enough so that the sample size error is much less than the required long term stability

Term	Definition
Main Bus Power	28 VDC unregulated S/C Power Bus
Mapping Uncertainty	The RMS error (one sigma) in the geolocation of measured or derived data samples expressed in geodetic coordinates based on a large number of repetitions of the measurement and/or derivation. An “error” is defined as the difference between the measured or derived value and the true value of a parameter. Mapping uncertainty is due to the combined effect of all systematic and random errors affecting geolocation.
Measurement Accuracy	The magnitude of the difference between the mean estimated value of a parameter and its true value (see definition). This estimate may be the result of a direct measurement, an indirect measurement, or an algorithmic derivation. The mean is based on a set of estimates satisfying the following two conditions: The set is large enough so that the sample size error (see definition) in the measurement accuracy is much smaller than the specified measurement accuracy value. The true value of the parameter is the same for all estimates in the set. The second condition is imposed because a measurement accuracy requirement must be met for any true value of the parameter within the measurement range (see definition), not in an average sense over the measurement range. In practice, such as in the analysis of simulation results or measured calibration/validation data, it is understood that measurements will be binned into sets for which the true value of the parameters falls into a narrow range, preferably a range much smaller than the required measurement range. For an ensemble of N estimates of the parameter x, the measurement accuracy bN is given by the following formula: bN = |mN - xT| where mN is the sample mean, xT is the true value of the parameter, and |…| denotes absolute value. The sample mean mN is given by the following formula: mN = (Si=1,N xi)/N where xi is the value obtained in the i‟th estimate of the parameter x and Si=1,N denotes summation from i = 1 to i = N.

Term	Definition
Measurement Error	The difference between the estimated value of a parameter and its true value. This estimate may be the result of a direct measurement, an indirect measurement, or an algorithmic derivation. The measurement error e is given by: $e = x_E - x_T$ where x_E is the estimate of the parameter x and x_T is its true value (see definition).
Measurement Precision	The standard deviation (one sigma) of an estimated parameter. This estimate may be the result of a direct measurement, an indirect measurement, or an algorithmic derivation. The standard deviation is based on a set of estimates satisfying the following two conditions: 1) The set is large enough so that the sample size error (see definition) in the measurement precision is much smaller than the specified measurement precision value. 2) The true value of the parameter is the same for all estimates in the set. The second condition is imposed because a measurement precision requirement must be met for any true value of the parameter within the measurement range (see definition), not in an average sense over the measurement range. In practice, such as in the analysis of simulation results or measured calibration/validation data, it is understood that measurements will be binned into sets for which the true value of the parameters falls into a narrow range, preferably a range much smaller than the required measurement range. For an ensemble of N estimates of the parameter x, the measurement precision sN is given by the following formula: $s_N = [S_{i=1,N} (x_i - m_N)^2/(N - 1)]^{1/2}$ where m_N is the sample mean (defined in the definition of measurement accuracy), x_i is the value obtained in the i"th estimate of the parameter x, and $S_{i=1,N}$ denotes summation from i = 1 to i = N.
Measurement Range	Range of values over which a parameter is to be estimated while meeting all other measurement requirements. This estimate may be the result of a direct measurement, an indirect measurement, or an algorithmic derivation.

Term	Definition
Measurement Uncertainty	The root-mean-square (RMS) of the measurement errors (see definition) for an estimated parameter. This estimate may be the result of a direct measurement, an indirect measurement, or an algorithmic derivation. The measurement uncertainty is based on a set of estimates satisfying the following two conditions: 1) The set is large enough so that the sample size error (see definition) in the measurement uncertainty is much smaller than the specified measurement uncertainty value. 2) The true value of the parameter is the same for all estimates in the set. The second condition is imposed because a measurement uncertainty requirement must be met for any true value of the parameter within the measurement range (see definition), not in an average sense over the measurement range. In practice, such as in the analysis of simulation results or measured calibration/validation data, it is understood that measurements will be binned into sets for which the true value of the parameters falls into a narrow range, preferably a range much smaller than the required measurement range. As defined herein, measurement uncertainty is due to the combined effects of all systematic and random errors. Also, as a consequence of its definition, measurement uncertainty converges to the square root of the sum of the squares (RSS) of the measurement accuracy and precision in the limit of infinitely large sets of measurements. For an ensemble of N estimates of a parameter x, the measurement uncertainty xN is given by the following formula: $x_N = [S_{i=1,N} (x_i - x_T)^2/N]^{1/2}$ where x_i is the value obtained in the i‟th estimate of the parameter, x_T is the true value of the parameter, and Si=1,N denotes summation from i = 1 to i = N.
Mission Data	Satellite data that consists of the primary output from the sensors that is processed into JPSS data products. It includes the sensed radiances, encoder outputs, time tags, calibration source data, etc. as appropriate for each sensor.
Modulation Transfer Function (MTF)	The magnitude of the Fourier transform of the end-to-end sensor Line Spread Function (LSF). The MTF is a function of two spatial frequencies associated with two orthogonal spatial directions, and it is equal to one at the origin by virtue of the normalization condition on the LSF.

Term	Definition
Operate	The ability to survive a condition (or set of conditions) and autonomously return to full performance capability upon removal of that condition. The article shall be capable of providing H&S telemetry and accept/execute commands while the Operate Conditions exist. The ability to withstand the applied environment without malfunction, loss of capability, change of operation state/mode, memory changes or need for outside intervention. Operate requires that the survival criteria be met.
Operational Availability	Operational Availability (AO) is defined as the probability that a system is operable and ready to perform its mission at any given time. AO is a function of mean time between critical failure (MTBCF) and mean time to restore functions (MTTRF) and will be calculated as: $A_o = \frac{MTBCF}{MTBCF+MTTRF}$
Operational Power	Operational power is used for instrument operational modes such as Science Data Collection, Calibration, and Standby.
Operational Services	Those Main Bus power services that are powered ON for Observatory nominal operations. When the Main Bus is within spec, the S/C and Instruments are expected to meet all performance requirements with Operational Services ON.
Orbital debris	Any object placed in space by humans that remains in orbit and no longer serves any useful function or purpose. Objects range from spacecraft to spent launch vehicle stages to components and also include materials, trash, refuse, fragments, or other objects which are overtly or inadvertently cast off or generated.
Overwrap Shield	Conductive material, used as an overwrap for a harness Wire Bundle, to provide additional shielding.
Passband	The range of frequencies that may pass to or from antenna or receiver components without being greatly attenuated.
Peak Operational Power	Peak power is the maximum power required by an instrument. Peak power does not include transients with a duration less than 20 milliseconds.
Perform	The ability of equipment to meet its specified performance. Perform requires that the Operate criteria be met The ability to meet all performance requirements for the specified conditions.

Term	Definition
PIM	Passive Intermodulation. The unintentional production of frequency cross products of multiple transmit signals mixing together in unshielded intentional nonlinear devices or unintentional nonlinear devices created incidentally by the random contact of conductive and semi-conductive materials on the spacecraft and payloads
Pixel	Contraction of “picture element”. In general, a pixel is defined as the smallest unit of information in a grid cell map or image. As applied to VIIRS, a pixel is defined as an individual sample of measured scene data at the finest resolution of the instrument in the mode in which it is operating. A pixel may be generated from one or more detector samples by aggregation, re- sampling, and/or any other data processing operations consistent with meeting the explicit and derived requirements for pixel radiometric, spatial, and temporal response characteristics. However, re-sampling is allowed only if required to implement aggregation of pixels from multiple detector samples. Depending on the degree of processing applied to the raw detector samples, a pixel may be dimensionless, e.g., a “digital number”, or may have units of radiance or reflectance. The spatial extent on the ground of a pixel (or pixel footprint) is determined by the two- dimensional system point spread function (or point source response function) associated with the pixel. In particular, the pixel width in the in-track (cross-track) direction is given by the horizontal spatial resolution (HSR) in the in-track (cross-track) directions. (See “Horizontal Spatial Resolution” and “Pixel Width”.) The pixel location (or pixel footprint location) on the ground is the ground location at which the point spread function associated with the pixel has a maximum. (See “Pixel Location”.)
Pointing	The process of controlling the location or direction of a Line of Sight with respect to an intended target location or direction.
Power Service	Any switched or unswitched, dedicated, Main Bus Power interface to a load.
Predicted	Used to document a nominal value in the ICD. These may be the result of calculations or measurements on a non-flight unit which is expected to be representative of the value for a flight unit.

Term	Definition
Primary Power	One of two redundant power services provided to a load from the Main Power Bus. Referred to as the “Prime” or “A” side power.
Primary power reference	The point on the spacecraft where all primary power returns are referenced. The primary power reference is the reference point for spacecraft voltage control
Primary Power Return	The isolated 28 V current return lead from the component primary power dc - to - dc converter input back to the spacecraft primary power distribution point
Raw Data Records (RDRs)	Full resolution, unprocessed digital sensor data, time-referenced and earth located (or orbit-located for in-situ measurements), with radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data should be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and lossless data compression are allowed. All calibration data will be retained and communicated to the ground without lossy compression. Note that for the real time transmission of raw data to field terminals, lossy compression is allowed. Additionally, reduced resolution is allowed in transmission of raw data to low data rate field terminals.
RE101	Radiated emissions, magnetic field, 30 Hz to 100 kHz
RE102	Radiated emissions, electric field, 10 kHz to 18 GHz
Redundant Power	One of two redundant power services provided to a load from the Main Power Bus. Referred to as the “Redundant” or “B” side power.
Reliability	The probability that an item can perform its intended function for a specified interval under stated conditions.
RF Ground	Low impedance, low inductance electrical bonding of electrical components and subsystems to the Chassis Ground Plane. Ensures that high frequency energy (RF) is bled to chassis ground efficiently, precluding EMI with electronics. Also ensures that, in the event of a fault, Chassis Ground Plane will provide low impedance to enable fault clearing and minimize Ldi/dt transients.

Term	Definition
RF Signal	RF signals are those which required coaxial cable and connections. RF signals typically have fundamental components above 4 MHz
RFI	- Radio Frequency Interference to on - board receivers due to on - board transmitters
Root Sum Square (RSS)	The square root of the sum of the squares of components of error or uncertainty.
RS101	Magnetic Field Radiated Susceptibility, 30Hz to 100kHz
RS103	Radiated susceptibility, electric field, 2 MHz to 40 GHz [modified, 10kHz to 40 GHz]
Safe-Mode Power	Safe-mode power is the power required by the instrument in instrument safe mode.
Safety Services	Those Main Bus power services that are powered ON only during hazardous operations.
Secondary Power	The output of any DC/DC power converter, providing regulated power for any purpose (ex. +15 VDC, +5 VDC, -15 VDC, etc.) Power which has been derived and isolated from primary power typically by a dc-to- dc converter, and used to power spacecraft interface to other circuits
Secondary Power Ground	A single point reference for each secondary power supply and signals powered by that supply.
Secondary Power Reference	The point within the component where all current returns from the secondary power circuits are referenced
Separately-mounted Instrument Components	Refers to each part of an instrument which is separately mounted onto the spacecraft by the spacecraft contractor. An example would be a scan head and an electronics box which are purposefully separated. Where an instrument is divided into multiple pieces, but is mounted onto the spacecraft via a single baseplate, that is not considered „separately-mounted‟ instrument components in this document.
Signal Reference	The reference within the component for digital and analog signals
Signal Return	The wire which carries the current of a digital or analog signal back to its source
Signal to Noise Ratio (SNR)	Average signal divided by the standard deviation of the signal.

