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DOCUMENT CHANGE NOTICE

1. ORIGINATOR NAME AND ADDRESS	2. APPROVED DATE	4. DOCUMENT NO.
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10. CONFIGURATION ITEM NOMENCLATURE	11. EFFECTIVITY
General Instrument Interface Specification (GIIS)	

THIS NOTICE INFORMS RECIPIENTS THAT THE DOCUMENT IDENTIFIED BY THE NUMBER (AND REVISION LETTER) SHOWN IN BLOCK 4 HAS BEEN CHANGED. THE PAGES CHANGED BY THIS DCN BEING THOSE FURNISHED HEREWITH AND CARRYING THE SAME DATE AS THIS DCN. THE PAGES OF THE PAGE NUMBERS AND DATES LISTED BELOW IN THE SUMMARY OF CHANGED PAGES, COMBINED WITH NON-LISTED PAGES OF THE ORIGINAL ISSUE OF THE REVISION SHOWN IN BLOCK 4, CONSTITUTE THE CURRENT VERSION OF THIS DOCUMENT.

12. DOCUMENT	13. PAGES CHANGED (INDICATE DELETIONS)	*S	*A	14. DATE
420-03-02, Rev. A				
CH-02	Pages iv, v-a, and page D-9	X		04/11/94
CH-03	Pages iv through v-b, ix, xiv through xvi, xviii through xx, xxii, xxvii through xxix, 2-1, 3-13, 3-26, 3-27, 4-1 through 4-3, 5-4 through 5-6, 5-9 through 5-11, 6-3 through 6-6, 6-11, 6-13 through 6-15, 6-17, 6-18, 7-3, 7-4, 7-11, 10-3, 10-6, 10-11, C-7, C-16, C-18, C-19, C-24, C-27, C-29, D-8, D-19, D-20, D-22, D-27, D-28, D-31 and page D-34	X		04/11/94
	Pages xv-a, xv-b, 3-14a, 3-14b, 5-6a, 5-6b, 10-5a, 10-5b, C-7a, C-7b, C-18a, C-18b, D-8a, D-8b, D-20a, D-20b, D-22a, and page D-22b were added by this change due to the wrap-around process.		X	04/11/94

15. TECHNICAL CONCURRENCE R Taylor DATE 4-18-94

EOS 420-CM-02 (4/92) "S" INDICATES SUPERSEDES EARLIER PAGE "A" INDICATES ADDED PAGE

April 18, 1994

TO: Distribution

FROM: EOS AM Accommodations Manager / R. Taylor

SUBJ: TRANSMITTAL OF CHANGE 2/3 TO GENERAL INSTRUMENT INTERFACE SPECIFICATION (GIIS)

ENCL: (1) Change Itemization
(2) Complete GIIS with Change 2/3 Incorporated

Enclosed for your use is Change 2/3 to the General Instrument Interface Specification (GIIS). The change reflects several changes to the C&DH interface which were discussed during the series of C&DH colloquia conducted be MMC with each instrument team. The change reflects the resolution of review comments which were received from the instrument teams.

One change which was contained in the proposed change package but which is not contained in the enclosed change is test packet requirements. These requirements will be proposed in the GIIS change 4 package to be circulated shortly for review. GIIS change 4 will include proposed reduced loads, and is planned to resolve all remaining TBRs for spacecraft CDR.

Instrument Managers - Please implement this change to the GIIS with your instrument teams.

If there are any questions on this matter, please contact the undersigned at 301-286-1271.

R. Taylor

GIIS Change 2 and 3 Justification - Approved by CCR 421-13-11-014

CHANGE 2

1. Table 50-1 Verification Responsibility and Methods Matrix

For both sections 3.7.6.2.2.1 (Torque Allowables) and 3.7.6.2.3.1 (Force Allowables) change verification responsibility from Spacecraft Provider to Instrument Provider, and change method from Inspection/Analysis, to Analysis/Test.

JUSTIFICATION: For correction of verification matrix, these parameters are instrument design and therefore can only be verified by the instrument.

CHANGE 3

1. Revise Section 2 - Applicable Documents Cited in the GIIS

FROM:

GE PN20008569 15 January 1993	EOS Observatory Electromagnetic Compatibility Control Plan

TO:

GE PN20008569 28 June 1993	EOS Observatory Electromagnetic Compatibility Control Plan

JUSTIFICATION: A new version of this document has been released.

2. Add the following section and Table 3-3a (see attached):

3.7.3.5 Sine Vibration Levels

The instrument interface shall be designed to withstand the qualification and acceptance sine vibration environment specified in Table 3-3a.

JUSTIFICATION: Martin Marietta and GSFC have agreed that sine vibration testing of the instrument is necessary. This CCR places the agreed upon sine vibration test environments for the instruments into the GIIS.

3. Revise dimension on Figure 3-8:

FROM: Dimension from the edge of the cold plate to the fourth row of holes is "10.755".

TO: Dimension from the edge of the coldplate to the fourth row of holes should be "10.775".

JUSTIFICATION: Typographical error was made when figure was updated in CH-1.

4. Revise section 3.13.5 as follows:

FROM: Coldplate plumbing clearances shall be as shown in (TDB 003).

TO: Coldplate plumbing clearances shall be agreed to by the instrument and spacecraft providers and documented in the Instrument ICD.

JUSTIFICATION: Plumbing clearance is dependent on instrument design and should be addressed on a case by case basis. The instrument ICD is the appropriate place to document this agreement.

5. Section 4.3.1.1: Delete TBR009. The value of this parameter (maximum allowable heat flux averaged over the spacecraft interface) has been finalized.

6. Section 4.4.2.2: Delete TBR010. The value of this parameter (maximum allowable temperature gradient across cold plate mechanical interface filler) has been finalized.

7. Section 4.6.1.5: Delete TBR011. The value of this parameter (thermal conductivity of cold plate filler material) has been finalized.

8. Delete section 5.2.2.3.2 (Instrument Conducted Common Mode Current).

JUSTIFICATION: This requirement exists in both the GIIS and EMC Control Plan. To avoid double spec'ing GSFC has requested that this requirement be deleted from the GIIS and remain in the EMC Control Plan which is invoked by the GIIS.

9. Revise section 5.2.2.4.2 as shown in the attached.

JUSTIFICATION: Spacecraft PDR design and analysis results, and reduction of power subsystem design power, permit the instrument differential mode impedance requirement to the reduced as shown in the attached.

10. Add section 5.3.2.3:

5.3.2.3 Passive Telemetry Interface Isolation
The instrument shall isolate passive bi-level and passive analog interfaces from chassis reference by >= 100 Kohms.

JUSTIFICATION: For consistency with GIS, this requirement is added to GIIS.

11. Delete section 5.3.5.2.1 because this requirement is covered in the EMC Control Plan.

12. Delete section 5.3.5.2.2 beacause this requirement is covered in the EMC Control Plan.

13. Add section 5.3.5.2.3:

5.3.5.2.3 Thermal Closeout Blanket Grounding

The spacecraft provider shall ensure that the thermal insulation blankets used for instrument closeout are electrically isolated from the instrument/instrument blankets.

JUSTIFICATION: The installation of the thermal blankets between the instrument and the spacecraft was not previously specified. The instrument ground islands require a single designated path between the instrument and the SRP. The thermal blankets which are used to close out the space between the instrument and the spacecraft must not provide a secondary path.

14. Revise section 6.1.2.4.2:

FROM: The command and telemetry bus task schedule shall allow for the transfer of a maximum of one command message on the bus once every other minor cycle.

TO: The command and telemetry bus task schedule shall allow for the transfer of a maximum of one command message on the bus once every minor cycle.

JUSTIFICATION: Design efforts to develop the command and telemetry bus transfer schedule have determined the need for more command message transfer slots. The limitation to once every other minor cycle was very constraining and would significantly limit the command transfer rate on the C&T bus. This revision reflects the maximum possible command transfer rate to a single C&T RT consistent with the bus utilization schedule.

15. Revise Section 6.1.2.4.3: Delete the paragraph following the section header 6.1.2.4.3.

JUSTIFICATION: This requirement is much too constraining on the design team in trying to maximize the bus utilization and develop the command and telemetry bus task schedule. The important requirements for the instrument are the requirements stated in the subsequent subsections 6.1.2.4.3.1, 6.1.2.4.3.2, and 6.1.2.4.3.3 which are not affected by this change.

16. Revise section 6.1.2.4.5:

FROM: The command and telemetry bus task schedule shall allow for a transfer of a data message containing memory dump data on the bus once every sixth minor cycle.

TO: The command and telemetry bus task schedule shall allow for a transfer of a data message containing memory dump data on the bus no sooner than once every sixth minor cycle or no later than once every 128 minor cycles.

JUSTIFICATION: This change is requested for two reasons:
a. The CTIU is required to support memory dump operations at a 1 kbps

downlink rate (which translates to a transfer every 128 minor cycles) and at a 16 kbps downlink rate (which translates to a transfer once every 6 minor cycles).
b. In addition, the CTIU has many periodic samples which must be gathered at very deterministic intervals. The current requirement for a memory dump message transfer once every 6th minor cycle causes conflicts in the scheduling of these periodic transfers.

17. Replace Figure 6-5 with updated figure attached. Changes are:
a. Change the mode code at the poll from "MC" to "MC1" and the mode code for end of transfer (EOT) from "MC DA" to "MC2".
b. MC2 changes from a "synchronize with data word" to a "synchronize without data word".
c. Revise packet definition in the Legend and subaddress equation.
d. Added Note in the Legend.

JUSTIFICATION: The EOT was changed to synchronize without data word since returning the status word with the number of words validated was redundant with the transfer validation function provided by 1553. Items a-b, for clarity it is prudent to identify the two different mode codes specifically. The EOT mode code was changed since operationally the "synchronize-with-data-word" was eliminated on the Low Rate Science Bus in previous changes to Table 6-1.

18. Revise section 6.3.5.8.4:

FROM: 6.3.5.8.4 End-of-Transfer Data Word Content - The BC shall end each packet transfer with a synchronize-with-data-word with the data word containing the number of 16-bit words validated by the BC.

TO: 6.3.5.8.4 End-of-Transfer - The BC shall end each packet transfer with a synchronize-without-data-word.

JUSTIFICATION: The EOT has been changed to a synchronize without-data-word in Figure 6-5 since no instruments were interested in using the data word content. This change makes the text consistent with Figure 6-5.

19. Revise Figure 6-6 data zone limits:

FROM: High Rate Science Data "X" Bits=8144 bits or less
Low Rate Science Data "X" Bits=61392 bits or less

TO: High Rate Science Data "X" Bits=976 bits (minimum) to 8144 bits (maximum)
Low Rate Science Data "X" Bits=976 bits (minimum) to 61392 bits (maximum)

JUSTIFICATION: Sending numerous very small packets to the SFE will generate too many interrupts and results in the inability of the SFE to maintain the service schedule for each of the instruments. Therefore, to ensure that the SFE is able to maintain the schedule and service al' the instruments in a timely manner without increasing the complexity o the software a great deal, it is necessary to state a minimum packet size. This change also supports the EOS ground system by incorporating a minimum packet size requirement and consequently eliminating the possibility of very small packets and a high packet rate to the ground system.

20. Table 6-6: Delete TBR017. The values of these parameters (low rate science bus subaddresses) have been finalized.

21. Delete section 6.3.5.8.1.

JUSTIFICATION: A result of establishing a minimum packet size of 1024 bits, including header for low rate science, a packet will never fit within a single 1553 message, thus making this requirement irrelevant.

22. Figure 6-7 (High Rate Link Timing)

FROM: CIR = Current Instrument's Rate-of-Transfer per link

TO: Instrument peak rate of transfer per high rate science data link (peak rate is peak allocation in UIID)

JUSTIFICATION: For clarification of definition of CIR. This parameter is important to high rate link timing requirements (time between 2 packets, or T2P).

23. Revise section 7.2.2.2.1.1:

FROM: The time tag for absolute time commands shall have a resolution of 128 milliseconds.

TO: The time tag for absolute time commands shall have a resolution of 1.024 seconds.

JUSTIFICATION: As a result of the FSWS Concept Review GSFC written action item by GSFC, it was determined that the ground operations personnel work with seconds rather than milliseconds. The current baseline now has a maximum of 8 ATCs having the same time tag. The minimum time between adjacent time tags of different values is 1.024 seconds. The spacecraft timing of transfers is based on 1.024 second major cycles and 8 ms minor cycles. Only one command transfer to an instrument can be accomplished in a minor cycle and a maximum of 8 transfers accomplished in a major cycle and provide adequate service to all RTs on the bus. The spacecraft is only capable of servicing the command time tags that are valid during the major cycle and cannot service any more time tags that become valid during that major cycle until the next major cycle. Therefore, it is not necessary to make the time tag resolution any finer than the time resolution of a major cycle.

24. Revise section 7.2.2.2.1.2:

FROM: Absolute time commands shall be sent to the instrument within 500 milliseconds after the instant when the command time tag and the spacecraft time are equal.

TO: Absolute time commands shall be sent to the instrument within 1.0 seconds after the instant when the command time tag and the spacecraft time tag are equal.

JUSTIFICATION: See item 29.

25. Revise section 7.2.2.2.1.3:

FROM: All absolute time command stored by the spacecraft shall have a unique time tag.

TO: There shall be a maximum of 8 absolute time commands total stored by the spacecraft with the same time tag.

JUSTIFICATION: See item 29.

26. Revise section 7.2.2.2.2.4:

FROM: The time delay between relative time commands in a RTS shall be an integer multiple (>0) of 128 msecs having a maximum value of 8388 seconds.

TO: The time delay between relative time commands in a RTS shall be an integer multiple (>0) of 1.024 seconds having a maximum value of 65,535 seconds.

JUSTIFICATION: See item 29.

27. Global change to sections 6 and 7: Change all instances of "SCC OK" to "IMOK".

JUSTIFICATION: In all spacecraft documentation, the "SCC OK" is the signal from the SCC to the CTIU which triggers the CTIU to send the "IMOK" to the instruments according to the C&T bus task schedule. There is a subtle differentiation between these two terms and for consistency between all program documentation the GIIS should be updated.

28. Revise section 7.5.2.1.1 as follows:

FROM: Upon receipt of the ... after 5 major cycles...

TO: Upon receipt of the ... for 5 consecutive major cycles ...

JUSTIFICATION: Reworded for clarification.

29. Revise section 10.3 as follows:

FROM: The spacecraft shall provide the following...
... d. Pointing jitter (over 1 sec) to within (TBD007) arcsec/axis (3 sigma).

TO: The spacecraft design shall be consistent with pointing performance at the instrument interface as allocated in the UIID.

JUSTIFICATION: Pointing performance allocations have been negotiated with the individual instruments and documented in the individual instrument UIIDs thus eliminating the need for the general requirements in the GIIS.

GENERAL INSTRUMENT INTERFACE SPECIFICATION

EOS-AM PROJECT

December 1, 1992
Rev. A

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

GENERAL INSTRUMENT INTERFACE SPECIFICATION

EOS–AM PROJECT

December 1, 1992
Rev. A

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(GIIS)

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This is a Project Office Controlled Document. Changes require prior approval of the Project Manager. Proposed changes shall be submitted to the EOS Project Configuration Management Officer (Code 421).

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CHANGE RECORD PAGE

CH-1

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1 INTRODUCTION

1.1 Scope

The interfaces between the Instrument and the Earth Observing System (EOS) Spacecraft and instrument accommodation equipment are controlled through the use of three documents. In hierarchical order, these are:

a. Unique Instrument Interface Document (UIID)
b. General Instrument Interface Specification (GIIS)
c. Interface Control Document (ICD)

In addition, the following provides explanatory information:

d. General Instrument Interface Specification Handbook (GIIS Handbook)

Any areas in which significant cost reduction to the total project could be realized by the change or relaxation of these requirements should be considered in developing the design. These modifications shall be brought to the attention of the Project for approval.

1.1.1 Unique Instrument Interface Document

Each UIID allocates Spacecraft resources to a specific instrument. It documents exceptions to the GIIS and GSFC 420–05–01, defines constraints and restraints imposed by that instrument on the Spacecraft and instrument accommodation equipment, and defines special accommodations to be provided for that instrument. It is controlled and maintained by the NASA GSFC EOS AM Project (Code 421), and represents an agreement between the Instrument Providers and the NASA GSFC EOS AM Project. The UIID is contractually imposed on the Spacecraft and Instrument Accommodation Equipment Provider.

1.1.2 General Instrument Interface Specification

The GIIS specifies the instrument interface requirements and defines the environments to which the Spacecraft will be subjected. It is controlled and maintained by the National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC). CH–1
The GIIS is contractually imposed on the Instrument, Spacecraft, and Instrument Accommodation Equipment Providers.

1.1.3 Interface Control Documents

Each ICD describes in detail the design implementation of the interfaces between a specific instrument and the Spacecraft and instrument accommodation equipment that meets the requirements of the GIIS and UIID. It is controlled and maintained by the Martin Marietta CH–1
Company (MMC) EOS Program, and represents an agreement between the Instrument Provider and MMC.

Instrument interfaces will be documented in one of five ICDs associated with each instrument. These ICDs describe the details of the electrical, mechanical, thermal, ground support equipment, and command and data handling interfaces.

1.1.4 General Instrument Interface Specification Handbook

The GIIS Handbook is a companion document to the GIIS. It provides further explanation of the Spacecraft–to–instrument interfaces as specified in the GIIS and, where applicable, describes the implementation of a requirement in the Spacecraft design. The GIIS Handbook is controlled and maintained by the MMC EOS Program. Its organization parallels the GIIS such that information relative to a specific requirement in the GIIS can be located under the same section heading in the GIIS Handbook. Although the GIIS Handbook is for information only, frequent referral to its explanatory material is recommended. CH–1

1.2 Change Authority

Changes to the GIIS are controlled by the EOS Systems Configuration Control Board in accordance with GSFC 420–02–02.

1.3 Terminology

Certain terminology is used consistently throughout the GIIS and GIIS Handbook, and are discussed in the following paragraphs. Abbreviations and Acronyms appear in Appendix B, Section 30.

Component – The EOS–AM mission instrument components are: (ASTER) MPS, CSP, SWIR, TIR, VEL, VSR; (CERES) CERES–FORE, CERES–AFT; MISR; MODIS; MOPITT.

Dimensions – All drawing dimensions are in millimeters. English values, when also reported, are given in inches.

Fixed–Base – For modeling purposes the fixed–base configuration of a component attached to its mounting surface means that the interface degrees of freedom fixed at the interface are only those restrained at the interface. For a bolted joint, only three translational degrees of freedom are restrained. There is no moment or torsion constant.

Instrument – The EOS–AM mission instruments are: ASTER, CERES, MISR, MODIS and MOPITT.

Instrument Accommodation Equipment – Equipment required to interface the Instrument to the Spacecraft.

Instrument Housekeeping Telemetry – The set of instrument data that is used, both on–board and on the ground, to determine and maintain the health and status of, and to operate the Instrument. Examples are instrument status and critical temperatures.

Safe Mode – A critical mode in which a fault(s) has occurred with the Spacecraft control computers or its support systems or loss of precision attitude control. The control of the Spacecraft is passed to a backup processor which maintains the Spacecraft in an Earth–oriented, or sun–pointing attitude once safe mode is obtained. However, there is no guarantee an Earth–oriented attitude will be maintained during transition to safe mode. During Spacecraft safe mode, each instrument and housekeeping subsystem will configure to a predefined state. The instrument safe mode will be a non–science data–generating state in which the Instrument is in a reduced power standby state. Spacecraft services available during safe mode will be as follows: **(TBD 001)** CH–1

Spacecraft – A fully integrated Spacecraft comprised of the Spacecraft bus and its payload.

Spacecraft Bus – The integrated assemblage of equipment which provides all housekeeping resources and services necessary to support the operations of an instrument set, including: mechanical support and alignment; attitude control; orbit determination and guidance; electrical power; temperature control and excess heat rejection; data communications; and data formatting, storage, and routing.

Survival Limits – The minimum temperature limits at which an instrument can be maintained indefinitely without affecting the ability of the Instrument to return to normal operations.

Survival Mode – A power–critical mode in which a fault(s) seriously threatens the health and safety of the Spacecraft. Transition into the survival mode will cause nonessential housekeeping equipment and instruments to power down with power available only for survival equipment. The Spacecraft control computer will maintain full control of the Spacecraft while in the survival mode.

Units – In general, SIU units are utilized to define the interface requirements. In the event that an item is manufactured in other units, these units will be used in requirement specification. For example, if English inserts are utilized for mounting the associated dimensions (diameter + thread) will be specified in English units (inches + threads per inch).

2 DOCUMENTS

2.1 Applicable Documents

The following documents of the exact issue shown form a part of the GIIS to the extent specified herein. In the event of a conflict between the documents referenced herein and the contents of this document, the order of precedence shall be as follows:

a. Contractual documents between NASA and the Instrument Providers
b. UIIDs
c. GIIS
d. Instrument ICDs

Applicable Documents Cited in the GIIS

ANSI X3.148–1988	Fiber Distributed Data Interface (FDDI) Token Ring Physical Layer Protocol (PHY)	
CCSDS 301.0–B–2	Recommendation for Space Data System Standards, Time Code Formats	
CCSDS 701.0–B–1	Recommendation for Space Data System Standards, Advanced Orbiting Systems, Networks and Data Links	
EIA–RS–422–A December 1978	Electronic Industries Association Standard Electrical Characteristics of Balanced Voltage Interface Circuits	
GE PN20005869 28 June 1993	EOS Observatory Electromagnetic Compatibility Control Plan	CH–3
GE20008607 10 March 1992	Ground Rules and Assumptions for Failure Modes and Effects Analysis (FMEA) (PA–500)	
GE20008579 24 June 1992	EOS–AM Spacecraft Requirements for Instrument Handling Fixtures	
GSFC 420–05–01 02 August 1991	Earth Observing System Performance Assurance Requirements for General Instruments	
GSFC 420–05–02, Rev. B 14 May 1992	Earth Observing System (EOS) Performance Assurance Requirements for the EOS Observatories	
GSFC–S–311–P–4/7 July 1973	Connectors, Electrical, Subminiature, Polarized Shell, High Density, for Space Flight Use, Detailed Specification for	CH–1
GSFC–S–311–P–4/9 July 1974	Connectors, Electrical, Polarized Shell, for Space Flight Use, Detailed Specification for	
GE IS20008503 26 August 1992	EOS–AM Spacecraft to Launch Vehicle Interface Requirements Document (ICD–103)	

JSC–22964 Version P–22, April 1988	Thermal Radiation Analyzer System (TRASYS) User's Manual
MCR–86–594 Version 2.2, Rev. 3	Systems Improved Numerical Differencing Analyzer and Fluid Integrator (SINDA '85/FLUINT) User's Manual
MIL–C–38999J 6 April 1990	Military Specification, Connectors, Electrical, Miniature, Quick Disconnect, ..., General Specification For CH–1
MIL–STD–1515A June 1981	Military Standard Fastener Systems for Aerospace Applications
MIL–STD–1522A 28 May 1984	Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems
MIL–STD–1553B, Notice 2 8 September 1986	Military Standard Aircraft Internal Time Division Command/Response Multiplex Data Bus
MSR–39 ISSN 0741–8019 November 1985	MacNeal–Schwendler Corporation (MSC)/NASTRAN Version 65 User's Manual
WSMCR 127–1 December 1989	Western Space and Missile Center Range Safety Regulations CH

2.2 Reference Documents

The following documents form a part of the GIIS for reference and information purposes only. They do not explicitly define requirements on the instruments as delineated herein.

GE 20008501, Rev. 1 March 13, 1992	Earth Observing System (EOS) General Interface Specification Handbook
GSFC 420–02–02 26 January 1990	Earth Observing System Configuration Management Plan

3 MECHANICAL REQUIREMENTS

All requirements specified in Section 3 shall be met at the mechanical interface and be consistent with the UIID allocations. For convenience, Table 3–1 summarizes the hardware responsibility.

3.1 Mechanical Interface Definitions

3.1.1 Spacecraft Mounting Interface Definition

The Spacecraft mounting interface is at the surface(s) of the Spacecraft where the Instrument is in contact with the Spacecraft.

3.1.2 Coldplate Mechanical Interface Definition

The coldplate mechanical interface is at the surface of the thermally conductive filler material which contacts the Instrument.

3.2 Envelopes

3.2.1 Instrument Envelope Allocation

3.2.1.1 Instrument Launch Phase Envelope

Instrument components in the launch configuration shall be contained within the instrument launch envelope as allocated in the UIID.

3.2.1.2 Instrument On–Orbit Envelope

Instrument components in the on–orbit configuration shall be contained within the instrument on–orbit envelope as allocated in the UIID.

3.2.2 Instrument Envelope Documentation

Each instrument component envelope shall be documented in the Instrument ICD with an accuracy of +0.0/–2.5 millimeters (mm).

3.2.3 External Configuration Changes

For an instrument with mechanisms that cause a change in the external envelope or external surfaces of the Instrument, the initial and final configurations, as well as the swept volumes, shall be documented in the Instrument ICD.

3.3 Fields of View

3.3.1 Fields–of–View Allocation

All instrument science and radiative cooler fields–of–view shall be within the UIID allocation.

TABLE 3-1. MECHANICAL INTERFACE HARDWARE RESPONSIBILITY

Section	Hardware	Responsibility
3.5.3.1	Mounting Hardware	Spacecraft Provider
3.5.4.1	Kinematic Mounts	Spacecraft Provider
3.5.4.1.1	Test Kinematic Mounts	Spacecraft Provider
3.5.4.1.2	Flight Kinematic Mounts	Spacecraft Provider
3.5.8.3	Optically Aligned Component Drill Template	Spacecraft Provider
3.5.8.4	Non-optically Aligned Component Drill Template	Instrument Provider
3.6.1	Instrument Optical Alignment Cube	Instrument Provider
3.9	Instrument Mass Model	Spacecraft Provider
3.12.1.3	Coldplate Mounting Hardware	Spacecraft Provider
3.12.3	Coldplate Drill Template	Spacecraft Provider
3.13.1	Coldplate Plumbing	Spacecraft Provider
3.13.2	Coldplate Plumbing Supports	Per Agreement
3.14.1	Instrument Accommodation Harnesses	Spacecraft Provider
3.14.1	Intra-Instrument Harnesses	Spacecraft Provider
3.14.4.1	Harness Tie Points	Per Agreement
3.14.5.5.1	Connectors Attached to Harnesses	Spacecraft Provider
3.14.5.5.2	Connectors Attached to the Instrument Components	Instrument Provider
3.14.5.6.2	Flight Plugs	Spacecraft Provider
3.14.5.7	Connector Protective Covers	Instrument Provider
3.14.5.9.1	Intra-Instrument Test Tees and Breakout Boxes	Instrument Provider
3.14.5.9.2	Instrument-to-Spacecraft Test Tees and Breakout Boxes	Spacecraft Provider
3.14.5.10.2	Buffer Connectors and Connector Savers	Instrument Provider
3.16	Handling Fixtures	Instrument Provider

3.3.2 Fields–of–View Accommodation

The Spacecraft Provider shall accommodate the instrument fields–of–view as allocated in the UIID.

3.3.3 Fields–of–View Documentation

The actual instrument fields–of–view shall be documented in the Instrument ICD.

3.4 Mass Properties

3.4.1 Instrument Mass Allocation

The instrument mass shall be less than or equal to that allocated in the UIID.

3.4.2 Instrument Mass Measurement

The mass of the Instrument shall be measured to ± 0.05 kilograms (kg).

3.4.3 Instrument Mass Documentation

The mass of the Instrument shall be documented in the Instrument ICD.

3.4.4 Instrument Mass Property Report

The Instrument Provider shall provide to GSFC a report containing the mass, center of mass, moments of inertia, and products of inertia for each component of the Instrument. If the Instrument contains movable masses, expendable masses, or deployables, the respective variations are to be documented in the report.

3.4.5 Instrument Mass Variability

3.4.5.1 Instrument Mass Variability Allocation

Any variability of the mass of the Instrument over the mission life shall be within the UIID allocation.

3.4.5.2 Instrument Mass Variability Documentation

Mass expulsion rate(s) and substance(s) shall be documented in the Instrument ICD.

3.4.6 Center of Mass Documentation

The launch and on–orbit center of mass of each instrument component shall be measured and reported to ±5 mm, referenced to the instrument coordinate axes as documented in the Instrument ICD.

3.4.7 Moments of Inertia

3.4.7.1 Moments of Inertia Determination

The moments of inertia of each component of the Instrument shall be measured or calculated.

3.4.7.2 Moments of Inertia Accuracy

Moments of inertia values shall be accurate to within ±10%.

3.4.7.3 Moments of Inertia Documentation

The moments of inertia of each component of the Instrument shall be documented in the Instrument ICD, referenced to the instrument coordinate axes.

3.4.7.4 Moments of Inertia Variation Documentation

If the Instrument contains movable masses, expendable masses, or deployables, the moments of inertia variations shall be documented in the Instrument ICD.

3.4.8 Products of Inertia

3.4.8.1 Products of Inertia Determination

The products of inertia of each component of the Instrument shall be measured or calculated.

3.4.8.2 Products of Inertia Accuracy

Products of inertia values shall be accurate to within ±10%.

3.4.8.3 Products of Inertia Documentation

The products of inertia of each component of the Instrument shall be documented in the Instrument ICD, referenced to the instrument coordinate axes.

3.4.8.4 Products of Inertia Variation Documentation

If the Instrument contains movable masses, expendable masses, or deployables, the products of inertia variations shall be documented in the Instrument ICD.

3.5 Mounting

3.5.1 Mounting Method

The method by which each instrument component is mounted to the Spacecraft shall be as defined in the UIID.

3.5.2 Mounting Interface

3.5.2.1 Mounting Interface Documentation

The mounting interface for each instrument component shall be documented in the Instrument ICD.

3.5.2.2 Mounting Hole Coordinates and Dimensions

Coordinates and dimensions of the actual holes for mounting bolts and inserts shall be specified at the mechanical interface.

3.5.3 Mounting Hardware

3.5.3.1 Mounting Hardware Provider

The Instrument mounting hardware shall be provided by the Spacecraft Provider.

3.5.3.2 Mounting Hardware Documentation

Instrument mounting hardware shall be defined and documented in the Instrument ICD.

3.5.3.3 Mounting Bolts

Mounting bolts shall be per MIL–STD–1515A.

3.5.4 Kinematic Mounts

3.5.4.1 Kinematic Mount Provider

The Spacecraft Provider shall provide all kinematic mounts.

3.5.4.1.1 Test Kinematic Mount Delivery

The Spacecraft Provider shall provide a complete set of test kinematic mounts on a schedule that is negotiated between the Spacecraft Provider and Instrument Provider.

3.5.4.1.2 Flight Kinematic Mount Delivery

The Spacecraft Provider shall provide the flight kinematic mount bearing assemblies to the Instrument Provider on a schedule that is negotiated between the Spacecraft Provider and Instrument Provider.

3.5.4.1.3 Instrument Kinematic Mount Assembly

The Instrument shall be delivered to the Spacecraft Provider with the flight kinematic mount bearing assemblies installed.

3.5.4.2 Kinematic Mount Characteristics

3.5.4.2.1 Kinematic Mount Structure

The kinematic mount shall consist of a bearing assembly which is attached to the Instrument and a strut assembly which is attached to the Spacecraft. The kinematic mount structure shall be consistent with the assemblies shown in Figures 3–1, 3–2, and 3–3. CH–1

3.5.4.2.2 Kinematic Mount Breakaway Torque

The kinematic mount bearing assembly shall have a no load breakaway torque of ≤50 (TBR 001) inch–pounds.

3.5.4.2.3 Kinematic Mount Angular Freedom of Movement

The kinematic mount bearing assembly shall have an angular freedom of movement of ≤ ±2.5 (TBR 002) degrees around the kinematic mount strut shaft.

3.5.4.2.4 Kinematic Mount Thermal Conductance

The kinematic mount assembly thermal conductance from the Instrument to the Spacecraft shall be 0.05 ± 0.02 (TBR 003) watts (W)/degree Centrigrade (C).

3.5.4.3 Kinematic Mounting

Instrument components requiring alignment knowledge shall be kinematically mounted and supported at three points.

3.5.4.3.1 Three–Point Kinematic Mount

Three–point kinematic mounting attachments shall consist of one KM3, one KM2, and one KM1 as identified below.

3.5.4.3.1.1 KM1

The KM1 shall restrain translational motion in one axis normal to the mounting plane.

3.5.4.3.1.2 KM2

The KM2 shall restrain translational motion in two perpendicular axes with one axis restraining motion normal to the mounting plane.

3.5.4.3.1.3 KM3

The KM3 shall restrain translational motion in three perpendicular axes.

