LAT Project Office – SLAC

DCN No. LAT-XR-816-01

DOCUMENT CHANGE NOTICE (DCN)

SHEET 1 **OF** 1

ORIGINATOR: Martin Nordby	**PHONE:** 650-926-3415	**DATE:** 6/26/02	
CHANGE TITLE: Revision of Mechanical Systems Level-III Specification		**ORG.:** SLAC	

DOCUMENT NUMBER	TITLE	NEW REV.
LAT-SS-00115	**LAT Mechanical Systems Subsystem Specification-**	**2**
	Level III Specification	

CHANGE DESCRIPTION (FROM/TO):
Multiple changes, untracked.
Changes include updating req's to match GLAST IRD, MSS, SPS changes for Spacecraft procurement.
Removed all links to LAT Performance Spec (LAT-SS-00010), to clarify ties to mission spec's

REASON FOR CHANGE:
To update req's to reflect changes in driving spec's

ACTION TAKEN: ☒ **Change(s) included in new release** ☐ **DCN attached to document(s), changes to be included in next revision**
☐ **Other (specify):**

DISPOSITION OF HARDWARE (IDENTIFY SERIAL NUMBERS):	DCN DISTRIBUTION:
☒ **No hardware affected (record change only)**	Tim Thurston Jim Martin Subsystem Managers Susan Morrison Marc Campell
☐ **List S/Ns which comply already:**	
☐ **List S/Ns to be reworked or scrapped:**	
☐ **List S/Ns to be built with this change:**	
☐ **List S/Ns to be retested per this change:**	
☐	

SAFETY, COST, SCHEDULE, REQUIREMENTS IMPACT? ☐ **YES** ☒ **NO**
If yes, CCB approval is required. Enter change request number:

APPROVALS	DATE	OTHER APPROVALS (specify):	DATE
ORIGINATOR: Martin Nordby (signature on file)	7/19/02	Deputy Prjt. Scientist- S. Ritz (signature on file)	7/24/02
ORG. MANAGER: Martin Nordby (signature on file)	7/19/02	T. Kamae (signature on file)	7/26/02
System Engineering: Tim Thurston (signature on file)	7/19/02		
Deputy- Jim Martin (signature on file)	7/24/02		
Instrument Management- B. Althouse (signature on file)	7/24/02		
DCC RELEASE: Natalie Cramar (signature on file)	7/26/02	Doc. Control Level: ☐ Subsystem ☒ LAT IPO ☐ GLAST Project	

GLAST LAT Subsystem Specification	Document # LAT-SS-00115-2	Date Effective 26 June 2002
	Author(s) Martin Nordby	Supersedes
	Subsystem/Office Mechanical Systems	

Document Title

LAT Mechanical Systems Subsystem Specification—Level III Specification

1. Change History Log

Revision	Effective Date	Description of Changes
1	21 Dec 01	Initial release
2	23 Feb 02	Added "Venting, Volatiles, and Particulates" section Moved "Configuration" section to top. Re-organized and re-numbered sections. Added sub-sections.
	23 Feb 02	Completely revised/re-wrote all requirements. Changes not tracked.
	26 Apr 02	Added 8.3 "Stay-Clear Volume", 8.5 "Provisions for LAT Integration and Test", and 13 "Grounding and Shielding" sections and all requirements in these sections.
	30 Apr 02	Added 8.5 "Stiffness", 11.5 "Thermal Control Operations", 12 "On-Orbit Environment", 16 "Analytical Modeling", and all requirements in these sections.
	10 May 02	Updated req's against 433-IRD-0001-B that was sent out with SC RFO Inserted new verification matrix
	14 June 02	Updated verification matrix. Added bus voltage ranges to 8.4
	14 June 02	Draft designation removed—ready for release

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3. Purpose

This document defines the level III subsystem requirements for the GLAST Large Area Telescope (LAT) Mechanical Systems.