Term	Definition
Spacecraft Attitude Determination Frame	The right-handed orthogonal reference frame which approximates the Spacecraft Body Frame and of which the Attitude Determination System on board the spacecraft determines inertial attitude. The Spacecraft Attitude Determination Frame is defined by the relative orientation of these datums with respect to the Spacecraft Body Frame, as established by measurements during installation alignment or on-orbit calibration.
Spacecraft Target Frame	The right-handed, orthogonal reference frame that, at any time, is the target attitude of the Spacecraft Attitude Determination Frame.
Static	Not changing significantly during normal on orbit operations
Survival	The ability to withstand the applied environment without any permanent loss of performance capability. Survival is required for both powered and unpowered states.
Survival Services	Those Main Bus power services that are powered ON when the Observatory is in Survival Mode.
Survival-Mode Power	Survival-mode power is power required by the instrument in Survival Mode, in order to operate survival heaters.
Survive	The ability to endure a condition (or set of conditions) without damage or degradation, such that, when conditions return to the specified performance range, the article will meet all performance specs without the loss of any margin. The article is NOT required to meet functional (Operational) or performance requirements while the Survival condition exists. Recovery from a Survival Condition may require Ground Ops intervention.
Swath Width	The swath width associated with an angular subtense of ± 55.84 degrees is approximately 3000 km for a satellite at 833 km altitude. The swath width associated with an angular subtense of ± 43.6 degrees is approximately 1700 km for a satellite at 833 km altitude.
Twisted Wire Group (T2, T4, T6, etc.)	A group of wires that are twisted together in an effort to reduce circuit loop area and coupling. These groups usually include the power or signal wires and their associated returns. They may also appear as Twisted Shielded Groups (TS2, TS4, TS6, etc.).

Term	Definition
Typical	Used to document a nominal value in the ICD. These may be the result of calculations or measurements on a non-flight unit which is expected to be representative of the value for a flight unit.
Unintentional Emissions	The signal or spectrum of emitted energy which is by - product of operation. Internally generated signals which are necessary for operation of a device but are not the specified and desired output are unintentional emissions (see intentional emissions)
Wavelength Categories	Visible 0.4 to 0.7 µm NIR Near Infrared 0.7 to 1.5 µm SWIR Short-wave Infrared 1.5 to
-- Visible/Infrared	3 µm MWIR Medium Wave Infrared 3 to 5 µm LWIR Long Wave Infrared 5 to 50 µm
Wire Bundle	A bundle of wires in the harness, that may include several Twisted Wire Groups, bundled together for their common functionality (Power, Signal, EED, etc.) and common destination. The bundle may include an overwrap shield.

Figure B-1 illustrates a framework for representing the train of components of Knowledge Uncertainty (Figure B-2) and Control Error (Figure B-3) between an Instrument Boresight and inertial references. Please note the following acronyms: Earth Centered Inertial (ECI) (J2000.0), Spacecraft Target Frame (STF), Spacecraft Attitude Determination Frame (SADF), Spacecraft Attitude Determination Reference (SADR), Spacecraft Attitude Reference (SAR), Spacecraft Body Frame (SBF), Instrument Attitude Reference (IAR), Spacecraft (SC). Spacecraft factors are indicated by solid arrows (<->) and instrument factors are indicated by dashed arrows (<- - ->).

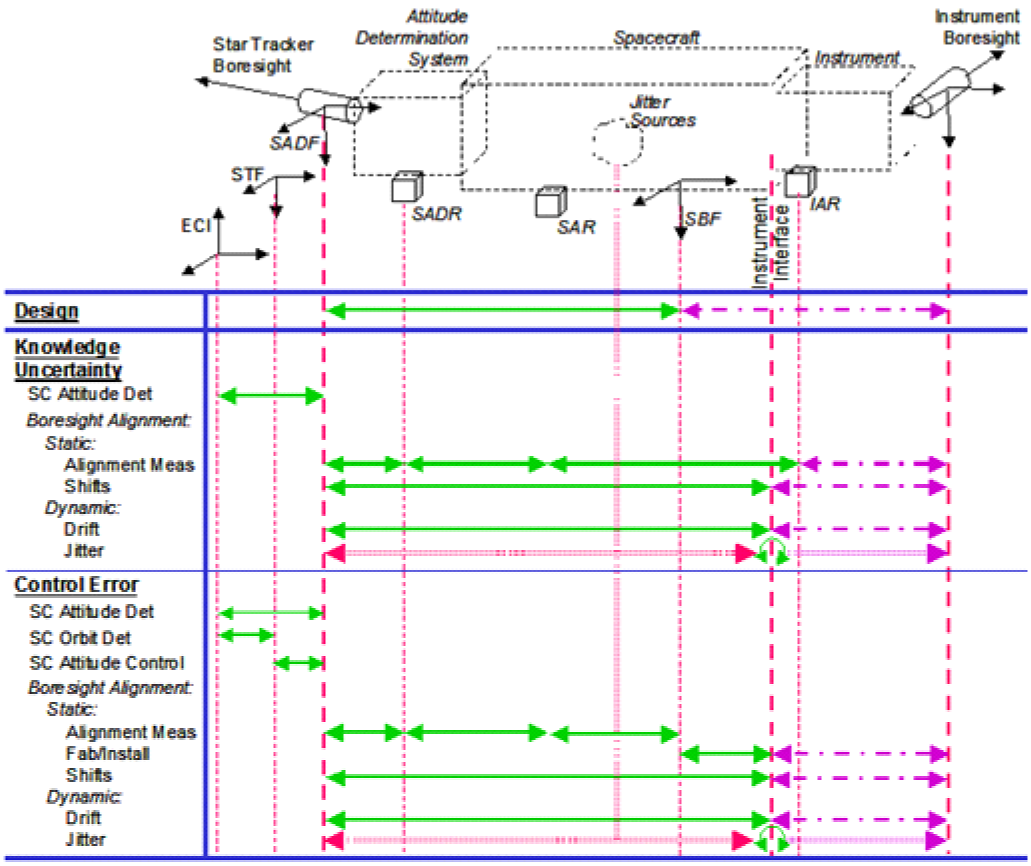


Figure B-1 Spacecraft/instrument allocation of knowledge and control.

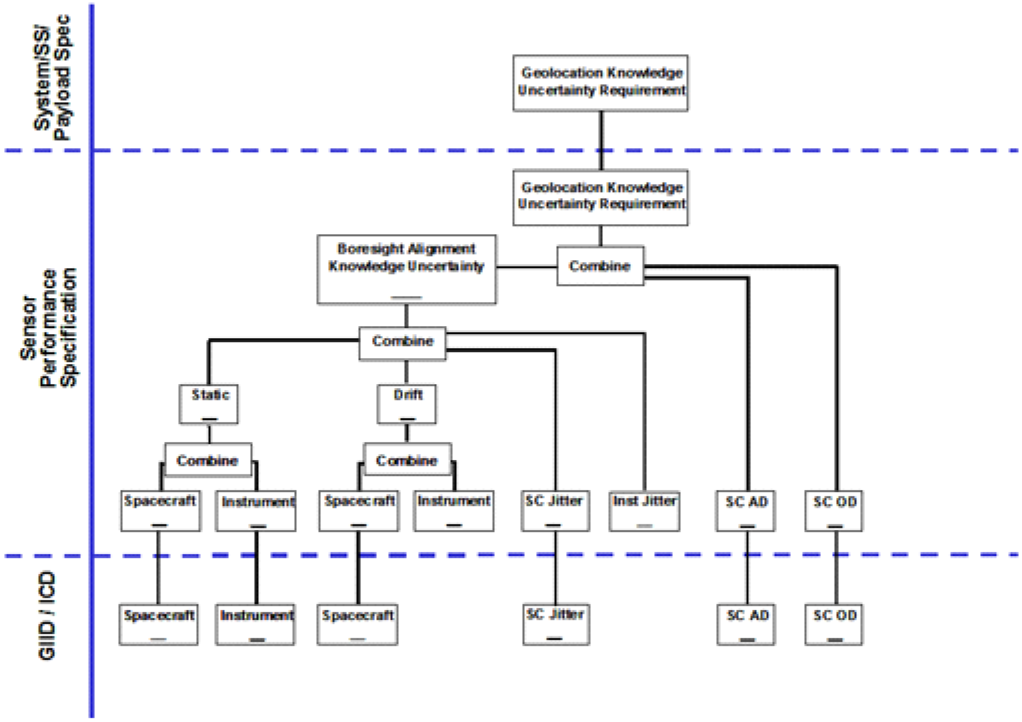


Figure B-2 Spacecraft/instrument allocation of geolocation knowledge uncertainty.

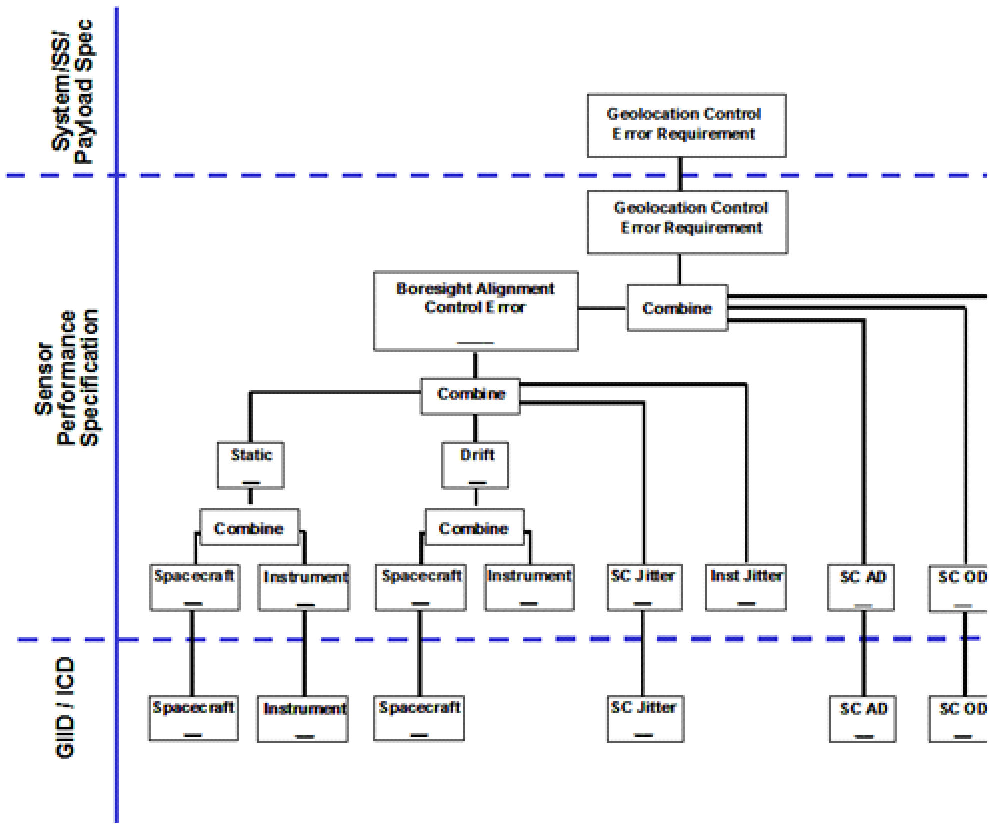


Figure B-3 Spacecraft/instrument allocation of geolocation control error.