CH-1

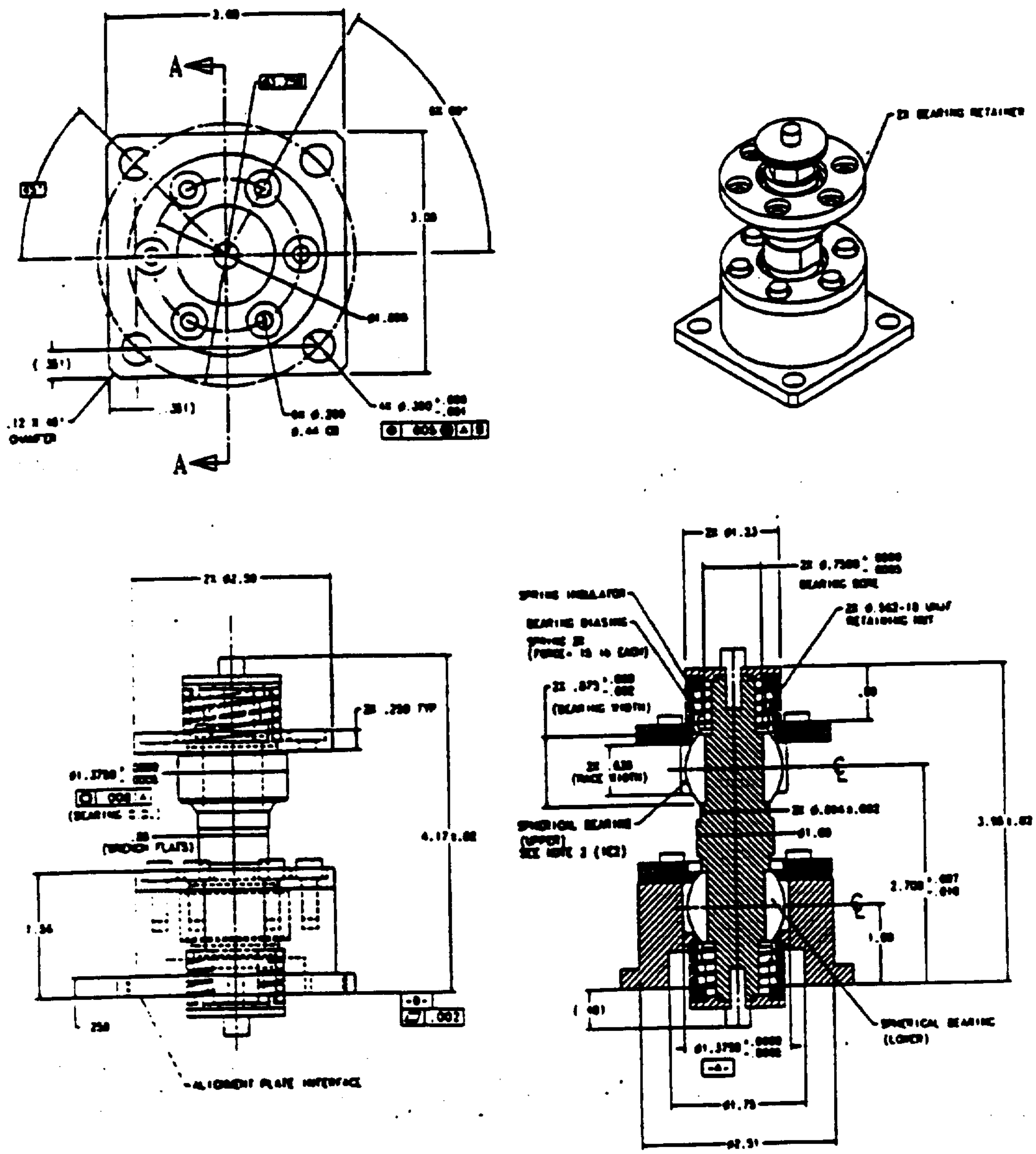

Figure 3-1. One-Axis Restrained Kinematic Mount Assembly (KM1)

CH-

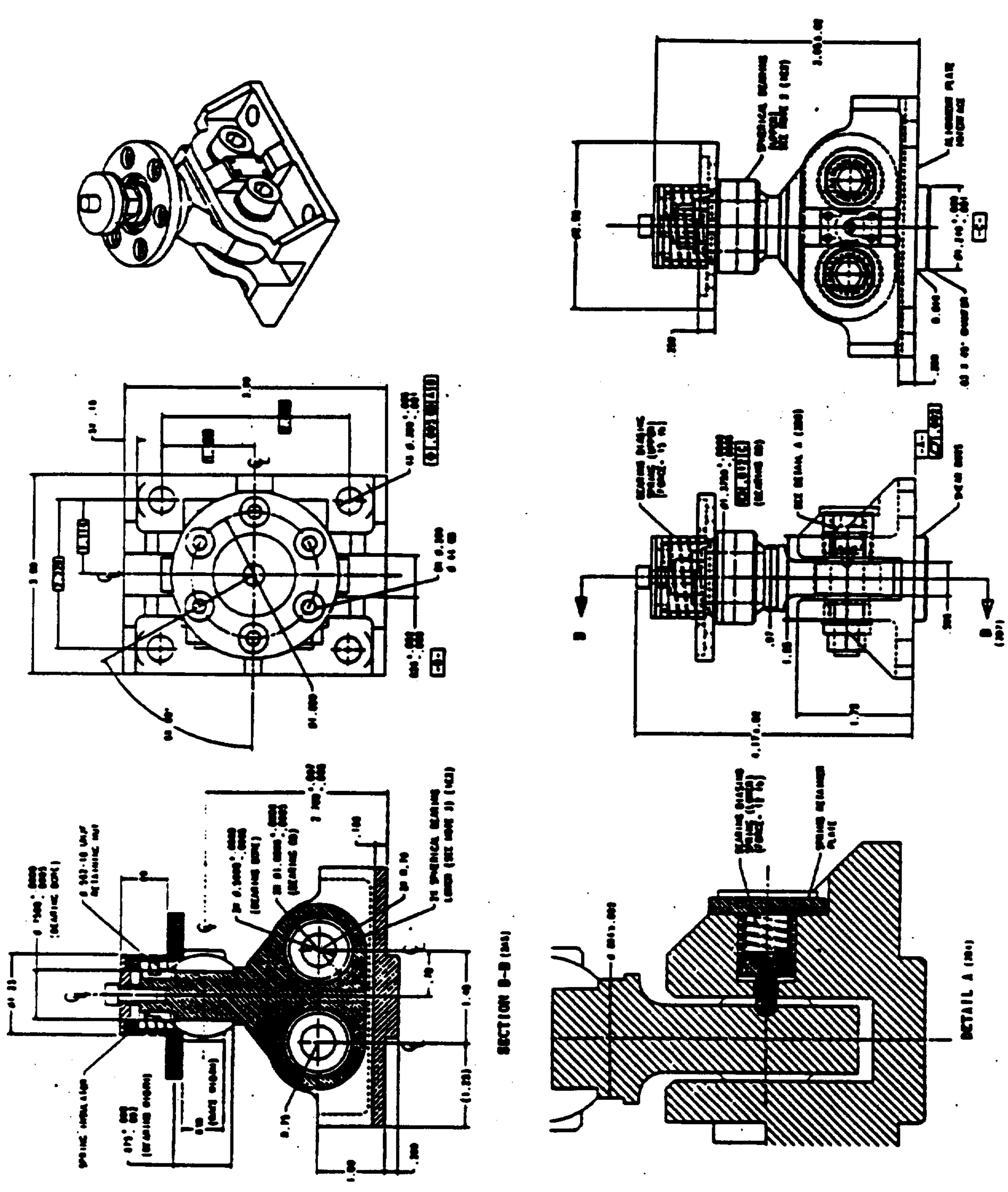

Figure 3–2. Two–Axis Restrained Kinematic Mount Assembly (KM2)

CH–1

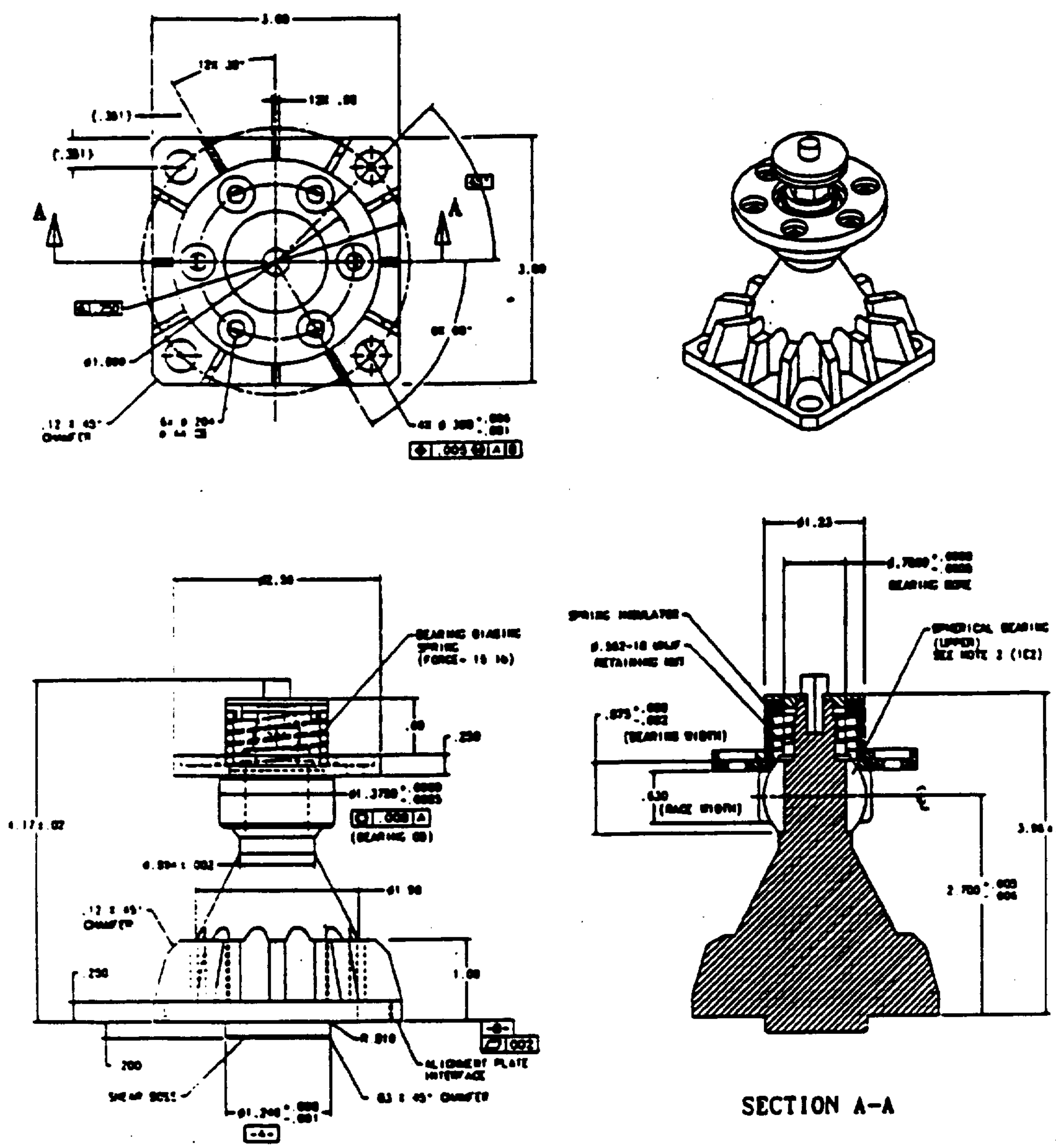

Figure 3–3. Three–Axis Restrained Kinematic Mount Assembly (KM3)

3.5.4.3.2 Three–Point Kinematic Mount Restrictions

The KM2 unrestrained axis of translational motion shall be parallel to a line drawn between the KM2 and KM3.

3.5.4.3.3 Kinematic Mount Stiffness

The stiffness for each type of kinematic mount shall be as shown in Table 3–2.

TABLE 3–2. KINEMATIC MOUNT STIFFNESS (TBR 014)

Type	Axial (lbs/in.)	Lateral (lbs/in.)
1–Axis	1.6E5	—
2–Axis	8.5E5	1.9E5
3–Axis	1.6E6	2.8E5
Axial – The constrained direction normal to the mounting plane Lateral – The constrained direction parallel to the mounting plane		

3.5.5 Spacecraft Mounting Surface

3.5.5.1 Spacecraft Mounting Surface Flatness

The Spacecraft mounting surface shall be flat to less than 0.83 mm/meter (m) peak to peak.

3.5.5.2 Spacecraft Mounting Surface Planarity

The Spacecraft mounting surface planarity shall be as documented in the Instrument ICD.

3.5.6 Instrument Mounting Surface

3.5.6.1 Instrument Mounting Surface Flatness

The instrument mounting surface flatness shall be as documented in the Instrument ICD.

3.5.6.2 Instrument Mounting Surface Planarity

The instrument mounting surface planarity shall be as documented in the Instrument ICD.

3.5.7 Mounting Location

3.5.7.1 Instrument Mounting Location

The Spacecraft Provider shall determine the location of instrument components on the Spacecraft.

3.5.7.2 Instrument Accommodation Equipment Mounting Location

The Spacecraft Provider shall determine the mounting location of instrument accommodation equipment on the Spacecraft.

3.5.7.3 Mounting Location Documentation

The mounting location of instrument components and instrument accommodation equipment shall be documented in the Instrument ICD.

3.5.8 Drill Templates

3.5.8.1 Drill Template Usage

Instrument, instrument accommodation equipment, Spacecraft, and test fixture interfaces shall be match drilled using templates to define the mounting hole patterns.

3.5.8.2 Drill Template Fabrication Requirements

The following requirements shall apply to drill template fabrication:

a. Aluminum plate with nominal thickness of 12.7 mm. CH–1
b. Steel slip–fit drill bushings for drilling both sides of the interface in all mounting holes.
c. Surface flatness to be better than 1.00 mm peak–to–peak. CH–1
d. Surface finish to be better than 3.2 micrometers (μm) root mean square (RMS).
e. Marked with the Spacecraft reference coordinate frame, marked to indicate proper template orientation, and marked to indicate which side is used for Spacecraft or Instrument drilling.
f. Drill templates for each component which requires alignment shall include an optical alignment cube bonded to the template and aligned with the Spacecraft reference coordinate frame.
g. Drill templates for components which do not requirement alignment shall not exceed the Instrument foot print.
h. Provided in a suitable, clean room compatible container which will contain all related hardware.

3.5.8.3 Optically Aligned Component Drill Template Provider

For optically aligned components a Spacecraft interface drill template drilled to the Instrument component mounting hole pattern shall be provided by the Spacecraft Provider to the Instrument Provider. CH–1

3.5.8.4 Non–optically Aligned Component Drill Template Provider

For components which do not require optical alignment the Instrument Provider shall provide the Spacecraft interface drill template, drilled to the Instrument component mounting hole pattern.

3.6 Alignment

3.6.1 Instrument Optical Alignment Cube

The Instrument shall include an optical alignment cube aligned with the instrument reference coordinate frame.

3.6.2 Optical Alignment Cube Requirements

3.6.2.1 Optical Alignment Cube Surface Area

Optical alignment cubes shall have a per face surface area of at least 645 mm^2.

3.6.2.2 Optical Alignment Cube Surface Orthogonality

Optical alignment cube surfaces shall be orthogonal to within ±1 Arc Second (arcsec).

3.6.2.3 Optical Alignment Cube Documentation

The location of all optical alignment cubes shall be documented in the Instrument ICD.

3.6.3 Alignment Responsibility

The Spacecraft Provider is responsible for aligning the Instrument to its mounting interface.

3.6.4 Alignment Angles

The measured alignment angles between the optical alignment cubes and the instrument boresight shall be documented in the Instrument ICD.

3.6.5 Pointing Allocations

The instrument pointing characteristics shall be as allocated in the UIID.

3.7 General Structural Design Requirements

3.7.1 Structural Support

3.7.1.1 Instrument Structural Support

The Spacecraft shall provide structural support for the Instrument.

3.7.1.2 Coldplate Structural Support

The Instrument shall provide structural support for the coldplate.

3.7.2 Instrument Structural Dynamics

Each plate mounted instrument component, configured for launch, shall have a fixed–base (see section 1.3 for definition) frequency of ≥50 hertz (Hz). Direct mount components instruments including kinematic mounts shall have a fixed base frequency of ≥35 Hz. The combined instrument components and Spacecraft structure shall have a coupled frequency of ≥35 Hz.

3.7.3 Interface Design Limit Loads Requirements

3.7.3.1 Limit Loads Application

Limit loads shall be applied at the center of mass (CM) of the Instrument and instrument accommodation equipment components, configured for launch, to design the mounting interface.

3.7.3.2 Limit Loads Application Axis

The loads shall be applied in one axis at a time and in such a way as to produce the maximum stresses.

3.7.3.3 Interface Design Limit Loads

The design limit loads for the Spacecraft–to–Instrument mounting interface shall be as defined in Table 3–3.

3.7.3.4 Random Vibration Levels

The instrument interface design shall be consistent with the qualification random vibration levels as defined in Table 3–3.

3.7.3.5 Sine Vibration Levels

The instrument interface shall be designed to withstand the qualification and acceptance sine vibration environment specified in Table 3–3a. CH–3

3.7.4 Coupled–Loads Analysis

3.7.4.1 Coupled–Loads Analysis Responsibility

Instrument–to–Spacecraft coupled–loads analysis shall be performed by the Spacecraft Provider.

3.7.4.2 Coupled–Loads Analysis Results

The coupled–loads analysis results for each instrument shall be reported to the respective Instrument Provider.

3.7.5 Pressurized System Design

Instrument requirements for the design of pressurized systems shall be as defined in the following:

a. MIL–STD–1522A, all sections, except in Section 5, Figure 2, only Approach A applies
b. WSMCR 127–1, Section 3.12

3.7.6 Environmental Requirements

3.7.6.1 Launch Survivability Design Requirements

3.7.6.1.1 Shock

The Instrument shall meet performance requirements following exposure to the shock environment specified in Figure 3–4. Instruments shall be designed to survive without performance degradation the peak shock defined in Table 3–3.

TABLE 3–3. SPACECRAFT/INSTRUMENT INTERFACE DESIGN LIMIT LOADS AND QUALIFICATION RANDOM VIBRATION LEVELS (TBR 005)

Instrument	Frequency Range (HZ)	Test Level (G^2/HZ)	Overall Level G_{rms}	Limit Load (G's)	Shock (G's)
ASTER–TIR	20 20–50 50–800 800–2000 2000	0.010 +2.4 db/octave 0.021 –2.4 db/octave 0.010	5.7	12	580
ASTER–SWIR	20 20–50 50–800 800–2000 2000	0.010 +3.6 db/octave 0.030 –3.6 db/octave 0.010	6.6	12	580
ASTER–VSR	20 20–80 80–700 700–2000 2000	0.015 +3 db/octave 0.060 –4.5 db/octave 0.010	8.6	15	580
ASTER–MPS	20 20–80 80–700 700–2000 2000	0.023 +3 db/octave 0.090 –6.0 db/octave 0.011	10.0	15	580
ASTER–VEL	20 20–80 80–700 700–2000 2000	0.015 +3 db/octave 0.060 –4.5 db/octave 0.010	8.6	15	580
ASTER–CSP	20 20–80 80–700 700–2000 2000	0.018 +3 db/octave 0.070 –5.5 db/octave 0.010	9.0	15	580
CERES	20 20–80 80–700 700–2000 2000	0.035 +3 db/octave 0.14 –6.0 db/octave 0.017	12.5	15	1200
MISR	20 20–50 50–800 800–2000 2000	0.010 +4.2 db/octave 0.036 –4.2 db/octave 0.010	7.1	12	580
MODIS	20 20–50 50–800 800–2000 2000	0.010 +2.3 db/octave 0.020 –2.3 db/octave 0.010	5.6	12	580
MOPITT (Kinematically Mounted)	20 20–50 50–800 800–2000 2000	0.010 +4.6 db/octave 0.040 –4.6 db/octave 0.010	7.4	12	580

NOTE:
The random vibration levels for kinematically mounted instrument are given at the truss node interface points. These levels are intended to cover structurally transmitted vibration only; it is recommended that larger instrument should also be given an acoustic test as a part of the qualification program. This would also apply to instrument components with large surface areas such as parabolic reflectors, large radiators, and large panels to which instrument components are directly attached.

TABLE 3–3a. SPACECRAFT/INSTRUMENT INTERFACE ACCEPTANCE AND QUALIFICATION SINE VIBRATION LEVELS

CH–3

Instrument	Qualification				Acceptance			
	X Axis (Thrust)		Y & Z Axis (Lateral)		X Axis (Thrust)		Y & Z Axis (Lateral)	
	Freq (HZ)	Level (G)	Freq (HZ)	Level (G)	Freq (HZ)	Level (G)	Freq (HZ)	Level (G)
ASTER–TIR	5–6 6–22 22–50	0.5 in D.A. 1.0 1.5	5–8 8–50	0.5 in D.A. 1.8	5–6 6–22 22–50	0.5 in D.A. 0.8 1.2	5–7 7–50	0.5 in D.A. 1.4
ASTER–SWIR	5–7 7–22 22–40 40–50	0.5 in D.A. 1.3 2.0 1.0	5–8 8–50	0.5 in D.A. 1.5	5–6 6–22 22–40 40–50	0.5 in D.A. 1.0 1.6 0.8	5–7 7–50	0.5 in D.A. 1.2
ASTER–VSR	5–6 6–20 20–40 40–50	.5 in D.A. 1.0 2.2 1.0	5–7 7–21 21–30 30–50	0.5 in D.A. 1.3 2.5 3.5	5–6 6–20 20–40 40–50	0.5 in D.A. 0.8 1.8 0.8	5–6 6–21 21–30 30–50	0.5 in D.A. 1.0 2.0 2.8
ASTER–MPS	5–12 12–50	.5 in D.A. 3.5	5–12 12–50	0.5 in D.A. 3.5	5–10 10–50	0.5 in D.A. 2.8	5–10 10–50	0.5 in D.A. 2.8
ASTER–VEL	5–12 12–50	.5 in D.A. 3.5	5–12 12–50	0.5 in D.A. 3.5	5–10 10–50	0.5 in D.A. 2.8	5–10 10–50	0.5 in D.A. 2.8
ASTER–CSP	5–12 12–50	.5 in D.A. 3.5	5–12 12–50	0.5 in D.A. 3.5	5–10 10–50	0.5 in D.A. 2.8	5–10 10.50	0.5 in D.A. 2.8
CERES	5–6 6–35 35–50	.5 in D.A. 1.0 2.5	5–6 6–30 30–50	0.5 in D.A. 1.0 3.5	5–6 6–35 35–50	0.5 in D.A. 0.8 2.0	5–6 6–30 30–50	0.5 in D.A. 0.8 2.8
MISR	5–6 6–24 24–42 42–50	.5 in D.A. 1.0 1.6 1.0	5–6 6–20 20–37 37–50	0.5 in D.A. 1.0 2.0 1.5	5–6 6–2 24–42 42–50	0.5 in D.A. 0.8 1.3 0.8	5–6 6–20 20–37 37–50	0.5 in D.A. 0.8 1.6 1.2
MODIS	5–8 8–15 15–35 35–50	.5 in D.A. 1.5 2.5 1.0	5–9 9–17 17–30 30–50	0.5 in D.A. 2.0 3.5 2.0	5–7 7–15 15–35 35–50	0.5 in D.A. 1.2 2.0 0.8	5–8 8–17 17–30 30–50	0.5 in D.A. 1.6 2.8 1.6
MOPITT (Kinematically Mounted)	5–9 9–50	.5 in D.A. 2.0	5–9 9–50	0.5 in D.A. 2.0	5–8 8–50	0.5 in D.A. 1.6	5–8 8–50	0.5 in D.A. 1.6

Notes:

(1) The instrument in test configuration shall include kinematic mounts, if applicable, and the mounting of the instrument to a test fixture shall duplicate the final instrument mounting configuration.

(2) It is acceptable to use one–Hertz–wide acceleration ramps for changing test "g" levels at test acceleration profile steps, provided the plateau frequency bandwidths depicted herein are maintained.

(3) Sweep rate for qualification testing is 2 octaves/minute.

(4) Sweep rate for acceptance and protoflight hardware is 4 octaves/minute.

(5) If required, the sine vibration test input levels shall be notched, based on low–level sine sweep survey prior to the protoflight level test in each axis, so as not to exceed 1.25 times the flight limit loads obtained from the final loads cycle. Notching criteria shall be established based on kinematic mount interface reaction loads or interface loads and response accelerations at critical points on the instrument structure. Notching criteria and notched sine input levels shall be submitted for review and approval by NASA/GSFC.

(6) The sinusiodal vibration test shall be performed once per axis in each axes which coincide with the spacecraft axes.

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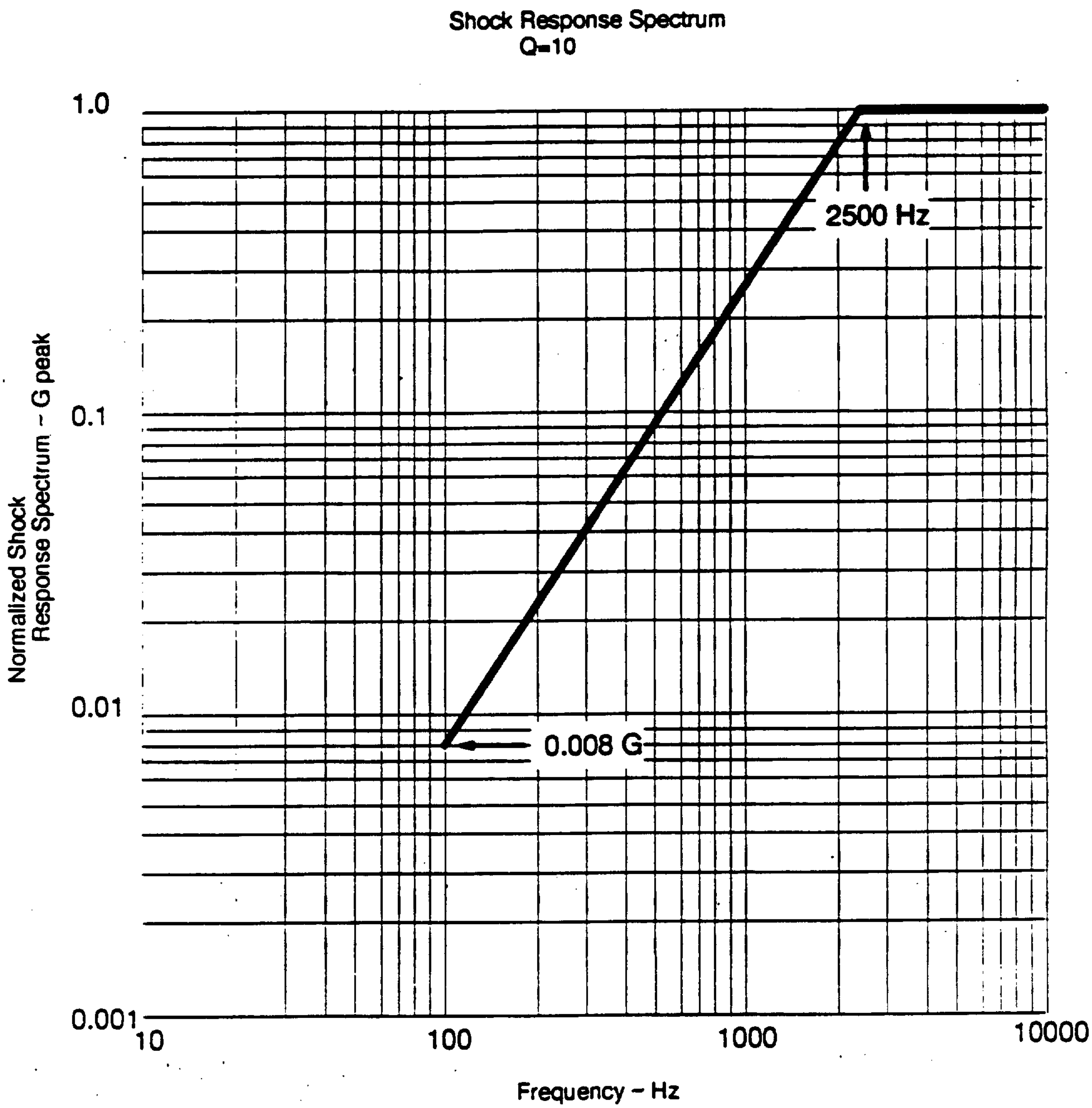


Figure 3-4. Normalized Shock Spectrum

3.7.6.1.2 Launch Pressure Profile

The Instrument shall be designed to withstand a maximum atmospheric pressure decay rate of 0.5 (TBR 006) psi/sec except for a short perturbation, not exceeding three seconds in duration, where the rate of decay will not exceed 0.76 (TBR 006) psi/sec.

3.7.6.1.3 Acoustics

The Instrument shall be designed to withstand acceptance and qualification/protoflight acoustic levels shall be as defined in Tables 3–4 and 3–5.

3.7.6.2 Orbital Environment

3.7.6.2.1 Acceleration

Instrument flight hardware shall be designed to withstand a maximum acceleration of 0.015 G on orbit without degradation of performance.

3.7.6.2.2 Torque

3.7.6.2.2.1 Torque Allowables

Torque reacted from the Instrument to the Spacecraft shall be less than the limits shown in Figures 3–5 , 3–6, and 3–7.

3.7.6.2.2.2 Torque Profile Documentation

The actual instrument torque versus time profile shall be documented in the Instrument ICD.

3.7.6.2.3 Force

3.7.6.2.3.1 Force Allowables

Rotational torques about the Spacecraft CM resulting from linear forces reacting from the Instrument to Spacecraft shall not exceed the values provided in Section 3.7.6.2.2.1.

3.7.6.2.3.2 Torque Documentation

The torques about the Spacecraft CM resulting from Instrument linear forces shall be documented in the Instrument ICD.

3.7.6.2.4 Angular Momentum

3.7.6.2.4.1 Allowable Angular Momentum

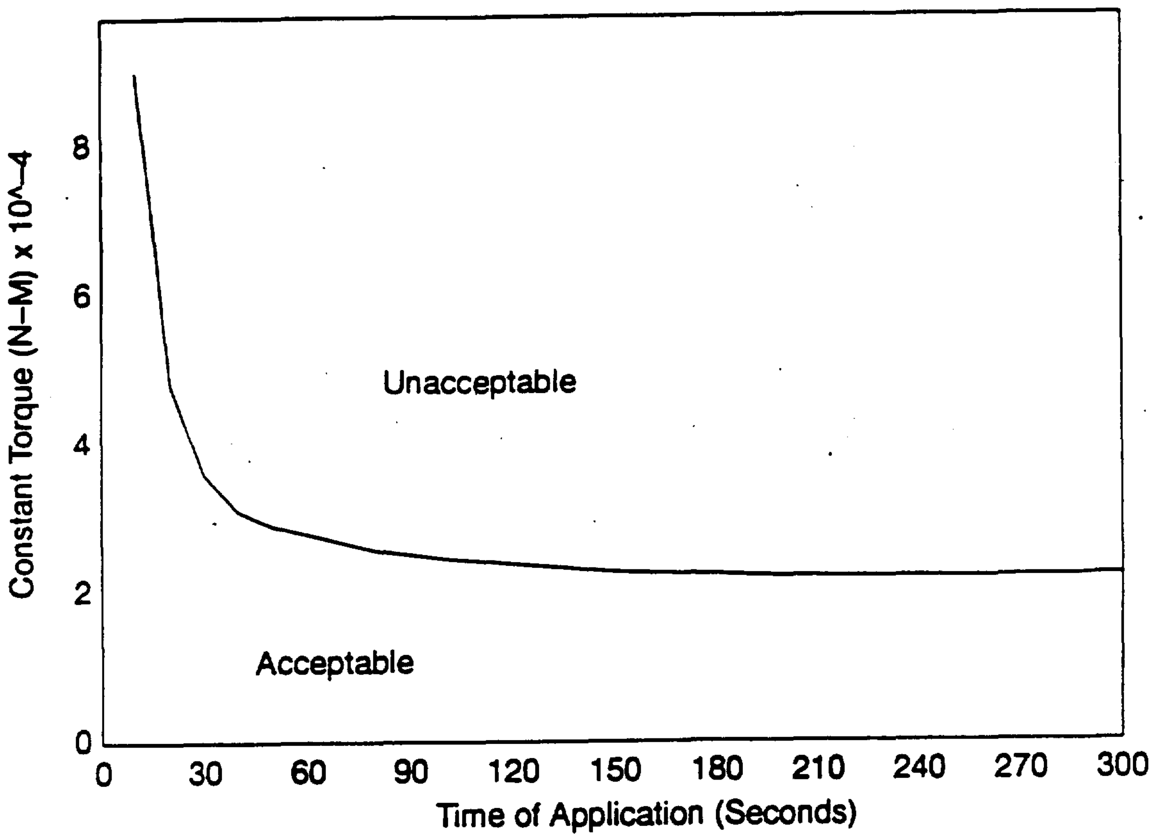
Steady state angular momentum reacted from the Instrument to the Spacecraft shall be less than 0.5 Newton–meter–second (N–m–sec) per axis.

TABLE 3–4. ACCEPTANCE ACOUSTIC LEVELS

One–Third Octave Center Frequency (Hz)	Noise Level (dB) re: 20 μN/m^2	Test Tolerance (dB)
25 32 40	—— 129.0 130.5	+3 –6
50 63 80	131.0 132.0 132.5	+3 –3
100 125 160	133.0 133.0 132.7	+3 –3
200 250 315	131.9 131.0 130.2	+3 –3
400 500 630	128.8 127.5 126.1	+3 –3
800 1000 1250	124.3 122.5 121.0	+3 –3
1600 2000 2500	119.0 117.5 116.0	+3 –3
3150 4000 5000	114.0 112.5 110.5	+3 –6
6300 8000 10000	108.5 109.7 110.5	+3 –6
Overall	142.8	+1 –1
Acceptance Duration: One Minute		

TABLE 3–5. QUALIFICATION/PROTOFLIGHT ACOUSTIC LEVELS

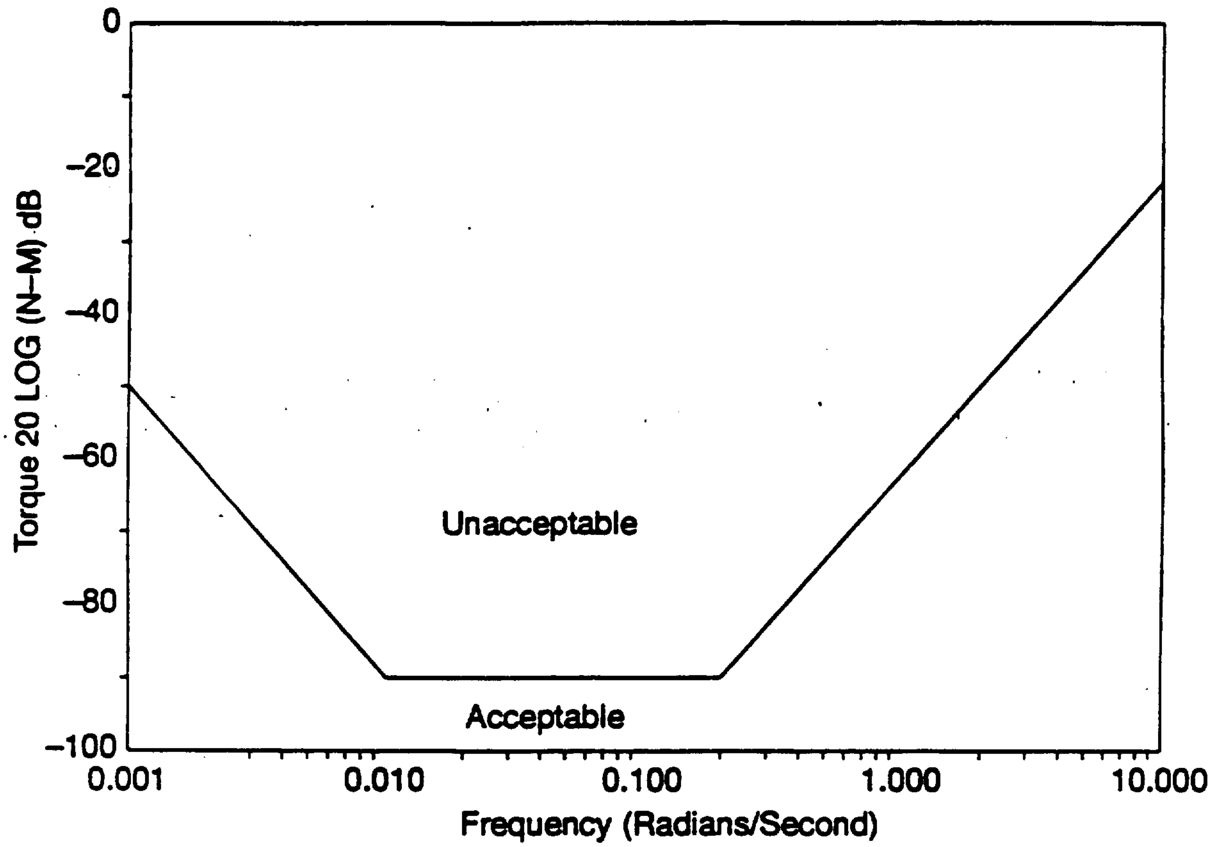
One–Third Octave Center Frequency (Hz)	Noise Level (dB) re: 20 μN/m²	Test Tolerance (dB)
25 32 40	— 132.0 133.5	+3 –6
50 63 80	134.0 135.0 135.5	+3 –3
100 125 160	136.0 136.0 135.7	+3 –3
200 250 315	134.9 134.0 133.2	+3 –3
400 500 630	131.8 130.5 129.1	+3 –3
800 1000 1250	127.3 125.5 124.0	+3 –3
1600 2000 2500	122.0 120.5 119.0	+3 –3
3150 4000 5000	117.0 115.5 113.5	+3 –6
6300 8000 10000	111.5 110.0 108.0	+3 –6
Overall	145.7	+1 –1
Protoflight Duration: One Minute Qualification Duration: Two Minutes		



Notes:

1. For constant torque less than 10 seconds, the impulse shall not exceed 9 x 10^{-3} N–m–sec.
2. No other constant instrument torque of the same polarity shall occur during the 200 seconds after the initial application ends.
3. If an impulse of opposite polarity occurs within 200 seconds, these requirements may be relaxed on a case–by–case basis.

Figure 3–5. Constant Torque/Impulse



Notes:

1. The amplitude of sinusoidal torque above 10 radians/second shall not exceed the 10 radians/second value.
2. The amplitude of sinusoidal torque below 0.001 radians/second shall not exceed the 0.001 radians/second value.
3. High frequency disturbances (such as stirling coolers) must be assessed on a case-by-case basis.