4. Scope

This specification captures the GLAST LAT requirements for the LAT mechanical systems. This includes both the structural support and the thermal control system for the LAT. It encompasses the subsystem performance requirements derived from higher level GLAST and LAT performance and operational requirements. The verification methods of each requirement are identified.

5. Definitions

5.1. Acronyms

ACD	Anticoincidence Detector
ASD	Acceleration Spectral Density
CAL	Calorimeter
CCP	Contamination Control Plan (LAT-MD-00404)
GEVS	"General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components"
ICD	Interface Control Documents between the LAT and LAT subsystems.
IRD	"GLAST LAT—Spacecraft Interface Requirements Document" (433-IRD-0001)
LAT	Large Area Telescope
LIP	LAT Interface Plane. The theoretical plane defined by the bottom surface of the Grid.

LPS	"LAT Performance Specification" (LAT-SS-00010)
GLAST	Gamma-ray Large Area Space Telescope
MAR	"Mission Assurance Requirements for the GLAST LAT" (433-MAR-0001)
MSS	"Mission System Specification" (433-SPEC-0001)
PPG	"Delta II Payload Planners Guide" (MDC 00H0016)
SPS	"Spacecraft Performance Specification" (433-SPEC-0003)
TBD	To Be Determined
TBR	To Be Resolved
TCS	Thermal Control System
TKR	Tracker

5.2. Definitions

A, Analysis: A quantitative evaluation of a complete system and /or subsystems by review/analysis of collected data.

All LAT operating modes: any mode where the LAT is on or partially on. This includes any stand-by or shut-down mode.

Arcmin: An arcmin is a measure of arc length. One arcmin is 1/60 degree.

Arcsec: An arcsec is a measure of lengths of arc. One arcsec is 1/60 arcmin

cm: centimeter

D, Demonstration: To prove or show, usually without measurement of instrumentation, that the project/product complies with requirements by observation of results.

g: unit of gravitational acceleration, g = 9.81 m/s^2

I, Inspection: To examine visually or use simple physical measurement techniques to verify conformance to specified requirements.

kg: Kilogram

LAT Coordinate System: Defined in LAT-TD-00035

m: meter

Max: Maximum

Mech: Mechanical Systems

Min: Minimum

Normal LAT operating mode: LAT fully on andtaking data

s, sec: seconds

Req: Requirement

S, Similarity: To shown capability of functioning based on heritage for similar components or materials

T, Testing: A measurement to prove or show, usually with precision measurements or instrumentation, that the project/product complies with requirements.

Validation: Process used to assure the requirement set is complete and consistent, and that each requirement is achievable.

Ver: Process used to ensure that the selected solutions meet specified requirements and properly integrate with interfacing products.

W: Watts

6. Applicable Documents

LAT-DS-00040-5, "LAT Mechanical Systems Instrument Stayclear," April 2002.

LAT-MD-00404, “LAT Contamination Control Plan”

LAT-TD-00450, “LAT Handling Plan.”

LAT-SS-00010, “GLAST LAT Performance Specification”, August 2000

433-IRD-0001, “Large Area Telescope (LAT) Instrument—Spacecraft Interface Requirements Document”, May, 2002.

433-SPEC-0001, “GLAST Mission System Specification”, May, 2002

433-SPEC-0003, “Spacecraft Performance Specification,” May, 2002.

433-OPS-0001, “GLAST Operations Concept Document”, Draft

LAT-SS-00115-2, “LAT Mechanical Systems Subsystem Specification—Level III Specification,” May, 2002..

433-MAR-0001, “Mission Assurance Requirements (MAR) for the Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)”, June 9, 2000

433-RQMT-0005, “EMI

GEVS-SE Rev A, “General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components”, June 1996. http://arioch.gsfc.nasa.gov/302/gevs-se/toc.htm

MDC 00H0016, “Delta II Payload Planners Guide (PPG)”, October 2000. http://www.boeing.com/defense-space/space/delta/docs/DELTA_II_PPG_2000.PDF

NPD 8010.2B, “NASA Policy Directive, Use of Metric System of Measurement in NASA Programs.”