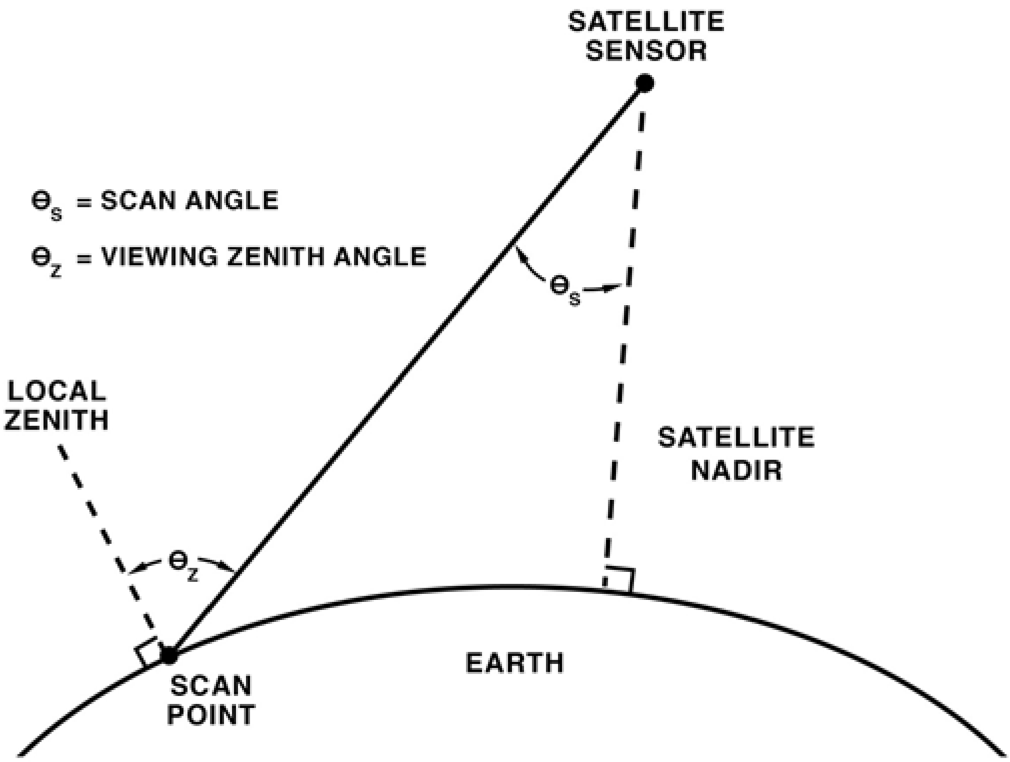


Figure B-4 Definition of Viewing Zenith Angle

APPENDIX C – VERIFICATION CROSS REFERENCE MATRIX (VCRM)

Table C-1 Verification Cross Reference Matrix (VCRM)

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
3.1 Interface Requirements	RB_PRD-184	Instrument	Inspection
3.2 Spacecraft Body Frame and Coordinate Systems	RB_PRD-186	Instrument	Inspection
3.3 Environmental Test Tolerances	RB_PRD-190	Instrument	Inspection
3.4 System of Units	RB_PRD-239	Instrument	Inspection
3.4 System of Units	RB_PRD-240	Instrument	Inspection
3.5 Mission Time Convention	RB_PRD-242	Instrument	Inspection
3.7 Mission Assurance Requirements	RB_PRD-247	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
3.7.1 Single Fault Tolerance Design Requirements	RB_PRD-250	Instrument	Analysis
3.7.1 Single Fault Tolerance Design Requirements	RB_PRD-251	Instrument	Analysis
3.7.2 Reliability Design Requirements	RB_PRD-253	Instrument	Analysis
3.7.3 Safety Requirements	RB_PRD-256	Instrument	Inspection
3.7.3 Safety Requirements	RB_PRD-257	Instrument	Inspection
3.8 Space Asset Protection/Security	RB_PRD-259	Instrument	Inspection
3.9 Orbital Debris	RB_PRD-261	Instrument	Analysis
4.1 Radiance Measurements	RB_PRD-270	Instrument	Inspection
4.1 Radiance Measurements	RB_PRD-271	Instrument	Inspection
4.1 Radiance Measurements	RB_PRD-272	Instrument	Inspection
4.1.1.1 Shortwave Measurement Bandpass	RB_PRD-275	Instrument	Test
4.1.1.2 Shortwave Measurement Out-Of-Band Response	RB_PRD-318	Instrument	Test
4.1.2.1 Longwave Measurement Bandpass	RB_PRD-323	Instrument	Test
4.1.2.2 Longwave Measurement Out-Of-Band Response	RB_PRD-361	Instrument	Test
4.1.3.1 Total Measurement RSR	RB_PRD-366	Instrument	Test
4.1.3.2 Total Measurement In-Band RSR	RB_PRD-406	Instrument	Analysis
4.1.3.2 Total Measurement In-Band RSR	RB_PRD-407	Instrument	Analysis
4.1.3.2 Total Measurement In-Band RSR	RB_PRD-408	Instrument	Analysis
4.2 Radiometric Measurements	RB_PRD-411	Instrument	Analysis

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
4.2.1 Radiometric Dynamic Ranges	RB_PRD-413	Instrument	Test
4.2.2 Radiometric Resolution	RB_PRD-422	Instrument	Test
4.2.3 Noise Equivalent Radiance (NER)	RB_PRD-424	Instrument	Test
4.2.4 Long-Term Radiance Measurement Expanded Uncertainties	RB_PRD-426	Instrument	Analysis
4.2.4 Long-Term Radiance Measurement Expanded Uncertainties	RB_PRD-429	Instrument	Analysis
4.2.4 Long-Term Radiance Measurement Expanded Uncertainties	RB_PRD-432	Instrument	Analysis
4.2.5 Short-Term Radiance Measurement Expanded Uncertainties	RB_PRD-437	Instrument	Analysis
4.2.5 Short-Term Radiance Measurement Expanded Uncertainties	RB_PRD-440	Instrument	Analysis
4.2.5 Short-Term Radiance Measurement Expanded Uncertainties	RB_PRD-443	Instrument	Analysis
4.2.6 Linearity	RB_PRD-447	Instrument	Test
4.2.7 In-Flight Calibration	RB_PRD-449	Instrument	Inspection
4.2.7 In-Flight Calibration	RB_PRD-450	Instrument	Inspection
4.2.7.1 Calibration Sources	RB_PRD-452	Instrument	Inspection
4.2.7.1 Calibration Sources	RB_PRD-453	Instrument	Inspection
4.2.7.1 Calibration Sources	RB_PRD-454	Instrument	Test
4.2.7.1 Calibration Sources	RB_PRD-455	Instrument	Inspection
4.2.7.1 Calibration Sources	RB_PRD-456	Instrument	Inspection
4.2.7.1 Calibration Sources	RB_PRD-457	Instrument	Test
4.2.7.1 Calibration Sources	RB_PRD-458	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
4.2.7.1 Calibration Sources	RB_PRD-459	Instrument	Analysis
4.2.7.3 Calibration Frequency	RB_PRD-463	Instrument	Analysis
4.3.1 Field Of Regard (FOR)	RB_PRD-469	Instrument	Inspection
4.3.2 PSF	RB_PRD-471	Instrument	Test
4.3.2 PSF	RB_PRD-473	Instrument	Analysis
4.3.2 PSF	RB_PRD-474	Instrument	Analysis
4.3.3 Spatial and Temporal Alignment	RB_PRD-481	Instrument	Test
4.3.3 Spatial and Temporal Alignment	RB_PRD-484	Instrument	Test
4.3.3 Spatial and Temporal Alignment	RB_PRD-485	Instrument	Test
4.3.3 Spatial and Temporal Alignment	RB_PRD-486	Instrument	Test
4.3.3 Spatial and Temporal Alignment	RB_PRD-487	Instrument	Test
5.2 Geolocation Requirements	RB_PRD-496	Instrument	Analysis
5.3.3 Nominal Observatory Attitude	RB_PRD-505	Instrument	Analysis
5.3.4.1 Earth-Pointing Safe-Mode	RB_PRD-515	Instrument	Analysis
5.3.4.2 Sun-Pointing Safe-Mode	RB_PRD-520	Instrument	Analysis
5.3.4.3 Special Observatory Attitudes – Science Calibration Maneuvers	RB_PRD-525	Instrument	Analysis
5.4.1 AI&T, and Ground Storage Phase	RB_PRD-576	Instrument	Analysis
5.4.1 AI&T, and Ground Storage Phase	RB_PRD-577	Instrument	Analysis
5.4.1 AI&T, and Ground Storage Phase	RB_PRD-579	Instrument	Analysis

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
5.4.2 Pre-Launch/Launch Site Processing Phase	RB_PRD-581	Instrument	Demonstration
5.4.2 Pre-Launch/Launch Site Processing Phase	RB_PRD-582	Instrument	Inspection
5.4.4 Satellite Activation, Checkout, and Commissioning Phase	RB_PRD-586	Instrument	Analysis
5.4.4 Satellite Activation, Checkout, and Commissioning Phase	RB_PRD-587	Instrument	Inspection
5.4.6.1 Availability	RB_PRD-593	Instrument	Analysis
5.4.6.1 Availability	RB_PRD-594	Instrument	Analysis
5.4.6.1 Availability	RB_PRD-595	Instrument	Analysis
5.5.1.1 Observatory OFF-Mode Functional Requirement	RB_PRD-655	Instrument	Demonstration
5.5.1.2 Launch Mode Functional Requirements	RB_PRD-658	Instrument	Inspection
5.5.1.2 Launch Mode Functional Requirements	RB_PRD-660	Instrument	Inspection
5.5.2 Instrument Modes	RB_PRD-685	Instrument	Test
5.5.2 Instrument Modes	RB_PRD-741	Instrument	Test
5.5.2 Instrument Modes	RB_PRD-742	Instrument	Inspection
5.5.2.1 Instrument OFF Mode	RB_PRD-745	Instrument	Demonstration
5.5.2.1 Instrument OFF Mode	RB_PRD-746	Instrument	Test
5.5.2.2 Instrument Survival Mode	RB_PRD-749	Instrument	Analysis
5.5.2.2 Instrument Survival Mode	RB_PRD-750	Instrument	Test
5.5.2.2 Instrument Survival Mode	RB_PRD-755	Instrument	Test
5.5.2.3 Instrument SAFE Mode	RB_PRD-758	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
5.5.2.3 Instrument SAFE Mode	RB_PRD-759	Instrument	Test
5.5.2.3 Instrument SAFE Mode	RB_PRD-761	Instrument	Test
5.5.2.3 Instrument SAFE Mode	RB_PRD-762	Instrument	Test
5.5.2.3 Instrument SAFE Mode	RB_PRD-763	Instrument	Inspection
5.5.2.3 Instrument SAFE Mode	RB_PRD-764	Instrument	Demonstration
5.5.2.3 Instrument SAFE Mode	RB_PRD-664	Instrument	Test
5.5.2.3 Instrument SAFE Mode	RB_PRD-665	Instrument	Test
5.5.2.4.1 Instrument Activation Mode	RB_PRD-769	Instrument	Test
5.5.2.4.1 Instrument Activation Mode	RB_PRD-770	Instrument	Test
5.5.2.4.1 Instrument Activation Mode	RB_PRD-771	Instrument	Test
5.5.2.4.2 Instrument Diagnostic Mode	RB_PRD-773	Instrument	Test
5.5.2.4.2 Instrument Diagnostic Mode	RB_PRD-774	Instrument	Test
5.5.2.5 Instrument Operational Mode	RB_PRD-779	Instrument	Test
5.5.2.5 Instrument Operational Mode	RB_PRD-780	Instrument	Analysis
5.5.2.5 Instrument Operational Mode	RB_PRD-786	Instrument	Test
5.5.2.5.1 Cross-Track Sub-Mode	RB_PRD-789	Instrument	Test
5.5.2.5.2 Bi-Axial Sub-Mode	RB_PRD-791	Instrument	Inspection
5.5.2.5.2 Bi-Axial Sub-Mode	RB_PRD-792	Instrument	Test
5.5.2.5.2 Bi-Axial Sub-Mode	RB_PRD-793	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
5.5.2.5.2 Bi-Axial Sub-Mode	RB_PRD-6358	Instrument	Test
5.5.2.5.3 Earth Target Sub-Mode	RB_PRD-795	Instrument	Test
5.5.2.5.4 Calibration Sub-Mode	RB_PRD-797	Instrument	Test
5.5.2.5.5 User-Defined Sub-Mode	RB_PRD-6360	Instrument	Test
5.5.2.5.5 User-Defined Sub-Mode	RB_PRD-6395	Instrument	Test
5.5.2.5.5 User-Defined Sub-Mode	RB_PRD-6397	Instrument	Test
5.5.2.5.5 User-Defined Sub-Mode	RB_PRD-6398	Instrument	Test
5.5.2.5.5 User-Defined Sub-Mode	RB_PRD-6361	Instrument	Test
6.1 Mechanical Requirements	RB_PRD-800	Instrument	Inspection
6.1 Mechanical Requirements	RB_PRD-801	Instrument	Inspection
6.1 Mechanical Requirements	RB_PRD-803	Instrument	Inspection
6.1.1 Mounting Provisions	RB_PRD-805	Instrument	Inspection
6.1.1 Mounting Provisions	RB_PRD-807	Instrument	Inspection
6.1.1 Mounting Provisions	RB_PRD-808	Instrument	Analysis
6.1.1 Mounting Provisions	RB_PRD-809	Instrument	Inspection
6.1.1 Mounting Provisions	RB_PRD-810	Instrument	Inspection
6.1.2 Mass Properties	RB_PRD-812	Instrument	Test
6.1.2 Mass Properties	RB_PRD-813	Instrument	Test
6.1.2 Mass Properties	RB_PRD-814	Instrument	Analysis