Figure 3-6. Sinusoidal Torque

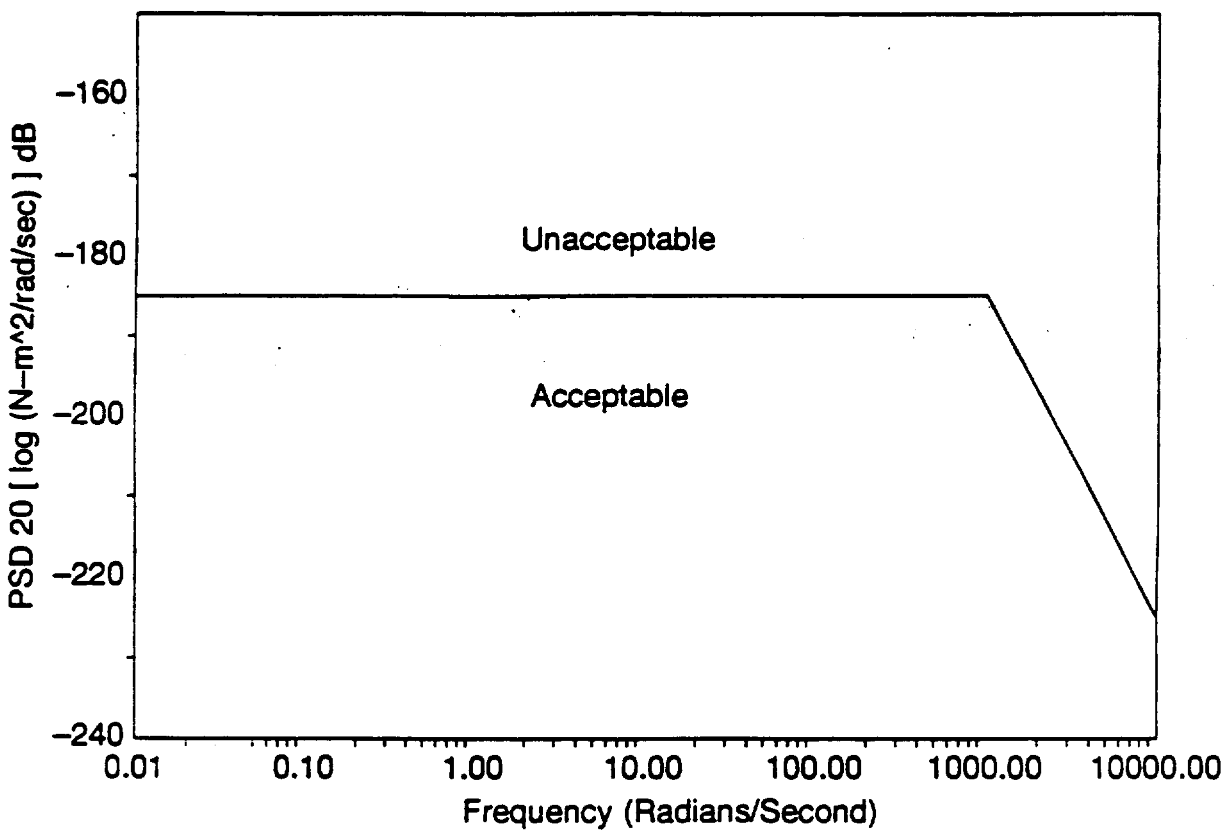


Figure 3–7. White Noise Torque

3.7.6.2.4.2 Angular Momentum Documentation

The angular momentum reacted from the Instrument to the Spacecraft shall be documented in the Instrument ICD.

3.7.6.2.4.3 Spacecraft Non–Operational Deployment Disturbance

The on–orbit non–operational Spacecraft disturbances produced by the uncaging or deployment of any mechanism or device shall be less than 1400 inch–pounds at the point of attachment.

3.7.6.2.4.4 Shock Generation On–Orbit

Instrument–produced shock shall be less than **(TBD 002).**

3.7.6.2.4.5 Instrument Orbital Shock Requirement

The Instrument shall be capable of surviving, without degradation, shock resulting from separation devices and other pyrotechnic devices initiated during its life.

3.8 Finite Element Model

The Instrument Provider shall provide to GSFC finite element models of the Instrument in accordance with the requirements listed in Appendix E, Section 60.1.

3.9 Instrument Mass Model

The Spacecraft Provider shall develop all instrument mass models required for Spacecraft mechanical testing.

3.10 Instrument Mechanisms

All instrument mechanisms which require restraint during launch shall be caged during launch without requiring power to maintain the caged condition.

3.10.1 Caging During Test and Launch

Instrument mechanisms which require caging and/or uncaging during test and launch shall be capable of being caged and uncaged by command and by manual insertion of accessible locking devices.

3.10.2 Caging On–Orbit

Instrument mechanisms which require uncaging and/or caging on–orbit shall be capable of being caged and uncaged by command.

3.10.3 Captive Hardware

All items to be installed, removed, or replaced at the Instrument or Spacecraft level shall utilize captive hardware.

3.10.4 Sealed Hardware

Electro–explosive devices (EEDs), hot–wax switches, or other devices shall be contained in sealed assemblies which do not allow escape of the actuating materials.

3.11 Venting Forces

3.11.1 Continuous Venting Forces

The Instrument shall limit continuous venting forces to ≤1.0E–05 pounds.

3.11.2 Random Venting Impulses

The Instrument shall limit random venting impulses to ≤0.028 pound–seconds per orbit.

3.11.3 Thrust Direction Adjustment

The direction of net thrust resulting from the expulsion of expendables by the Instrument shall be adjustable at the Spacecraft level.

3.11.4 Venting Force Documentation

The Instrument venting forces shall be documented with respect to magnitude, direction, duration, and frequency in the Instrument ICD.

3.12 Coldplate Mechanical Interface Requirements

The mechanical specifications of the coldplate and its associated hardware are given in Table 3–6.

3.12.1 Coldplate Mounting

3.12.1.1 Coldplate Mounting Bolts

The coldplate shall be mounted to the Instrument using 24 #10 bolts passing through the coldplate and attaching to the Instrument with threaded inserts on the instrument side of the interface.

3.12.1.2 Coldplate Bolt Pattern

The bolt pattern for the coldplate shall be as shown in Figure 3–8.

TABLE 3–6. COLDPLATE EQUIPMENT MECHANICAL SPECIFICATIONS

Item	Dimensions (mm)	Mass (kg)	Center of Mass Location (mm)
Coldplate	711 x 305 x 68	6.13	Geometrical Center
Coldplate Liquid Lines (2 per coldplate)	3.2 diameter	0.06/m	Geometrical Center
Coldplate Liquid Line Minimum Bend Radius	12.7		
Coldplate Vapor Lines (2 per coldplate)	6.4 diameter	0.09/m	Geometrical Center
Coldplate Vapor Line Minimum Bend Radius	25.4		
Coldplate Vapor and Liquid Line Insulation Thickness	6.4	0.02/m	Geometrical Center

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3.12.1.3 Coldplate Mounting Hardware Provider

The Spacecraft Provider shall provide the coldplate mounting hardware to the Instrument Provider.

3.12.1.4 Coldplate Mounting Hardware Documentation

The coldplate mounting hardware shall be defined and documented in the Instrument ICD.

3.12.2 Instrument Surface for Coldplate Mechanical Interface

3.12.2.1 Instrument Surface Flatness

The instrument surface for the coldplate mechanical interface shall be flat to less than 0.42 mm/m peak–to–peak.

3.12.2.2 Instrument Surface Finish

The instrument surface finish for the coldplate mechanical interface shall not exceed a roughness of 1.6 micrometers (μm) RMS.

3.12.3 Coldplate Drill Template

The coldplate drill template shall be provided by the Spacecraft Provider to the Instrument Provider.

3.12.3.1 Coldplate Drill Template Usage

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The instrument shall be match drilled using the coldplate drill template to define the mounting hole pattern

3.12.4 Coldplate Mounting Surface Area

The coldplate mounting surface area shall be as defined in Figure 3–8.

3.12.5 Coldplate Mounting Surface

3.12.5.1 Coldplate Mounting Surface Flatness

The coldplate mounting surface shall be flat to less than 0.42 mm/m peak–to–peak.

3.12.5.2 Coldplate Mounting Surface Finish

The coldplate mounting surface shall not exceed a roughness of 1.6 μm RMS.

3.12.6 Coldplate Mechanical Interface Filler Installation Responsibility

The mechanical installation responsibility of the filler between the coldplate and instrument surfaces shall be an agreement between the Instrument Provider and the Spacecraft Provider.

3.12.7 Coldplate Mechanical Interface Filler Installation Responsibility Documentation

The mechanical installation responsibility of the filler between the coldplate and instrument surfaces shall be documented in the Instrument ICD.

3.12.8 Coldplate Mass Properties

Coldplate mass and CM shall be as defined in Table 3–6.

3.13 Coldplate Plumbing

3.13.1 Coldplate Plumbing Provider

Coldplate plumbing between the coldplate and the Spacecraft shall be provided by the Spacecraft Provider.

3.13.2 Coldplate Plumbing Support Provider

The Instrument Provider and the Spacecraft Provider shall agree upon the provider of the coldplate plumbing supports.

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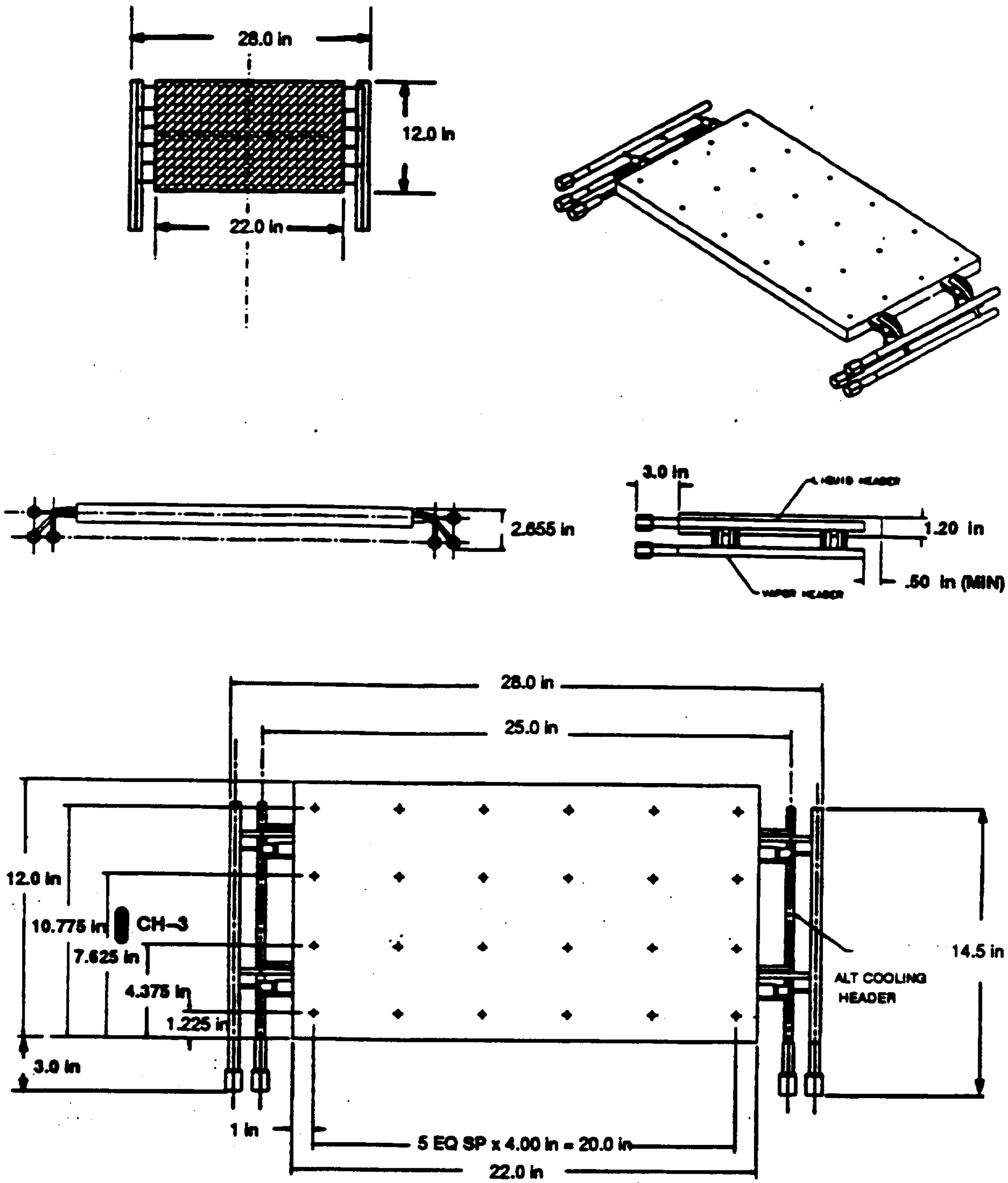

NOTES:

1. [hatched box] = Coldplate mounting surface.

Figure 3-8. Coldplate Configuration

3.13.3 Coldplate Plumbing Support Documentation

The provider of the coldplate plumbing supports shall be documented in the Instrument ICD.

3.13.4 Coldplate Plumbing Location

All coldplate plumbing locations shall be documented in the Instrument ICD.

3.13.5 Coldplate Plumbing Clearance

Coldplate plumbing clearances shall be agreed to by the instrument and spacecraft providers and documented in the Instrument ICD. CH–3

3.13.6 Coldplate Plumbing Documentation

Routing of coldplate plumbing lines and location of coldplate plumbing supports shall be documented in the Instrument ICD.

3.13.7 Coldplate Plumbing Dimensions and Mass Properties

Coldplate plumbing dimensions and mass properties shall be as defined in Table 3–6.

3.14 Harnesses

3.14.1 Harness Provider

All harnessing shall be provided by the Spacecraft Provider.

3.14.2 Harness Hardware Documentation

Harnesses, connectors, ground straps, and associated service loops shall be documented in the Instrument ICD.

3.14.3 Harness Wiring Requirements

All requirements for harness construction, pin–to–pin wiring, cable type, etc. shall be documented in the Instrument ICD.

3.14.4 Tie Points

3.14.4.1 Tie Point Locations and Provider

The provider and the locations of harness tie points shall be an agreement between the Instrument Provider and the Spacecraft Provider, as required.

3.14.4.2 Tie Point Documentation

The provider and the locations of tie points shall be documented in the Instrument ICD.

3.14.5 Connectors

3.14.5.1 Connector Mating

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

3.14.5.2 Connector Clearance

At least 20 mm of clearance shall be provided around the outside of mated connector plugs.

3.14.5.3 Connector Location

Connector locations and types shall be documented in the Instrument ICD.

3.14.5.4 Keying

Connectors shall be different sizes, different types, or uniquely keyed to prevent improper connection.

3.14.5.5 Interface Connector Provider

3.14.5.5.1 Harness Connectors

All connectors attached to harnesses between two instrument components or between instrument components and instrument accommodation equipment shall be provided by the Spacecraft Provider.

3.14.5.5.2 Instrument Component Connectors

All connectors attached to instrument components shall be provided by the Instrument Provider.

3.14.5.5.3 Connector Types

All external connectors to be used by the Instrument for instrument–to–spacecraft interfaces shall be selected from Table 3–7.

3.14.5.5.4 Connector Type Documentation

The connector types used by the Instrument shall be documented in the Instrument ICD.

3.14.5.6 Flight Plugs

3.14.5.6.1 Flight Plug Installation

Flight plugs requiring installation prior to launch shall be capable of being installed at the Spacecraft level.

TABLE 3–7. APPROVED INSTRUMENT INTERFACE CONNECTORS (TBR 008)

Signal Type	Instrument Connector	Harness Connector	Comments
Primary Power	MS27508*XXFXXP or MS27474TXXFXXP per MIL–C–38999J Series II	MS27484TXXFXXS per MIL–C–38999J Series II	1. *: Select class E or T. 2. XX: Select shell size and insert arrangement appropriate for interface. Use size 20 contacts. 3. Mil–C–38999J connectors must use low–outgassing materials or be baked out to meet the outgassing requirements of GSFC 420–05–01 and 420–05–02
Point–to–Point Interfaces	MS27508*XXFXXS or MS27474TXXFXXS per MIL–C–38999J Series II	MS27484TXXFXXP per MIL–C–38999J Series II	1. *: Select class E or T. 2. XX: Select shell size and insert arrangement appropriate for interface. Use size 22 contacts. 3. Mil–C–38999J connectors must use low–outgassing materials or be baked out to meet the outgassing requirements of GSFC 420–05–01 and 420–05–02
	Subminiature D connector which is equivalent to GSFC S311P407–XS–B–12 or GSFC S311P409–XS–B–12	GSFC S311P407–XP–B–12 or GSFC S311P409–XP–B–12 with laser welded seams (TBR)	1. Subminiature D connectors must be mounted, bonded, and gasketed to the inside surface of a shielded component in order to meet the shielding requriements of the EMC Control Plan unless the shell has a solid body
Low Rate Science Bus & Command and Telemetry bus	Raychem D–621–0412–P Triaxial (Jack w/ Pin)	Raychem D–621–0411–S Triaxial (Plug w/ Socket Contact)	1. Mates with Raychem 7724C8664 Data Bus Cable 2. Connectors must be baked out to meet the outgassing requirements of GSFC 420–05–01 and 420–05–02
Time Mark & Freq. Bus	Trompeter (TBR) BJ3159AC–221 Bulkhead Jack	Trompeter (TBR) PL3155AC–221 Plug	1. Mates with Gore CXN 2702 100 ohm Twinaxial Shielded Cable 2. Connectors must be baked out to meet the outgassing requirements of GSFC 420–05–01 and 420–05–02
High Rate Science Link	SMA (Jack)	Gore S01 SMA, Straight	1. Mates with Gore G2 or G3 Coaxial Cable 2. Connectors must be baked out to meet the outgassing requirements of GSFC 420–05–01 and 420–05–02

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3.14.5.6.2 Flight Plug Responsibility

Flight plugs, if required, shall be provided by the Spacecraft Provider.

3.14.5.6.3 Flight Plug Documentation

Flight plugs and their locations shall be documented in the Instrument ICD.

3.14.5.7 Connector Protective Covers

Captive covers shall be provided by the Instrument Provider for all instrument connectors which are not mated to harnesses or flight plugs.

3.14.5.8 Test Connectors

3.14.5.8.1 Test Connector Accessibility

Test connectors shall be accessible at the integrated Spacecraft level.

3.14.5.8.2 Test Connector Documentation

Test connectors and their locations shall be documented in the Instrument ICD.

3.14.5.9 Breakout Boxes

3.14.5.9.1 Intra–Instrument Breakout Boxes

Intra–Instrument test tees and breakout boxes shall be provided by the Instrument Provider.

3.14.5.9.2 Instrument–to–Spacecraft Interface Breakout Boxes

Test–tees and breakout boxes for Instrument–to–Spacecraft interfaces shall be provided by Spacecraft Provider.

3.14.5.10 Buffer Connectors and Connector Savers

3.14.5.10.1 Buffer Connector and Connector Saver Utilization

Instrument buffer connectors and connector savers shall be utilized prior to Spacecraft–level system tests.

3.14.5.10.2 Buffer Connector and Connector Saver Provider

Instrument buffer connectors and connector savers shall be provided by the Instrument Provider.

3.14.5.11 Electrical Connector Constraints

The connector half which has direct current (dc) voltage sources >60 volts (V) shall have socket contacts.

3.15 Access

3.15.1 Access Identification

Access requirements shall be documented in the Instrument ICD.

3.15.2 General Access

All items to be installed, removed, or replaced at the instrument or Spacecraft level shall be accessible without disassembly except for the removal of thermal insulation blankets.

3.16 Handling Fixtures

The Instrument Provider shall provide handling fixtures, which meet the requirements of GE20008579, for each component weighing in excess of 16 kg.

3.17 Launch Site Equipment Installation and Removal

3.17.1 Non–Flight Equipment

All items to be removed prior to flight shall be red with a red "Remove Before Flight" tag.

3.17.2 Flight Equipment

All items to be installed prior to flight shall be of a natural or neutral color except for thermal insulation blankets.

3.17.3 Flight and Non–Flight Equipment Documentation

All items to be installed or removed prior to flight shall be documented in the Instrument ICD.

4 THERMAL REQUIREMENTS

4.1 Thermal Interface Description

All interface requirements specified in Section 4 shall be met at the mechanical interface defined in Section 3.1 and shall be consistent with the UIID allocations.

4.2 Thermal Design

4.2.1 Instrument Thermal Design Provider

The Instrument Provider shall be responsible for the thermal design of the Instrument.

4.2.2 Instrument Thermal Design

The Instrument design shall provide for:

a. Maintaining the Instrument within its temperature limits

b. Instrument attainment of minimum turn–on temperature via survival power

c. Instrument thermal isolation

4.3 Heat Transfer

4.3.1 Heat Transfer with the Spacecraft

4.3.1.1 Average Heat Flux

The heat transfer flux averaged over the Spacecraft mechanical interface shall be $\leq$15.5 W/m^2, during normal operations. CH–3

4.3.1.2 Heat Transfer Distribution

The heat transfer distribution at the Spacecraft mechanical interface shall be reviewed by the Spacecraft Provider.

4.3.2 Heat Transfer with the Coldplate

The heat transfer flux averaged over the coldplate mechanical interface shall be $\leq$1550.0 W/m^2 and $\geq$ 155.0 W/m^2. CH–1

4.3.3 Heat Transfer Distribution Documentation

Instruments which exceed a heat transfer flux of 1 W/in^2 for any square inch of the coldplate shall document the distribution of heat fluxes in the Instrument ICD and the thermal math model.

4.3.4 Environmental Heat Transfer

The Instrument shall be designed for the space thermal environment consistent with all orbits defined in Section 10. CH–1

4.3.5 Deleted C 1

4.4 Temperature

4.4.1 Spacecraft Temperature Range

The Spacecraft temperature range at the mounting interface shall be:

a. 0 to +30°C during normal operations

b. −25 to +50°C during survival modes CH-1

4.4.2 Coldplate Temperature Requirements

4.4.2.1 Coldplate Temperature Range

The Spacecraft shall maintain the mounting surface of the coldplate at a temperature of 20 +5/−0°C during the Operational Initialize phase Standby mode and Operational phase Science and Orbit Adjust modes for a maximum instrument heat flux of 1 W/in^2 for any square inch.

4.4.2.2 Coldplate Interface Filler Temperature Gradient

The temperature gradient across the coldplate mechanical interface filler from the Instrument coldplate mounting surface to the coldplate surface shall be ≤2.0°C. C. 3

4.4.3 Instrument Temperature Range

Temperature limits for Instrument components during ground test and orbital operations shall be documented in the Instrument ICD.

4.4.4 Test Coldplate Temperatures During Instrument Qualification Testing

For the special case of an Instrument or portions of an Instrument controlled by a coldplate, the test coldplate interface temperature shall be maintained at +35°C and +10°C, maximum and minimum, respectively, for qualification testing.

4.4.5 Test Coldplate Temperatures During Instrument Acceptance Testing

For the special case of an Instrument or portions of an Instrument controlled by a coldplate, the test coldplate interface temperature shall be maintained at +30°C and +15°C, maximum and minimum, respectively, for acceptance testing.

4.5 Temperature Monitoring

4.5.1 Mechanical Interface Temperature Monitoring

The Spacecraft shall monitor and report in the Spacecraft housekeeping telemetry the temperature of the mechanical interface.

4.5.2 Instrument Temperature Monitoring

All items for which health and safety temperature limits have been established shall be monitored via passive analog telemetry.

4.5.3 Temperature Sensor Location

The location of all instrument temperature sensors shall be documented in the Instrument ICD.

4.6 Thermal Control Hardware

4.6.1 Coldplate

4.6.1.1 Coldplate Capacity

Coldplates shall be capable of acquiring 250 W of thermal dissipation.

4.6.1.2 Coldplate Configuration

Coldplate configuration shall be as shown in Figure 3–8.

4.6.1.3 Coldplate Mounting Orientation

For operation of the flight coldplate during capillary pumped heat transport system (CPHTS) performance testing, the coldplate mechanical interface planes parallel to the Spacecraft X–Z or Y–Z planes shall be oriented such that the coldplate header pipes are perpendicular to the Spacecraft Z axis.

4.6.1.4 Coldplate Mounting Elevation

For operation of the flight coldplate during CPHTS performance testing, the coldplate mechanical interface shall not exceed a distance of 250 mm from the Spacecraft mounting interface.

4.6.1.5 Coldplate Mechanical Interface Filler Conductivity

The thermal conductivity of the coldplate thermally conductive filler material shall be $\geq$0.5 watts per square inch per degree C. CH–3

4.6.1.6 Test Coldplate Requirements

The test coldplate shall be identical to the flight coldplate in performance, mass, dimensions, and mounting.

4.6.2 Heaters

4.6.2.1 Survival Heaters

Instruments shall utilize heaters to maintain temperatures at or above minimum survival limits.

4.6.2.2 Survival Heater Control

Instruments shall utilize thermal control devices for the survival heaters.

4.6.3 Thermal Control Hardware

4.6.3.1 Thermal Control Hardware Responsibility

The responsibility for providing the thermal control hardware shall be as defined above and in Table 4–1.

TABLE 4–1. THERMAL CONTROL HARDWARE RESPONSIBILITY

Hardware	Responsibility
Instrument Thermal Control Hardware	Instrument Provider
Flight and Test Coldplates	Spacecraft Provider
Flight and Test Coldplates Mechanical Interface Filler	Spacecraft Provider
Coldplate Thermal Insulation Blankets	Instrument Provider
Thermal Insulation Blankets to Interface between the Instrument Thermal Insulation Blankets and the Spacecraft Thermal Insulation Blankets	Spacecraft Provider
Instrument Accommodation Equipment Thermal Insulation Blankets	Spacecraft Provider

4.6.3.2 Thermal Control Hardware Documentation

Thermal control hardware shall be documented in the Instrument ICD.

4.7 Thermal Models

4.7.1 Surface Model

The Instrument Provider shall provide to GSFC an instrument surface model in accordance with the requirements listed in Appendix E, Section 60.2.2.

4.7.2 Reduced Node Thermal Math Model

The Instrument Provider shall provide to GSFC reduced node thermal math models in accordance with the requirements listed in Appendix E, Section 60.2.3.

4.7.3 Detailed Thermal Math Model

The Instrument Provider shall provide to GSFC a report documenting the nodal description and results of the detailed thermal analysis in accordance with the requirements listed in Appendix E, Section 60.2.4.

5 ELECTRICAL REQUIREMENTS

5.1 Electrical Interface Requirements

All requirements in Section 5 shall be met at the electrical interface and all allocations shall be consistent with the UIID.

5.1.1 Electrical Interfaces

The electrical interfaces (see Figure 5–1) include the following:

a. Power Interface

b. Grounding Interface

c. Command and Data Handling Interface

d. Other Interfaces

5.1.2 Electrical Interface Definitions

5.1.2.1 Electrical Interface Location

The electrical interface is at the Instrument end of the Instrument–to–Instrument–Accommodation–Equipment harness connector mating surfaces.

5.1.2.2 Operational Power

Operational power is used for instrument operational modes such as Science Data Collection, Calibration, and Standby.

5.1.2.2.1 Peak Power

Peak power is the maximum power required by an Instrument. Peak power does not include transients with a duration less than 20 milliseconds.

5.1.2.2.2 Average 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.

5.1.2.3 Survival–Mode Power

Survival–mode power is power required by the Instrument in Survival Mode.

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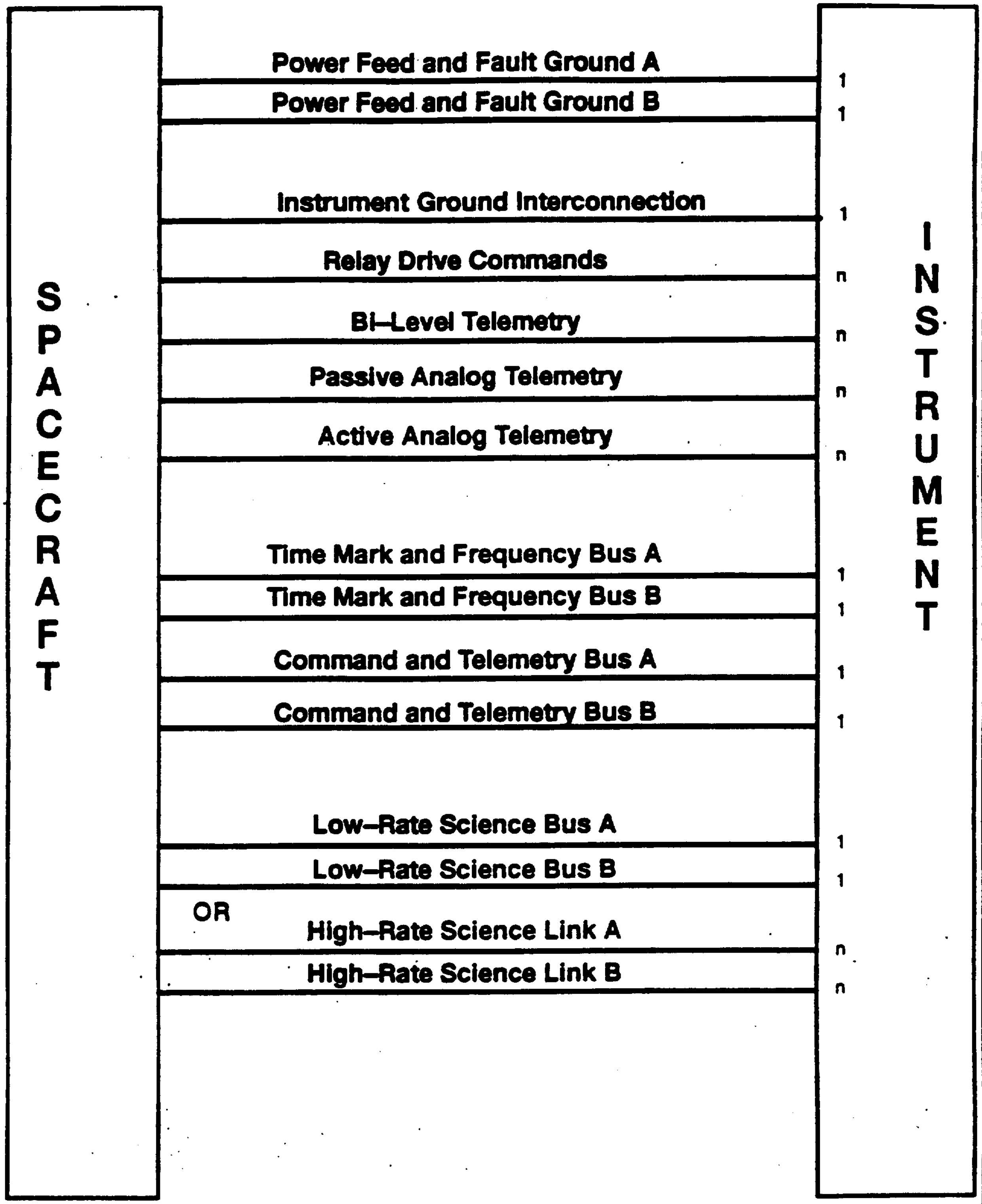

Notes:

1. Each interface includes a signal wire and a return wire.
2. Number (n) of interfaces is instrument dependent and allocated in the UIID.

Figure 5–1. Physical Electrical Interfaces

5.1.2.4 Safe–Mode Power

Safe–mode power is the power required by the Instrument in safe mode.

5.1.2.5 Launch–Phase Power

Launch–phase power is the power required by the Instrument in launch phase.

5.2 Power

This section specifies the characteristics, connections, and control of the Spacecraft power provided to the Instrument and requirements at this interface.

5.2.1 Instrument Power Allocations

The Spacecraft shall provide suitable power harnesses to support the allocated power levels.

5.2.1.1 Operational Power Allocation

The instrument power consumed in operational modes shall be less than or equal to the average and peak operational power levels allocated in the UIID.

5.2.1.2 Survival Power Allocation

The instrument power consumed in survival mode shall be less than or equal to the survival power allocated in the UIID.

5.2.1.3 Launch–phase Power Allocation

The instrument power consumed in launch phase shall be less than or equal to the launch–phase power allocated in the UIID.

5.2.1.4 Power Interface Allocation

The number of power interfaces used by an instrument shall be consistent with the number allocated in the UIID.

5.2.1.5 Instrument Power–Level Documentation

The actual power levels for all instrument modes shall be documented in the Instrument ICD.

5.2.2 Power Characteristics

5.2.2.1 Voltage

The Spacecraft shall supply instrument power at 120 ±4% volts direct current (Vdc).

5.2.2.1.1 Voltage Transients

The Instrument shall perform when subjected to voltage transients per CS06 requirements specified in GE PN20005869.

5.2.2.1.2 Abnormal Steady–State Voltage Limits

Under abnormal conditions the Instrument shall survive, without permanent degradation, steady–state voltages in the range:

$0 \leq V \leq 132$ Vdc

5.2.2.2 Power Source Impedance

The Spacecraft power source impedance as seen at the instrument electrical interface shall be ≤0.8 ohm for frequencies ≤9 kilohertz (kHz), increasing at not more than a 6 **(TBR 015)** microhenry slope from 9 kHz to 1 megahertz (MHz).

5.2.2.3 Current

5.2.2.3.1 Instrument Current Transients

The following instrument requirements shall be measured when supplied by a voltage source having the impedance characteristics similar to the Spacecraft power source impedance.

a. Instrument current peaks associated with both turn–on inrush current and non–repetitive operational current transients shall not exceed 200% of the instrument peak power current between 50 microseconds (µsec) and 10 milliseconds (msec) after the start of the transient and shall return to steady state within 10 msec from the time of the peak of the transient.

b. During normal operations the Instrument shall limit current transient rate of change to ≤20 milliamps (mA)/µsec.

c. The Instrument shall limit turn–on inrush current transient rate of change to ≤50 mA/µsec.

d. The Instrument shall limit turn–off current transient rate of change to ≤50 mA/µsec.

5.2.2.3.2 Deleted CH–3

5.2.2.3.3 Overcurrent Protection

The Spacecraft shall provide protection of the Spacecraft power system by providing overcurrent protection devices on each instrument power connection.

5.2.2.3.3.1 Overcurrent Protection Device Size

The size of the overcurrent protection devices for each Instrument shall be an agreement between the Spacecraft Provider and the Instrument Provider.

5.2.2.3.3.2 Overcurrent Protection Device Size Documentation

The agreed–upon size and characteristics of an overcurrent protection device shall be documented in the Instrument ICD.

5.2.2.4 Instrument Power Input Impedance

The instrument prime power input filter shall present a symmetrical common mode and differential mode impedance to the prime power bus, as represented by the AC impedance of the differential mode and common mode input filters.

5.2.2.4.1 Instrument Common Mode Impedance

The instrument common mode impedance, as measured from the prime power feed or prime power feed return to chassis ground, shall be ≥160 **(TBR 016)** ohms at frequencies ≥100 kHz to 10 MHz generally increasing as frequency increases.

5.2.2.4.2 Instrument Differential Mode Impedance

The differential mode input impedance (Z_{dm}) between DC and 20 kHz shall be ≥ a minimum impedance (Z_{min}) where Z_{min} is calculated using the following equation: CH–3

$$Z_{min} = 1600/P_{in(max)} \times Z_{ref}$$ CH–3

Z_{min} – minimum allowed differential mode impedance
Z_{dm} – differential mode impedance
$P_{in(max)}$ – peak power allocated
Z_{ref} – reference impedance

where Z_{ref} is shown in Figure 5-2.