LAT-TD-00035-1, “LAT Coordinate System,” December 5, 2000.

LAT-TD-00125-1, “Mass and Power Allocation Recommendations,” April 2001.

7. Sub-System Description

The LAT Mechanical Systems subsystem includes the structural support and thermal control system for the LAT. Structurally, this includes the Grid mounting structure, all hardware needed to mount TKR, CAL, and ACD subsystem modules, and attachment points for the spacecraft interface structure and the LAT Radiators.

Thermally, this includes the LAT Radiators, heat pipes, X-LAT Plate and thermal control heaters, thermistors, and control system to regulate the LAT temperature while on orbit. This also includes the interface thermally conductive joints for the TKR, CAL, and ACD. Furthermore, it includes MLI on the underside of the X-LAT Plate and all additional panels and plates under the Grid to completely close out the underside volume of the LAT for EMI shielding.

8. Configuration

8.1. Mass

The total mass of Mechanical Systems shall be no more than 323 kg. [same as LAT-TD-00125-1 | Ver: I]

The mass of Mechanical Systems subassemblies shall not exceed that shown Table 1, below. [derived from LAT-TD-00125-1 | Ver: I]

Assembly	Mass Budget	Description
Grid Assembly	131 kg	Grid, Top Flange heat pipes, inserts, CAL mounting hardware
Radiator Assemblies	86 kg	2 Radiators
X-LAT/EMI Box Assembly	93 kg	Down Spout heat pipes, HP Patch Plates, Radiator Mount Brackets, X-LAT Plates, box side panels, mounting hardware, bulkhead connectors

Table 1: Mechanical Systems Component Mass Allocations

8.2. Center of Gravity

The center of gravity of Mechanical Systems and associated hardware shall be less than z = -530.2 mm (530.2 mm below the LAT z = 0 plane). [derived from IRD 3.2.2.5 | Ver: I]

The centers of gravity of Mechanical Systems subassemblies shall not exceed that shown in Table 2, below. [derived from IRD 3.2.2.5 | Ver: I]

Assembly	Max Center of Gravity	Description
Grid Assembly	-104 mm	Ht below LAT XY-plane
Radiator Assemblies	-1335 mm	Ht below LAT XY-plane
X-LAT/EMI Box Assembly	-390 mm	Ht below LAT XY-plane

Table 2: Mechanical Systems Component Center of Gravity Allocations

8.3. Stay-Clear Volume and Dimensions

Mechanical Systems components and assemblies, including Radiators, shall stay within the static envelope, and not place other subsystem components outside said envelope, as defined in the IRD, Appendix A. [same as IRD 3.2.2.1 | Ver: I]

The maximum Radiator area shall be 5.4 m^2. [same as IRD 3.2.3.4.1 | Ver: I]

Radiators shall be configured as 2 separate Radiators, each no wider than 1.85 m. [same as IRD 3.2.3.4.1 | Ver: I]

Radiators shall be positioned according to IRD Appendix A. [same as IRD 3.2.2.3 | Ver: I]

Mount points for spacecraft support of the LAT shall be as shown in IRD Appendix A. [same as IRD 3.2.2.3 | Ver: I]

8.4. Power

During any LAT operation mode, the power allocation for Mechanical Systems components shall be no greater than 48 W of conditioned power. [derived from LAT-TD-00125-1 | Ver: D]

When the LAT is off, the orbit-average power allocation for all survival heaters shall be no greater than 300 W, at the minimum voltage of 27 V, and 350 W at the maximum voltage of 29 V. [derived from IRD 3.2.4.1.7.6 | Ver: D]

When the LAT is off, the peak power allocation for all survival heaters shall be no greater than 350 W. [same as IRD 3.2.4.1.7.6 | Ver: D]