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.1.2 Mass Properties	RB_PRD-815	Instrument	Analysis
6.1.2 Mass Properties	RB_PRD-816	Instrument	Analysis
6.1.3 Venting and Purge	RB_PRD-819	Instrument	Inspection
6.1.4 Pointing and Alignment Reference	RB_PRD-821	Instrument	Inspection
6.1.4 Pointing and Alignment Reference	RB_PRD-822	Instrument	Inspection
6.1.4 Pointing and Alignment Reference	RB_PRD-823	Instrument	Test
6.1.4 Pointing and Alignment Reference	RB_PRD-824	Instrument	Test
6.1.4 Pointing and Alignment Reference	RB_PRD-825	Instrument	Inspection
6.1.4 Pointing and Alignment Reference	RB_PRD-826	Instrument	Inspection
6.1.4 Pointing and Alignment Reference	RB_PRD-827	Instrument	Inspection
6.1.4 Pointing and Alignment Reference	RB_PRD-828	Instrument	Inspection
6.1.5.1.1 Strength	RB_PRD-833	Instrument	Inspection
6.1.5.1.1 Strength	RB_PRD-834	Instrument	Inspection
6.1.5.1.2 Ultimate Design Loads	RB_PRD-837	Instrument	Analysis
6.1.5.1.3 Yield Design Loads	RB_PRD-839	Instrument	Analysis
6.1.5.1.4 Joint Separation	RB_PRD-841	Instrument	Analysis
6.1.5.2.1 Fastener Retention	RB_PRD-844	Instrument	Inspection
6.1.5.2.2 Locking Features	RB_PRD-846	Instrument	Inspection
6.1.5.2.2 Locking Features	RB_PRD-847	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.1.5.2.2 Locking Features	RB_PRD-848	Instrument	Inspection
6.1.5.2.2 Locking Features	RB_PRD-849	Instrument	Inspection
6.1.5.2.2 Locking Features	RB_PRD-850	Instrument	Inspection
6.1.5.2.2 Locking Features	RB_PRD-851	Instrument	Inspection
6.1.5.2.3 Locking Features Verification	RB_PRD-853	Instrument	Inspection
6.1.5.2.3 Locking Features Verification	RB_PRD-854	Instrument	Inspection
6.1.5.2.3 Locking Features Verification	RB_PRD-855	Instrument	Test
6.1.5.2.3 Locking Features Verification	RB_PRD-856	Instrument	Test
6.1.5.2.3 Locking Features Verification	RB_PRD-857	Instrument	Test
6.1.5.2.4 Locking Features Installation	RB_PRD-859	Instrument	Inspection
6.1.5.2.4 Locking Features Installation	RB_PRD-860	Instrument	Inspection
6.1.5.2.4.1 Thread Engagement, Dimensions, and Tolerances	RB_PRD-862	Instrument	Inspection
6.1.5.2.4.1.1 Fastener Length Selection for Thread Engagement	RB_PRD-864	Instrument	Inspection
6.1.5.2.4.1.1 Fastener Length Selection for Thread Engagement	RB_PRD-865	Instrument	Inspection
6.1.5.2.4.1.1 Fastener Length Selection for Thread Engagement	RB_PRD-866	Instrument	Analysis
6.1.5.2.4.1.2 Bolt Grip Selection to Prevent Interference	RB_PRD-871	Instrument	Inspection
6.1.5.2.4.1.2 Bolt Grip Selection to Prevent Interference	RB_PRD-872	Instrument	Inspection
6.1.5.2.4.2 Fastener Installation Specification and Control	RB_PRD-874	Instrument	Inspection
6.1.5.2.4.3 Installation Torque Specification and Control	RB_PRD-876	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.1.5.2.4.3 Installation Torque Specification and Control	RB_PRD-877	Instrument	Inspection
6.1.5.3 Fastened Joints Criteria	RB_PRD-879	Instrument	Analysis
6.1.5.4 Strength Under Ultimate Design Loads	RB_PRD-881	Instrument	Analysis
6.1.5.4.1 Ultimate Strength Analysis for Tensile Loading	RB_PRD-883	Instrument	Analysis
6.1.5.4.2 Ultimate Strength Analysis for Shear Loading	RB_PRD-885	Instrument	Analysis
6.1.5.4.2 Ultimate Strength Analysis for Shear Loading	RB_PRD-886	Instrument	Analysis
6.1.5.4.3 Ultimate Strength Analysis for Combined Loading	RB_PRD-888	Instrument	Analysis
6.1.5.4.4 Strength Under Yield Design Loads	RB_PRD-890	Instrument	Analysis
6.1.5.4.5 Joint Separation Analysis	RB_PRD-895	Instrument	Analysis
6.1.5.4.5 Joint Separation Analysis	RB_PRD-896	Instrument	Analysis
6.1.6.1 Torque/Force Margins	RB_PRD-900	Instrument	Analysis
6.1.6.1 Torque/Force Margins	RB_PRD-901	Instrument	Analysis
6.1.6.1 Torque/Force Margins	RB_PRD-902	Instrument	Test
6.1.6.1 Torque/Force Margins	RB_PRD-903	Instrument	Test
6.1.6.1 Torque/Force Margins	RB_PRD-904	Instrument	Test
6.1.6.1 Torque/Force Margins	RB_PRD-905	Instrument	Analysis
6.1.6.1 Torque/Force Margins	RB_PRD-906	Instrument	Analysis
6.1.6.1 Torque/Force Margins	RB_PRD-925	Instrument	Analysis
6.1.6.1 Torque/Force Margins	RB_PRD-926	Instrument	Analysis

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.1.6.1 Torque/Force Margins	RB_PRD-927	Instrument	Inspection
6.1.6.2 Binding/Jamming/Seizing	RB_PRD-929	Instrument	Inspection
6.1.6.2.1 Clearances	RB_PRD-931	Instrument	Analysis
6.1.6.2.1 Clearances	RB_PRD-932	Instrument	Analysis
6.1.6.2.2 Tolerancing	RB_PRD-934	Instrument	Analysis
6.1.6.2.3.1 Lubricant Compatibility	RB_PRD-937	Instrument	Test
6.1.6.2.3.2 Lubricant Life	RB_PRD-944	Instrument	Test
6.1.6.2.3.2 Lubricant Life	RB_PRD-945	Instrument	Analysis
6.1.6.2.3.3 Bearing Lubrication	RB_PRD-947	Instrument	Test
6.1.6.2.3.3 Bearing Lubrication	RB_PRD-948	Instrument	Inspection
6.1.6.3.1 Caging of Deployables	RB_PRD-951	Instrument	Inspection
6.1.6.3.1 Caging of Deployables	RB_PRD-952	Instrument	Demonstration
6.1.6.3.1 Caging of Deployables	RB_PRD-953	Instrument	Test
6.1.6.3.1 Caging of Deployables	RB_PRD-954	Instrument	Test
6.1.6.3.2 Indication of Deployment/Release Status	RB_PRD-956	Instrument	Test
6.1.6.4 Springs	RB_PRD-958	Instrument	Inspection
6.1.6.4 Springs	RB_PRD-959	Instrument	Analysis
6.1.6.5 Dampers	RB_PRD-961	Instrument	Inspection
6.1.6.5 Dampers	RB_PRD-962	Instrument	Inspection

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6.1.6.5 Dampers	RB_PRD-963	Instrument	Inspection
6.1.6.6 Harmonic Drives	RB_PRD-965	Instrument	Inspection
6.1.6.6 Harmonic Drives	RB_PRD-966	Instrument	Inspection
6.1.6.7 Bearings	RB_PRD-968	Instrument	Inspection
6.1.6.7 Bearings	RB_PRD-969	Instrument	Inspection
6.1.6.7 Bearings	RB_PRD-970	Instrument	Analysis
6.1.6.7 Bearings	RB_PRD-973	Instrument	Inspection
6.1.6.7 Bearings	RB_PRD-974	Instrument	Analysis
6.1.6.8 Mechanical Stops	RB_PRD-976	Instrument	Inspection
6.1.6.8 Mechanical Stops	RB_PRD-977	Instrument	Analysis
6.1.6.8 Mechanical Stops	RB_PRD-978	Instrument	Analysis
6.1.6.8 Mechanical Stops	RB_PRD-979	Instrument	Analysis
6.1.6.8 Mechanical Stops	RB_PRD-980	Instrument	Analysis
6.1.6.9 Switches	RB_PRD-982	Instrument	Inspection
6.1.6.9 Switches	RB_PRD-983	Instrument	Inspection
6.1.6.9 Switches	RB_PRD-984	Instrument	Inspection
6.1.6.10 Mechanism Performance and Strength Analysis	RB_PRD-986	Instrument	Analysis
6.1.6.10 Mechanism Performance and Strength Analysis	RB_PRD-987	Instrument	Analysis
6.1.6.11 Mechanism Installation	RB_PRD-998	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.2.1 Strength and Stiffness	RB_PRD-1001	Instrument	Analysis
6.2.1 Strength and Stiffness	RB_PRD-1002	Instrument	Analysis
6.2.1 Strength and Stiffness	RB_PRD-1003	Instrument	Analysis
6.2.1 Strength and Stiffness	RB_PRD-1004	Instrument	Analysis
6.2.1 Strength and Stiffness	RB_PRD-1005	Instrument	Analysis
6.2.1 Strength and Stiffness	RB_PRD-1006	Instrument	Analysis
6.2.1 Strength and Stiffness	RB_PRD-1007	Instrument	Analysis
6.2.1 Strength and Stiffness	RB_PRD-1008	Instrument	Analysis
6.2.1 Strength and Stiffness	RB_PRD-1009	Instrument	Inspection
6.2.2.1 Static Liftoff Loads (Flight Limit Loads)	RB_PRD-1058	Instrument	Analysis
6.2.2.2.1 Acoustic Loads	RB_PRD-1064	Instrument	Analysis
6.2.2.2.2 Random Mechanical Vibration	RB_PRD-1069	Instrument	Test
6.2.2.2.3 Mechanical Shock	RB_PRD-6371	Instrument	Test
6.2.2.2.3 Mechanical Shock	RB_PRD-1088	Instrument	Test
6.2.2.2.4 Resonant Frequency Constraints	RB_PRD-1090	Instrument	Test
6.2.2.2.4 Resonant Frequency Constraints	RB_PRD-1091	Instrument	Test
6.2.3.1 Uncompensated Momentum	RB_PRD-1094	Instrument	Analysis
6.2.3.2.1 Periodic Disturbance Torque Limits	RB_PRD-1097	Instrument	Analysis
6.2.3.2.2 Constant Disturbance Torque Limits	RB_PRD-1118	Instrument	Analysis