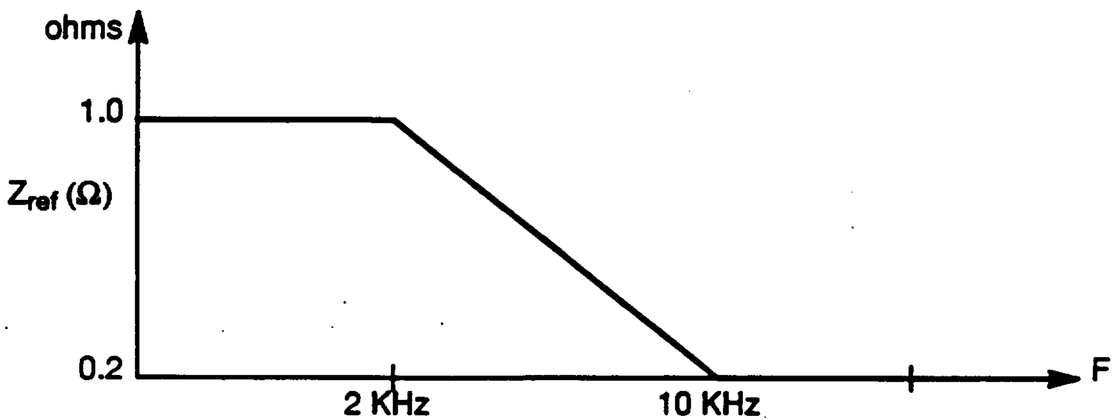

Figure 5-2. Instrument Differential Mode Reference Impedance

Where the differential mode input impedance is below the value of Z_{min}, as defined by the above equation, the phase over that frequency range shall be within the limits as defined in Figure 5-2a. CH-3

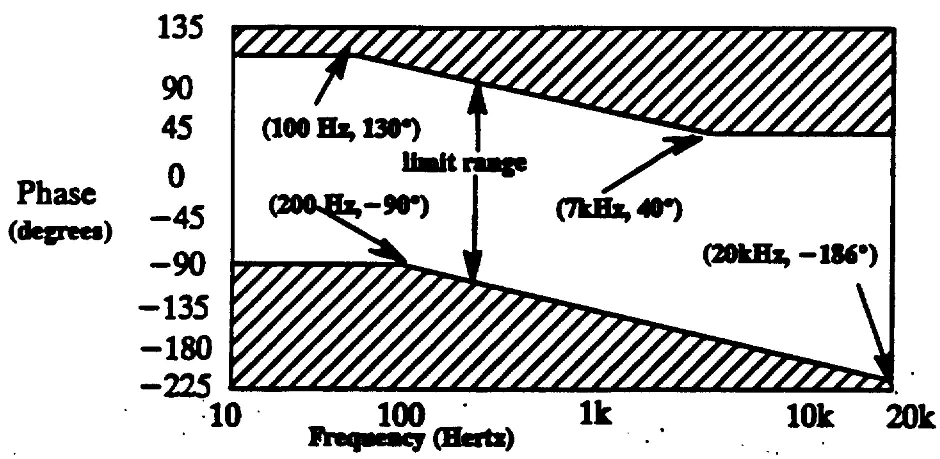

Figure 5-2a. Differential Mode Input Impedance Required Phase Characteristic CH-3

5.2.3 Power Control

5.2.3.1 Power Connections

A single power interface shall consist of two power feeds routed via two separate connectors. These connections are designated as power feeds A and B.

5.2.3.2 Power Application

In the absence of a fault on either power feed, the Spacecraft shall continuously apply power to each feed.

5.2.3.3 Power Fault Tolerance

The Instrument and Spacecraft shall be tolerant, as a minimum, to a single fault occurring in the power interface circuit on either side of the interface.

5.2.3.4 Instrument Equipment Separation

Instrument survival and operational equipment shall use separate electrical components and operate independently of each other.

5.2.3.5 Instrument Power Control

The Instrument shall provide separate power control for each separate power interface and for survival and operational equipment.

5.3 Grounds, Returns, and References

The following terms are defined to facilitate specification of the ground, return, reference and bonding requirements which are specified starting with Section 5.3.1:

Bond: A low–impedance electrical connection between two conductive elements.

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Chassis Reference: The point within a component at which signal reference and secondary power return leads are referenced to the instrument chassis.

Fault Ground: A conductor intended to carry fault currents in the event that the 120 Vdc input is short–circuited in the Instrument.

Instrument Chassis: The metal enclosure which shields the Instrument's electronics.

Instrument Chassis Ground Terminal: External connection to the Instrument's chassis reference.

Isolated Secondary Power: Isolated secondary power is power derived from another power source whose loads of which are completely isolated from Instrument to Spacecraft interface electronics.

Prime Power Reference: The point on the Spacecraft where all primary power returns are referenced. The Prime Power Reference is the reference point for Spacecraft voltage control.

Primary Power Return: The isolated 120 V current return lead from the primary side of the instrument power dc–to–dc converter back to the Spacecraft power distribution point.

Secondary Power: Power which has been derived and isolated from primary power typically by a dc–to–dc converter and used to power Spacecraft interface circuits.

Secondary Power Reference: The point within the Instrument where all current returns from the secondary power (except isolated secondary power) circuits are referenced.

Signal Reference: The reference within the Instrument for digital and analog signals.

Signal Reference Ground: The Spacecraft conducting plate or other structure to which all ground interconnections are connected.

Signal Return: The wire which carries the current of a digital or analog signal back to its source.

5.3.1 Power Leads and Returns

Each instrument primary power lead shall have a distinct, separate, and isolated return. Power on feed A shall be returned only on return A, and power on feed B shall be returned only on return B.

5.3.1.1 Power Harnessing

The Spacecraft shall route each instrument primary power return and fault conductor in an electrically shielded harness with the primary power supply lead.

5.3.1.2 Isolation

Isolation requirements from primary power to chassis and primary power to secondary power shall be adhered to at each primary power input.

5.3.1.2.1 Deleted

CH-1

5.3.1.2.2 120 V Primary Power Isolation

The 120 V primary power leads and returns shall each be isolated from signal and chassis references by $>10^6$ ohms (dc) and <0.5 microfarad when measured at the instrument input.

5.3.1.2.3 Secondary Power Isolation

Secondary power shall be isolated from 120 Vdc primary power by $>10^6$ ohms (dc).

5.3.1.3 Power Reference

5.3.1.3.1 Prime Power Reference

The Spacecraft shall reference 120 Vdc power returns to the Signal Reference Ground only at the Spacecraft Prime Power Reference point.

5.3.1.3.2 Secondary Power Return

Secondary power circuits shall provide current return leads from each instrument component which utilizes secondary power. These secondary power returns shall be referenced to the Secondary Power Reference.

5.3.1.3.3 Secondary Power Reference

The Instrument shall bond the Secondary Power Reference to the chassis reference.

5.3.1.3.4 Isolated Secondary Power Referencing

If isolated secondary power is used within the Instrument, then isolated returns shall not be left floating. In this instance isolated returns shall be connected to chassis reference through a resistance whose value is selected by the Instrument.

5.3.2 Signal Reference

The Instrument shall be designed such that the Secondary Power Reference and the signal reference for Spacecraft interface circuits are electrically the same point.

5.3.2.1 Signal Reference Constraints

Neither signal nor chassis reference points shall be used as power conductors.

5.3.2.2 Differential Signal Isolation

The Instrument shall isolate differential receiver leads from chassis reference by >3 kilohms and <0.01 microfarad. CH–1

5.3.2.3 Passive Telemetry Interface Isolation

The instrument shall isolate passive bi–level and passive analog telemetry interfaces from chassis reference by $\geq$100 kilohms. CH–3

5.3.3 Instrument Grounding

5.3.3.1 Instrument Ground Interconnection

The Spacecraft Provider shall provide a common electrically conductive ground interconnection for the Instrument and its associated instrument accommodation equipment.

5.3.3.2 Component Grounding

5.3.3.2.1 Component Ground Location

The Instrument shall provide a designated chassis ground terminal on each component, as close to all electrical connectors as possible.

5.3.3.2.2 Component Ground Connection

The Spacecraft Provider shall electrically bond the chassis ground terminal of each instrument component to the instrument ground interconnection.

5.3.3.2.3 Component Bonding Straps

Where direct contact is not possible between surfaces and/or movable metal–to–metal joints are present, bonding straps shall be used.

5.3.3.3 Connector Grounding

The Instrument shall electrically bond all instrument interface connectors to the instrument chassis.

5.3.3.4 Chassis Reference Current

Instruments shall not use their chassis to conduct power and signal currents under normal conditions.

5.3.4 Fault Ground

5.3.4.1 Instrument Fault Ground Requirements

5.3.4.1.1 Instrument Fault Ground Connection

The Instrument shall provide a designated fault ground pin at each prime power input connector.

5.3.4.1.2 Instrument Fault Ground Routing

The Instrument shall route a fault ground wire with each prime power lead to each component within the instrument which uses prime power.

5.3.4.1.3 Instrument Fault Ground Wire Grounding

The Instrument shall connect the fault ground wire to chassis at the prime power input for that component.

5.3.4.2 Spacecraft Fault Ground Requirements

5.3.4.2.1 Spacecraft Fault Ground Routing

The Spacecraft Provider shall route a fault ground wire with each prime power feed and return.

5.3.4.2.2 Fault Ground Wire Connection to Instrument Ground Interconnection

The Spacecraft Provider shall connect each fault ground wire to the instrument ground interconnection.

5.3.4.2.3 Fault Ground Wire Connection to Primary Power Reference

The Spacecraft Provider shall connect each fault ground wire to the Primary Power Reference.

5.3.5 Signal Reference Ground

5.3.5.1 Instrument Ground Interconnection Referencing

The Spacecraft Provider shall electrically connect the instrument ground interconnection to the Signal Reference Ground.

5.3.5.2 Thermal Blanket Grounding

5.3.5.2.1 Deleted CH–3

5.3.5.2.2 Deleted CH–3

5.3.5.2.3 Thermal Closeout Blanket Grounding

The spacecraft provider shall ensure that the thermal insulation blankets used for instrument closeout are electrically isolated from the instrument/instrument blankets. CH–3

5.4 Command and Data Handling Interface

This section describes the physical interface requirements for the command and data handling (C&DH) services which includes the science data bus, command and telemetry bus, time mark and frequency bus, and the discrete command and telemetry interfaces.

5.4.1 General Signal Interface Requirements

5.4.1.1 Interface Conductors

All signal interfaces shall use paired conductors. Paired conductors may include twisted pair, coaxial, twinaxial, and dual coaxial types.

5.4.1.2 Interface Redundancy

5.4.1.2.1 Redundant Interface Terminology

Redundant interfaces are designated side A or side B . CH–1

5.4.1.2.2 Redundant Interface Usage

5.4.1.2.2.1 Command and Telemetry Bus Interfaces

CH–1

The Instrument shall be capable of receiving commands on either side A or side B of the command and telemetry bus interfaces at all times.

5.4.1.2.2.2 Deleted

CH–1

5.4.1.2.2.3 Deleted

CH–1

5.4.1.2.3 Interface Fault Tolerance

The Instrument and Spacecraft shall be tolerant, as a minimum, to a single fault occurring in a signal interface circuit on either side of the interface.

5.4.1.3 Interface Circuitry Isolation

For redundant interfaces the Instrument shall maintain separate side A and side B interface circuitry and connectors. The signal reference for side A and side B interface circuitry shall be the same. CH–1

5.4.2 Point–to–Point Command and Telemetry Interfaces

The Spacecraft shall provide the following point–to–point command and telemetry services to each instrument as allocated in the UIID: CH–1

a. Relay Drive Commands

b. Passive Bi–Level Telemetry CH–1

c. Passive Analog Telemetry

d. Active Analog Telemetry

5.4.2.1 Relay Drive Commands

A relay drive command shall be a pulsed command with the current drive capability to energize coils of latching relays.

5.4.2.1.1 Deleted CH–1

5.4.2.1.2 Relay Drive Command Characteristics

The Spacecraft shall provide relay drive commands having the following characteristics:

Pulse Active:	+25 V (load current of 360 mA maximum) to +29 V (load current of 2 mA minimum)
Pulse Duration (t):	50 < t <60 msec exclusive of rise and fall times (measured with active pulse amplitude ≥25 V)
Rise/Fall Time:	Controlled between 0.5 msec minimum and 1.5 msec maximum (defined as transition time between 1 to 25 V)
Overcurrent Detector:	Command will be terminated if load current exceeds 425 ± 15 mA
Maximum Discrete Command Rate:	10 commands per second

5.4.2.1.3 Relay Drive Command Load Characteristics

The relay drive command relay drivers shall be designed to operate within the following range of load characteristics:

Pulse Active Load:	2 mA minimum 360 mA maximum
Load Capacitance	0.2 microfarad maximum (includes cable and user relay capacitance)

In addition, the Instrument shall provide series redundant suppression diodes in parallel with relay coils.

5.4.2.2 Deleted

CH–1

5.4.2.2.1 Deleted

CH–1

5.4.2.2.2 Deleted

CH–1

5.4.2.3 Passive Bi–Level Telemetry Interface

Passive bi–level telemetry shall be capable of sensing the state of relay contacts by defining a logic state within the instrument accommodation equipment that indicates whether a relay contact is open or closed.

5.4.2.3.1 Deleted

CH–1

5.4.2.3.2 Passive Bi–Level Telemetry Signal Characteristics

The signal characteristics of the passive bi–level telemetry with respect to signal reference return shall be as follows:

Logic "0" (Closed) Level:	Load (contact) resistance <500 ohms
Logic "1" (Open) Level:	Load (contact) resistance >1 megohm
Source Impedance:	≥1 megohm, not sampled
Logic "0" (Closed) Sense Current:	1 mA ±0.5% driven through closed relay contacts
Load Capacitance:	<1800 picofarads (includes cable and relay contact)

5.4.2.4 Passive Analog Telemetry Interfaces

5.4.2.4.1 Deleted

CH–1

5.4.2.4.2 Passive Analog Telemetry Signal Characteristics

The signal characteristics of the passive analog telemetry from the Instrument to the Spacecraft with respect to signal reference return shall be as follows:

Sensor Resistance Range:	0–5 kilohms
Source Impedance:	≥1 megohm, not sampled
Sense Current during Sample:	1.0 mA ±0.5%
Load Capacitance:	<1800 picofarads
A/D Resolution:	8 bits
A/D Accuracy:	±1.0% of full scale (+5V) ±0.5 LSB

5.4.2.5 Active Analog Telemetry Interfaces

5.4.2.5.1 Deleted

C.

5.4.2.5.2 Active Analog Telemetry Signal Characteristics

The signal characteristics of the active analog telemetry from the Instrument to the Spacecraft with respect to signal reference return shall be as follows:

Input Voltage Range:	0 to 5 Vdc.
Load Impedance:	≥1 megohm
Instrument Fault Voltage:	–16 to +16 Vdc per line with respect to Instrument signal reference
Fault Voltage Limit:	–16 to +16 Vdc per line with respect to Instrument Accommodation equipment signal reference
Common Mode Voltage:	–1 to +1 Vdc with respect to the Signal Reference Ground at the Instrument Accommodation equipment interface
A/D Resolution:	8 bits
A/D Accuracy:	±1.0% of full scale (+5Vdc) ±0.5 LSB

5.4.3 Time Mark and Frequency Bus

The Spacecraft shall provide a redundant time mark and frequency bus to each Instrument with a reference frequency and an encoded time mark signal.

5.4.3.1 Time Mark and Frequency Bus Electrical Characteristics

The electrical characteristics of the time mark and frequency bus shall comply with EIA–RS–422.

5.4.3.2 Reference Frequency Characteristics

The characteristics of the reference frequency shall be as follows:

Reference Frequency Beginning of Life:	1.000 MHz ±.001 Hz (±1 part in 10^9)
End–of–Life Accuracy:	≤1 part in 10^8 **(TBR 012)** at 5 years
Short Term Drift:	≤1 part in 10^{10} **(TBR 013)** in one minute

5.4.3.3 Time Mark Encoding

The time mark instant shall be encoded on the reference frequency signal, as shown in Figure 6–4.

5.4.3.4 Time Mark Accuracy

The accuracy of the time mark shall be ≤100 μsec with respect to UTC with reference update (once per hour minimum).

5.4.4 Command and Telemetry Bus Electrical Interface

A command and telemetry bus shall be provided to the Instruments.

5.4.4.1 Command and Telemetry Bus Electrical Characteristics

The electrical characteristics of the command and telemetry bus interface shall comply with MIL–STD–1553B, Notice 2. In addition, each command and telemetry bus interface shall be dual redundant per MIL–STD–1553B, Section 4.6.3 and shall be individually transformer coupled per MIL–STD–1553B, Section 4.5.1.5.1, and subsections.

5.4.5 Science Data Electrical Interface

Science data is comprised of all the information required to accomplish the scientific mission of the Instrument. This includes sensor output, data which is used for interpretation of sensor data, and data which is used to monitor or evaluate Instrument performance.

Science data is transferred from the Instrument via either a redundant low–rate Science data interface or a redundant high–rate science data interface.

5.4.5.1 Science Data Interface Control

The Spacecraft shall connect the Instrument to either the low–rate science data or the high–rate science data interface(s) as allocated in the UIID.

5.4.5.2 Low–Rate Science Data Interface Electrical Characteristics

The electrical characteristics of the low–rate science data interface shall comply with MIL–STD–1553B, Notice 2. In addition, each low–rate science data interface shall be dual redundant per MIL–STD–1553B, Section 4.6.3 and shall be individually transformer coupled per MIL–STD–1553B, Section 4.5.1.5.1, and subsections.

5.4.5.3 High–Rate Science Data Interface Electrical Requirements

5.4.5.3.1 High–Rate Interface Circuitry

5.4.5.3.1.1 Instrument High–Rate Science Data Interface Circuitry

The Instrument shall use differential drivers to drive the high–rate science data interface.

5.4.5.3.1.2 Instrument High–Rate Science Data Signal Interface Coupling

The Instrument shall capacitively couple the differential signal into the high–rate interface cable.

5.4.5.3.1.3 Spacecraft High–Rate Science Data Interface Circuitry

The Spacecraft shall provide differential receivers for the high–rate science data interface.

5.4.5.3.1.4 High–Rate Science Data Interface Polarity Inversion

The Spacecraft shall not introduce polarity inversion between the output of the driver and the output of the receiver.

5.4.5.3.2 High–Rate Science Data Interface Electrical Characteristics

The electrical signal parameters for the driver of the high–rate science data interface shall be as follows:

Differential Signal Voltage @ Driver Output:	0.6 Vac peak–to–peak minimum 1.0 Vac peak–to–peak maximum
Common Mode Voltage @ Driver Output:	1.0 Vac peak–to–peak maximum
Transmission Rate:	63.5 megabits per second (Mbps), asynchronous
Cable Type:	Dual Coaxial, Modified Gore G2, 50 ohm
Cable Length:	12 meters maximum

5.5 Other Interfaces

5.5.1 Test Point Interfaces

An Instrument may elect to use test points to provide external access to internal Instrument circuitry via GSE. Use of Instrument test points shall meet the following general requirements.

5.5.1.1 Spacecraft Integration and Test Use

Instrument test points shall not be used during Spacecraft integration and test, except as expressly approved and documented in formal procedures.

5.5.1.2 Performance Verification Limitation

Instrument data collected to verify acceptance or qualification of Instrument performance requirements shall be acquired through flight interfaces and not through test point interfaces.

5.5.1.3 Keyed Connectors

All test points shall be brought out to a separate, keyed connector(s) which shall be easily accessible. Separate test connectors shall be used to segregate classes of signals. When not in use and prior to launch, the connectors shall be protected with flight qualified covers.

5.5.1.4 Power and Load Isolation

The Instrument shall not be powered through, nor significantly loaded, by test point interface circuitry, including connection to external GSE.

5.5.1.5 Failure Propagation

Test point interface circuitry shall not propagate failures to instrument flight circuitry. This includes credible failures in GSE connected externally to the test point interface connectors.

5.5.1.6 Short–Circuit Isolation

Test point short–circuit isolation shall also be provided. The Instrument shall operate within specification in the event any test point is shorted to the power bus, ground, or another test point, and upon removal of the short.

5.5.1.7 Grounding Integrity

Test point interface circuitry shall not compromise instrument grounding requirements, either by design or use.

5.5.1.8 EMI/EMC

The test point interface, test point GSE, and associated cabling shall meet the requirements of GE PN20005869.

5.5.1.9 Flight Standards

Test points shall be designed and implemented in accordance with all applicable flight standards and component ratings, including the requirements of GSFC 420–05–01.

5.5.1.10 Mechanical Requirements

Test point implementations shall meet the mechanical requirements of Section 3.

5.5.2 Test Point Interface Documentation

Test point interfaces, functions and GSE interconnection shall be documented in the Instrument ICD.

5.6 Failure Modes and Effect Analysis

Failure Modes and Effect Analysis (FMEA) of the Spacecraft–Instrument circuitry shall be documented and reported to GSFC in accordance with GE20008607.

6 COMMAND AND DATA HANDLING REQUIREMENTS

All requirements in Section 6 define the utilization of the Command and Data Handling Interfaces.

6.1 Command and Telemetry Bus

6.1.1 Command and Telemetry Bus Configuration

On the command and telemetry bus the Instrument shall be configured as a remote terminal (RT) and the Spacecraft shall be configured as a bus controller (BC), with the message handling and control functions as defined in MIL–STD–1553B, all sections except as expressly prohibited herein.

6.1.1.1 Command and Telemetry Bus Transfer Method

The transmission method described in MIL–STD–1553B Section 4.3.3 shall be used for the transfer of data on the command and telemetry bus.

6.1.1.1.1 Command and Telemetry Bus MIL–STD–1553B Mode Code Utilization

Only the MIL–STD–1553B mode codes listed in Table 6–1 shall be utilized by the command and telemetry bus and all other codes are invalid.

6.1.1.1.2 Command and Telemetry Data Transfers

All data transferred on the command and telemetry bus shall be transferred using MIL–STD–1553B messages defined in MIL–STD–1553B, Section 4.3.3.6.

6.1.1.1.2.1 Data Transfers to the Instrument

All data transferred to the Instrument on the command and telemetry bus shall be a BC–to–RT transfer initiated and controlled by the BC.

6.1.1.1.2.2 Data Transfers from the Instrument

All data transferred from the Instrument on the command and telemetry bus shall be a RT–to–BC transfer initiated and controlled by the BC.

6.1.1.1.3 Broadcast Mode on the Command and Telemetry Bus

The broadcast mode of operation described in MIL–STD–1553B, Section 4.3.3.6.7 and subsections shall be prohibited.

6.1.2 Command and Telemetry Bus Transfer Timing

The Spacecraft shall control the timing of transfers on the command and telemetry bus based on minor cycles, major cycles and master cycles.

TABLE 6-1. MIL-STD-1553B MODE CODE UTILIZATION

Transmit/ Receive Bit	Mode Code	Function	Associated Data Word
1	00010	Transmit status word	No
1	00001	Synchronize (see note 1)	No
1	00011	Initiate self-test	No
1	00100	Transmitter shutdown	No
1	00101	Override transmitter shutdown	No
1	00110	Inhibit terminal flag bit	No
1	01000	Reset remote terminal	No
1	10000	Transmit vector word (see note 1)	Yes
0	10001	Synchronize (see note 2)	Yes
1	10010	Transmit last command	Yes
1	10011	Transmit BIT word	Yes

Notes:
1. Used on the Low Rate Science Data Bus only.
2. Used on the Command and Telemetry Bus only.

6.1.2.1 Minor Cycle Length

A minor cycle on the command and telemetry bus shall be an 8 millisecond period ±100µsec.

6.1.2.1.1 Minor Cycle Task List

The BC shall process and perform a specified set of transfers (called a task list) each minor cycle.

6.1.2.1.2 Minor Cycle Task List Completion

Upon completion of the task list specified for a minor cycle, the BC shall remain idle until the start of the next minor cycle.

6.1.2.2 Major Cycle Length

A major cycle shall consist of 128 minor cycles.

6.1.2.3 Master Cycle Length

A master cycle shall consist of 64 major cycles.

6.1.2.4 Command and Telemetry Bus Task Scheduling

The following types of data messages can be transferred on the command and telemetry bus:

a. Synchronize–With–Data Word Message

b. Command Message

c. Housekeeping Telemetry Message

d. IMOK Message CH–3

e. Safe Mode Command Message

f. Ancillary Data Message

g. Time Code Data Message.

h. Memory Load Data Message

i. Memory Dump Data Message

6.1.2.4.1 Synchronize with Data Word

The command and telemetry bus task schedule shall allow for the transfer of a maximum of one synchronize–with–data–word message on the bus each minor cycle.

6.1.2.4.1.1 Synchronize with Data Word Transfer Frequency

The BC shall issue a synchronize–with–data–word message to each instrument RT once every 32 minor cycles on a scheduled basis.

6.1.2.4.1.2 Synchronize with Data Word Transfer Timing

The BC shall issue the synchronize–with–data–word message to the RT within 200 μsec after the start of the minor cycle.

6.1.2.4.1.3 Data Word Content

The data word associated with the synchronize–with–data–word message shall indicate the minor cycle count of the major cycle and major cycle count of the master cycle in which the message is transferred.

6.1.2.4.1.4 Data Word Content Format

The format of the contents of the data word associated with the synchronize-with-data-word message shall be as shown in Figure 6-1.

1553B Command Word

Remote Terminal ID	0	00000 or 11111	10001
0 – 4	5	6 – 10	11 – 15

Data Word 1

0	0	major cycle count	0	minor cycle count
0	1	2 – 7	8	9 – 15

Figure 6-1. Command and Telemetry Bus Synchronize-with-Data-Word Message

6.1.2.4.1.5 Instrument Response to Data Word

The Instrument shall synchronize its telemetry transfer schedules to the major and minor cycle count delivered in the data word associated with the synchronize-with-data-word message.

6.1.2.4.1.6 Instrument Telemetry Transfer Schedule

The Instrument shall perform its telemetry transfer such that each telemetry point is unambiguously identifiable by the major cycle count and position in the message data field.

6.1.2.4.2 Command Transfers

The command and telemetry bus task schedule shall allow for the transfer of a maximum of one command message on the bus once every minor cycle. CH-3

6.1.2.4.3 Deleted CH-3

6.1.2.4.3.1 Instrument Normal Housekeeping Telemetry Collection

The Spacecraft shall collect the normal housekeeping telemetry from the Instrument once per major cycle on a scheduled basis.

6.1.2.4.3.2 Instrument Critical Health and Safety Housekeeping Telemetry Collection

The Spacecraft shall collect the critical health and safety housekeeping telemetry from the Instrument once per major cycle on a scheduled basis.

6.1.2.4.3.3 Instrument Housekeeping Telemetry Readiness

The Instrument shall have telemetry ready for each scheduled transfer at the start of the minor cycle for which that transfer is scheduled.

6.1.2.4.4 Memory Load Transfers

A data message containing memory load data shall be treated as a command message within the command and telemetry bus task schedule.

6.1.2.4.5 Memory Dump Transfers

The command and telemetry bus task schedule shall allow for a transfer of a data message containing memory dump data on the bus no sooner than once every sixth minor cycle or no later than once every 128 minor cycles. CH–3

6.1.2.4.6 IMOK, Ancillary Data, Time Code Data, and Safe Mode Commands CH–3

The command and telemetry bus task schedule shall allow for the transfer of a data message containing a IMOK message, ancillary data message, time code data message, or safe mode command message on the bus once per minor cycle. CH–3

6.1.2.4.6.1 IMOK, Ancillary Data, and Time Code Data Transfer Frequency CH–3

The Spacecraft shall issue a IMOK, an ancillary data message, and a time code data message to each instrument once per major cycle on a scheduled basis.

6.1.3 Command And Telemetry Bus Data

6.1.3.1 Commands

6.1.3.1.1 Real–Time Commands

All instrument real–time commands shall be limited to one MIL–STD–1553B message in length.

6.1.3.1.2 Stored Commands

All instrument commands stored and distributed by the Spacecraft Control Computer (SCC) shall be limited to 2 16–bit data words in length.

6.1.3.1.3 Safe–Mode Command Structure

The safe–mode command message shall be a "receive" message to subaddress 7 with one data word containing "D734" hexidecimal.

6.1.3.1.4 IMOK Command Structure

CH–3

The IMOK command message shall be a "receive" message to subaddress 5 with one data word containing "600D" hexidecimal.

6.1.3.2 Memory Load and Dump Initiate Command Structures

6.1.3.2.1 Load Initiate Command Structure

The memory load initiate command message shall be structured as shown in Figure 6–2.

6.1.3.2.2 Dump Initiate Command Structure

The memory dump initiate command message shall be structured as shown in Figure 6–3.

6.1.3.3 Memory Load Data Messages

Memory load data shall be transferred via multiple MIL–STD–1553B messages.

6.1.3.4 Memory Dump Data Messages

Memory dump data shall be transferred via multiple MIL–STD–1553B messages.

6.1.3.5 Ancillary Data Messages

6.1.3.5.1 Ancillary Data Contents

The contents of the Spacecraft ancillary data shall be as shown in Table 6–2.

6.1.3.5.2 Ancillary Data Message Format

Each Spacecraft ancillary data message data field shall be 512 bits in length formatted as shown in Table 6–3.

6.1.3.6 Time Code Data Messages

6.1.3.6.1 Time Code Data Contents

The time code data shall be Spacecraft time presented in a CCSDS standard day segmented time code format as defined in CCSDS 301.0–B–2, Section 2.3.

6.1.3.6.2 Time Code Data Epoch

The epoch shall be of the implicit type as defined in CCSDS 301.0–B–2, Section 2.1.1. The epoch shall be 1958 January 1.

Load Initiate Command:

1553B Command Word

Remote Terminal ID	0	00001	Word Count
0–4	5	6–10	11–15

	Word	Field	Bits
Command Description	1	Reserved for Instrument Use	0–15
Load Description Information	2	Reserved for Instrument Use	0–15
	3	Load Start Address – Bits 0–15	0–15
	4	Load Start Address – Bits 16–31	0–15
	5	Word Count – Bits 0–15	0–15
	6	Word Count – Bits 16–31	0–15
	7	Verification Code – Bits 0–15	0–15
	8	Verification Code – Bits 16–31	0–15

Figure 6–2. Memory Load Initiate Command

Dump Initiate Command:

1553B Command Word

Remote Terminal ID	0	00001	Word Count
0–4	5	6–10	11–15

	Word	Field	Bits
Command Description	1	Reserved for Instrument Use	0–15
Dump Description Information	2	Reserved for Instrument Use	0–15
	3	Dump Start Address – Bits 0–15	0–15
	4	Dump Start Address – Bits 16–31	0–15
	5	Word Count – Bits 0–15	0–15
	6	Word Count – Bits 16–31	0–15

Figure 6–3. Memory Dump Initiate Command

6.1.3.6.3 Time Code Data Format

The time code data message shall be a "receive" message to subaddress 6 with 4 data words. This data message shall be formatted as shown in Table 6-4.

TABLE 6-2. SPACECRAFT ANCILLARY DATA MESSAGE CONTENTS

Description	Notes	Resolution (*)	Range (*)	Sampling Time (**)
Packet header	CCSDS packet header for downlink, used for ground routing and processing. May be ignored by instruments.	N/A	N/A	N/A
Secondary Header ID Flag	Flag indicating "Non-CCSDS-Defined Secondary Header." Always a data zero. This field is part of the secondary header of the packet for downlink.	N/A	N/A	N/A
Time Stamp	Epoch of the data in the ancillary data message. Spacecraft clock time in CCSDS Day-Segmented Format. The "P-field" is implied, and equals "01000001" binary. The code epoch is 1958 January 1. This field is part of the secondary header of the packet for downlink.	1 microsec	1958 – 2047	N/A
Flag Byte	Flags for ground data processing control. First (most significant) bit is the "quick look" bit which, when set to a data one, indicates that quick-look processing should be performed. Other bits are reserved and will contain data zeroes. This field is part of the secondary header of the packet for downlink.	N/A	N/A	N/A
Time Conversion	Estimated difference between UTC and the Spacecraft Clock. This may be added to the Spacecraft Clock time to derive UTC time.	1 microsec	$\pm 8.3 \times 10^{6}$ microsec	0
Spacecraft Position (X,Y,Z)	The estimated position of the spacecraft, expressed in the Earth Center Inertial frame (mean Equator and Equinox of J2000).	0.125 meters	$\pm 268 \times 10^{6}$ meters	0
Spacecraft Velocity (X,Y,Z)	The estimated velocity of the spacecraft, expressed in the Earth Center Inertial frame (mean Equator and Equinox of J2000).	244×10^{-6} meters/sec	$\pm 524 \times 10^{3}$ meters/sec	0
Attitude Angles (Roll, Pitch, Yaw)	The estimated attitude of the spacecraft, expressed in the Orbital Reference frame.	1.0 arcsec	±2048 arcsec	TBD 004
Attitude Rates (Roll, Pitch, Yaw)	The estimated attitude rates of the spacecraft, expressed in the Spacecraft Reference frame.	0.5 arcsec/sec	±1024 arcsec/sec	TBD 004
Magnetic Coil Currents (X, Y, Z)	Currents flowing in each of the magnetic torquer coils used for Spacecraft momentum unloading.	15.6×10^{-3} amps	±2.0 amps	TBD 004
Solar Array Current	Current flowing from the Spacecraft solar array.	1.0 amps	0 – 256 amps	TBD 004
Solar Position (X, Y, Z)	Components of a unit vector, expressed in the Spacecraft Reference frame, pointing in the direction of the Sun.	7.8×10^{-3}	±1	0
Moon Position (X, Y, Z)	Components of a unit vector, expressed in the Spacecraft Reference frame, pointing in the direction of the Moon.	7.8×10^{-3}	±1	0
Reserved	Denotes fields within message which are reserved for future application. These fields must not be interpreted by instruments.	N/A	N/A	N/A

NOTES: (*) Resolutions and Ranges are approximate. Exact values are defined by formats.
(**) Sampling time of data relative to epoch of Time Stamp, in milliseconds.

TABLE 6-3. SPACECRAFT ANCILLARY DATA MESSAGE FORMAT

Data Word # (*)	Starting (MSB) Bit (**)	No. Bits (***)	Description	Units	Format	Scaling
1	0	48	Packet header	N/A	N/A	N/A
4	0	1	Secondary Header ID Flag	N/A	N/A	N/A
4	1	63	Time Stamp	microsec	CDS	N/A
8	0	8	Flag Byte	N/A	N/A	N/A
8	8	24	Time Conversion	microsec	2C	0
10	0	32	Spacecraft Position – X	meters	2C	–3
12	0	32	Spacecraft Position – Y	meters	2C	–3
14	0	32	Spacecraft Position – Z	meters	2C	–3
16	0	32	Spacecraft Velocity – X	meters/sec	2C	–12
18	0	32	Spacecraft Velocity – Y	meters/sec	2C	–12
20	0	32	Spacecraft Velocity – Z	meters/sec	2C	–12
22	0	4	Reserved	–	–	–
22	4	12	Attitude Angle – Roll	arcsec	2C	0
23	0	4	Reserved	–	–	–
23	4	12	Attitude Angle – Pitch	arcsec	2C	0
24	0	4	Reserved	–	–	–
24	4	12	Attitude Angle – Yaw	arcsec	2C	0
25	0	4	Reserved	–	–	–
25	4	12	Attitude Rate – Roll	arcsec/sec	2C	–1
26	0	4	Reserved	–	–	–
26	4	12	Attitude Rate – Pitch	arcsec/sec	2C	–1
27	0	4	Reserved	–	–	–
27	4	12	Attitude Rate – Yaw	arcsec/sec	2C	–1
28	0	8	Magnetic Coil Current – X	Amperes	2C	–6
28	8	8	Magnetic Coil Current – Y	Amperes	2C	–6
29	0	8	Magnetic Coil Current – Z	Amperes	2C	–6
29	8	8	Solar Array Current	Amperes	US	0
30	0	8	Solar Position – X	N/A	2C	–7
30	8	8	Solar Position – Y	N/A	2C	–7
31	0	8	Solar Position – Z	N/A	2C	–7
31	8	8	Moon Position – X	N/A	2C	–7
32	0	8	Moon Position – Y	N/A	2C	–7
32	8	8	Moon Position – Z	N/A	2C	–7

Notes:
(*) = Data word numbers indicate position of data word in MIL-STD-1553B bus message. Word 1 is transmitted first.
(**) = Bit numbers indicate position of MSB in 16-bit data word field of MIL-STD-1553B data word. Bit 0 is transmitted first.
(***) = Values which extend beyond the end of a 16-bit data word are continued starting with bit 0 of the next data word.
N/A = Not Applicable
CDS = CCSDS Day Segmented, implied P-field of "01000001"
2C = 2's complement
US = unsigned
MSB = most significant bit
LSB = least significant bit
LSB weight is 2^n units, where ^{n} is the scaling

TABLE 6–4. SPACECRAFT TIME CODE DATA MESSAGE FORMAT

Data Word # (*)	Starting (MSB) Bit (**)	No. Bits (***)	Description	Units	Format	Scaling
1	0	16	Days since 1958 January 1	Days	US	0
2/3	0	32	Millisecond of Day	msec	US	0
4	0	16	Microsecond of Millisecond	microsec	US	0

Notes:
(*) = Data word numbers indicate position of data word in MIL–STD–1553B bus message. Word 1 is the first data word transmitted.
(**) = Bit numbers indicate position of MSB in 16–bit data word field of MIL–STD–1553B data word. Bit 0 is the first bit transmitted.
(***) = Values which extend beyond the end of a 16–bit data word are continued starting bit 0 of the next data word.
N/A = Not Applicable
2C = 2's complement
US = unsigned
MSB = most significant bit
LSB = least significant bit
LSB weight is 2^n units, where ^{n} is the scaling

6.1.4 Command and Telemetry Bus Protocols

6.1.4.1 Instrument Command and Telemetry Bus RT Address Assignment

All instrument RT addresses on the command and telemetry bus shall be assigned by the Spacecraft Provider and documented in the Instrument ICD.