Mechanical Systems electrical systems shall function normally when the LAT main bus voltage is in the range of 27 V – 29 V, DC. [same as IRD 3.2.4.1.3.1 | Ver: D]

Mechanical Systems electrical systems shall function normally when the LAT survival bus voltages (2 buses) are in the range of 27 V – 29 V, DC. [same as IRD 3.2.4.1.7.2 | Ver: D]

8.5. Stiffness

The fixed-base stiffness of the Mechanical Systems structures, with all subsystems interfaces intact, shall produce a first-mode frequency of greater than 50 Hz. [same as IRD 3.2.2.8.1.2 | Ver: T]

8.6. Provisions for Integration and Test

LAT Integration Accommodations

Mechanical Systems shall provide purge plena to allow constant inside-out purging of the LAT instrument with either nitrogen or air, at a rate not to exceed TBD liters per minute, total. [derived from TBD | Ver: D]

TBD—Ground Support Equipment attachment points and loads

TBD—Electronics box access needs

Provisions for Alignment and Surveying

TBD—Surveying lines-of-sight

TBD—Surveying fiducial locations and access

TBD—alignment tolerances

Ground Environment

Mechanical Systems components and materials shall be capable of being stored and operated continuously in a class 100,000 environment. [same as IRD 3.2.1.5.4 | Ver: A]

Mechanical Systems components and assemblies shall be capable of fully functioning and being stored in the range of ground ambient environments described in Table 3, below. [Ver: D]

Environment	Low	High	Driving Req
Operating temperature	15 C	30 C	IRD 3.2.1.5.1
Storage temperature	0 C	40 C	LPS (TBD)
Operating/storage relative humidity	30 %	55%	IRD 3.2.1.5.2

Table 3: Ground Ambient Environments

Test Provisions

During Observatory thermal-vacuum testing, Mechanical Systems components and the TCS shall be capable of full functionality while tested with the LAT –X-axis aligned with the gravity force vector, and YZ-plane horizontal (i.e.: "lying on its side"). [same as IRD 3.2.3.7 | Ver: T, A]

Observatory Integration Provisions

After Observatory integration, any LAT-SC connector on the LAT side shall be capable of de-/re-mating without requiring any other LAT-SC connector to be de-mated. [same as IRD 3.2.4.6.3 | Ver: I]

The LAT shall be capable of mating/de-mating to the SC without de-mating any internal LAT cables. [same as IRD 3.2.4.6.4 | Ver: I]

Any and all LAT ground test connectors shall be easily accessible for mating/de-mating after the LAT is integrated to the SC. [same as IRD 3.2.4.6.5 | Ver: I]

9. LAT Alignment

9.1. Alignment

The Grid structure with CAL, ACD, and TKR mounted, shall maintain alignment of subsystem interfaces to 30 arc-minutes with respect to the LAT Interface Plane (LIP), after ground testing and launch. [derived from (TBD) | Ver: I]

During launch, the Grid structure with CAL, ACD, and TKR mounted, shall maintain alignment of subsystem interfaces to less than 5 arc-minutes with respect to the LIP. [derived from (TBD) | Ver: A]

During launch, the Grid structure with CAL, ACD, and TKR mounted, shall prevent subsystem modules from colliding or touching each other, or those of neighboring subsystems. [derived from (TBD) | Ver: A]

9.2. Alignment Stability

The Grid structure with CAL, ACD, and TKR mounted, shall maintain alignment of the TKR interface to less than 7 arc-seconds, 1 σ radial, with respect to the LIP, during normal LAT operating modes. This applies while the LAT is subject to the thermal environments listed in Section 11, below. [same as MSS 3.3.1.11.1.2 | Ver: T (TBD), A]

The Grid structure with CAL, ACD, and TKR mounted, shall maintain alignment of the TKR interface to less than 7 arc-seconds, 1 σ radial, with respect to the LIP, during all slews, re-orientations, and re-pointing. This applies while the LAT is subject to the thermal environments listed in Section 11, below. [same as MSS 3.1.4.2.1.1 | Ver: A]