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.2.3.2.2 Constant Disturbance Torque Limits	RB_PRD-1121	Instrument	Analysis
6.2.3.4 Rotation	RB_PRD-1142	Instrument	Analysis
6.3.1.1 Instrument Power Requirements	RB_PRD-1151	Instrument	Test
6.3.1.1 Instrument Power Requirements	RB_PRD-1152	Instrument	Test
6.3.1.1 Instrument Power Requirements	RB_PRD-1153	Instrument	Analysis
6.3.1.1 Instrument Power Requirements	RB_PRD-1154	Instrument	Test
6.3.1.1.1 Power Services	RB_PRD-1158	Instrument	Inspection
6.3.1.1.1 Power Services	RB_PRD-1159	Instrument	Inspection
6.3.1.1.1 Power Services	RB_PRD-1160	Instrument	Inspection
6.3.1.1.1 Power Services	RB_PRD-1161	Instrument	Inspection
6.3.1.1.1 Power Services	RB_PRD-1162	Instrument	Inspection
6.3.1.1.1 Power Services	RB_PRD-1163	Instrument	Inspection
6.3.1.1.1 Power Services	RB_PRD-1164	Instrument	Inspection
6.3.1.1.1 Power Services	RB_PRD-1188	Instrument	Test
6.3.1.1.1 Power Services	RB_PRD-1189	Instrument	Test
6.3.1.1.1.1 Survival Heater Power Services	RB_PRD-1192	Instrument	Inspection
6.3.1.1.1.1 Survival Heater Power Services	RB_PRD-1193	Instrument	Inspection
6.3.1.2 Power Fault Tolerance	RB_PRD-1195	Instrument	Inspection
6.3.1.2 Power Fault Tolerance	RB_PRD-1196	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.3.1.2 Power Fault Tolerance	RB_PRD-1198	Instrument	Test
6.3.1.2 Power Fault Tolerance	RB_PRD-1199	Instrument	Test
6.3.1.2 Power Fault Tolerance	RB_PRD-1200	Instrument	Test
6.3.1.2 Power Fault Tolerance	RB_PRD-1202	Instrument	Inspection
6.3.1.3.1 Operational Voltage	RB_PRD-1205	Instrument	Test
6.3.1.3.1 Operational Voltage	RB_PRD-6354	Instrument	Test
6.3.1.3.1 Operational Voltage	RB_PRD-6355	Instrument	Test
6.3.1.3.2.1 Current Transients	RB_PRD-1208	Instrument	Analysis
6.3.1.3.2.1.2 Turn-off Transients	RB_PRD-1217	Instrument	Inspection
6.3.1.3.2.1.2 Turn-off Transients	RB_PRD-1218	Instrument	Inspection
6.3.1.3.2.1.2 Turn-off Transients	RB_PRD-1219	Instrument	Analysis
6.3.1.3.2.1.3 Operational Transients	RB_PRD-1221	Instrument	Test
6.3.1.3.2.1.3 Operational Transients	RB_PRD-1222	Instrument	Test
6.3.1.3.3 Component Load Ripple	RB_PRD-1225	Instrument	Test
6.3.1.3.3.1 Reflected Ripple	RB_PRD-1227	Instrument	Test
6.3.1.3.3.1 Reflected Ripple	RB_PRD-1229	Instrument	Test
6.3.1.3.3.1 Reflected Ripple	RB_PRD-1230	Instrument	Test
6.3.1.3.3.1 Reflected Ripple	RB_PRD-1231	Instrument	Test
6.3.1.3.4 Bus Impedance	RB_PRD-1236	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.3.1.4 Instrument High-Voltage Restriction	RB_PRD-1238	Instrument	Demonstration
6.3.1.4 Instrument High-Voltage Restriction	RB_PRD-1239	Instrument	Inspection
6.3.2.1 Main Bus Power Return Ground	RB_PRD-1246	Instrument	Test
6.3.2.1 Main Bus Power Return Ground	RB_PRD-1247	Instrument	Test
6.3.2.1 Main Bus Power Return Ground	RB_PRD-1248	Instrument	Test
6.3.2.1 Main Bus Power Return Ground	RB_PRD-1249	Instrument	Inspection
6.3.2.2 Secondary Power Return Ground	RB_PRD-1251	Instrument	Inspection
6.3.2.2 Secondary Power Return Ground	RB_PRD-1252	Instrument	Inspection
6.3.2.2 Secondary Power Return Ground	RB_PRD-1253	Instrument	Inspection
6.3.2.2 Secondary Power Return Ground	RB_PRD-1254	Instrument	Inspection
6.3.2.2 Secondary Power Return Ground	RB_PRD-1255	Instrument	Inspection
6.3.2.2 Secondary Power Return Ground	RB_PRD-1256	Instrument	Test
6.3.2.3 RF Ground Bonding	RB_PRD-1262	Instrument	Test
6.3.2.3 RF Ground Bonding	RB_PRD-1263	Instrument	Test
6.3.2.3 RF Ground Bonding	RB_PRD-1264	Instrument	Test
6.3.3.1 EMI Filtering of Spacecraft Power	RB_PRD-1272	Instrument	Inspection
6.3.3.2 EMI/EMC General Requirements	RB_PRD-1275	Instrument	Test
6.3.3.2.1 Conducted Susceptibility (CS)	RB_PRD-1278	Instrument	Test
6.3.3.2.1 Conducted Susceptibility (CS)	RB_PRD-1281	Instrument	Test

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6.3.3.2.1 Conducted Susceptibility (CS)	RB_PRD-1284	Instrument	Test
6.3.3.2.1 Conducted Susceptibility (CS)	RB_PRD-1305	Instrument	Test
6.3.3.2.1 Conducted Susceptibility (CS)	RB_PRD-1306	Instrument	Test
6.3.3.2.1 Conducted Susceptibility (CS)	RB_PRD-1309	Instrument	Inspection
6.3.3.2.1 Conducted Susceptibility (CS)	RB_PRD-1310	Instrument	Test
6.3.3.2.2.1 Radiated Susceptibility, RS101	RB_PRD-1315	Instrument	Test
6.3.3.2.2.2 Radiated Susceptibility RS103	RB_PRD-1319	Instrument	Test
6.3.3.2.3.1 Magnetic Field Radiated Emissions, RE101	RB_PRD-1322	Instrument	Test
6.3.3.2.3.2 Electric Field Radiated Emissions, RE102	RB_PRD-1326	Instrument	Test
6.3.3.2.3.2 Electric Field Radiated Emissions, RE102	RB_PRD-1327	Instrument	Inspection
6.3.3.2.3.2 Electric Field Radiated Emissions, RE102	RB_PRD-1328	Instrument	Inspection
6.3.3.2.3.2 Electric Field Radiated Emissions, RE102	RB_PRD-1329	Instrument	Test
6.3.3.2.3.2 Electric Field Radiated Emissions, RE102	RB_PRD-1330	Instrument	Test
6.3.3.3 Magnetic Requirements	RB_PRD-1341	Instrument	Test
6.3.3.3 Magnetic Requirements	RB_PRD-1342	Instrument	Test
6.3.4 Data and Signal Interfaces	RB_PRD-1344	Instrument	Inspection
6.3.4.1 Spacecraft/Instrument Data Bus	RB_PRD-1346	Instrument	Inspection
6.3.4.1.1 Instrument 1553 Data Bus	RB_PRD-1349	Instrument	Inspection
6.3.4.1.1 Instrument 1553 Data Bus	RB_PRD-1350	Instrument	Inspection

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6.3.4.1.1 Instrument 1553 Data Bus	RB_PRD-1352	Instrument	Inspection
6.3.4.1.1 Instrument 1553 Data Bus	RB_PRD-1353	Instrument	Inspection
6.3.4.1.1 Instrument 1553 Data Bus	RB_PRD-1354	Instrument	Inspection
6.3.4.1.1 Instrument 1553 Data Bus	RB_PRD-1355	Instrument	Inspection
6.3.4.1.1 Instrument 1553 Data Bus	RB_PRD-1358	Instrument	Inspection
6.3.4.1.1 Instrument 1553 Data Bus	RB_PRD-1359	Instrument	Inspection
6.3.4.1.2 Instrument SpaceWire Link	RB_PRD-1364	Instrument	Inspection
6.3.4.1.2 Instrument SpaceWire Link	RB_PRD-1365	Instrument	Inspection
6.3.4.1.2 Instrument SpaceWire Link	RB_PRD-1366	Instrument	Demonstration
6.3.4.1.2 Instrument SpaceWire Link	RB_PRD-1367	Instrument	Demonstration
6.3.4.1.2 Instrument SpaceWire Link	RB_PRD-1368	Instrument	Demonstration
6.3.4.2 Passive Analog Telemetry	RB_PRD-1370	Instrument	Inspection
6.3.4.2 Passive Analog Telemetry	RB_PRD-1373	Instrument	Test
6.3.4.3 Passive Bi-level Telemetry	RB_PRD-1375	Instrument	Test
6.3.4.4 Discrete Command Interfaces	RB_PRD-1379	Instrument	Inspection
6.3.4.4 Discrete Command Interfaces	RB_PRD-1380	Instrument	Inspection
6.3.4.4 Discrete Command Interfaces	RB_PRD-1381	Instrument	Test
6.3.4.4 Discrete Command Interfaces	RB_PRD-1392	Instrument	Inspection
6.3.4.4 Discrete Command Interfaces	RB_PRD-1393	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.3.4.6.1 Electro Explosive Devices (EED)	RB_PRD-1402	Instrument	Inspection
6.3.4.6.1 Electro Explosive Devices (EED)	RB_PRD-1403	Instrument	Inspection
6.3.4.6.1 Electro Explosive Devices (EED)	RB_PRD-1404	Instrument	Inspection
6.3.4.6.1 Electro Explosive Devices (EED)	RB_PRD-1405	Instrument	Demonstration
6.3.4.6.1 Electro Explosive Devices (EED)	RB_PRD-1406	Instrument	Inspection
6.3.4.6.2 Non-Explosive Devices (NED)	RB_PRD-1408	Instrument	Inspection
6.3.4.6.2 Non-Explosive Devices (NED)	RB_PRD-1409	Instrument	Inspection
6.3.4.6.2 Non-Explosive Devices (NED)	RB_PRD-1410	Instrument	Inspection
6.3.4.7 External Test Point Interfaces	RB_PRD-1412	Instrument	Inspection
6.3.4.7 External Test Point Interfaces	RB_PRD-1413	Instrument	Inspection
6.3.4.7 External Test Point Interfaces	RB_PRD-1414	Instrument	Inspection
6.3.4.7 External Test Point Interfaces	RB_PRD-1415	Instrument	Inspection
6.3.5 Multipaction and Corona	RB_PRD-1417	Instrument	Analysis
6.3.6 Flight Electronics Design and Development	RB_PRD-1419	Instrument	Test
6.3.7.1 Connector Identification	RB_PRD-1422	Instrument	Inspection
6.3.7.2 Connector Keying	RB_PRD-1424	Instrument	Inspection
6.3.7.3 Connector Design Selection	RB_PRD-1426	Instrument	Inspection
6.3.7.3 Connector Design Selection	RB_PRD-1428	Instrument	Inspection
6.3.7.3 Connector Design Selection	RB_PRD-1429	Instrument	Inspection