6.1.4.2 MIL–STD–1553B Message Identification

The subaddress shall indicate the type of data contained in the MIL–STD 1553B message on the command and telemetry bus.

6.1.4.2.1 MIL–STD–1553B Message Subaddress Definition

The MIL–STD–1553B message subaddresses for the command and telemetry bus shall be as defined in Table 6–5.

6.1.4.2.2 Instrument Specific Subaddresses

All MIL–STD–1553B message subaddresses utilized specifically by the instrument shall be negotiated and documented in the Instrument ICD.

6.2 Time Mark and Frequency Bus

A time mark instant and reference frequency to be used with time code data (described in Section 6.1.3.6) are provided via the time mark and frequency bus.

TABLE 6–5. COMMAND AND TELEMETRY BUS MIL–STD–1553B MESSAGE SUBADDRESSES

Subaddress	Name	Transmit/ Receive Bit
1	Instrument Command	0
2	Load Data	0
2	Dump Data	1
4	Ancillary Data	0
5	IMOK	0
6	Time Code Data	0
7	Safe Mode Command	0
9	Loop Back	1 or 0
17	Normal Housekeeping Telemetry Data	1
18	Critical Health and Safety Telemetry Data	1
0 or 31	Mode Code	1 or 0
All remaining subaddress numbers are reserved		

CH–3

6.2.1 Time Code Data Valid Indication

The time mark instant, on the time mark and frequency bus, shall indicate when the transmitted time code data, transmitted on the command and telemetry bus, is valid.

6.2.2 Time Information Timing

The timing relationship between time code data, reference frequency, and the encoded time mark instant shall be as shown in Figure 6–4.

6.3 Low Rate Science Data Bus

The low–rate science data packets shall be transferred from the Instrument to the Spacecraft via the low–rate science data bus.

6.3.1 Low–Rate Science Data Interface Configuration

On the low–rate science data bus the instrument shall be configured as an RT and the spacecraft shall be configured as a BC, with the message handling and control functions as defined in MIL–STD–1553B, all sections except as expressly prohibited herein.

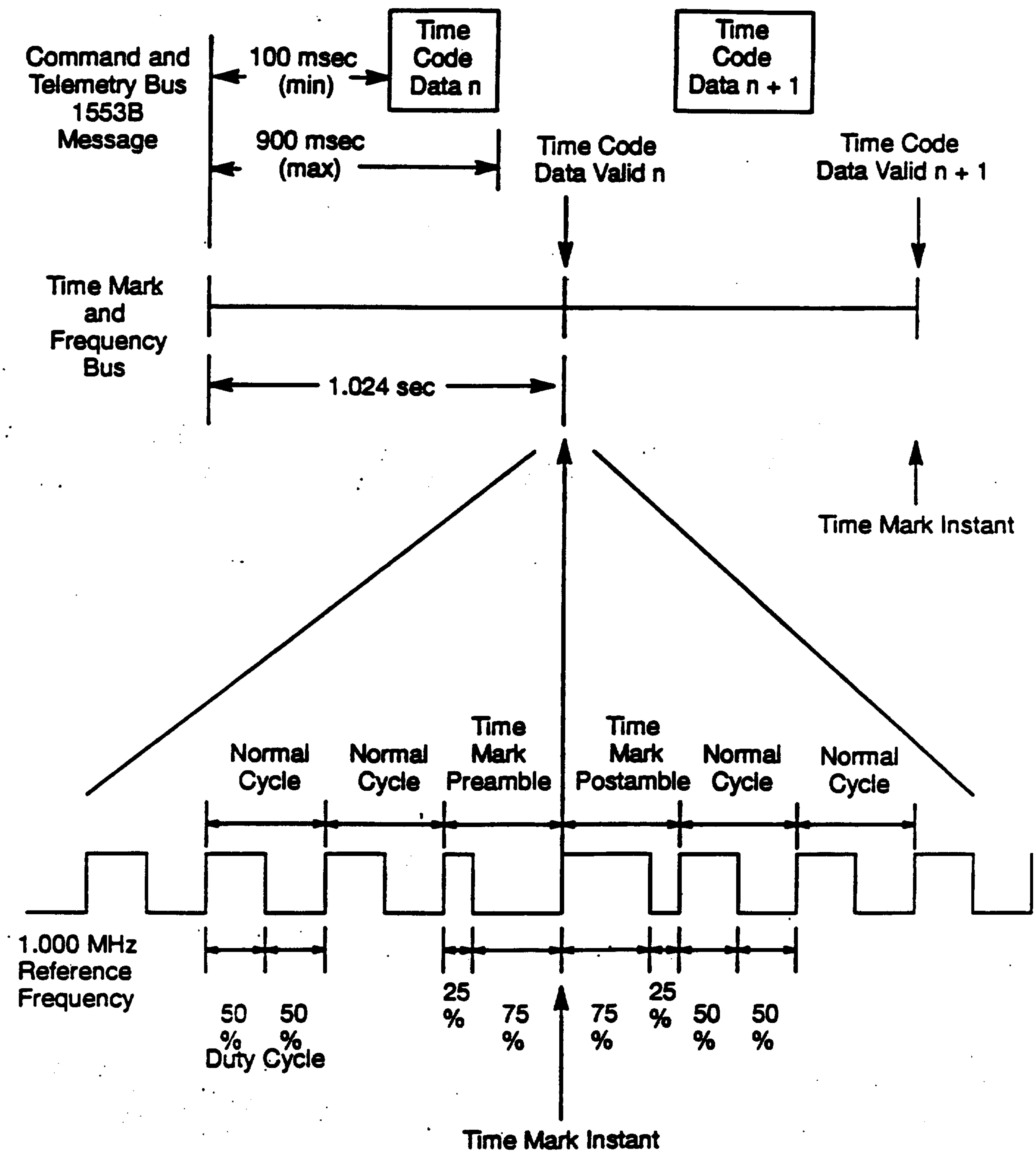


Figure 6-4. Time and Frequency Timing

6.3.2 Broadcast Mode on the Low–Rate Science Data Bus

The broadcast mode of operation described in MIL–STD–1553B Section 4.3.3.6.7 and subsections shall be prohibited on the low–rate science data bus.

6.3.3 Low–Rate Science Data Transfer Timing

The timing of packet transfers via the low–rate science data bus shall be as shown in Figure 6–5.

6.3.4 Low–Rate Science Data Bus Data Format

All low–rate instruments shall be required to assemble their science data into source packets compatible with the Path Packet Service described in CCSDS 701.0–B–1, Section 3.3.3. The format of these packets is shown in Figure 6–6.

6.3.5 Low–Rate Science Data Bus Transfer Protocol

6.3.5.1 Low–Rate Science Data Bus RT Address Assignment

All instrument RT Addresses on the low–rate science data bus shall be assigned by the Spacecraft Provider and documented in the Instrument ICD.

6.3.5.2 Low–Rate Science Data Bus MIL–STD–1553B Mode Code Utilization

Only the MIL–STD–1553B mode codes listed in Table 6–1, except for the synchronize–with–data–word mode code, shall be utilized by the low–rate science data bus and all other codes are invalid.

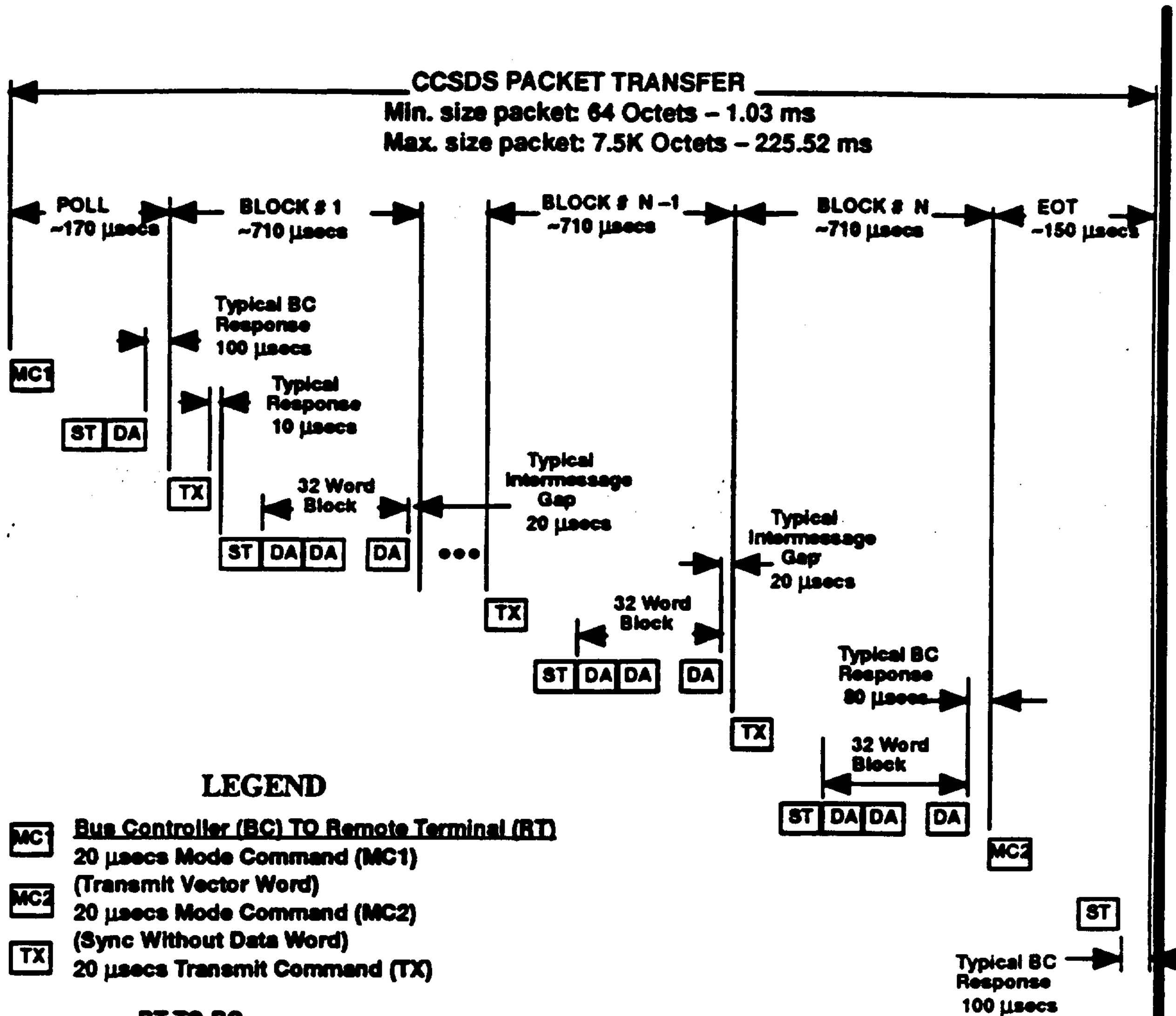
6.3.5.3 Low–Rate Science Data Bus MIL–STD–1553B Message Subaddresses

The MIL–STD–1553B message subaddresses utilized on the low–rate science data bus shall be as defined in Table 6–6.

TABLE 6–6. LOW–RATE SCIENCE DATA BUS MIL–STD–1553B MESSAGE SUBADDRESSES CH–3

Subaddress	Name	Transmit/ Receive Bit
1–8	Not Valid	don't care
9	Loop Back	1 or 0
10–25	Instrument Science Data Packet	1
26–30	Not Valid	don't care
0 or 31	Mode Code	1 or 0

CH–3



LEGEND

Bus Controller (BC) TO Remote Terminal (RT)

- MC1 — 20 µsecs Mode Command (MC1) (Transmit Vector Word)
- MC2 — 20 µsecs Mode Command (MC2) (Sync Without Data Word)
- TX — 20 µsecs Transmit Command (TX)

RT TO BC

- ST — 20 µsecs Status Word (ST)
- DA — 20 µsecs Data Word (DA) (16 Data Bits per word)

Packet = N blocks of 32 Data Wrods in consecutive subaddresses:
N=1 for min. size packet
N=120 for max size packet

Subaddress for block N= 10 + MOD 16(N–1)

Note:
1. The retransmission of block n–1 is performed using the alternate bus if the subaddress field is not incremented.

2. At each transition from subaddress 25 to subaddress 10 the intermessage Gap = 20 ms.

Figure 6–5. Low–Rate Science Data Bus Interface Protocol

HEADER (48 BITS)							DATA ZONE ("X" BITS)		
PACKET IDENTIFICATION				PACKET SEQUENCE CONTROL		PACKET LENGTH	SECONDARY HEADER		INSTRUMENT DATA FIELD
VERSION	TYPE	SEC HDR FLAG	APPLIC. PROC. ID	SEQUENCE FLAGS	PACKET SEQUENCE COUNT		TIME TAG NOTE 1	QUICK LOOK FLAG	VARIABLE LENGTH
3 BITS	1 BIT	1 BIT	11 BITS	2 BITS	14 BITS	16 BITS	64 BITS	8 BITS	(X–72) BITS

PATH SERVICE USERS

NOTES:

1. The Science Data time tag is placed in the secondary header field by the Instrument.

SCIENCE DATA PACKET FORMAT

Version: 000

Type: 0

Secondary Header Flag: Set to "1"

Application Process ID: Allocated in UIID

Sequence Flags: For instrument's use

Packet Sequence Count: Sequential count of packets associate with an APID

Packet Length: Contains the binary count in octets of the data in the Data Zone as the number of octets – 1 or (["X"/8] – 1).

Secondary Header:

Time Tag: Contains the science data time tag as Spacecraft time in CCSDS day segmented time code format. The first bit must always be set to zero (0) to indicate a non–CCSDS defined secondary header.

Quick Look Flag: The instrument sets the first bit (MSB) of this octet to "1" if the packet is included in the quick look data set. If the first bit (MSB) is set to "0" the packet is not included in the quick look data set.

High Rate Science Data "X" Bits = 976 bits (minimum) to 8144 bits (maximum) CH–3
Low Rate Science Data "X" Bits = 976 bits (minimum) to 61392 bits (maximum)

Figure 6–6. CCSDS Version 1 Source Packet Format

6.3.5.4 Low–Rate Science Data Polling

The Spacecraft shall poll the Instrument for a complete source packet using the MIL–STD–1553B transmit vector word.

6.3.5.5 Low–Rate Science Data Packet Readiness

When the Instrument has a complete source packet ready for transfer, the Instrument shall set the service request bit in the MIL–STD–1553B status word.

6.3.5.6 Total Packet Length Indication

The Instrument shall indicate the number of octets to be transferred in the data word associated with the transmit vector word poll.

6.3.5.7 Low–Rate Science Data Packet Transfer

6.3.5.7.1 Low–Rate Instrument Polling Interval

The interval between successive polls of a single low–rate instrument shall be less than 2 seconds and greater than or equal to 20 milliseconds. CH–1

6.3.5.7.2 Low–Rate Science Data Throughput Interval

The Spacecraft shall accommodate the instrument science data rate–of–transfer allocation when average over any 2–second interval.

6.3.5.7.3 Low–Rate Science Data Packet Transfer Timing

The transfer of complete low–rate science data packets shall occur in such a manner which satisfies the timing equation:

$$\frac{PL(N) + PL(N+1)}{T2P(N)} \leq CIR, \text{ for all } N.$$

PL(N): Length of packet N, in bits

T2P(N): Time in seconds from the assertion of the service request bit for packet N to the assertion of the service request bit for packet N+2

CIR: Current Instrument rate–of–transfer allocation (bits per second)

6.3.5.8 Low–Rate Science Data Packet Transfer Method

The packet transfer shall be accomplished by MIL–STD–1553B messages.

6.3.5.8.1 Deleted

CH–3

6.3.5.8.2 Multiple Message Packet Transfer

If the packet length is greater than 512 bits, multiple consecutive messages sent to consecutive subaddresses starting with subaddress 10 shall be used to transfer the packet. For multiple consecutive messages which exceed the number of available subaddresses, once the last available subaddress has been used the subaddress sequence shall be restarted at subaddress 10 after a minimum delay of 20 milliseconds. CH–1

6.3.5.8.3 Transferring an Odd Number of Octets

If a message has an odd number of octets, the last octet shall be transferred in the most significant octet of a 16 bit word.

6.3.5.8.4 End of Transfer

CH–3

The BC shall end each packet transfer with a synchronize–without–data word.

6.4 High–Rate Science Data Interface

High–rate science data packets shall be transferred to the Spacecraft via redundant, isolated, high speed interfaces designated as the high–rate link.

6.4.1 High–Rate Link Science Data Rate

The maximum science data rate, before encoding, into a single high–rate link shall not exceed 50 Mbps including packet header.

6.4.1.1 High–Rate Link Allocation

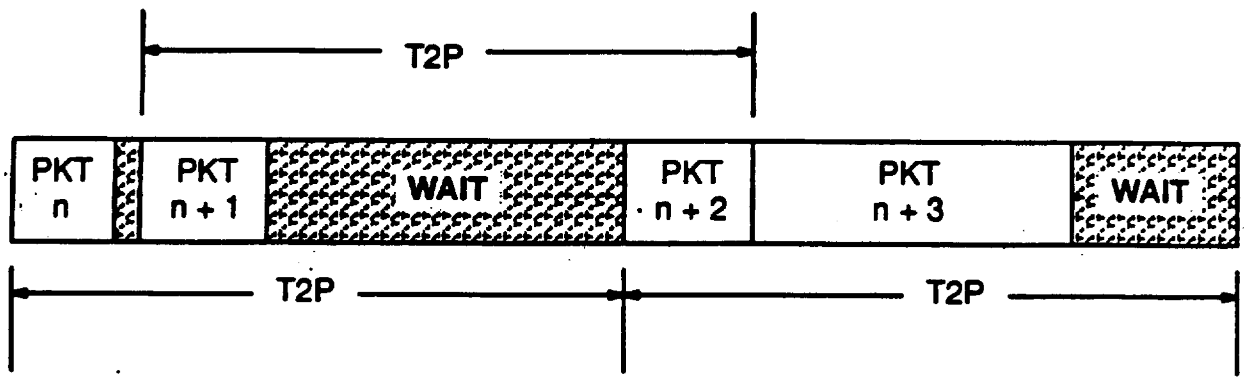
The number of high–rate links allocated to a single instrument shall be sufficient to accommodate the data rate allocated in the UIID.

6.4.2 High–Rate Science Data Packet Transfer Timing

The Instrument shall transfer complete source packets in a manner which satisfies the timing shown in Figure 6–7.

6.4.2.1 High–Rate Science Data Interface Data Format

All high–rate instruments shall be required to assemble their science data into source packets compatible with the Path Packet Service described in CCSDS 701.0–B–1, Section 3.3.3. The format of these packets is shown in Figure 6–6.



PACKET LENGTH

PKTn...PKTn + 2 < PL(max)
PKTn + 3 = PL(max)

$$T2P \geq \frac{2 \times PL\ (max)}{CIR}$$

LEGEND:

T2P = Instrument time to transfer two packets
CIR = Instrument Peak rate of transfer per high rate science data link (peak rate is peak allocation in UIID) CH–3
PL(max) = Maximum Packet Length including header for the Instrument's current mode

Figure 6–7. High–Rate Link Timing

6.4.3 High–Rate Science Data Transfer Protocol

6.4.3.1 Data Encoding

The Instrument shall encode the data and clock information on the high–rate link in compliance with the FDDI physical layer protocol as defined in American National Standards Institute (ANSI) X3.148–1988, Table 1. This is "4B/5B" encoding combined with non–return to zero invert on ones (NRZI).

6.4.3.2 High–Rate Science Data Message Format

6.4.3.2.1 High–Rate Science Data Message Symbols

High–rate science data messages shall be assembled as sequences of pairs of active symbols; i.e., an even number of symbols is included in each message field.

6.4.3.2.2 High–Rate Science Data Message Fields

Each high–rate science data message, also designated "High Speed Data Unit" (HSDU), shall be comprised of five fields, defined and ordered as shown in Table 6–7.

6.4.3.2.3 High–Rate Science Data Message Info Field Transmission

The Instrument shall transmit only symbols O–F from the time the message control field is transmitted and the time the ending delimiter is transmitted.

6.4.3.3 High–Rate Link Preamble

For instruments which power down the high rate interface between transmissions, prior to transmitting a packet, the high–rate link shall be powered, and the Instrument shall send a minimum of 20 idle (I) symbols over a period of 250 μsec.

6.4.3.4 High–Rate Link Transmission Gap

Instruments which do not power down the high–rate link interface between transmissions shall transmit a continuous stream of J–K symbols between active packet transmissions.

TABLE 6–7. HIGH–RATE SCIENCE DATA MESSAGE FORMAT

PA (20+ if needed)	SD (2+)	MC (2)	INFO (CCSDS Version 1 Packet) (2048 max)	ED (2)

Field	Name	No. of Symbols (Note 1)	Encoding	Comments
1	Preamble (PA)	20+	II	A minimum of 10 pairs of idle symbols are contained in this field (Always paired)
2	Starting Delimiter (SD)	2 or more	JK	Signifies the beginning of a message (Always paired)
3	Message Control (MC)	2		
	MC (Symbol 1) Message Class		R or S	R = System test message S = Synchronous message
	MC (Symbol 2) Message Grade		R	R = Grade 2 Service
4	Information (INFO)	256–2048	0–F	If MC1 = R, INFO contains a system test message defined in Section 7.1.4 if MC1 = S, INFO contains CCSDS Version 1 source packets of instrument data
5	Ending Delimiter (ED)	2	TT	Termination

Notes
1. Each symbol is 5 bits

7 COMMAND AND DATA HANDLING OPERATIONAL REQUIREMENTS

All requirements in Section 7 define utilization restrictions and specific tasks performed by the command and data handling interfaces.

7.1 Science Data

7.1.1 Science Data Interface Allocation

Each instrument shall be designated as either a low-rate or a high-rate instrument according to its peak data rate as allocated in the UIID.

7.1.2 Science Data Types

7.1.2.1 Low-Rate Science Data

A low-rate instrument is any instrument that generates data for the science data interface at bit rates <100 kbps.

7.1.2.2 High-Rate Science Data

A high-rate instrument is any instrument that generates data for the science data interface at equivalent bit rates ≥100 kbps.

7.1.2.3 Engineering Data

Instruments with a science data rate ≥ 20 Kbps shall packetize its engineering data separately with a separate Application Process ID (APID).

7.1.3 Science Data Requirements

7.1.3.1 Application Process ID

The APID portion of the CCSDS Version 1 source packet primary header definition will be defined prior to instrument integration to the EOS Spacecraft.

7.1.3.1.1 Application Process ID Allocation

The APIDs shall be as allocated in the UIID and shall remain fixed throughout the mission life.

7.1.3.1.2 Application Process ID Documentation

The APIDs shall be documented in the Instrument ICD.

7.1.4 Science Data Interface Test Packet Requirements

(TBD 005)

7.2 Commands

7.2.1 Point–to–Point Commands

The point–to–point interfaces shall provide discrete relay drive commands to the Instrument. CH–1

7.2.1.1 Spacecraft Required Point–to–Point Commands

The Instrument shall accept and execute the following Spacecraft required commands issued via the point–to–point command interfaces.

7.2.1.1.1 Instrument Operational Equipment ON and OFF Commands

The Instrument shall provide the Spacecraft the capability to turn the instrument operational equipment ON and OFF via discrete relay drive commands.

7.2.1.1.2 Instrument Survival Equipment ON and OFF Commands

The Instrument shall provide the Spacecraft the capability to turn the instrument survival equipment ON and OFF via discrete relay drive commands.

7.2.1.2 Instrument Point–to–Point Commands

Any remaining point–to–point command interfaces not used for Spacecraft–required point–to–point commands shall be available for instrument use.

7.2.1.2.1 Instrument Fault Recovery

The point–to–point command interfaces shall provide the ability to conduct limited diagnostics and reconfiguration of the Instrument, to re–establish communications via the command and telemetry bus, and to support recovery from limited anomalies and failures associated with the Instrument.

7.2.1.2.1.1 Instrument Fault Isolation

Reconfiguration of instrument block redundant subsystems required for instrument fault isolation shall be accomplished via the point–to–point command interfaces.

7.2.2 Command and Telemetry Bus Commands

The command and telemetry bus shall provide for the transfer of real–time, stored, or spacecraft–generated commands to the Instrument.

7.2.2.1 Real–Time Commands

The Instrument shall define the following real–time commands issued via the command and telemetry bus to initiate the associated activities.

7.2.2.1.1 Memory Load Initiation

The BC shall initiate all instrument memory loads with a load initiate command message.

7.2.2.1.2 Memory Dump Initiation

The BC shall initiate all instrument memory dumps with a dump initiate command message.

7.2.2.2 Stored Commands

There shall be two types of stored commands available to the Instrument: absolute time commands and relative time commands.

7.2.2.2.1 Absolute Time Commands

7.2.2.2.1.1 Absolute Time Command Time Tag Resolution

The time tag for absolute time commands shall have a resolution of 1.024 seconds. CH–3

7.2.2.2.1.2 Absolute Time Command Distribution

Absolute time commands shall be sent to the instrument within 1.024 seconds after the instant when the command time tag and spacecraft time are equal. CH–3

7.2.2.2.1.3 Absolute Time Command Time Tag Uniqueness

There shall be a maximum of 8 absolute time commands total stored by the Spacecraft with the same time tag. CH–3

7.2.2.2.2 Relative Time Commands

7.2.2.2.2.1 Relative Time Sequence

Relative time commands which are related to each other shall be organized into a relative time sequence (RTS).

7.2.2.2.2.2 Relative Time Sequence Distribution

The distribution of a RTS shall be triggered by an absolute time command, real–time command, or a command from the telemetry monitor.

7.2.2.2.2.3 Relative Time Sequence Distribution Timing

Each command in a RTS shall be separated in time by a time delay.

7.2.2.2.2.4 Relative Time Command Time Delay

The time delay between relative time commands in a RTS shall be an integer multiple (>0) of 1.024 seconds having a maximum value of 65,535 seconds. CH–3

7.2.2.3 Spacecraft Control Computer Issued Commands

The Instrument shall accept and execute the following commands issued by the SCC via the command and telemetry bus.

7.2.2.3.1 Telemetry Monitor Commands

The SCC shall provide the capability to issue a command via the command and telemetry bus to initiate an action based upon a pre-determined telemetry state monitored by the onboard telemetry monitor.

7.2.2.3.2 Instrument Telemetry Monitor Commands

The Instrument shall define all commands to be issued by the SCC based upon the predetermined state of telemetry monitored by the SCC.

7.2.2.3.3 IMOK Indication and Safe-Mode Command CH-3

7.2.2.3.3.1 IMOK Indication

The Spacecraft shall transmit an IMOK indication via the command and telemetry bus once per major cycle on a scheduled basis.

7.2.2.3.3.2 Safe-Mode Command

The Spacecraft shall provide to the Instrument, via the command and telemetry bus, a safe-mode command which indicates a failure of the computer system controlling the Spacecraft.

7.2.2.3.4 Instrument Survival Mode Commands

The Instrument shall define a stored command or stored command sequence consisting of ≤10 commands for use by the Spacecraft to transition the Instrument into its survival mode from any operational mode or its safe mode.

7.2.2.4 Interface Selection

7.2.2.4.1 Time Mark and Frequency Bus Selection

The Instrument shall accept a command indicating which time mark and frequency bus to use, bus A or bus B.

7.2.2.4.2 Redundant High-Rate Link Selection

The Instrument shall accept a command indicating which side of the high-rate link interface to have active, side A or side B.

7.2.2.5 High Rate Link Test Command

A high–rate Instrument shall accept a command to transmit a system test message across the interface as defined in Section 7.1.4.

7.2.3 Instrument Command Documentation

All commands to be transferred to the Instrument via the point–to–point command interfaces and the command and telemetry bus and their structure shall be documented in the Instrument ICD.

7.2.4 Command Requirements

7.2.4.1 Command Uniqueness

Each command shall be unique and have the same effect in all instrument modes for which the command is applicable.

7.2.4.2 Critical Commands

Initiation of critical or hazardous functions shall use, as a minimum, distinct enable and execute commands.

7.2.4.3 Command Sequence

The Instrument shall be designed such that commands may be sent or executed in any sequence without damage to the instrument.

7.2.5 Command Restraints

The restraints imposed in this subsection shall apply to all command types.

7.2.5.1 Toggle Commands

No state–dependent or "toggle" commands shall be allowed.

7.2.5.2 Command Format Consistency

For any command, the command format shall be identical for every mission phase and every instrument mode for which the command is applicable.

7.2.5.3 Multifunction Commands

Within commands transferred that control a number of 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.

7.3 Telemetry

7.3.1 Point-to-Point Telemetry

The following types of telemetry are provided via redundant point-to-point connections:

a. Passive Bi-Level Telemetry

b. Passive Analog Telemetry

c. Active Analog Telemetry

7.3.1.1 Instrument Status

The point-to-point telemetry interfaces shall be used to provide an independent source of instrument status data and instrument health and safety information in all instrument operating modes.

7.3.1.2 Required Point-to-Point Telemetry

The Instrument shall provide as a minimum the following telemetry to the Spacecraft via the point-to-point telemetry interfaces:

a. Status of all functions commanded via point-to-point interfaces

b. Telemetry for the determination of instrument health and safety

The Spacecraft shall provide the following telemetry for the Instrument Power interfaces: CH-1

a. Instrument input current for each primary power input in all modes

b. Instrument input voltage for each primary power input in all modes

7.3.1.3 Instrument Point-to-Point Telemetry Sampling Rate

The Spacecraft shall provide sampling rates of 1.024 seconds, 8.192 seconds, and 65.536 seconds for instrument point-to-point telemetry interfaces.

7.3.1.4 Instrument Point-to-Point Telemetry Sampling Rate Definition

The Instrument shall define the rate at which each telemetry point shall be sampled to allow adequate time for intervention in case of a pending failure.

7.3.2 Command and Telemetry Bus Telemetry

7.3.2.1 Instrument Housekeeping Telemetry Types

7.3.2.1.1 Normal Instrument Housekeeping Telemetry

The instrument housekeeping telemetry data stream shall contain all information, including the data contained in the critical health and safety telemetry data stream, required for instrument monitoring and operations.

7.3.2.1.2 Critical Health and Safety Telemetry

The Instrument shall provide a subset of normal housekeeping telemetry called critical health and safety telemetry via the command and telemetry bus in all modes, except OFF.

7.3.2.2 Instrument Telemetry Limits

7.3.2.2.1 Instrument Normal Housekeeping Telemetry Data Limits

Instrument normal housekeeping telemetry data shall not exceed 512 bits per major cycle for each instrument.

7.3.2.2.2 Instrument Critical Health and Safety Telemetry Data Limits

Instrument critical health and safety housekeeping telemetry data per major cycle for each instrument shall be negotiated and documented in the Instrument ICD.

7.3.2.3 Telemetry Monitor

7.3.2.3.1 Spacecraft Monitoring of Instrument Telemetry

The Spacecraft shall provide the capability to monitor selected telemetry points in the instrument normal housekeeping telemetry stream and initiate an action within the Instrument based upon a pre–determined telemetry state.

7.3.2.3.2 Instrument Telemetry Monitoring Transfer Rates

The Spacecraft telemetry monitor shall be capable of monitoring telemetry transferred at rates of once every 1, 8, and 64 major cycles identified by the major cycle number.

7.3.2.3.3 Instrument Telemetry Word Format

All telemetry values which appear in a single MIL–STD–1553B word must repeat on the same schedule.

7.3.3 Telemetry Interface Utilization Documentation

7.3.3.1 Instrument Point–to–Point Telemetry Documentation

All Spacecraft provided point–to–point telemetry interfaces utilized by the Instrument shall be documented in the Instrument ICD.

7.3.3.2 Instrument Point–to–Point Telemetry Sampling Rate Documentation

The sampling rate of each instrument point–to–point telemetry point shall be documented in the Instrument ICD.

7.3.3.3 Instrument Housekeeping Telemetry Documentation

The Instrument normal housekeeping telemetry points and the subset of critical health and safety telemetry point and their associated states shall be defined and documented in the Instrument ICD.

7.3.3.4 Instrument Housekeeping Telemetry Sampling Rate Documentation

The sampling rate of each instrument housekeeping telemetry point shall be documented in the Instrument ICD.

7.3.3.5 Instrument Housekeeping Telemetry Format Documentation

The instrument's housekeeping telemetry format shall be documented in the Instrument ICD.

7.3.3.6 Instrument Telemetry Monitoring Documentation

All instrument housekeeping telemetry points to be monitored by the Spacecraft shall be documented in the Instrument ICD.

7.3.3.7 Instrument Transfer Schedule Documentation

The schedule for all scheduled data transfers via the command and telemetry bus shall be documented in the Instrument ICD.

7.3.3.8 Command and Telemetry Bus Data Transfer Schedule Adaptability

The Instrument shall be designed such that a new command and telemetry bus schedule can be uploaded, changing the time of scheduled instrument transfers to a different minor cycle within the major cycle.

7.3.4 Telemetry Requirements

7.3.4.1 Telemetry Sampling Rates

All telemetry points shall be sampled as a minimum once per master cycle.

7.3.4.2 Command Verification

7.3.4.2.1 Command Receipt Verification

Command receipt shall be verified via critical health and safety telemetry subset.

7.3.4.2.2 Command Execution Verification

Command execution shall be verified via critical health and safety telemetry.

7.3.4.2.3 Command Verification Sampling Rate

Telemetry to verify proper response to a command shall be sampled at a rate ≤ once every 8.192 seconds.

7.3.4.2.4 Command Execution Verification Telemetry

Telemetry used to directly verify command execution shall change value only for those commands being verified.

7.3.4.3 Instrument Mode Dependency

The instrument telemetry stream format shall be the same for all instrument modes.

7.3.4.4 Instrument Activity Dependency

The instrument telemetry stream format shall be the same for on–orbit operations as for I&T activities.

7.3.4.5 Configuration Dependant Telemetry

All telemetry used for determining instrument configuration shall be unique to a given configuration.

7.3.4.6 Synchronization Restrictions

The Instrument shall not use the time mark and frequency bus to synchronize activities associated with instrument housekeeping telemetry gathering or sampling.

7.3.4.7 Instrument Telemetry Mnemonic Format

The instrument telemetry mnemonic shall be formatted as shown in Figure 7–1.

7.3.4.8 Telemetry Name

The telemetry name shall be identified by the user using only alphanumeric characters and the underscore (_).

7.4 Command and Telemetry Bus Data

7.4.1 Memory Loads

Memory loads to the Instrument shall be via the command and telemetry bus.

7.4.2 Memory Dumps

Memory dumps from the Instrument shall be via the command and telemetry bus.

ELEMENT																ITEM															
Character																Character															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SUBSYSTEM			RESERVED													A	B	C	FOR INSTRUMENT USE												

<u>ELEMENT FIELD</u>

The first three characters of the ELEMENT field indicate the SUBSYSTEM as defined below:
AST – ASTER
CEF – CERES–FORE
CEA – CERES–AFT
MIS – MISR
MOD – MODIS
MOP – MOPITT

<u>ITEM FIELD</u>

A. The first character of the ITEM field indicates the telemetry TYPE as defined below:

I – Current
V – Voltage
T – Temperature
B – Bi–level Status
P – Power
C – Configuration Information
S – Status Information
D – Memory or Dump Data

B. The second character of the ITEM field indicates the telemetry SOURCE as defined below.

R – Real or Raw Data: (data unmodified by software)
S – Flight Software Generated Data: (data generated by flight software using raw data inputs)
P – Pseudo or Derived Data: (data generated by ground software using raw or flight software generated data inputs)

C. The third character of the ITEM field is always an UNDERSCORE.

Figure 7–1. Instrument Telemetry Mnemonic Format

7.4.3 Ancillary Data

The Spacecraft shall provide a standard set of Spacecraft ancillary data to each instrument via the command and telemetry bus. The Spacecraft will also insert this data in the science data stream for downlink.

7.4.4 Time Code Data

The Spacecraft shall provide spacecraft time to the Instrument via the command and telemetry bus.

7.5 Autonomy

7.5.1 Instrument Mode and State Changes

7.5.1.1 Infrequently Changed Parameters

Operational parameters whose values change infrequently or take on the same value each time a defined instrument mode is entered shall be stored in instrument memory and changed via the command and telemetry bus only when modification of the parameter is required.

7.5.1.2 Normal Instrument State Changes

Command sequences which set internal instrument states for normal mode changes shall be stored and performed internal to the instrument.

7.5.1.3 Mode Changes

Instrument mode changes which affect instrument data rates shall be externally commanded via real–time or stored commands.

7.5.2 Safe and Survival Modes

7.5.2.1 Instrument Safe–Mode

7.5.2.1.1 Instrument Safe–Mode Entry

Upon receipt of the safe–mode command or if the Instrument does not receive the IMOK indication for 5 consecutive major cycles, the Instrument shall initiate entry into its safe mode. CH–3

7.5.2.1.2 Instrument Safe–Mode Configuration

The instrument shall autonomously configure to its safe mode within 30 seconds after entry into safe mode is initiated.

7.5.2.1.3 Safe–Mode Entry Override

The instrument safe mode entry initiation shall be capable of being inhibited by command.

7.5.2.1.4 Duration of Safe–Mode

Once Safe–Mode sequence has been initiated, the transition into safe mode shall be completed and the instrument shall remain in safe mode until changed by external intervention.

7.5.2.2 Instrument Survival Mode

The instrument survival mode shall be a state in which the Instrument is powered down to a minimum power state utilizing survival equipment only.

7.5.2.2.1 Spacecraft Survival Mode Entry

Upon entry into the Spacecraft survival mode, the Spacecraft shall issue the instrument defined command or sequence of commands to each instrument to transition the Instrument into its survival mode.

7.5.2.2.2 Instrument Survival Mode Entry

The Instrument shall transition into its survival mode within 30 seconds after survival mode entry is initiated.

7.5.2.2.3 Duration of Survival Mode

Once Survival–Mode sequence has been initiated, the transition into survival mode shall be completed and the instrument shall remain in survival mode until changed by external intervention.

7.5.2.3 Instrument Safe and Survival Modes Documentation

The instrument safe and survival modes shall be documented in the Instrument ICD.

7.5.3 Memory Load Verification

The integrity of a memory load shall be verified on–board.

7.5.4 Time Mark and Frequency Bus Loss

The Instrument shall be capable of operating in the event either or both side A and side B time mark and frequency bus interfaces are inoperative.

8 CONTAMINATION CONTROL REQUIREMENTS

Instrument contamination control requirements are delineated in GSFC 420–05–01, Section 9. Spacecraft–level contamination control requirements are delineated in GSFC 420–05–02, Section 9.

In addition, the following contamination control requirements apply.

8.1 Contamination Protection Design

The instrument design shall include its own contamination protection. (See Section 10 for a description of environments during I&T and on orbit.)

8.2 Contamination Protection Measures Documentation

All contamination protection measures to be taken after delivery of the Instrument shall be documented in the Instrument ICD.

8.3 Instrument Purge Implementation Documentation

Instrument purge requirements shall be documented in the Instrument ICD.

8.4 Instrument Venting Documentation

The number, location, size, vent path, and operation time of vents shall be documented in the Instrument ICD.

8.5 Surface Avoidance

The Spacecraft shall place the Instrument such that the vent effluents will not directly impinge on another contamination–sensitive surface.

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9 VERIFICATION AND REQUIREMENTS RESPONSIBILITY

The requirements for formal verification of the interfaces between the Spacecraft, instrument accommodation equipment, and instrument shall be as specified in this section. These verification requirements define the extent to which the Spacecraft, Instrument Accommodation Equipment, and Instrument must demonstrate the capability to meet the interface requirements specified in this document. This verification determines that the interfaces conform to the requirements.

Descriptions of methods necessary to verify these interface requirements are provided in the GIIS Handbook.

9.1 Requirements Responsibility Matrix

Responsibility for implementing the requirements specified in this document shall be as defined in Appendix C, Table 40–1.

9.2 Verification Responsibility and Methods Matrix

The organization responsible for the verification of the requirements specified in this document and the method(s) verification shall be as defined in Appendix D, Table 50–1. It is up to the responsible organization to determine the level of assembly at which verification will take place per GSFC 420–05–01 or GSFC 420–05–02, as applicable.

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10 ENVIRONMENTS

10.1 Ephemerides

10.1.1 Orbital Characteristics

The instrument design shall be consistent with the following nominal orbital characteristics and the associated environments:

Semi–Major Axis (Mean)	7078 kilometers (km)
Altitude Range	700 km to 737 km (705 km at equator)
Inclination	98.2°
Descending Node (Local Mean Solar Time)	1030 hours ±15 min
Repetition Interval	233 revolutions/16 days
Repetition Accuracy (Cross Track)	±20 km (3σ) at all latitudes
Solar Beta Angle (β)*	13° < β < 31°

*(angle between solar vector and orbital plane)

10.1.2 Transfer Orbit Characteristics

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The instrument design shall be consistent with the following nominal transfer orbit characteristics and the associated environments:

Perigee	550 kilometers (km) minimum
Apogee	686 km minimum
Inclination	98.2°
Descending Node (Local Mean Solar Time)	1030 hours ±15 min
Solar Beta Angle (β)*	13° < β < 31°

*(angle between solar vector and orbital plane)

10.1.3 Sun–Pointing Safe Mode Orbital Characteristics

In sun–pointing safe mode the Spacecraft will maintain a sun pointing attitude with the normal of the solar array aligned with the solar vector throughout the orbit. The solar array will remain stationary with the normal of the solar cell plane facing toward the –X end of the Spacecraft. Only two–axis (±15° pitch and ±18° yaw) attitude control will be maintained during sun–pointing safe mode.

10.2 Spacecraft Reference Coordinate Frame

The Spacecraft Reference Coordinate Frame, as shown in Figure 10–1, is right handed and orthogonal.

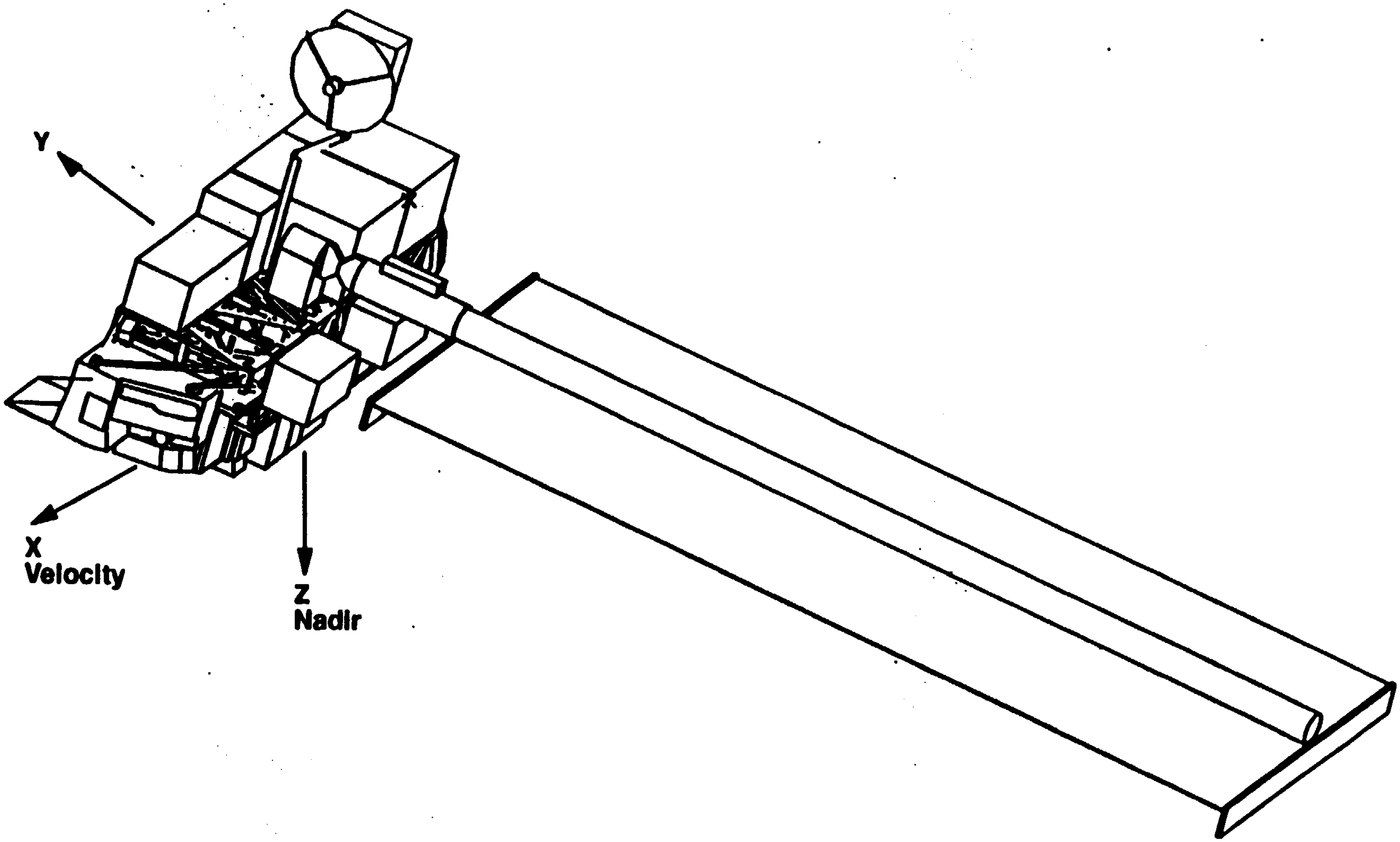

Figure 10–1. Spacecraft Reference Coordinate Frame

10.3 Pointing

The spacecraft design shall be consistent with pointing performance at the instrument interface as allocated in the UIID. CH–3

10.4 Thermal Environments

The thermal environments are segregated into prelaunch, launch, ascent, transfer orbit, and orbit environments.

10.4.1 Prelaunch, Launch, Ascent Thermal Environment

The prelaunch, launch, and ascent thermal environments for the EOS–AM mission are defined in GE IS20008503 (ICD–103).

10.4.2 Deleted CH–1

10.4.3 Thermal Environment CH–1

The transfer orbit, on–orbit, and sun pointing safe mode thermal environments for the EOS–AM mission are defined in part by the following thermal flux design parameters:

	Minimum	Maximum
Solar Radiation	0.856 W/in2	0.915 W/in2
Albedo	0.311	0.336
Earth Infrared Radiation	0.148 W/in2	0.157 W/in2

CH–1

10.5 Total Ionizing Dose Environment

The Instrument shall meet performance requirements when exposed to the total dose due to the trapped proton, electron, and solar proton radiation environment which will be experienced by the Spacecraft as shown in Figure 10–2.

10.6 Single Event Upset and Latchup

The instrument shall use the cosmic ray integral linear electron transfer (LET) distribution shown in Figure 10–3, the solar flare environment for a single solar flare shown in Figure 10–3a, and the trapped, free space proton environment shown in Figure 10–3b to make single event upset (SEU) and single event latchup (SEL) calculations. The solar flare enviroment used for these calculations shall consist of three flares, each lasting four days. CH–3

The peak proton flux environment over the South Atlantic Anomaly is defined as follows:

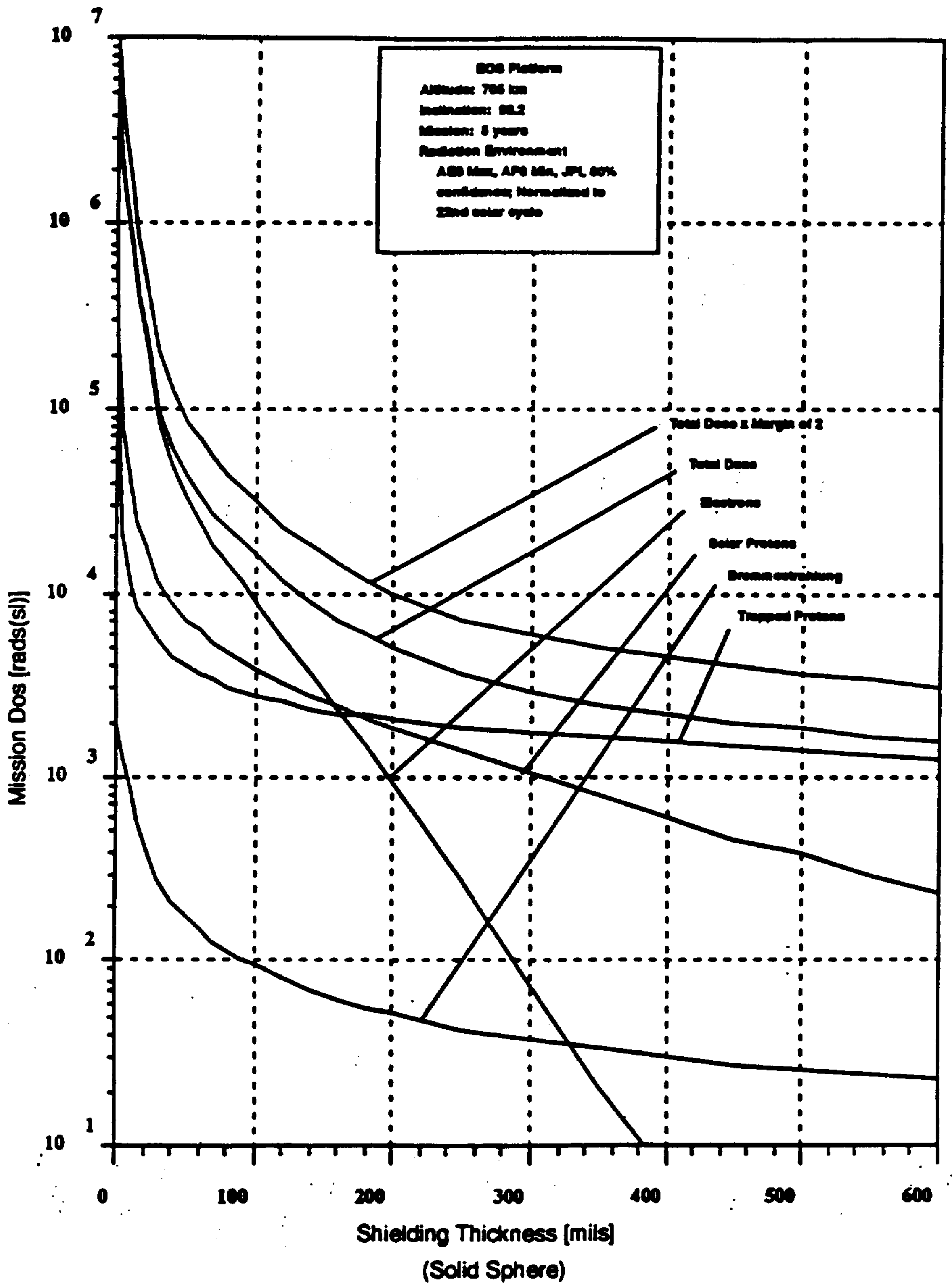

Figure 10–2. Total Ionizing Dose Radiation Environment

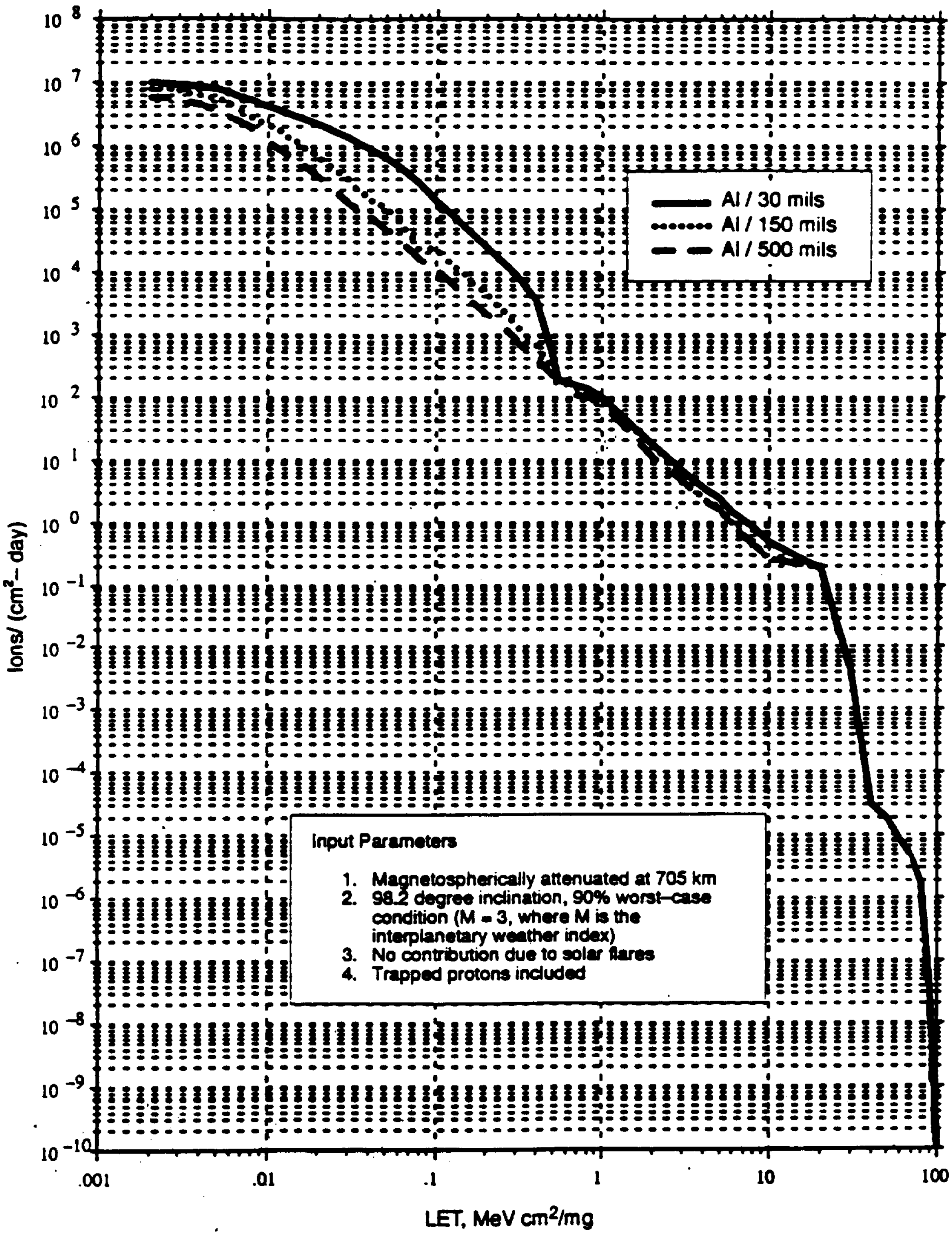

Figure 10–3. Cosmic Ray Linear Energy Transfer (LET) Spectrum

CH-

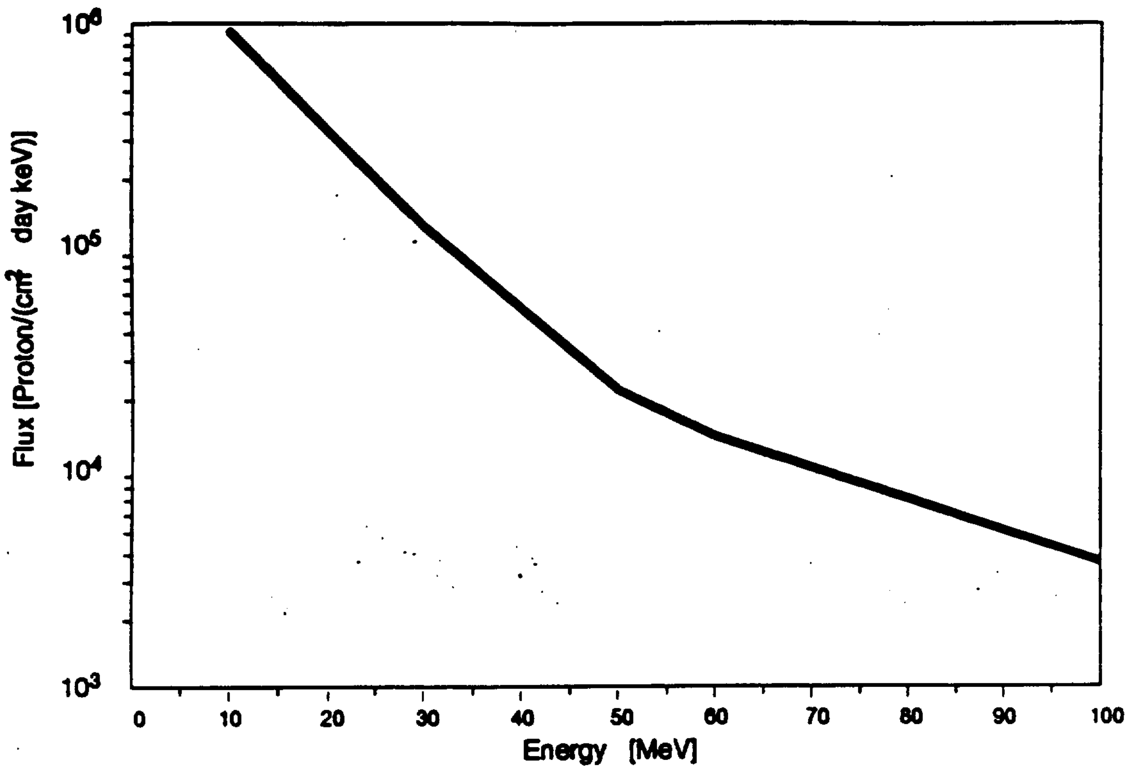

Figure 10–3a. Solar Flare Proton Fluence for a Single Flare

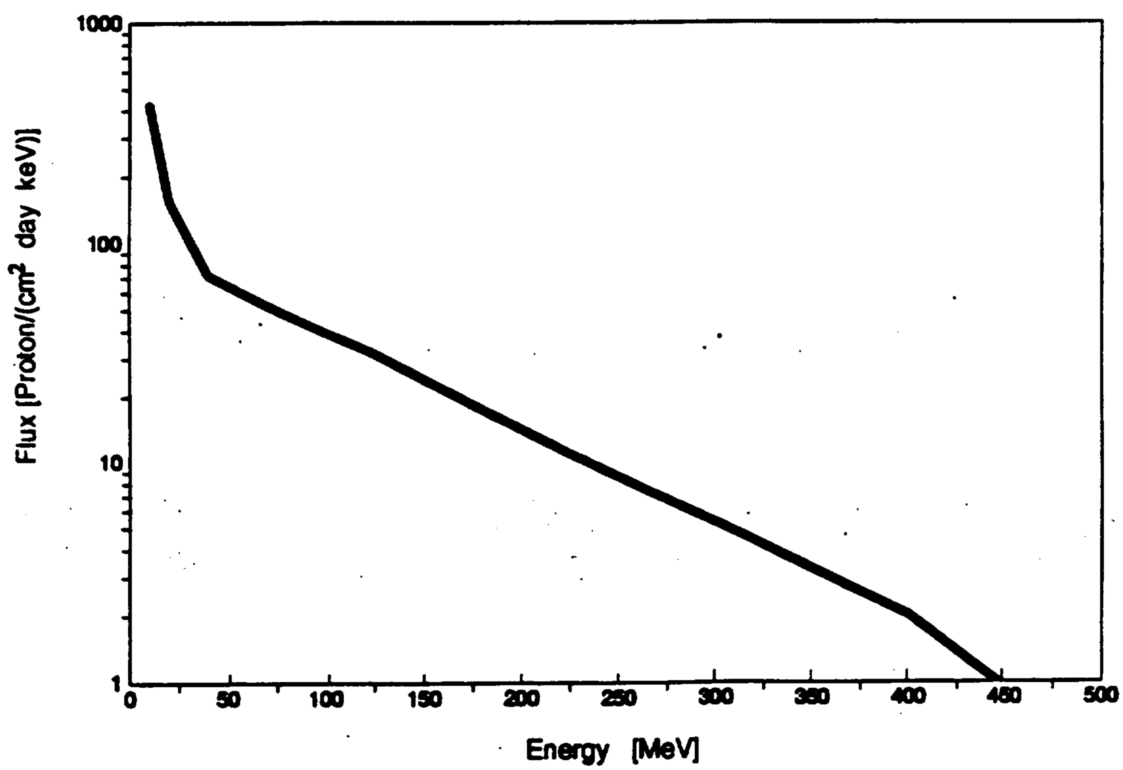

Figure 10–3b. Daily Average Trapped Proton Flux

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Proton Energy	Flux
$\geq$10 MeV	5.8×10^3 cm^{-2} sec^{-1}
$\geq$40 MeV	4.3×10^3 cm^{-2} sec^{-1}
$\geq$100 MeV	2.2×10^3 cm^{-2} sec^{-1}

CH-3

10.7 Atomic Oxygen

The Instrument shall meet performance requirements during exposure to atomic oxygen (AO) experienced during a 705 km polar orbit for five years. Atomic oxygen fluence for ram oriented surfaces is shown in Figure 10–4 .

10.8 Micrometeoroids

The Instrument will be subjected to hypervelocity impacts of meteoroids. The worst–case micrometeoroid environment is shown in Figure 10–5. Particle densities are assumed to be:

2.0 gm/centimeter (cm)^3 for particles with mass $<10^{-6}$ gm

1.0 gm/cm^3 for particles with mass 10^{-6} gm through 10^{-2} gm

0.5 gm/cm^3 for particles with mass $>10^{-2}$ gm

Mean meteoroid velocity is estimated at 19 km/sec.

10.9 Space Debris

The Instrument will be subjected to hypervelocity impacts by orbital, man–made space debris traveling at an average velocity of 10 km/sec. Particle densities are 4.0 gm/cm^3 for particles under 0.62 cm diameter and vary for particles above 0.62 cm diameter (i.e. approximately 0.5 gm). Particles with mass $\geq$ 0.5 gm relates to desinty as [density = 2.8 x diameter $^{-0.74}$] and is assumed to have spherical shape. Figure 10–6 indicates the worst–case space debris, fluence for randomly tumbling and ram oriented surfaces. To determine the fluence for surfaces with attitudes other than ram, the fluences for randomly tumbling are multiplied by the factors provided in Table 10–1. CH-3

10.10 Magnetic Fields

10.10.1 Instrument–Generated Magnetic Fields

The Instrument Provider shall measure the intensity and direction of the magnetic field produced by the Instrument.

10.10.2 Magnetic Fields Documentation

The Instrument Provider shall document the measured instrument–generated magnetic field intensity and direction data in the Instrument ICD.

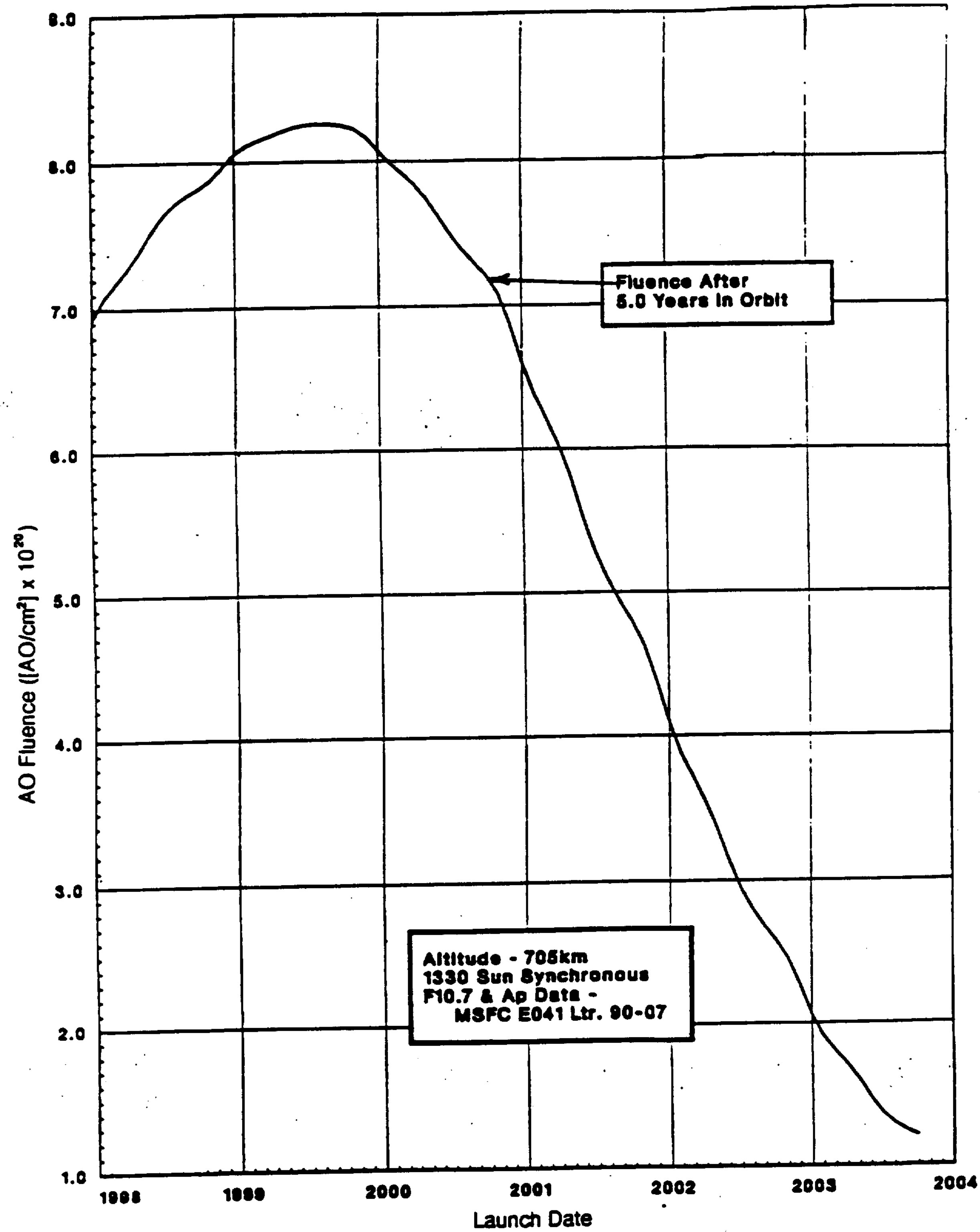

Figure 10–4. Atomic Oxygen Fluences for EOS–AM

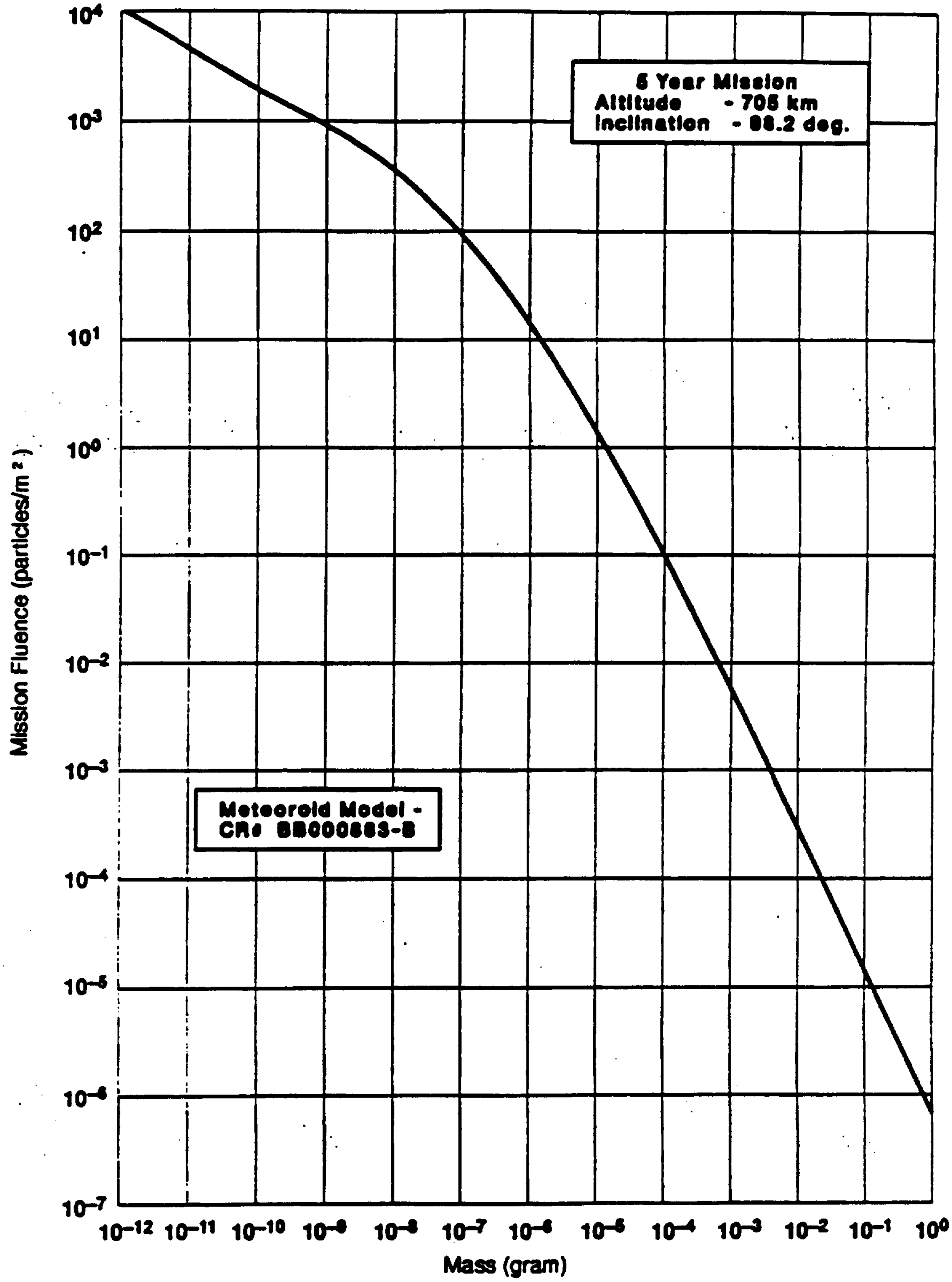

Figure 10–5. Micrometeoroid Environment

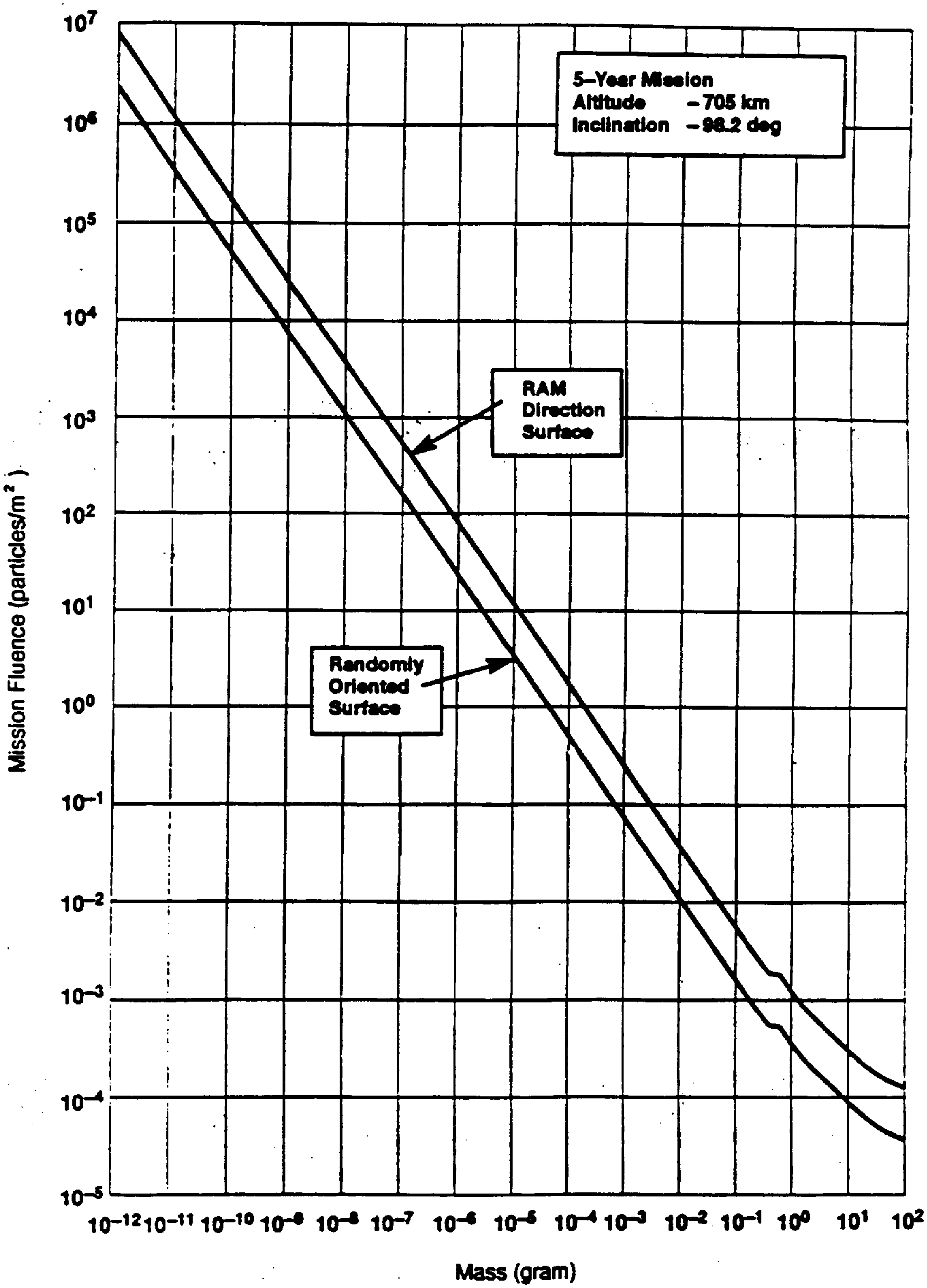

Figure 10-6. Space Debris

TABLE 10–1. MULTIPLES FOR SPACE DEBRIS FLUENCE ON ORIENTED SURFACES (I.E., SURFACES WITH A SPECIFIED ATTITUDE)

Azimuth Angle	Zenith Angle 90°	75° or 105°	60° or 120°	45° or 135°	30° or 150°	15° or 165°	0° or 180°
0°	3.413	3.296	2.955	2.413	1.706	0.883	0.000
15°	3.301	3.188	2.858	2.334	1.650	0.854	0.000
30°	2.987	2.885	2.586	2.112	1.493	0.773	0.000
45°	2.503	2.418	2.168	1.770	1.252	0.648	0.000
60°	1.889	1.825	1.636	1.336	0.945	0.489	0.000
75°	1.302	1.257	1.127	0.920	0.651	0.337	0.000
90°	0.864	0.834	0.748	0.611	0.432	0.224	0.000
105°	0.418	0.404	0.362	0.296	0.209	0.108	0.000
120°	0.183	0.177	0.158	0.129	0.091	0.047	0.000
135°	0.090	0.087	0.078	0.064	0.045	0.023	0.000
150°	0.031	0.030	0.027	0.022	0.016	0.008	0.000
165°	0.004	0.004	0.004	0.003	0.002	0.001	0.000
180°	0.000	0.000	0.000	0.000	0.000	0.000	0.000

10.10.3 Spacecraft Magnetic Fields

The Instrument shall meet all performance requirements in the presence of the ambient magnetic field defined in GE20005869.