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6.3.7.3 Connector Design Selection	RB_PRD-1430	Instrument	Inspection
6.3.7.3 Connector Design Selection	RB_PRD-1431	Instrument	Inspection
6.3.7.3 Connector Design Selection	RB_PRD-1432	Instrument	Inspection
6.3.7.3 Connector Design Selection	RB_PRD-1433	Instrument	Inspection
6.3.7.4 Unused Connector Contacts	RB_PRD-1435	Instrument	Inspection
6.3.7.4 Unused Connector Contacts	RB_PRD-1436	Instrument	Inspection
6.3.7.4 Unused Connector Contacts	RB_PRD-1437	Instrument	Inspection
6.3.7.5 Connector Accessibility	RB_PRD-1439	Instrument	Inspection
6.3.7.5 Connector Accessibility	RB_PRD-1440	Instrument	Inspection
6.3.7.5 Connector Accessibility	RB_PRD-1441	Instrument	Inspection
6.3.7.5 Connector Accessibility	RB_PRD-1442	Instrument	Inspection
6.3.7.6 Harness Wiring Requirements	RB_PRD-1444	Instrument	Inspection
6.3.7.6 Harness Wiring Requirements	RB_PRD-1445	Instrument	Inspection
6.3.7.6 Harness Wiring Requirements	RB_PRD-1446	Instrument	Inspection
6.3.7.6 Harness Wiring Requirements	RB_PRD-1447	Instrument	Inspection
6.3.7.6 Harness Wiring Requirements	RB_PRD-1449	Instrument	Inspection
6.3.7.6 Harness Wiring Requirements	RB_PRD-1450	Instrument	Inspection
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1452	Instrument	Inspection
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1453	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1454	Instrument	Inspection
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1455	Instrument	Inspection
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1456	Instrument	Inspection
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1457	Instrument	Inspection
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1458	Instrument	Inspection
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1459	Instrument	Inspection
6.3.7.7 Harness Grouping, Routing and Shielding	RB_PRD-1460	Instrument	Test
6.4.1 General	RB_PRD-1464	Instrument	Inspection
6.4.1 General	RB_PRD-1466	Instrument	Analysis
6.4.2 Operational Temperature and Heat Transfer Limits	RB_PRD-1469	Instrument	Test
6.4.2 Operational Temperature and Heat Transfer Limits	RB_PRD-1472	Instrument	Analysis
6.4.3 Survival Temperature Limits	RB_PRD-1475	Instrument	Analysis
6.4.4 Thermal Margins	RB_PRD-1477	Instrument	Inspection
6.4.4 Thermal Margins	RB_PRD-1479	Instrument	Inspection
6.4.4 Thermal Margins	RB_PRD-1480	Instrument	Inspection
6.4.4 Thermal Margins	RB_PRD-1481	Instrument	Test
6.4.4 Thermal Margins	RB_PRD-1482	Instrument	Inspection
6.4.5 Survival Heater Sizing	RB_PRD-1486	Instrument	Test
6.4.5 Survival Heater Sizing	RB_PRD-1487	Instrument	Analysis

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6.4.5 Survival Heater Sizing	RB_PRD-1488	Instrument	Inspection
6.4.5 Survival Heater Sizing	RB_PRD-1489	Instrument	Analysis
6.4.6 Contamination Control	RB_PRD-1491	Instrument	Analysis
6.4.6.1 Instrument Cleanliness Requirements	RB_PRD-1497	Instrument	Test
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1528	Instrument	Inspection
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1529	Instrument	Inspection
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1530	Instrument	Test
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1531	Instrument	Test
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1532	Instrument	Analysis
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1533	Instrument	Test
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1535	Instrument	Analysis
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1536	Instrument	Inspection
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1537	Instrument	Inspection
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1538	Instrument	Inspection
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1539	Instrument	Inspection
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1540	Instrument	Inspection
6.4.6.2 Contamination Control Detailed Requirements	RB_PRD-1542	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1544	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1545	Instrument	Inspection

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6.4.6.2.1 Optical Witness Samples	RB_PRD-1546	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1547	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1548	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1549	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1550	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1551	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1553	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1554	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1555	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1556	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1557	Instrument	Inspection
6.4.6.2.1 Optical Witness Samples	RB_PRD-1558	Instrument	Inspection
6.4.6.2.2 Instrument Purge Equipment	RB_PRD-1562	Instrument	Test
6.4.6.2.2 Instrument Purge Equipment	RB_PRD-1563	Instrument	Inspection
6.4.6.2.2 Instrument Purge Equipment	RB_PRD-1564	Instrument	Inspection
6.4.6.2.2 Instrument Purge Equipment	RB_PRD-1565	Instrument	Inspection
6.4.6.2.2 Instrument Purge Equipment	RB_PRD-1566	Instrument	Inspection
6.4.6.2.2 Instrument Purge Equipment	RB_PRD-1567	Instrument	Inspection
6.4.6.2.2 Instrument Purge Equipment	RB_PRD-1568	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.4.7.1 Thermal Recovery	RB_PRD-1571	Instrument	Analysis
6.4.7.1 Thermal Recovery	RB_PRD-1572	Instrument	Analysis
6.4.7.2.2 Spacecraft IR Backload Heat Flux	RB_PRD-1595	Instrument	Analysis
6.5.1 General Command and Telemetry (Consultative Committee for Space Data Systems (CCSDS)/Packets)	RB_PRD-1624	Instrument	Test
6.5.1 General Command and Telemetry (Consultative Committee for Space Data Systems (CCSDS)/Packets)	RB_PRD-1625	Instrument	Test
6.5.1 General Command and Telemetry (Consultative Committee for Space Data Systems (CCSDS)/Packets)	RB_PRD-1626	Instrument	Test
6.5.1 General Command and Telemetry (Consultative Committee for Space Data Systems (CCSDS)/Packets)	RB_PRD-1627	Instrument	Test
6.5.1 General Command and Telemetry (Consultative Committee for Space Data Systems (CCSDS)/Packets)	RB_PRD-1628	Instrument	Demonstration
6.5.1 General Command and Telemetry (Consultative Committee for Space Data Systems (CCSDS)/Packets)	RB_PRD-1634	Instrument	Inspection
6.5.1.1 Mission Data	RB_PRD-1636	Instrument	Inspection
6.5.1.2 Data Packetization	RB_PRD-1639	Instrument	Test
6.5.1.2 Data Packetization	RB_PRD-1640	Instrument	Test
6.5.1.2 Data Packetization	RB_PRD-1641	Instrument	Test
6.5.1.2 Data Packetization	RB_PRD-1642	Instrument	Test
6.5.1.2 Data Packetization	RB_PRD-1643	Instrument	Test
6.5.1.2 Data Packetization	RB_PRD-1645	Instrument	Inspection

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6.5.1.3.1 Test Packets	RB_PRD-1659	Instrument	Test
6.5.1.3.1 Test Packets	RB_PRD-1660	Instrument	Test
6.5.1.3.1 Test Packets	RB_PRD-1661	Instrument	Test
6.5.1.3.1 Test Packets	RB_PRD-1662	Instrument	Inspection
6.5.1.3.1 Test Packets	RB_PRD-1663	Instrument	Inspection
6.5.1.3.1 Test Packets	RB_PRD-1664	Instrument	Demonstration
6.5.1.3.1 Test Packets	RB_PRD-1665	Instrument	Demonstration
6.5.1.3.2 Memory Dump Packets	RB_PRD-1667	Instrument	Test
6.5.1.3.2 Memory Dump Packets	RB_PRD-1668	Instrument	Inspection
6.5.1.3.2 Memory Dump Packets	RB_PRD-1669	Instrument	Inspection
6.5.1.3.3 Engineering Packets	RB_PRD-1671	Instrument	Test
6.5.1.3.4 Housekeeping Telemetry Packets	RB_PRD-1674	Instrument	Test
6.5.1.3.4 Housekeeping Telemetry Packets	RB_PRD-1675	Instrument	Test
6.5.1.3.4 Housekeeping Telemetry Packets	RB_PRD-1682	Instrument	Test
6.5.1.3.4 Housekeeping Telemetry Packets	RB_PRD-1683	Instrument	Test
6.5.1.3.5 Dwell Packets	RB_PRD-1685	Instrument	Test
6.5.1.3.5 Dwell Packets	RB_PRD-1686	Instrument	Inspection
6.5.1.3.6 Calibration Packets	RB_PRD-1688	Instrument	Inspection
6.5.1.3.6 Calibration Packets	RB_PRD-1689	Instrument	Inspection

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6.5.1.3.7 LEO&A Packets	RB_PRD-1691	Instrument	Inspection
6.5.1.3.7 LEO&A Packets	RB_PRD-1692	Instrument	Test
6.5.1.3.7 LEO&A Packets	RB_PRD-1693	Instrument	Inspection
6.5.1.3.8 Diagnostic Packets	RB_PRD-1696	Instrument	Test
6.5.1.3.8 Diagnostic Packets	RB_PRD-1697	Instrument	Inspection
6.5.1.3.8 Diagnostic Packets	RB_PRD-1698	Instrument	Test
6.5.1.3.9 Science Packets	RB_PRD-1700	Instrument	Inspection
6.5.1.3.9 Science Packets	RB_PRD-1701	Instrument	Inspection
6.5.1.3.10 Telemetry Monitoring Packets	RB_PRD-1707	Instrument	Inspection
6.5.2 Commanding	RB_PRD-1735	Instrument	Analysis
6.5.2 Commanding	RB_PRD-1736	Instrument	Analysis
6.5.2.1 Command Verification	RB_PRD-1738	Instrument	Test
6.5.2.1 Command Verification	RB_PRD-1739	Instrument	Test
6.5.2.1 Command Verification	RB_PRD-1740	Instrument	Test
6.5.2.1 Command Verification	RB_PRD-1741	Instrument	Test
6.5.2.1 Command Verification	RB_PRD-1742	Instrument	Test
6.5.2.2 Real-time Ground Commands	RB_PRD-1744	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-1747	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-1748	Instrument	Test

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6.5.2.3 Stored Commands	RB_PRD-1749	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-1750	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-1751	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-1752	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-1753	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-6362	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-6363	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-6364	Instrument	Test
6.5.2.3 Stored Commands	RB_PRD-6365	Instrument	Test
6.5.2.4 Command Restraints	RB_PRD-1755	Instrument	Inspection
6.5.2.4 Command Restraints	RB_PRD-1756	Instrument	Inspection
6.5.2.4 Command Restraints	RB_PRD-1757	Instrument	Analysis
6.5.2.4 Command Restraints	RB_PRD-1758	Instrument	Inspection
6.5.2.4 Command Restraints	RB_PRD-1759	Instrument	Inspection
6.5.2.4 Command Restraints	RB_PRD-1761	Instrument	Test
6.5.2.5 Critical Command	RB_PRD-1763	Instrument	Test
6.5.2.5 Critical Command	RB_PRD-1764	Instrument	Test
6.5.3 Telemetry	RB_PRD-1766	Instrument	Test
6.5.3 Telemetry	RB_PRD-1767	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.5.3 Telemetry	RB_PRD-1768	Instrument	Inspection
6.5.3.1 Instrument Health and Status Telemetry	RB_PRD-1770	Instrument	Inspection
6.5.3.1 Instrument Health and Status Telemetry	RB_PRD-1771	Instrument	Test
6.5.3.1.1 Telemetry Diagnostic Data	RB_PRD-1773	Instrument	Inspection
6.5.3.1.1 Telemetry Diagnostic Data	RB_PRD-1774	Instrument	Test
6.5.3.1.1 Telemetry Diagnostic Data	RB_PRD-1775	Instrument	Test
6.5.4 Timing	RB_PRD-1782	Instrument	Inspection
6.5.4 Timing	RB_PRD-1783	Instrument	Test
6.5.4 Timing	RB_PRD-1785	Instrument	Analysis
6.5.4 Timing	RB_PRD-1786	Instrument	Analysis
6.5.4.1 Time Code Data and Format	RB_PRD-1789	Instrument	Inspection
6.5.4.2 Time Code Data Transfer	RB_PRD-1794	Instrument	Test
6.5.4.3 Missing Time Code Data	RB_PRD-1798	Instrument	Test
6.5.5 Internal Observatory Data Communications	RB_PRD-1802	Instrument	Inspection
6.5.5.1 Instrument Data Rates	RB_PRD-1807	Instrument	Inspection
6.5.5.1 Instrument Data Rates	RB_PRD-1808	Instrument	Test
6.6.1 Instrument Fault Detection and Response	RB_PRD-1825	Instrument	Test
6.6.1 Instrument Fault Detection and Response	RB_PRD-1826	Instrument	Analysis
6.6.1 Instrument Fault Detection and Response	RB_PRD-1827	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.6.1.2 Ground Override of Autonomous Functions	RB_PRD-1831	Instrument	Test
6.6.2 Flight Processor	RB_PRD-1834	Instrument	Analysis
6.6.2 Flight Processor	RB_PRD-1873	Instrument	Test
6.6.2 Flight Processor	RB_PRD-1874	Instrument	Test
6.6.2 Flight Processor	RB_PRD-1875	Instrument	Test
6.6.2 Flight Processor	RB_PRD-1876	Instrument	Inspection
6.6.3 Flight Software Detailed Requirements	RB_PRD-1878	Instrument	Inspection
6.6.3.1 Software Revision Number Identification	RB_PRD-1881	Instrument	Inspection
6.6.3.1 Software Revision Number Identification	RB_PRD-1882	Instrument	Test
6.6.3.1 Software Revision Number Identification	RB_PRD-1883	Instrument	Test
6.6.3.1 Software Revision Number Identification	RB_PRD-1884	Instrument	Test
6.6.3.2 Software Cyclic Redundancy Check	RB_PRD-1886	Instrument	Test
6.6.3.2 Software Cyclic Redundancy Check	RB_PRD-1887	Instrument	Test
6.6.3.3 Event Log	RB_PRD-1889	Instrument	Test
6.6.3.3 Event Log	RB_PRD-1890	Instrument	Inspection
6.6.3.4 Processor Watchdog	RB_PRD-1893	Instrument	Test
6.6.3.4 Processor Watchdog	RB_PRD-1894	Instrument	Test
6.6.3.4 Processor Watchdog	RB_PRD-1895	Instrument	Test
6.6.3.4 Processor Watchdog	RB_PRD-1896	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.6.3.5.1 Volatile Memory Error Correction	RB_PRD-1899	Instrument	Inspection
6.6.3.5.2 Memory Cyclic Redundancy Check	RB_PRD-1901	Instrument	Inspection
6.6.3.6 Instrument Memory Dump Capability	RB_PRD-1904	Instrument	Test
6.6.3.6 Instrument Memory Dump Capability	RB_PRD-1905	Instrument	Test
6.6.3.6 Instrument Memory Dump Capability	RB_PRD-1906	Instrument	Test
6.6.3.6 Instrument Memory Dump Capability	RB_PRD-1908	Instrument	Test
6.6.3.6 Instrument Memory Dump Capability	RB_PRD-1909	Instrument	Inspection
6.6.3.6 Instrument Memory Dump Capability	RB_PRD-1910	Instrument	Inspection
6.6.3.6 Instrument Memory Dump Capability	RB_PRD-1911	Instrument	Inspection
6.6.3.7 Memory Load Capability	RB_PRD-1913	Instrument	Test
6.6.3.7 Memory Load Capability	RB_PRD-1915	Instrument	Test
6.6.3.7 Memory Load Capability	RB_PRD-1916	Instrument	Test
6.6.3.7 Memory Load Capability	RB_PRD-1918	Instrument	Inspection
6.6.3.7 Memory Load Capability	RB_PRD-1919	Instrument	Inspection
6.6.3.7.1 Instrument Software and Table Upload Protections	RB_PRD-1921	Instrument	Test
6.6.3.7.1 Instrument Software and Table Upload Protections	RB_PRD-1923	Instrument	Test
6.6.3.7.1 Instrument Software and Table Upload Protections	RB_PRD-1924	Instrument	Test
6.6.3.7.1 Instrument Software and Table Upload Protections	RB_PRD-1925	Instrument	Test
6.6.3.8 Bootstrap and Application Code Environment	RB_PRD-1927	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
6.6.3.8 Bootstrap and Application Code Environment	RB_PRD-1928	Instrument	Inspection
6.6.3.8 Bootstrap and Application Code Environment	RB_PRD-1929	Instrument	Inspection
7.1 Pressure	RB_PRD-1933	Instrument	Analysis
7.2 Magnetic	RB_PRD-1935	Instrument	Test
7.3 Meteoroids and Manmade Orbital Debris	RB_PRD-1937	Instrument	Analysis
7.4 General Radiation	RB_PRD-2226	Instrument	Analysis
7.4.1 Total Ionizing Dose Environment	RB_PRD-2228	Instrument	Analysis
7.4.1 Total Ionizing Dose Environment	RB_PRD-2229	Instrument	Analysis
7.4.1 Total Ionizing Dose Environment	RB_PRD-2230	Instrument	Analysis
7.4.1 Total Ionizing Dose Environment	RB_PRD-2232	Instrument	Analysis
7.4.1 Total Ionizing Dose Environment	RB_PRD-2233	Instrument	Test
7.4.1 Total Ionizing Dose Environment	RB_PRD-2234	Instrument	Inspection
7.4.2.1 Single Events Radiation Environment	RB_PRD-2658	Instrument	Analysis
7.4.2.1 Single Events Radiation Environment	RB_PRD-2659	Instrument	Analysis
7.4.2.1 Single Events Radiation Environment	RB_PRD-2660	Instrument	Analysis
7.4.2.1 Single Events Radiation Environment	RB_PRD-2661	Instrument	Inspection
7.4.2.1 Single Events Radiation Environment	RB_PRD-2662	Instrument	Analysis
7.4.2.1 Single Events Radiation Environment	RB_PRD-2663	Instrument	Analysis
7.4.2.1 Single Events Radiation Environment	RB_PRD-2664	Instrument	Analysis

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7.4.2.1 Single Events Radiation Environment	RB_PRD-2665	Instrument	Test
7.4.2.1 Single Events Radiation Environment	RB_PRD-2666	Instrument	Test
7.4.2.1 Single Events Radiation Environment	RB_PRD-2667	Instrument	Test
7.4.2.1 Single Events Radiation Environment	RB_PRD-2668	Instrument	Test
7.4.2.1 Single Events Radiation Environment	RB_PRD-2669	Instrument	Test
7.4.2.1.1 Galactic Cosmic Ray (GCR) LET Spectrum	RB_PRD-2688	Instrument	Analysis
7.4.2.1.1 Galactic Cosmic Ray (GCR) LET Spectrum	RB_PRD-2689	Instrument	Analysis
7.4.2.1.1 Galactic Cosmic Ray (GCR) LET Spectrum	RB_PRD-2690	Instrument	Analysis
7.4.2.1.2 High Energy Proton Fluence	RB_PRD-3130	Instrument	Analysis
7.4.2.1.2 High Energy Proton Fluence	RB_PRD-3131	Instrument	Analysis
7.4.2.1.2 High Energy Proton Fluence	RB_PRD-3132	Instrument	Analysis
7.4.2.1.2 High Energy Proton Fluence	RB_PRD-3133	Instrument	Analysis
7.4.2.2 Displacement Damage	RB_PRD-3417	Instrument	Analysis
7.4.2.2 Displacement Damage	RB_PRD-3418	Instrument	Analysis
7.4.2.2 Displacement Damage	RB_PRD-3419	Instrument	Inspection
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3717	Instrument	Inspection
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3718	Instrument	Analysis
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3739	Instrument	Inspection
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3740	Instrument	Inspection

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7.4.3 Spacecraft Charging from All Sources	RB_PRD-3741	Instrument	Inspection
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3742	Instrument	Test
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3743	Instrument	Test
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3744	Instrument	Test
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3745	Instrument	Inspection
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3746	Instrument	Inspection
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3747	Instrument	Test
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3748	Instrument	Test
7.4.3 Spacecraft Charging from All Sources	RB_PRD-3749	Instrument	Inspection
7.5 Atomic Oxygen	RB_PRD-3775	Instrument	Analysis
7.6.1 External RF Environment	RB_PRD-3780	Instrument	Test
7.6.1 External RF Environment	RB_PRD-3890	Instrument	Test
7.6.1 External RF Environment	RB_PRD-3891	Instrument	Test
7.7.1 Temperatures	RB_PRD-3896	Instrument	Analysis
7.7.2 Free Molecular Heating	RB_PRD-3900	Instrument	Analysis
8.1 Mission Requirements Verification	RB_PRD-3905	Instrument	Inspection
8.1 Mission Requirements Verification	RB_PRD-3928	Instrument	Inspection
8.1 Mission Requirements Verification	RB_PRD-3929	Instrument	Inspection
8.1 Mission Requirements Verification	RB_PRD-3930	Instrument	Inspection

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8.2.1 Electrical Interface Testing	RB_PRD-3957	Instrument	Test
8.2.1 Electrical Interface Testing	RB_PRD-3958	Instrument	Test
8.2.2 Comprehensive Performance Tests (CPT's)	RB_PRD-3964	Instrument	Test
8.2.2 Comprehensive Performance Tests (CPT's)	RB_PRD-3965	Instrument	Test
8.2.3 Limited Performance Tests (LPT's)	RB_PRD-3970	Instrument	Test
8.2.3 Limited Performance Tests (LPT's)	RB_PRD-3971	Instrument	Test
8.2.5 Flight Hardware Operating Time (Burn-In) and Failure Free Performance	RB_PRD-3984	Instrument	Test
8.3 EMC/EMI Testing	RB_PRD-3987	Instrument	Test
8.3 EMC/EMI Testing	RB_PRD-3988	Instrument	Inspection
8.3 EMC/EMI Testing	RB_PRD-6372	Instrument	Inspection
8.3.1 Radiated Emissions	RB_PRD-3991	Instrument	Test
8.3.1 Radiated Emissions	RB_PRD-3993	Instrument	Test
8.3.3 Radiated Susceptibility	RB_PRD-3998	Instrument	Test
8.3.4 Charging Verification	RB_PRD-4000	Instrument	Test
8.4 Structural and Mechanical Verification Requirements	RB_PRD-4002	Instrument	Test
8.4 Structural and Mechanical Verification Requirements	RB_PRD-4003	Instrument	Test
8.4.1 Structural Loads Qualification	RB_PRD-4075	Instrument	Analysis
8.4.1 Structural Loads Qualification	RB_PRD-4076	Instrument	Test
8.4.1 Structural Loads Qualification	RB_PRD-4077	Instrument	Test