10.11 EMI/EMC Requirements

The instrument design shall incorporate the requirements defined in GE20005869.

10.12 Spacecraft Charging

10.12.1 Instrument Electrostatic Discharge Control

Instrument electrostatic discharge (ESD) control requirements are delineated in GSFC 420–05–01, Section 8.

10.12.2 Spacecraft Electrostatic Discharge Analysis

An ESD analysis shall be performed at the Spacecraft level.

10.12.3 Spacecraft External Surface Charging

The Spacecraft external surface will charge to approximately –120 V with respect to space plasma. In the auroral regions the potential may be significantly higher for brief periods (approximately 10 sec). The plasma environment is defined in Table 10–2.

TABLE 10–2. PLASMA ENVIRONMENT

Particle	Density	Temperature
Ambient electrons	$10^3 - 2 \times 10^6$ cm^{-3}	0.1 – 0.39 eV
Ambient positive ions	$10^3 - 2 \times 10^6$ cm^{-3}	0.07 – 0.34 eV
* High energy electron flux	$10^8 - 10^{10}$ cm^{-3} 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		

CH–3

CH–3

APPENDIX A

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APPENDIX B

30 ACRONYMS AND ABBREVIATIONS

A	Area
ANSI	American National Standards Institute
AO	Atomic Oxygen
arcsec	Arc Second
APID	Application Process ID
AWG	American Wire Gauge
BC	Bus Controller
BOL	Beginning of Life
cm	centimeter
C	Centigrade
CCSDS	Consultative Committee for Space Data Systems
C&DH	Command and Data Handling
CM	Center of Mass
dB	Decibel
DC or dc	Direct Current
DIA	Diameter
degDegrees	
ED	Ending Delimiter
EED	Electro–Explosive Device
EIA	Electronic Industries Association
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOL	End of Life
EOS	Earth Observing System
eq. Al	Equivalent Aluminum
ESD	Electrostatic Discharge
FDDI	Fiber Distributed Data Interface
FEM	Finite Element Model
FLUINT	Fluid Integrator
FMEA	Failure Modes and Effects Analysis
G	Gravity (acceleration term)
GE	General Electric Company

GIIS	General Instrument Instrument Specification
gm	Gram
G_{RMS}	Gravity Root Mean Square
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HSDU	High Speed Data Unit
Hz	Hertz
ICD	Interface Control Document
ID	Identification
INFO	Information
IR	Infrared
I&T	Integration and Test
JSC	Johnson Space Center
kbps	Kilobits per Second
kg	Kilogram
kHz	Kilohertz
km	Kilometer
KM	Kinematic Mount
LET	Linear Electron Transfer
M	Interplanetary Weather Index
m	Meter
mA	Milliampere
MAC	Media Access Control
MAX (max)	Maximum
Mbps	Megabits per Second
MC	Message Control
MeV	Mega electron Volts
MHz	Megahertz
MIL–STD	Military Standard
MIN	Minimum
min	Minute
mm	Millimeter
MSC	MacNeal–Schwendler Corporation
msec	Millisecond
MSFC	Marshall Space Flight Center

μA	Microampere
μm	Micrometer
μN	Micronewton
μsec	Microsecond
μT	Micro Tesla
N	Newton
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NRZI	Non–Return to Zero Inverting
NSI	NASA Standard Initiator
OD	Outer Diameter
PA	Preamble
PHY	Physical Layer Protocol
PMP	Payload Mounting Plate
psi	pounds per square inch
rad	Radian
rads	Radiation
RMS (rms)	Root Mean Square
RT	Remote Terminal
SD	Starting Delimiter
sec	Second
SEL	Single Event Latchup
SEU	Single Event Upset
Si	Silicon
SINDA	Systems Improved Numerical Differencing Analyzer
SMSI	Standard Manned Spaceflight Initiator
ster	Steradian
TBD	To Be Determined
TBR	To Be Resolved
TRASYS	Thermal Radiation Analyzer System
UIID	Unique Instrument Interface Document
UTC	Universal Time Code
V	Voltage
Vdc	Volts Direct Current
W	Watt

WSMCR	Western Space and Missile Center Range
Wt	Weight

APPENDIX C

40 REQUIREMENTS RESPONSIBILITY MATRIX

The requirements responsibility cross–reference matrix is shown in Table 40–1.

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3	MECHANICAL REQUIREMENTS		X	X
3.1	Mechanical Interface Definitions	X		
3.1.1	Spacecraft Mounting Interface Definition	X		
3.1.2	Coldplate Mechanical Interface Definition	X		
3.2	Envelopes	X		
3.2.1	Instrument Envelope Allocation	X		
3.2.1.1	Instrument Launch Mode Envelope		X	
3.2.1.2	Instrument On–Orbit Envelope		X	
3.2.2	Instrument Envelope Documentation			X
3.2.3	External Configuration Changes			X
3.3	Fields of View	X		
3.3.1	Fields–of–View Allocation		X	
3.3.2	Fields–of–View Accommodation			X
3.3.3	Fields–of–View Documentation			X
3.4	Mass Properties	X		
3.4.1	Instrument Mass Allocation		X	
3.4.2	Instrument Mass Measurement		X	
3.4.3	Instrument Mass Documentation			X
3.4.4	Instrument Mass Property Report		X	

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.4.5	Instrument Mass Variability	X		
3.4.5.1	Instrument Mass Variability Allocation		X	
3.4.5.2	Instrument Mass Variability Documentation			X
3.4.6	Center of Mass Documentation			X
3.4.7	Moments of Inertia	X		
3.4.7.1	Moments of Inertia Determination		X	
3.4.7.2	Moments of Inertia Accuracy		X	
3.4.7.3	Moments of Inertia Documentation			X
3.4.7.4	Moments of Inertia Variation Documentation			X
3.4.8	Products of Inertia	X		
3.4.8.1	Products of Inertia Determination		X	
3.4.8.2	Products of Inertia Accuracy		X	
3.4.8.3	Products of Inertia Documentation			X
3.4.8.4	Products of Inertia Variation Documentation			X
3.5	Mounting	X		
3.5.1	Mounting Method		X	
3.5.2	Mounting Interface	X		
3.5.2.1	Mounting Interface Documentation			X
3.5.2.2	Mounting Hole Coordinates and Dimensions		X	X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.5.3	Mounting Hardware	X		
3.5.3.1	Mounting Hardware Provider			X
3.5.3.2	Mounting Hardware Documentation			X
3.5.3.3	Mounting Bolts		X	X
3.5.4	Kinematic Mounts	X		
3.5.4.1	Kinematic Mount Provider			X
3.5.4.1.1	Test Kinematic Mount Delivery		X	X
3.5.4.1.2	Flight Kinematic Mount Delivery		X	X
3.5.4.1.3	Instrument Kinematic Mount Assembly		X	
3.5.4.2	Kinematic Mount Characteristics	X		
3.5.4.2.1	Kinematic Mount Structure			X
3.5.4.2.2	Kinematic Mount Breakaway Torque			X
3.5.4.2.3	Kinematic Mount Angular Freedom of Movement			X
3.5.4.2.4	Kinematic Mount Thermal Conductance			X
3.5.4.3	Kinematic Mounting		X	
3.5.4.3.1	Three–Point Kinematic Mount		X	X
3.5.4.3.1.1	KM1			X
3.5.4.3.1.2	KM2			X
3.5.4.3.1.3	KM3			X

TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.5.4.3.2	Three-Point Kinematic Mount Restrictions		X	
3.5.4.3.3	Kinematic Mount Stiffness			X
3.5.5	Spacecraft Mounting Surface	X		
3.5.5.1	Spacecraft Mounting Surface Flatness			X
3.5.5.2	Spacecraft Mounting Surface Planarity			X
3.5.6	Instrument Mounting Surface	X		
3.5.6.1	Instrument Mounting Surface Flatness		X	
3.5.6.2	Instrument Mounting Surface Planarity		X	
3.5.7	Mounting Location	X		
3.5.7.1	Instrument Mounting Location			X
3.5.7.2	Instrument Accommodation Equipment Mounting Location			X
3.5.7.3	Mounting Location Documentation			X
3.5.8	Drill Templates	X		
3.5.8.1	Drill Template Usage		X	X
3.5.8.2	Drill Template Fabrication Requirements		X	X
3.5.8.3	Optically Aligned Component Drill Template Provider		X	X
3.5.8.4	Non-optically Aligned Component Drill Template Provider		X	
3.6	Alignment	X		
3.6.1	Instrument Optical Alignment Cube		X	
3.6.2	Optical Alignment Cube Requirements	X		

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.6.2.1	Optical Alignment Cube Surface Area		X	X
3.6.2.2	Optical Alignment Cube Surface Orthogonality		X	X
3.6.2.3	Optical Alignment Cube Documentation			X
3.6.3	Alignment Responsibility			X
3.6.4	Alignment Angles			X
3.6.5	Pointing Allocations		X	
3.7	General Structural Design Requirements	X		
3.7.1	Structural Support	X		
3.7.1.1	Instrument Structural Support			X
3.7.1.2	Coldplate Structural Support		X	
3.7.2	Instrument Structural Dynamics		X	
3.7.3	Interface Design Limit Loads Requirements	X		
3.7.3.1	Limit Loads Application		X	X
3.7.3.2	Limit Loads Application Axis		X	X
3.7.3.3	Interface Design Limit Loads		X	X
3.7.3.4	Random Vibration Levels		X	
3.7.3.5	Sine Vibration Levels		X	
3.7.4	Coupled–Loads Analysis	X		
3.7.4.1	Coupled–Loads Analysis Responsibility			X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.7.4.2	Coupled–Loads Analysis Results			X

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TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.7.5	Pressurized System Design		X	
3.7.6	Environmental Requirements	X		
3.7.6.1	Launch Survivability Design Requirements	X		
3.7.6.1.1	Shock		X	
3.7.6.1.2	Launch Pressure Profile		X	
3.7.6.1.3	Acoustics			X
3.7.6.2	Orbital Environment	X		
3.7.6.2.1	Acceleration		X	
3.7.6.2.2	Torque	X		
3.7.6.2.2.1	Torque Allowables		X	
3.7.6.2.2.2	Torque Profile Documentation			X
3.7.6.2.3	Force	X		
3.7.6.2.3.1	Force Allowables		X	
3.7.6.2.3.2	Torque Documentation			X
3.7.6.2.4	Angular Momentum	X		
3.7.6.2.4.1	Allowable Angular Momentum		X	X
3.7.6.2.4.2	Angular Momentum Documentation			X
3.7.6.2.4.3	Spacecraft Non-Operational Deployment Disturbance		X	X
3.7.6.2.4.4	Shock Generation On-Orbit		X	

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.7.6.2.4.5	Instrument Orbital Shock Requirement		X	X
3.8	Finite Element Model		X	
3.9	Instrument Mass Model			X
3.10	Instrument Mechanisms		X	
3.10.1	Caging During Test and Launch		X	
3.10.2	Caging On–Orbit		X	
3.10.3	Captive Hardware		X	X
3.10.4	Sealed Hardware		X	X
3.11	Venting Forces	X		
3.11.1	Continuous Venting Forces		X	
3.11.2	Random Venting Impulses		X	
3.11.3	Thrust Direction Adjustment		X	X
3.11.4	Venting Force Documentation			X
3.12	Coldplate Mechanical Interface Requirements	X		
3.12.1	Coldplate Mounting	X		
3.12.1.1	Coldplate Mounting Bolts	X	X	X
3.12.1.2	Coldplate Bolt Pattern		X	X
3.12.1.3	Coldplate Mounting Hardware Provider		X	X
3.12.1.4	Coldplate Mounting Hardware Documentation			X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.12.2	Instrument Surface for Coldplate Mechanical Interface		X	
3.12.2.1	Instrument Surface Flatness		X	
3.12.2.2	Instrument Surface Finish		X	
3.12.3	Coldplate Drill and Stayout Zone Template	X		
3.12.3.1	Coldplate Stayout Zone Template			X
3.12.3.2	Coldplate Drill Template		X	
3.12.4	Coldplate Mounting Surface Area			X
3.12.5	Coldplate Mounting Surface	X		
3.12.5.1	Coldplate Mounting Surface Flatness			X
3.12.5.2	Coldplate Mounting Surface Finish			X
3.12.6	Coldplate Mechanical Interface Filler Installation Responsibility		X	X
3.12.7	Coldplate Mechanical Interface Filler Installation			X
	Responsibility Documentation			
3.12.8	Coldplate Mass Properties			X
3.13	Coldplate Plumbing	X		
3.13.1	Coldplate Plumbing Provider			X
3.13.2	Coldplate Plumbing Support Provider		X	X
3.13.3	Coldplate Plumbing Support Documentation			X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.13.4	Coldplate Plumbing Location			X
3.13.5	Coldplate Plumbing Clearance			X
3.13.6	Coldplate Plumbing Documentation			X
3.13.7	Coldplate Plumbing Dimensions and Mass Properties			X
3.14	Harnesses	X		
3.14.1	Harness Provider			X
3.14.2	Harness Hardware Documentation			X
3.14.3	Harness Wiring Requirements			X
3.14.4	Tie Points	X		
3.14.4.1	Tie Point Locations and Provider		X	X
3.14.4.2	Tie Point Documentation			X
3.14.5	Connectors	X		
3.14.5.1	Connector Mating		X	X
3.14.5.2	Connector Clearance		X	X
3.14.5.3	Connector Location			X
3.14.5.4	Keying		X	X
3.14.5.5	Interface Connector Provider	X		
3.14.5.5.1	Harness Connectors			X
3.14.5.5.2	Instrument Component Connectors		X	

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.14.5.5.3	Connector Types		X	X
3.14.5.5.4	Connector Type Documentation			X
3.14.5.6	Flight Plugs	X		
3.14.5.6.1	Flight Plug Installation		X	X
3.14.5.6.2	Flight Plug Responsibility			X
3.14.5.6.3	Flight Plug Documentation			X
3.14.5.7	Connector Protective Covers		X	
3.14.5.8	Test Connectors	X		
3.14.5.8.1	Test Connector Accessibility		X	X
3.14.5.8.2	Test Connector Documentation			X
3.14.5.9	Breakout Boxes		X	
3.14.5.9.1	Intra–Instrument Breakout Boxes	X		
3.14.5.9.2	Instrument–to–Spacecraft Interface Breakout Boxes		X	X
3.14.5.10	Buffer Connectors and Connector Savers	X		
3.14.5.10.1	Buffer Connector and Connector Saver Utilization		X	
3.14.5.10.2	Buffer Connector and Connector Saver Provider		X	
3.14.5.11	Electrical Connector Constraints		X	X
3.15	Access	X		
3.15.1	Access Identification			X

TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
3.15.2	General Access		X	X
3.16	Handling Fixtures		X	
3.17	Launch Site Equipment Installation and Removal	X		
3.17.1	Non–Flight Equipment		X	
3.17.2	Flight Equipment		X	
3.17.3	Flight and Non–Flight Equipment Documentation			X
4	THERMAL REQUIREMENTS	X		
4.1	Thermal Interface Description		X	X
4.2	Thermal Design	X		
4.2.1	Instrument Thermal Design Provider		X	
4.2.2	Instrument Thermal Design		X	
4.3	Heat Transfer	X		
4.3.1	Heat Transfer with the Spacecraft	X		
4.3.1.1	Average Heat Flux		X	X
4.3.1.2	Heat Transfer Distribution			X
4.3.2	Heat Transfer with the Coldplate		X	X
4.3.3	Heat Transfer Distribution Documentation		X	X
4.3.4	Environmental Heat Transfer		X	
4.3.5	Deleted			

TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
4.4	Temperature	X		
4.4.1	Spacecraft Temperature Range			X
4.4.2	Coldplate Temperature Requirements	X		
4.4.2.1	Coldplate Temperature Range			X
4.4.2.2	Coldplate Interface Filler Temperature Gradient			X
4.4.3	Instrument Temperature Range			X
4.4.4	Test Coldplate Temperatures During Instrument Qualification Testing			X
4.4.5	Test Coldplate Temperatures During Instrument Acceptance Testing			X
4.5	Temperature Monitoring	X		
4.5.1	Mechanical Interface Temperature Monitoring			X
4.5.2	Instrument Temperature Monitoring		X	X
4.5.3	Temperature Sensor Location			X
4.6	Thermal Control Hardware	X		
4.6.1	Coldplate	X		
4.6.1.1	Coldplate Capacity			X
4.6.1.2	Coldplate Configurations			X
4.6.1.3	Coldplate Mounting Orientation		X	X
4.6.1.4	Coldplate Mounting Elevation		X	X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
4.6.1.5	Coldplate Mechanical Interface Filler			X
4.6.1.6	Test Coldplate Requirements			X
4.6.2	Heaters	X		
4.6.2.1	Survival Heaters		X	
4.6.2.2	Survival Heater Control		X	
4.6.3	Thermal Control Hardware	X		
4.6.3.1	Thermal Control Hardware Responsibility		X	X
4.6.3.2	Thermal Control Hardware Documentation			X
4.7	Thermal Models	X		
4.7.1	Surface Model		X	
4.7.2	Reduced Node Thermal Math Model		X	
4.7.3	Detailed Thermal Math Model		X	
5	ELECTRICAL REQUIREMENTS	X		
5.1	Electrical Interface Requirements		X	X
5.1.1	Electrical Interfaces	X		
5.1.2	Electrical Interface Definitions	X		
5.1.2.1	Electrical Interface Location	X		
5.1.2.2	Operational Power	X		
5.1.2.2.1	Peak Power	X		

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
5.1.2.2.2	Average Power	X		
5.1.2.3	Survival–Mode Power	X		
5.1.2.4	Safe–Mode Power	X		
5.1.2.5	Launch–Phase Power	X		
5.2	Power	X		
5.2.1	Instrument Power Allocations			X
5.2.1.1	Operational Power Allocation		X	
5.2.1.2	Survival Power Allocation		X	
5.2.1.3	Launch–Phase Power Allocation		X	
5.2.1.4	Power Interface Allocation		X	
5.2.1.5	Instrument Power Level Documentation			X
5.2.2	Power Characteristics	X		
5.2.2.1	Voltage			X
5.2.2.1.1	Voltage Transients		X	
5.2.2.1.2	Abnormal Steady–State Voltage Limits		X	
5.2.2.2	Power Source Impedance			X
5.2.2.3	Current	X		
5.2.2.3.1	Instrument Current Transients		X	
5.2.2.3.2	Deleted			

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
5.2.2.3.3	Overcurrent Protection			X
5.2.2.3.3.1	Overcurrent Protection Device Size		X	X
5.2.2.3.3.2	Overcurrent Protection Device Size Documentation			X
5.2.2.4	Instrument Power Input Impedance		X	
5.2.2.4.1	Instrument Common Mode Impedance		X	
5.2.2.4.2	Instrument Differential Mode Impedance		X	
5.2.3	Power Control	X		
5.2.3.1	Power Connections			X
5.2.3.2	Power Application			X
5.2.3.3	Power Fault Tolerance		X	X
5.2.3.4	Instrument Equipment Separation		X	
5.2.3.5	Instrument Power Control		X	
5.3	Grounds, Returns, and References	X		
5.3.1	Power Leads and Returns		X	X
5.3.1.1	Power Harnessing			X
5.3.1.2	Isolation		X	
5.2.1.2.1	Deleted		X	
5.3.1.2.2	120 V Primary Power Isolation		X	
5.3.1.2.3	Transient Protected Circuit Isolation		X	

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
5.3.1.2.4	Secondary Power Isolation		X	
5.3.1.3	Power Reference	X		
5.3.1.3.1	Primary Power Reference			X
5.3.1.3.2	Secondary Power Return		X	
5.3.1.3.3	Secondary Power Reference		X	
5.3.1.3.4	Isolated Secondary Power Referencing		X	
5.3.2	Signal Reference		X	
5.3.2.1	Signal Reference Constraints		X	X
5.3.2.2	Differential Signal Isolation		X	
5.3.2.3	Passive Telemetry Interface Isolation		X	
5.3.3	Instrument Grounding	X		
5.3.3.1	Instrument Ground Interconnection			X
5.3.3.2	Component Grounding	X		
5.3.3.2.1	Component Ground Location		X	
5.3.3.2.2	Component Ground Connection			X
5.3.3.2.3	Component Bonding Straps		X	X
5.3.3.3	Connector Grounding		X	
5.3.3.4	Chassis Reference Current		X	
5.3.4	Fault Ground	X		

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
5.3.4.1	Instrument Fault Ground Requirements	X		
5.3.4.1.1	Instrument Fault Ground Connection		X	

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
5.3.4.1.2	Instrument Fault Ground Routing		X	
5.3.4.1.3	Instrument Fault Ground Wire Grounding		X	
5.3.4.2	Spacecraft Fault Ground Requirements	X		
5.3.4.2.1	Spacecraft Fault Ground Routing			X
5.3.4.2.2	Fault Ground Wire Connection to Instrument Ground Interconnection			X
5.3.4.2.3	Fault Ground Wire Connection to Primary Power Reference			X
5.3.5	Signal Reference Ground	X		
5.3.5.1	Instrument Ground Interconnection Referencing			X
5.3.5.2	Thermal Blanket Grounding	X		
5.3.5.2.1	Deleted		X	X
5.3.5.2.2	Deleted			X
5.3.5.2.3	Thermal Closeout Blanket Grounding			X
5.4	Command and Data Handling Interface	X		
5.4.1	General Signal Interface Requirements	X		
5.4.1.1	Interface Conductors		X	X
5.4.1.2	Interface Redundancy	X		
5.4.1.2.1	Redundant Interface Terminology	X		
5.4.1.2.2	Redundant Interface Usage	X		

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TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)					
Section		Not Applicable	Instrument Provider	Spacecraft Provider	
5.4.1.2.2.1	Command and Telemetry Bus Interfaces		X		CH-1
5.4.1.2.2.2	Deleted				
5.4.1.2.2.3	Deleted				
5.4.1.2.3	Interface Fault Tolerance		X	X	
5.4.1.3	Interface Circuitry Isolation		X		
5.4.2	Point-to-Point Command and Telemetry Interfaces			X	
5.4.2.1	Relay Drive Commands			X	
5.4.2.1.1	Deleted				CH-1
5.4.2.1.2	Relay Drive Command Characteristics			X	
5.4.2.1.3	Relay Drive Command Load Characteristics		X	X	
5.4.2.2	Deleted				CH-1
5.4.2.2.1	Deleted				
5.4.2.2.2	Deleted				
5.4.2.3	Passive Bi-Level Telemetry Interface		X	X	
5.4.2.3.1	Deleted				CH-1
5.4.2.3.2	Passive Bi-Level Telemetry Signal Characteristics		X	X	
5.4.2.4	Passive Analog Telemetry Interfaces	X			
5.4.2.4.1	Number of Passive Analog Telemetry Points			X	
5.4.2.4.2	Passive Analog Telemetry Signal Characteristics		X		

TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
5.4.2.5	Active Analog Telemetry Interfaces	X		
5.4.2.5.1	Deleted			
5.4.2.5.2	Active Analog Telemetry Signal Characteristics		X	
5.4.3	Time Mark and Frequency Bus			X
5.4.3.1	Time Mark and Frequency Bus Electrical Characteristics		X	X
5.4.3.2	Reference Frequency Characteristics			X
5.4.3.3	Time Mark Encoding			X
5.4.3.4	Time Mark Accuracy			X
5.4.4	Command and Telemetry Bus Electrical Interface			X
5.4.4.1	Command and Telemetry Bus Electrical Characteristics		X	X
5.4.5	Science Data Electrical Interface	X		
5.4.5.1	Science Data Interface Control			X
5.4.5.2	Low–Rate Science Data Interface Electrical Characteristics		X	X
5.4.5.3	High–Rate Science Data Interface Electrical Requirements	X		
5.4.5.3.1	High–Rate Interface Circuitry	X		
5.4.5.3.1.1	Instrument High–Rate Science Data Interface Circuitry		X	
5.4.5.3.1.2	Instrument High–Rate Science Data Signal Interface Coupling		X	
5.4.5.3.1.3	Spacecraft High–Rate Science Data Interface Circuitry			X
5.4.5.3.1.4	High–Rate Science Data Interface Polarity Inversion		X	

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
5.4.5.3.1.5	High–Rate Science Data Interface Cable Shield Grounding		X	
5.4.5.3.2	High–Rate Science Data Interface Electrical Characteristics		X	X
5.5	Other Interfaces	X		
5.5.1	Test Point Interfaces		X	
5.5.1.1	Spacecraft Integration and Test Use		X	
5.5.1.2	Performance Verification Limitation		X	
5.5.1.3	Keyed Connectors		X	
5.5.1.4	Power and Load Isolation		X	
5.5.1.5	Failure Propagation		X	
5.5.1.6	Short–Circuit Isolation		X	
5.5.1.7	Grounding Integrity		X	
5.5.1.8	EMI/EMC		X	
5.5.1.9	Flight Standards		X	
5.5.1.10	Mechanical Requirements		X	
5.5.2	Test Point Interface Documentation			X
5.6	Failure Modes and Effects Analysis			X
6	COMMAND AND DATA HANDLING REQUIREMENTS		X	X
6.1	Command and Telemetry Bus	X		
6.1.1	Command and Telemetry Bus Configuration		X	X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
6.1.1.1	Command and Telemetry Bus Transfer Method		X	X
6.1.1.1.1	Command and Telemetry Bus MIL–STD–1553B Mode Code Utilization		X	X
6.1.1.1.2	Command and Telemetry Data Transfers		X	X
6.1.1.1.2.1	Data Transfers to the Instrument		X	X
6.1.1.1.2.2	Data Transfers from the Instrument		X	X
6.1.1.1.3	Broadcast Mode on the Command and Telemetry Bus		X	X
6.1.2	Command and Telemetry Bus Transfer Timing			X
6.1.2.1	Minor Cycle Length			X
6.1.2.1.1	Minor Cycle Task List			X
6.1.2.1.2	Minor Cycle Task List Completion			X
6.1.2.2	Major Cycle Length			X
6.1.2.3	Master Cycle Length			X
6.1.2.4	Command and Telemetry Bus Task Scheduling	X		
6.1.2.4.1	Synchronize with Data Word			X
6.1.2.4.1.1	Synchronize with Data Word Transfer Frequency			X
6.1.2.4.1.2	Synchronize with Data Word Transfer Timing			X
6.1.2.4.1.3	Data Word Content			X
6.1.2.4.1.4	Data Word Content Format			X

TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)					
Section		Not Applicable	Instrument Provider	Spacecraft Provider	
6.1.2.4.1.5	Instrument Response to Data Word		X		
6.1.2.4.1.6	Instrument Telemetry Transfer Schedule		X		
6.1.2.4.2	Command Transfers			X	
6.1.2.4.3	Deleted	X			CH-3
6.1.2.4.3.1	Instrument Normal Housekeeping Telemetry Collection			X	
6.1.2.4.3.2	Instrument Critical Health and Safety Housekeeping Telemetry Collection			X	
6.1.2.4.3.3	Instrument Housekeeping Telemetry Readiness		X		
6.1.2.4.4	Memory Load Transfers		X	X	
6.1.2.4.5	Memory Dump Transfers		X	X	
6.1.2.4.6	IMOK, Ancillary Data, Time Code Data, and Safe Mode Commands			X	CH-3
6.1.2.4.6.1	IMOK, Ancillary Data, and Time Code Data Transfer Frequency			X	
6.1.3	Command And Telemetry Bus Data	X			
6.1.3.1	Commands	X			
6.1.3.1.1	Real-Time Commands		X		
6.1.3.1.2	Stored Commands		X		
6.1.3.1.3	Safe-Mode Command Structure			X	
6.1.3.1.4	IMOK Command Structure			X	CH-3

TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
6.1.3.2	Memory Load and Dump Initiate Command Structures	X		
6.1.3.2.1	Load Initiate Command Structure		X	
6.1.3.2.2	Dump Initiate Command Structure		X	
6.1.3.3	Memory Load Data Messages			X
6.1.3.4	Memory Dump Data Messages			X
6.1.3.5	Ancillary Data Messages	X		
6.1.3.5.1	Ancillary Data Contents			X
6.1.3.5.2	Ancillary Data Message Format			X
6.1.3.6	Time Code Data Messages	X		
6.1.3.6.1	Time Code Data Contents			X
6.1.3.6.2	Time Code Data Epoch			X
6.1.3.6.3	Time Code Data Format			X
6.1.4	Command and Telemetry Bus Protocols	X		
6.1.4.1	Instrument Command and Telemetry Bus RT Address Assignment		X	X
6.1.4.2	MIL-STD-1553B Message Identification		X	X
6.1.4.2.1	MIL-STD-1553B Message Subaddress Definition		X	X
6.1.4.2.2	Instrument Specific Subaddresses		X	X
6.2	Time Mark and Frequency Bus			X

TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
6.2.1	Time Code Data Valid Indication			X
6.2.2	Time Information Timing			X
6.3	Low Rate Science Data Bus		X	X
6.3.1	Low-Rate Science Data Interface Configuration		X	X
6.3.2	Broadcast Mode on the Low-Rate Science Data Bus		X	X
6.3.3	Low-Rate Science Data Transfer Timing		X	X
6.3.4	Low-Rate Science Data Bus Data Format		X	
6.3.5	Low-Rate Science Data Bus Transfer Protocol	X		
6.3.5.1	Low-Rate Science Data Bus RT Address Assignment			X
6.3.5.2	Low-Rate Science Data Bus MIL-STD-1553B Mode Code Utilization		X	X
6.3.5.3	Low-Rate Science Data Bus MIL-STD-1553B Message Subaddresses		X	X
6.3.5.4	Low-Rate Science Data Polling			X
6.3.5.5	Low-Rate Science Data Packet Readiness		X	
6.3.5.6	Total Packet Length Indication		X	
6.3.5.7	Low-Rate Science Data Packet Transfer	X		
6.3.5.7.1	Low-Rate Instrument Polling Interval			X
6.3.5.7.2	Low-Rate Science Data Throughput Interval			X
6.3.5.7.3	Low-Rate Science Data Packet Transfer Timing		X	X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
6.3.5.8	Low–Rate Science Data Packet Transfer Method		X	X
6.3.5.8.1	Deleted		X	X	CH–3
6.3.5.8.2	Multiple Message Packet Transfer		X	X
6.3.5.8.3	Transferring an Odd Number of Octets		X	X
6.3.5.8.4	End–of–Transfer Data Word Content			X
6.4	High–Rate Science Data Interface		X	X
6.4.1	High–Rate Link Science Data Rate		X	
6.4.1.1	High–Rate Link Allocation		X	X
6.4.2	High–Rate Science Data Packet Transfer Timing		X	X
6.4.2.1	High–Rate Science Data Interface Data Format		X	
6.4.3	High–Rate Science Data Transfer Protocol	X		
6.4.3.1	Data Encoding		X	
6.4.3.2	High–Rate Science Data Message Format		X	
6.4.3.2.1	High–Rate Science Data Message Symbols		X	
6.4.3.2.2	High–Rate Science Data Message Fields		X	
6.4.3.2.3	High–Rate Science Data Message Info–Field Transmission		X	
6.4.3.3	High–Rate Link Preamble		X	
6.4.3.4	High–Rate Link Transmission Gap		X	
7	Command and Data Handling Operational Requirements		X	X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
7.1	Science Data	X		
7.1.1	Science Data Interface Allocation		X	X
7.1.2	Science Data Types	X		
7.1.2.1	Low–Rate Science Data	X		
7.1.2.2	High–Rate Science Data	X		
7.1.2.3	Engineering Data		X	
7.1.3	Science Data Requirements	X		
7.1.3.1	Application Process ID		X	X
7.1.3.1.1	Application Process ID Allocation		X	X
7.1.3.1.2	Application Process ID Documentation			X
7.1.4	Science Data Interface Test Packet Requirements (TBD 005)			
7.2	Commands	X		
7.2.1	Point–to–Point Commands			X
7.2.1.1	Spacecraft Required Point–to–Point Commands		X	
7.2.1.1.1	Instrument Operational Equipment ON and OFF Commands		X	
7.2.1.1.2	Instrument Survival Equipment ON and OFF Commands		X	
7.2.1.2	Instrument Point–to–Point Commands		X	X
7.2.1.2.1	Instrument Fault Recovery		X	X
7.2.1.2.1.1	Instrument Fault Isolation		X	X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
7.2.2	Command and Telemetry Bus Commands			X
7.2.2.1	Real–Time Commands		X	
7.2.2.1.1	Memory Load Initiation			X
7.2.2.1.2	Memory Dump Initiation			X
7.2.2.2	Stored Commands			X
7.2.2.2.1	Absolute Time Commands	X		
7.2.2.2.1.1	Absolute Time Command Time Tag Resolution		X	
7.2.2.2.1.2	Absolute Time Command Distribution			X
7.2.2.2.1.3	Absolute Time Command Time Tag Uniqueness			X
7.2.2.2.2	Relative Time Commands	X		
7.2.2.2.2.1	Relative Time Sequence		X	
7.2.2.2.2.2	Relative Time Sequence Distribution		X	
7.2.2.2.2.3	Relative Time Sequence Distribution Timing		X	
7.2.2.2.2.4	Relative Time Command Time Delay		X	
7.2.2.3	Spacecraft Control Computer Issued Commands		X	
7.2.2.3.1	Telemetry Monitor Commands			X
7.2.2.3.2	Instrument Telemetry Monitor Commands		X	
7.2.2.3.3	IMOK Indication and Safe–Mode Command	X		
7.2.2.3.3.1	IMOK Indication			X

TABLE 40-1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
7.2.2.3.3.2	Safe-Mode Command			X
7.2.2.3.4	Instrument Survival Mode Commands		X	
7.2.2.4	Interface Selection	X		
7.2.2.4.1	Time Mark and Frequency Bus Selection		X	
7.2.2.4.2	Redundant High-Rate Link Selection		X	
7.2.2.5	High-Rate Link Test Command		X	
7.2.3	Instrument Command Documentation			X
7.2.4	Command Requirements	X		
7.2.4.1	Command Uniqueness		X	
7.2.4.2	Critical Commands		X	
7.2.4.3	Command Sequence		X	
7.2.5	Command Restraints		X	
7.2.5.1	Toggle Commands		X	
7.2.5.2	Command Format Consistency		X	
7.2.5.3	Multifunction Commands		X	
7.3	Telemetry	X		
7.3.1	Point-to-Point Telemetry	X		
7.3.1.1	Instrument Status		X	X
7.3.1.2	Spacecraft-Required Point-to-Point Telemetry		X	X

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
7.3.1.3	Instrument Point–to–Point Telemetry Sampling Rate			X
7.3.1.4	Instrument Point–to–Point Telemetry Sampling Rate Definition		X	
7.3.2	Command and Telemetry Bus Telemetry	X		
7.3.2.1	Instrument Housekeeping Telemetry Types	X		
7.3.2.1.1	Normal Instrument Housekeeping Telemetry		X	
7.3.2.1.2	Critical Health and Safety Telemetry		X	
7.3.2.2	Instrument Telemetry Limits	X		
7.3.2.2.1	Instrument Normal Housekeeping Telemetry Data Limits		X	
7.3.2.2.2	Instrument Critical Health and Safety Telemetry Data Limits		X	X
7.3.2.3	Telemetry Monitor	X		
7.3.2.3.1	Spacecraft Monitoring of Instrument Telemetry			X
7.3.2.3.2	Instrument Telemetry Monitoring Sampling Rates			X
7.3.3	Telemetry Interface Utilization Documentation	X		
7.3.3.1	Instrument Point–to–Point Telemetry Documentation			X
7.3.3.2	Instrument Point–to–Point Telemetry Sampling Rate Documentation			X
7.3.3.3	Instrument Housekeeping Telemetry Documentation			X
7.3.3.4	Instrument Housekeeping Telemetry Sampling Rate			X
	Documentation			

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
7.3.3.5	Instrument Housekeeping Telemetry Format Documentation			X
7.3.3.6	Instrument Telemetry Monitoring Documentation			X
7.3.3.7	Instrument Transfer Schedule Documentation			X
7.3.3.8	Command and Telemetry Bus Data Transfer Schedule Adaptability		X	X
7.3.4	Telemetry Requirements	X		
7.3.4.1	Telemetry Sampling Rates		X	X
7.3.4.2	Command Verification	X		
7.3.4.2.1	Command Receipt Verification		X	
7.3.4.2.2	Command Execution Verification		X	
7.3.4.2.3	Command Verification Sampling Rate		X	
7.3.4.2.4	Command Execution Verification Telemetry		X	
7.3.4.3	Instrument Mode Dependency		X	
7.3.4.4	Instrument Activity Dependency		X	
7.3.4.5	Configuration Dependant Telemetry		X	
7.3.4.6	Synchronization Restrictions		X	
7.3.4.7	Instrument Housekeeping Telemetry Availability		X	
7.3.4.8	Instrument Housekeeping Telemetry Mnemonic Naming Convention		X	X
7.3.4.8.1	Subsystem Identifiers		X	X

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
7.3.4.8.2	Telemetry Type Identification		X	X
7.3.4.8.3	Telemetry Source Identification		X	X
7.3.4.8.4	Telemetry Name		X	X
7.4	Command and Telemetry Bus Data	X		
7.4.1	Memory Loads		X	X
7.4.2	Memory Dumps		X	X
7.4.3	Ancillary Data			X
7.4.4	Time Code Data			X
7.5	Autonomy	X		
7.5.1	Instrument Mode and State Changes	X		
7.5.1.1	Infrequently Changed Parameters		X	
7.5.1.2	Normal Instrument State Changes		X	
7.5.1.3	Mode Changes		X	X
7.5.2	Safe and Survival Modes	X		
7.5.2.1	Instrument Safe–Mode	X		
7.5.2.1.1	Instrument Safe–Mode Entry		X	
7.5.2.1.2	Instrument Safe–Mode Configuration		X	
7.5.2.1.3	Safe–Mode Entry Override		X	
7.5.2.1.4	Duration of Safe–Mode		X	

TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)				
Section		Not Applicable	Instrument Provider	Spacecraft Provider
7.5.2.2	Instrument Survival Mode		X	
7.5.2.2.1	Spacecraft Survival Mode Entry			X
7.5.2.2.2	Instrument Survival Mode Entry		X	
7.5.2.2.3	Duration of Survival Mode		X	
7.5.2.6	Instrument Safe and Survival Modes Documentation			X
7.5.3	Memory Load Verification		X	
7.5.4	Time Mark and Frequency Bus Loss		X	
8	CONTAMINATION CONTROL REQUIREMENTS	X		
8.1	Contamination Protection Design		X	
8.2	Contamination Protection Measures Documentation			X
8.3	Instrument Purge Documentation			X
8.4	Instrument Venting Allocation			X
8.5	Instrument Venting Documentation			X
8.6	Surface Avoidance			X
10	ENVIRONMENTS		X	X
10.1	Ephemerides	X		
10.1.1	Orbital Characteristics		X	
10.1.2	Transfer Orbit Characteristics		X	
10.1.3	Sun–Pointing Safe Mode Orbital Characteristics		X	

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
10.2	Spacecraft Reference Coordinate Frame	X		
10.3	Pointing			X
10.4	Thermal Environments	X		
10.4.1	Prelaunch, Launch, Ascent Thermal Environment	X		
10.4.2	Deleted	X		
10.4.3	Thermal Environment	X		
10.5	Total Ionizing Dose Environment		X	
10.6	Single Event Upset and Latchup		X	X
10.7	Atomic Oxygen		X	
10.8	Micrometeoroids	X		
10.9	Space Debris	X		
10.10	Magnetic Fields	X		
10.10.1	Instrument–Generated Magnetic Fields		X	
10.10.2	Magnetic Fields Documentation		X	
10.10.3	Spacecraft Magnetic Fields		X	
10.11	EMI/EMC Requirements		X	
10.12	Spacecraft Charging	X		
10.12.1	Instrument Electrostatic Discharge Control	X		

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TABLE 40–1. REQUIREMENTS RESPONSIBILITY MATRIX (Continued)

Section		Not Applicable	Instrument Provider	Spacecraft Provider
10.12.2	Spacecraft Electrostatic Discharge Analysis			X
10.12.3	Spacecraft External Surface Charging	X		

APPENDIX D

50 VERIFICATION RESPONSIBILITY AND METHODS MATRIX

The verification responsibility and methods cross–reference matrix is shown in Table 50–1.

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3	MECHANICAL REQUIREMENTS		X	X	A, D, I, T
3.1	Mechanical Interface Definitions	X			
3.1.1	Spacecraft Mounting Interface Definition	X			
3.1.2	Coldplate Mechanical Interface Definition	X			
3.2	Envelopes	X			
3.2.1	Instrument Envelope Allocation	X			
3.2.1.1	Instrument Launch Mode Envelope		X	X	I
3.2.1.2	Instrument On–Orbit Envelope		X	X	I
3.2.2	Instrument Envelope Documentation		X		I
3.2.3	External Configuration Changes		X		I
3.3	Fields of View	X			
3.3.1	Fields–of–View Allocation			X	I
3.3.2	Fields–of–View Accommodation		X		A
3.3.3	Fields–of–View Documentation		X		I
3.4	Mass Properties	X			
3.4.1	Instrument Mass Allocation			X	T
3.4.2	Instrument Mass Measurement			X	T

LEGEND:

General

, = And
/ = Or

Method

A = Analysis
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Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.4.3	Instrument Mass Documentation		X		I
3.4.4	Instrument Mass Property Report			X	I
3.4.5	Instrument Mass Variability	X			
3.4.5.1	Instrument Mass Variability Allocation			X	A, T
3.4.5.2	Instrument Mass Variability Documentation		X		I
3.4.6	Center of Mass Documentation		X	X	I, T
3.4.7	Moments of Inertia	X			
3.4.7.1	Moments of Inertia Determination			X	A/T
3.4.7.2	Moments of Inertia Accuracy			X	I
3.4.7.3	Moments of Inertia Documentation		X		I
3.4.7.4	Moments of Inertia Variation Documentation		X		
3.4.8	Products of Inertia	X			
3.4.8.1	Products of Inertia Determination			X	A/T
3.4.8.2	Products of Inertia Accuracy			X	I
3.4.8.3	Products of Inertia Documentation		X		I
3.4.8.4	Products of Inertia Variation Documentation		X		I
3.5	Mounting	X			

Table caption: TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

LEGEND:

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, = And
/ = Or

Method

A = Analysis
D = Demonstration
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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.5.1	Mounting Method		X	X	I
3.5.2	Mounting Interface	X			
3.5.2.1	Mounting Interface Documentation		X		I
3.5.2.2	Mounting Hole Coordinates and Dimensions		X	X	I
3.5.3	Mounting Hardware	X			
3.5.3.1	Mounting Hardware Provider		X	X	I
3.5.3.2	Mounting Hardware Documentation		X		I
3.5.3.3	Mounting Bolts		X	X	I
3.5.4	Kinematic Mounts	X			
3.5.4.1	Kinematic Mount Provider		X		I
3.5.4.1.1	Test Kinematic Mount Delivery			X	I
3.5.4.1.2	Flight Kinematic Mount Delivery			X	I
3.5.4.1.3	Instrument Kinematic Mount Assembly		X	X	I
3.5.4.2	Kinematic Mount Characteristics	X			
3.5.4.2.1	Kinematic Mount Structure		X		I
3.5.4.2.2	Kinematic Mount Breakaway Torque		X		T/A
3.5.4.2.3	Kinematic Mount Angular Freedom of Movement		X		T/A

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TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.5.4.2.4	Kinematic Mount Thermal Conductance		X		T/A
3.5.4.3	Kinematic Mounting		X	X	I
3.5.4.3.1	Three-Point Kinematic Mount		X	X	I
3.5.4.3.1.1	KM1		X	X	A, I
3.5.4.3.1.2	KM2		X	X	A, I
3.5.4.3.1.3	KM3		X	X	A, I
3.5.4.3.2	Three-Point Kinematic Mount Restrictions		X	X	A, I
3.5.4.3.3	Kinematic Mount Stiffness		X		A, T
3.5.5	Spacecraft Mounting Surface	X			
3.5.5.1	Spacecraft Mounting Surface Flatness		X		I
3.5.5.2	Spacecraft Mounting Surface Planarity		X		I
3.5.6	Instrument Mounting Surface	X			
3.5.6.1	Instrument Mounting Surface Flatness		X		I
3.5.6.2	Instrument Mounting Surface Planarity		X		I
3.5.7	Mounting Location	X			
3.5.7.1	Instrument Mounting Location		X		A
3.5.7.2	Instrument Accommodation Equipment Mounting Location		X		A

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TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.5.7.3	Mounting Location Documentation		X		I
3.5.8	Drill Templates	X			
3.5.8.1	Drill Template Usage		X	X	I
3.5.8.2	Drill Template Fabrication Requirements		X	X	I
3.5.8.3	Optically Aligned Drill Template Provider		X		I
3.5.8.4	Non–optically Aligned Component Drill Template Provider			X	I
3.6	Alignment	X			
3.6.1	Instrument Optical Alignment Cube			X	I
3.6.2	Optical Alignment Cube Requirements	X			
3.6.2.1	Optical Alignment Cube Surface Area		X	X	I
3.6.2.2	Optical Alignment Cube Surface Orthogonality		X	X	I
3.6.2.3	Optical Alignment Cube Documentation		X		I
3.6.3	Alignment Responsibility		X		I
3.6.4	Alignment Angles		X		I
3.6.5	Pointing Allocations		X	X	I
3.7	General Structural Design Requirements	X			

LEGEND:

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, = And
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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.7.1	Structural Support	X			
3.7.1.1	Instrument Structural Support		X		A, T
3.7.1.2	Coldplate Structural Support			X	A, T
3.7.2	Instrument Structural Dynamics			X	A, T
3.7.3	Interface Design Limit Loads Requirements	X			
3.7.3.1	Limit Loads Application		X	X	A
3.7.3.2	Limit Loads Application Axis		X	X	A
3.7.3.3	Interface Design Limit Loads		X	X	A
3.7.3.4	Random Vibration Levels		X	X	A, T
3.7.3.5	Sine Vibration Levels		X	X	A,T
3.7.4	Coupled–Loads Analysis	X			
3.7.4.1	Coupled–Loads Analysis Responsibility		X		I
3.7.4.2	Coupled–Loads Analysis Results		X		I
3.7.5	Pressurized System Design		X	X	I, T
3.7.6	Environmental Requirements	X			
3.7.6.1	Launch Survivability Design Requirements	X			
3.7.6.1.1	Shock		X	X	A, I, T

CH–3

LEGEND:

General
, = And
/ = Or

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.7.6.1.2	Launch Pressure Profile		X	X	A, T

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)						
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method	
3.7.6.1.3	Acoustics		X		T	
3.7.6.2	Orbital Environment	X				
3.7.6.2.1	Acceleration			X	A, D, T	
3.7.6.2.2	Torque	X				
3.7.6.2.2.1	Torque Allowables			X	A,T	CH–2
3.7.6.2.2.2	Torque Profile Documentation		X		I	
3.7.6.2.3	Force	X				
3.7.6.2.3.1	Force Allowables			X	A,T	CH–2
3.7.6.2.3.2	Torque Documentation		X		I	
3.7.6.2.4	Angular Momentum	X				
3.7.6.2.4.1	Allowable Angular Momentum		X		A, T	
3.7.6.2.4.2	Angular Momentum Documentation		X		I	
3.7.6.2.4.3	Spacecraft Non–Operational Deployment Disturbance			X	A, T	
3.7.6.2.4.4	Shock Generation On–Orbit			X	A, T	
3.7.6.2.4.5	Instrument Orbital Shock Requirement		X		A, D, T	
3.8	Finite Element Model			X	I	

LEGEND:

General

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.9	Instrument Mass Model		X		I
3.10	Instrument Mechanisms		X	X	D
3.10.1	Caging During Test and Launch		X	X	D
3.10.2	Caging On–Orbit		X	X	D
3.10.3	Captive Hardware		X	X	I
3.10.4	Sealed Hardware		X	X	D, I
3.11	Venting Forces	X			
3.11.1	Continuous Venting Forces			X	T
3.11.2	Random Venting Impulses			X	T
3.11.3	Thrust Direction Adjustment		X		D
3.11.4	Venting Force Documentation		X		I
3.12	Coldplate Mechanical Interface Requirements	X			
3.12.1	Coldplate Mounting	X			
3.12.1.1	Coldplate Mounting Bolts		X	X	D
3.12.1.2	Coldplate Bolt Pattern		X	X	D,I
3.12.1.3	Coldplate Mounting Hardware Provider		X		I
3.12.1.4	Coldplate Mounting Hardware Documentation		X		I

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.12.2	Instrument Surface for Coldplate Mechanical Interface	X			
3.12.2.1	Instrument Surface Flatness			X	I
3.12.2.2	Instrument Surface Finish			X	I
3.12.3	Coldplate Drill and Stayout Zone Template	X			
3.12.3.1	Coldplate Stayout Zone Template			X	I
3.12.3.2	Coldplate Drill Template			X	I
3.12.4	Coldplate Mounting Surface Area			X	I
3.12.5	Coldplate Mounting Surface	X			
3.12.5.1	Coldplate Mounting Surface Flatness		X		I
3.12.5.2	Coldplate Mounting Surface Finish		X		I
3.12.6	Coldplate Mechanical Interface Filler Installation		X		I
	Responsibility				
3.12.7	Coldplate Mechanical Interface Filler Installation		X		I
	Responsibility Documentation				
3.12.8	Coldplate Mass Properties		X		I, A
3.13	Coldplate Plumbing	X			

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.13.1	Coldplate Plumbing Provider		X		I
3.13.2	Coldplate Plumbing Support Provider		X		I
3.13.3	Coldplate Plumbing Support Documentation		X		I
3.13.4	Coldplate Plumbing Location		X		I
3.13.5	Coldplate Plumbing Clearance		X		I
3.13.6	Coldplate Plumbing Documentation		X		I
3.13.7	Coldplate Plumbing Dimensions and Mass Properties		X		I
3.14	Harnesses	X			
3.14.1	Harness Provider		X	X	I
3.14.2	Harness Hardware Documentation		X		I
3.14.3	Harness Wiring Requirements		X		I
3.14.4	Tie Points	X			
3.14.4.1	Tie Point Locations and Provider		X	X	I
3.14.4.2	Tie Point Documentation		X		I
3.14.5	Connectors	X			
3.14.5.1	Connector Mating		X	X	D

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TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.14.5.2	Connector Clearance		X	X	I
3.14.5.3	Connector Location		X		I
3.14.5.4	Keying		X	X	I
3.14.5.5	Interface Connector Provider	X			
3.14.5.5.1	Harness Connectors		X	X	I
3.14.5.5.2	Instrument Component Connectors			X	I
3.14.5.5.3	Connector Types			X	I
3.14.5.5.4	Connector Type Documentation		X		I
3.14.5.6	Flight Plugs	X			
3.14.5.6.1	Flight Plug Installation		X		D
3.14.5.6.2	Flight Plug Responsibility		X	X	I
3.14.5.6.3	Flight Plug Documentation		X		I
3.14.5.7	Connector Protective Covers		X		I
3.14.5.8	Test Connectors	X			
3.14.5.8.1	Test Connector Accessibility		X		D
3.14.5.8.2	Test Connector Documentation		X		I
3.14.5.9	Breakout Boxes	X			

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TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
3.14.5.9.1	Intra-Instrument Breakout Boxes		X	X	I
3.14.5.9.2	Instrument-to-Spacecraft Interface Breakout Boxes		X	X	I
3.14.5.10	Buffer Connectors and Connector Savers	X			
3.14.5.10.1	Buffer Connector and Connector Saver Utilization			X	I
3.14.5.10.2	Buffer Connector and Connector Saver Provider			X	I
3.14.5.11	Electrical Connector Constraints		X	X	I
3.15	Access	X			
3.15.1	Access Identification		X		I
3.15.2	General Access		X	X	D
3.16	Handling Fixtures		X		I
3.17	Launch Site Equipment Installation and Removal	X			I
3.17.1	Non-Flight Equipment		X		I
3.17.2	Flight Equipment		X		I
3.17.3	Flight and Non-Flight Equipment Documentation		X		I
4	THERMAL REQUIREMENTS	X			
4.1	Thermal Interface Description		X	X	A, D, I, T
4.2	Thermal Design	X			

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
4.2.1	Instrument Thermal Design Provider			X	A, D, I, T
4.2.2	Instrument Thermal Design			X	A, D, I, T
4.3	Heat Transfer	X			
4.3.1	Heat Transfer with the Spacecraft	X			
4.3.1.1	Average Heat Flux		X		A, T
4.3.1.2	Heat Transfer Distribution		X		A
4.3.2	Heat Transfer with the Coldplate		X		A, T
4.3.3	Heat Transfer Distribution Documentation		X		I
4.3.4	Environmental Heat Transfer		X	X	A, T
4.3.5	Deleted				
4.4	Temperature	X			
4.4.1	Spacecraft Temperature Range		X		A, T
4.4.2	Coldplate Temperature Requirements	X			
4.4.2.1	Coldplate Temperature Range		X		A, T
4.4.2.2	Coldplate Interface Filler Temperature Gradient		X		A, T
4.4.3	Instrument Temperature Range		X		I

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TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
4.4.4	Test Coldplate Temperatures During Instrument Qualification		X		A, T
	Testing				
4.4.5	Test Coldplate Temperatures During Instrument Acceptance		X		A, T
	Testing				
4.5	Temperature Monitoring	X			
4.5.1	Mechanical Interface Temperature Monitoring		X		D
4.5.2	Instrument Temperature Monitoring		X		D
4.5.3	Temperature Sensor Location		X		I
4.6	Thermal Control Hardware	X			
4.6.1	Coldplate	X			
4.6.1.1	Coldplate Capacity		X		A, T
4.6.1.2	Coldplate Configuration		X		I
4.6.1.3	Coldplate Mounting Orientation		X		I
4.6.1.4	Coldplate Mounting Elevation		X		I
4.6.1.5	Coldplate Mechanical Interface Filler		X		I, T
4.6.1.6	Test Coldplate Requirements		X		I, T

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
4.6.2	Heaters	X			
4.6.2.1	Survival Heaters		X	X	A, T
4.6.2.2	Survival Heater Control		X		D, I
4.6.3	Thermal Control Hardware	X			
4.6.3.1	Thermal Control Hardware Responsibility		X		I
4.6.3.2	Thermal Control Hardware Documentation		X		I
4.7	Thermal Models	X			
4.7.1	Surface Model			X	I
4.7.2	Reduced Node Thermal Math Model			X	I
4.7.3	Detailed Thermal Math Model			X	I
5	ELECTRICAL REQUIREMENTS	X			
5.1	Electrical Interface Requirements		X	X	A, D, I, T
5.1.1	Electrical Interfaces	X			
5.1.2	Electrical Interface Definitions	X			
5.1.2.1	Electrical Interface Location	X			
5.1.2.2	Operational Power	X			
5.1.2.2.1	Peak Power	X			

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Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
5.1.2.2.2	Average Power	X			
5.1.2.3	Survival-Mode Power	X			
5.1.2.4	Safe-Mode Power	X			
5.1.2.5	Launch-Phase Power	X			
5.2	Power	X			
5.2.1	Instrument Power Allocations		X		A, I
5.2.1.1	Operational Power Allocation		X	X	A, D
5.2.1.2	Survival Power Allocation		X	X	A, D
5.2.1.3	Launch-Phase Power Allocation		X	X	A, D
5.2.1.4	Power Interface Allocation			X	I
5.2.1.5	Instrument Power Level Documentation		X		I
5.2.2	Power Characteristics	X			
5.2.2.1	Voltage		X		T
5.2.2.1.1	Voltage Transients		X	X	T, D
5.2.2.1.2	Abnormal Steady-State Voltage Limits			X	A, T, D
5.2.2.2	Power Source Impedance		X		A, T
5.2.2.3	Current	X			

TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
5.2.2.3.1	Instrument Current Transients			X	T
5.2.2.3.2	Deleted				
5.2.2.3.3	Overcurrent Protection		X		I, A
5.2.2.3.3.1	Overcurrent Protection Device Size		X		A, I
5.2.2.3.3.2	Overcurrent Protection Device Size Documentation		X		I
5.2.2.4	Instrument Power Input Impedance			X	A, T
5.2.2.4.1	Instrument Common Mode Impedance			X	T
5.2.2.4.2	Instrument Differential Mode Impedance			X	T
5.2.3	Power Control	X			
5.2.3.1	Power Connections		X		I
5.2.3.2	Power Application		X		D
5.2.3.3	Power Fault Tolerance		X	X	A
5.2.3.4	Instrument Equipment Separation			X	I, D
5.2.3.5	Instrument Power Control		X	X	D
5.3	Grounds, Returns, and References	X			
5.3.1	Power Leads and Returns		X		I
5.3.1.1	Power Harnessing		X		I, T

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
5.3.1.2	Isolation			X	T, A
5.3.1.2.1	Deleted			X	T
5.3.1.2.2	120 V Primary Power Isolation			X	T, A
5.3.1.2.3	Transient Protected Circuit Isolation			X	T, A
5.3.1.2.4	Secondary Power Isolation			X	T, A
5.3.1.3	Power Reference	X			
5.3.1.3.1	Primary Power Reference		X		I, D
5.3.1.3.2	Secondary Power Return			X	I, D
5.3.1.3.3	Secondary Power Reference			X	I, D
5.3.1.3.4	Isolated Secondary Power Referencing			X	I, D
5.3.2	Signal Reference			X	I
5.3.2.1	Signal Reference Constraints		X	X	I, T, A
5.3.2.2	Differential Signal Isolation		X	X	T
5.3.2.3	Passive Telemetry Interface Isolation		X	X	T
5.3.3	Instrument Grounding	X			
5.3.3.1	Instrument Ground Interconnection		X		T
5.3.3.2	Component Grounding	X			

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
5.3.3.2.1	Component Ground Location		X	X	I

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
5.3.3.2.2	Component Ground Connection		X		I, T
5.3.3.2.3	Component Bonding Straps		X	X	I
5.3.3.3	Connector Grounding			X	I, T
5.3.3.4	Chassis Reference Current			X	I, T
5.3.4	Fault Ground	X			
5.3.4.1	Instrument Fault Ground Requirements	X			
5.3.4.1.1	Instrument Fault Ground Connection			X	I
5.3.4.1.2	Instrument Fault Ground Routing			X	I
5.3.4.1.3	Instrument Fault Ground Wire Grounding			X	I
5.3.4.2	Spacecraft Fault Ground Requirements	X			
5.3.4.2.1	Spacecraft Fault Ground Routing		X		I
5.3.4.2.2	Fault Ground Wire Connection to Instrument Ground Interconnection		X		I
5.3.4.2.3	Fault Ground Wire Connection to Primary Power Reference		X		I
5.3.5	Signal Reference Ground	X			
5.3.5.1	Instrument Ground Interconnection Referencing		X		I, T
5.3.5.2	Thermal Blanket Grounding	X			

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
5.3.5.2.1	Deleted		X	X	I, T
5.3.5.2.2	Deleted		X		T
5.3.5.2.3	Thermal Closeout Blanket Grounding		X		I, T
5.4	Command and Data Handling Interface	X			
5.4.1	General Signal Interface Requirements	X			
5.4.1.1	Interface Conductors		X	X	I
5.4.1.2	Interface Redundancy	X			
5.4.1.2.1	Redundant Interface Terminology	X			
5.4.1.2.2	Redundant Interface Usage	X			
5.4.1.2.2.1	Command and Telemetry Bus Interfaces		X	X	D
5.4.1.2.2.2	Deleted				
5.4.1.2.2.3	Deleted				
5.4.1.2.3	Interface Fault Tolerance		X	X	I, A
5.4.1.3	Interface Circuitry Isolation			X	I, A, D
5.4.2	Point–to–Point Command and Telemetry Interfaces		X		I, D
5.4.2.1	Relay Drive Commands		X		A, D
5.4.2.1.1	Deleted				

CH–1 (5.3.5.2.1–5.3.5.2.3)
CH–1 (5.4.1.2.2.1–5.4.1.2.2.3)
CH–1 (5.4.2.1.1)

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
5.4.2.1.2	Relay Drive Command Characteristics		X		T

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)						
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method	
5.4.2.1.3	Relay Drive Command Load Characteristics		X		T	
				X	I, T	
5.4.2.2	Deleted					CH–1
5.4.2.2.1	Deleted					
5.4.2.2.2	Deleted					
5.4.2.3	Passive Bi–Level Telemetry Interface		X	X	D	
5.4.2.3.1	Deleted					CH–1
5.4.2.3.2	Passive Bi–Level Telemetry Signal Characteristics		X	X	I, T	
5.4.2.4	Passive Analog Telemetry Interfaces	X				
5.4.2.4.1	Deleted					CH–1
5.4.2.4.2	Passive Analog Telemetry Signal Characteristics		X	X	T	
5.4.2.5	Active Analog Telemetry Interfaces	X				
5.4.2.5.1	Deleted					CH–1
5.4.2.5.2	Active Analog Telemetry Signal Characteristics		X	X	I, T	
5.4.3	Time Mark and Frequency Bus		X		I, D	
5.4.3.1	Time Mark and Frequency Bus Electrical Characteristics		X		I, T	

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
5.4.3.2	Reference Frequency Characteristics		X	X	I, T
5.4.3.3	Time Mark Encoding		X		T, D
5.4.3.4	Time Mark Accuracy		X		T
5.4.4	Command and Telemetry Bus Electrical Interface		X		I
5.4.4.1	Command and Telemetry Bus Electrical Characteristics		X	X	I, T
5.4.5	Science Data Electrical Interface	X			
5.4.5.1	Science Data Interface Control		X		I, D
5.4.5.2	Low–Rate Science Data Interface Electrical Characteristics		X	X	I, T
5.4.5.3	High–Rate Science Data Interface Electrical Requirements	X			
5.4.5.3.1	High–Rate Interface Circuitry	X			
5.4.5.3.1.1	Instrument High–Rate Science Data Interface Circuitry			X	I
5.4.5.3.1.2	Instrument High–Rate Science Data Signal Interface			X	I
	Coupling				
5.4.5.3.1.3	Spacecraft High–Rate Science Data Interface Circuitry		X		I

LEGEND:

General		Method	
,	= And	A	= Analysis
/	= Or	D	= Demonstration
		I	= Inspection
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TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

	Status		Phase B COMPLETE		Phase A COMPLETE
5.4.5.3.1.4	High-Rate Science Data Interface Polarity Inversion			X	T
5.4.5.3.2	High-Rate Science Data Interface Electrical Characteristics		X	X	I, T
5.5	Other Interfaces	X			
5.5.1	Test Point Interfaces			X	A, D, I, T
5.5.1.1	Spacecraft Integration and Test Use			X	I
5.5.1.2	Performance Verification Limitation			X	D
5.5.1.3	Keyed Connectors			X	I
5.5.1.4	Power and Load Isolation			X	D, T, A
5.5.1.5	Failure Propagation			X	A
5.5.1.6	Short-Circuit Isolation			X	T, A
5.5.1.7	Grounding Integrity			X	I, T, A
5.5.1.8	EMI/EMC			X	I, T, A
5.5.1.9	Flights Standards			X	I
5.5.1.10	Mechanical Requirements			X	I, T, A
5.5.2	Test Point Interface Documentation		X		I
5.6	Failure Modes and Effect Analysis		X		I

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
6	COMMAND AND DATA HANDLING REQUIREMENTS		X	X	A, D, I, T
6.1	Command and Telemetry Bus	X			
6.1.1	Command and Telemetry Bus Configuration		X		I
6.1.1.1	Command and Telemetry Bus Transfer Method		X		D
6.1.1.1.1	Command and Telemetry Bus MIL–STD–1553B Mode		X		D
	Code Utilization				
6.1.1.1.2	Command and Telemetry Data Transfers		X		D
6.1.1.1.2.1	Data Transfers to the Instrument		X		D
6.1.1.1.2.2	Data Transfers from the Instrument		X		D
6.1.1.1.3	Broadcast Mode on the Command and Telemetry Bus		X		D
6.1.2	Command and Telemetry Bus Transfer Timing		X		D
6.1.2.1	Minor Cycle Length		X		D, T
6.1.2.1.1	Minor Cycle Task List		X		D
6.1.2.1.2	Minor Cycle Task List Completion		X		D
6.1.2.2	Major Cycle Length		X		D, T

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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
6.1.2.3	Master Cycle Length		X		D, T
6.1.2.4	Command and Telemetry Bus Task Scheduling	X			
6.1.2.4.1	Synchronize with Data Word		X		D
6.1.2.4.1.1	Synchronize with Data Word Transfer Frequency		X		D
6.1.2.4.1.2	Synchronize with Data Word Transfer Timing		X		D, T
6.1.2.4.1.3	Data Word Content		X		D
6.1.2.4.1.4	Data Word Content Format		X		D, I
6.1.2.4.1.5	Instrument Response to Data Word		X		D
6.1.2.4.1.6	Instrument Telemetry Transfer Schedule		X		D
6.1.2.4.2	Command Transfers		X		D
6.1.2.4.3	Deleted	X			
6.1.2.4.3.1	Instrument Normal Housekeeping Telemetry Collection		X		D
6.1.2.4.3.2	Instrument Critical Health and Safety Housekeeping		X		D
	Telemetry Collection				
6.1.2.4.3.3	Instrument Housekeeping Telemetry Readiness		X		D
6.1.2.4.4	Memory Load Transfers		X		D

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TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method	
6.1.2.4.5	Memory Dump Transfers		X		D	
6.1.2.4.6	IMOK, Ancillary Data, Time Code Data, and Safe Mode		X		D	CH-3
	Commands					
6.1.2.4.6.1	IMOK, Ancillary Data, and Time Code Data Transfer		X		D	CH-3
	Frequency					
6.1.3	Command And Telemetry Bus Data	X				
6.1.3.1	Commands	X				
6.1.3.1.1	Real-Time Commands		X		D, I	
6.1.3.1.2	Stored Commands		X		D, I	
6.1.3.1.3	Safe-Mode Command Structure		X		D, I	
6.1.3.1.4	IMOK Command Structure		X		D, I	CH-3
6.1.3.2	Memory Load and Dump Initiate Command Structures	X				
6.1.3.2.1	Load Initiate Command Structure		X		D, I	
6.1.3.2.2	Dump Initiate Command Structure		X		D, I	
6.1.3.3	Memory Load Data Messages					

LEGEND:

General
, = And
/ = Or

Method
A = Analysis
D = Demonstration
I = Inspection
T = Test

TABLE 50-1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)					
Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
6.1.3.4	Memory Dump Data Messages				
6.1.3.5	Ancillary Data Messages	X			
6.1.3.5.1	Ancillary Data Contents		X		D, I
6.1.3.5.2	Ancillary Data Message Format		X		D, I
6.1.3.6	Time Code Data Messages	X			
6.1.3.6.1	Time Code Data Contents		X		D, I
6.1.3.6.2	Time Code Data Epoch		X		D, I
6.1.3.6.3	Time Code Data Format		X		D, I
6.1.4	Command and Telemetry Bus Protocols	X			
6.1.4.1	Instrument Command and Telemetry Bus RT Address Assignment		X		D, I
6.1.4.2	MIL-STD-1553B Message Identification		X		D, I
6.1.4.2.1	MIL-STD-1553B Message Subaddress Definition		X		D, I
6.1.4.2.2	Instrument Specific Subaddresses		X		D, I
6.2	Time Mark and Frequency Bus	X			
6.2.1	Time Code Data Valid Indication		X		D, T
6.2.2	Time Information Timing		X		D, T

LEGEND:

General

, = And
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TABLE 50–1. VERIFICATION RESPONSIBILITY AND METHODS MATRIX (Continued)

Section		Not Applicable	Spacecraft Provider	Instrument Provider	Method
6.3	Low Rate Science Data Bus		X		D
6.3.1	Low–Rate Science Data Interface Configuration		X		I
6.3.2	Broadcast Mode on the Low–Rate Science Data Bus		X		D
6.3.3	Low–Rate Science Data Transfer Timing		X		D, T
6.3.4	Low–Rate Science Data Bus Data Format		X		I
6.3.5	Low–Rate Science Data Bus Transfer Protocol	X			
6.3.5.1	Low–Rate Science Data Bus RT Address Assignment		X		D, I
6.3.5.2	Low–Rate Science Data Bus MIL–STD–1553B Mode Code Utilization		X		D
6.3.5.3	Low Rate Science Data Bus MIL–STD–1553B Message Subaddresses		X	X	D
6.3.5.4	Low–Rate Science Data Polling		X		D
6.3.5.5	Low–Rate Science Data Packet Readiness		X		D
6.3.5.6	Total Packet Length Indication		X		D
6.3.5.7	Low–Rate Science Data Packet Transfer	X			
6.3.5.7.1	Low–Rate Instrument Polling Interval		X		D, T

LEGEND:

General
- , = And
- / = Or

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