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8.4.1 Structural Loads Qualification	RB_PRD-4078	Instrument	Test
8.4.1 Structural Loads Qualification	RB_PRD-4079	Instrument	Test
8.4.1 Structural Loads Qualification	RB_PRD-4080	Instrument	Test
8.4.1 Structural Loads Qualification	RB_PRD-4081	Instrument	Inspection
8.4.1 Structural Loads Qualification	RB_PRD-4082	Instrument	Analysis
8.4.2 Acoustic Testing	RB_PRD-4084	Instrument	Test
8.4.2.1 Acceptance Level Acoustic Testing	RB_PRD-4086	Instrument	Test
8.4.2.1 Acceptance Level Acoustic Testing	RB_PRD-4087	Instrument	Test
8.4.2.2 Protoflight Level Acoustic Testing	RB_PRD-4089	Instrument	Test
8.4.2.2 Protoflight Level Acoustic Testing	RB_PRD-4090	Instrument	Test
8.4.3 Random Vibration Testing	RB_PRD-4092	Instrument	Test
8.4.3 Random Vibration Testing	RB_PRD-4093	Instrument	Test
8.4.3 Random Vibration Testing	RB_PRD-4094	Instrument	Test
8.4.3 Random Vibration Testing	RB_PRD-4100	Instrument	Test
8.4.3 Random Vibration Testing	RB_PRD-4101	Instrument	Test
8.4.3.1 Random Vibration After Rework	RB_PRD-4106	Instrument	Test
8.4.3.1 Random Vibration After Rework	RB_PRD-4113	Instrument	Test
8.4.3.1 Random Vibration After Rework	RB_PRD-4116	Instrument	Test
8.4.4 Sine Vibration Testing	RB_PRD-4120	Instrument	Test

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8.4.4 Sine Vibration Testing	RB_PRD-4121	Instrument	Test
8.4.4 Sine Vibration Testing	RB_PRD-4122	Instrument	Test
8.4.4 Sine Vibration Testing	RB_PRD-4124	Instrument	Test
8.4.5.1 General	RB_PRD-4142	Instrument	Test
8.4.5.2 Instrument Level Self-Induced Shock Testing	RB_PRD-4147	Instrument	Test
8.5 Mechanism Verification	RB_PRD-4149	Instrument	Test
8.5.1 Mechanism Qualification Testing	RB_PRD-4151	Instrument	Test
8.5.1 Mechanism Qualification Testing	RB_PRD-4152	Instrument	Test
8.5.1 Mechanism Qualification Testing	RB_PRD-4153	Instrument	Test
8.5.1 Mechanism Qualification Testing	RB_PRD-4154	Instrument	Test
8.5.2 Mechanism Acceptance Testing	RB_PRD-4156	Instrument	Test
8.5.2 Mechanism Acceptance Testing	RB_PRD-4157	Instrument	Test
8.5.2 Mechanism Acceptance Testing	RB_PRD-4158	Instrument	Test
8.5.2 Mechanism Acceptance Testing	RB_PRD-4159	Instrument	Test
8.5.2.1 Functional Test Structuring	RB_PRD-4161	Instrument	Test
8.5.2.1 Functional Test Structuring	RB_PRD-4162	Instrument	Test
8.5.2.1 Functional Test Structuring	RB_PRD-4163	Instrument	Test
8.5.2.1 Functional Test Structuring	RB_PRD-4164	Instrument	Test
8.5.2.2 Run-In Testing	RB_PRD-4167	Instrument	Test

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8.5.2.2 Run-In Testing	RB_PRD-4168	Instrument	Test
8.5.2.2 Run-In Testing	RB_PRD-4169	Instrument	Test
8.5.2.2 Run-In Testing	RB_PRD-4170	Instrument	Test
8.5.2.3 Motor Characterization Testing	RB_PRD-4172	Instrument	Test
8.5.2.3 Motor Characterization Testing	RB_PRD-4173	Instrument	Test
8.5.2.3 Motor Characterization Testing	RB_PRD-4183	Instrument	Test
8.5.3 Life Test	RB_PRD-4186	Instrument	Inspection
8.5.3.1 Design Life Verification Tests	RB_PRD-4188	Instrument	Inspection
8.5.3.1 Design Life Verification Tests	RB_PRD-4189	Instrument	Test
8.5.3.1 Design Life Verification Tests	RB_PRD-4190	Instrument	Inspection
8.5.3.1 Design Life Verification Tests	RB_PRD-4191	Instrument	Inspection
8.5.3.1 Design Life Verification Tests	RB_PRD-4192	Instrument	Test
8.5.3.1 Design Life Verification Tests	RB_PRD-4193	Instrument	Test
8.5.3.1 Design Life Verification Tests	RB_PRD-4194	Instrument	Test
8.5.3.1 Design Life Verification Tests	RB_PRD-4195	Instrument	Inspection
8.5.3.1 Design Life Verification Tests	RB_PRD-4196	Instrument	Test
8.5.3.1 Design Life Verification Tests	RB_PRD-4197	Instrument	Test
8.5.3.1 Design Life Verification Tests	RB_PRD-4198	Instrument	Inspection
8.5.3.1 Design Life Verification Tests	RB_PRD-4199	Instrument	Inspection

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
8.5.3.2 Life Test Unit	RB_PRD-4201	Instrument	Inspection
8.5.3.2 Life Test Unit	RB_PRD-4202	Instrument	Analysis
8.5.3.3 Life Test Instrumentations	RB_PRD-4204	Instrument	Test
8.5.3.3 Life Test Instrumentations	RB_PRD-4205	Instrument	Test
8.5.3.3 Life Test Instrumentations	RB_PRD-4206	Instrument	Inspection
8.5.3.4 Life Test Setup	RB_PRD-4208	Instrument	Inspection
8.5.3.4 Life Test Setup	RB_PRD-4209	Instrument	Inspection
8.5.3.4 Life Test Setup	RB_PRD-4210	Instrument	Analysis
8.5.3.4 Life Test Setup	RB_PRD-4211	Instrument	Analysis
8.5.3.5 Life Test Considerations	RB_PRD-4214	Instrument	Test
8.5.3.5 Life Test Considerations	RB_PRD-4215	Instrument	Test
8.5.3.5 Life Test Considerations	RB_PRD-4216	Instrument	Test
8.5.3.5 Life Test Considerations	RB_PRD-4217	Instrument	Inspection
8.5.3.5 Life Test Considerations	RB_PRD-4218	Instrument	Test
8.5.3.5 Life Test Considerations	RB_PRD-4219	Instrument	Inspection
8.6.1 Thermal Vacuum Cycling	RB_PRD-4222	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4223	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4224	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4225	Instrument	Test

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8.6.1 Thermal Vacuum Cycling	RB_PRD-4226	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4227	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4228	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4229	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4230	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4231	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4232	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4233	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4234	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4235	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4236	Instrument	Test
8.6.1 Thermal Vacuum Cycling	RB_PRD-4237	Instrument	Test
8.6.2 Thermal Design Margin (Thermal Balance) Testing	RB_PRD-4239	Instrument	Test
8.6.2 Thermal Design Margin (Thermal Balance) Testing	RB_PRD-4240	Instrument	Test
8.6.2 Thermal Design Margin (Thermal Balance) Testing	RB_PRD-4241	Instrument	Test
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4243	Instrument	Inspection
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4244	Instrument	Test
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4245	Instrument	Test
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4246	Instrument	Test

Paragraph Number and Heading	DOORS ID	Verification Level	Verification Method
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4247	Instrument	Test
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4248	Instrument	Test
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4249	Instrument	Test
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4250	Instrument	Test
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4251	Instrument	Test
8.6.3 Contamination/Bake-Out Requirements	RB_PRD-4252	Instrument	Test
9.1 General I&T Design Requirements	RB_PRD-4255	Instrument	Inspection
9.1 General I&T Design Requirements	RB_PRD-4257	Instrument	Inspection
9.1 General I&T Design Requirements	RB_PRD-4258	Instrument	Inspection
9.1 General I&T Design Requirements	RB_PRD-4259	Instrument	Inspection
9.1 General I&T Design Requirements	RB_PRD-4260	Instrument	Inspection
9.1 General I&T Design Requirements	RB_PRD-4261	Instrument	Inspection
9.1 General I&T Design Requirements	RB_PRD-4262	Instrument	Inspection
9.1 General I&T Design Requirements	RB_PRD-4263	Instrument	Inspection
9.1 General I&T Design Requirements	RB_PRD-4264	Instrument	Inspection
9.2 Ground Support Equipment	RB_PRD-4267	Instrument	Inspection
9.2 Ground Support Equipment	RB_PRD-4268	Instrument	Inspection
9.2 Ground Support Equipment	RB_PRD-4275	Instrument	Demonstration
9.2 Ground Support Equipment	RB_PRD-4277	Instrument	Inspection

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9.2.1 Electrical Ground Support Equipment (EGSE)	RB_PRD-4279	Instrument	Inspection
9.2.1 Electrical Ground Support Equipment (EGSE)	RB_PRD-4281	Instrument	Inspection
9.2.1 Electrical Ground Support Equipment (EGSE)	RB_PRD-4282	Instrument	Inspection
9.2.1 Electrical Ground Support Equipment (EGSE)	RB_PRD-1356	Instrument	Inspection
9.2.1 Electrical Ground Support Equipment (EGSE)	RB_PRD-1357	Instrument	Inspection
9.2.1.1 Instrument GSE to Spacecraft I&T GSE Interface	RB_PRD-4285	Instrument	Test
9.2.1.1 Instrument GSE to Spacecraft I&T GSE Interface	RB_PRD-4286	Instrument	Test
9.2.1.1 Instrument GSE to Spacecraft I&T GSE Interface	RB_PRD-4287	Instrument	Test
9.2.1.1 Instrument GSE to Spacecraft I&T GSE Interface	RB_PRD-4288	Instrument	Test
9.2.1.1 Instrument GSE to Spacecraft I&T GSE Interface	RB_PRD-4289	Instrument	Inspection
9.2.1.2 Instrument GSE Requirements	RB_PRD-4291	Instrument	Test
9.2.1.2 Instrument GSE Requirements	RB_PRD-4292	Instrument	Test
9.2.1.2 Instrument GSE Requirements	RB_PRD-4293	Instrument	Inspection
9.2.1.2 Instrument GSE Requirements	RB_PRD-4294	Instrument	Test
9.2.2.1 MGSE Functional Requirements	RB_PRD-4298	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4302	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4303	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4304	Instrument	Test
9.2.2.2 MGSE Design Requirements	RB_PRD-4305	Instrument	Inspection

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9.2.2.2 MGSE Design Requirements	RB_PRD-4306	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4307	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4308	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4309	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4310	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4311	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4312	Instrument	Inspection
9.2.2.2 MGSE Design Requirements	RB_PRD-4313	Instrument	Inspection
10.1 Ambient Environment Requirements	RB_PRD-4317	Instrument	Analysis
10.1 Ambient Environment Requirements	RB_PRD-4318	Instrument	Analysis
10.1 Ambient Environment Requirements	RB_PRD-4319	Instrument	Analysis
10.2 Packaging Requirements	RB_PRD-4321	Instrument	Inspection
10.2 Packaging Requirements	RB_PRD-4322	Instrument	Inspection
10.3 Observatory Handling	RB_PRD-4324	Instrument	Analysis
10.3 Observatory Handling	RB_PRD-4325	Instrument	Inspection
10.4 Transportation Requirements	RB_PRD-4327	Instrument	Inspection
10.4 Transportation Requirements	RB_PRD-4329	Instrument	Inspection
10.4 Transportation Requirements	RB_PRD-4330	Instrument	Inspection
10.4 Transportation Requirements	RB_PRD-4331	Instrument	Inspection

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10.4 Transportation Requirements	RB_PRD-4332	Instrument	Inspection
10.4 Transportation Requirements	RB_PRD-4333	Instrument	Inspection
10.5 Environment for Storage	RB_PRD-4335	Instrument	Inspection
11.1 Verification Cross Reference	RB_PRD-4338	Instrument	Inspection