10. Structural Load Environment

10.1. Structural Loads

Mechanical Systems components and assemblies shall be capable of full operational performance after exposure to the **static loads** due to the launch environment described in Table 4 below, with the CAL, TKR, and ACD loads and interfaces in place, as defined in their respective ICD's. Note that all Mechnical Systems components are considered primary structures. [same as IRD 3.2.2.8.2 | Ver: T, A]

Event	Lateral	Axial (+) Thrust	Axial (-) Thrust
Lift-off, Transonic	+/- 5.1g	+4.1g	-1.4g
MECO	+/- 0.2g	+6.2 +/- 0.6g	- 0.2g

Table 4: Static-Equivalent Center-of-Gravity Launch Loads

Mechanical Systems components and assemblies shall be designed to be capable of withstanding static loads in the thrust and lateral axes simultaneously. [same as IRD 3.2.2.8.2 | Ver: A]

Mechanical Systems components and assemblies shall be capable of withstanding the time **rate of change of pressure** in the launch vehicle fairing, as shown in Figure 1, below. [derived from (TBD), PPG 4.2.2, Figure 4-6 | Ver: A]

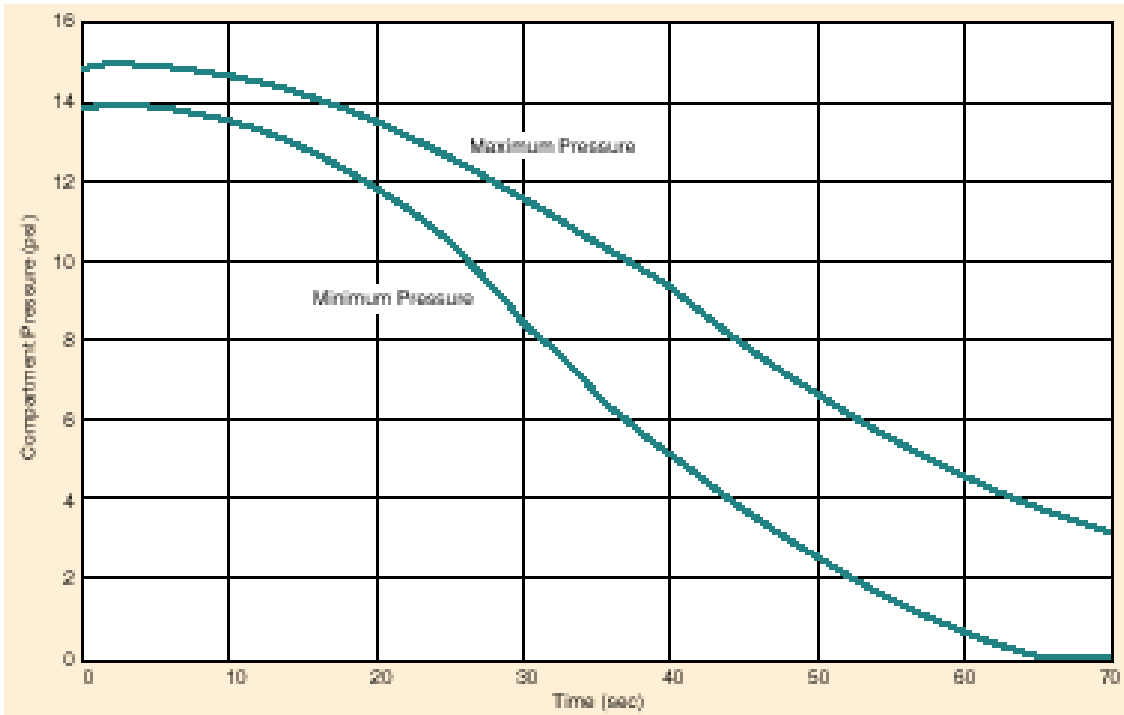

Figure 4-6. Delta II Payload Fairing Compartment Absolute Pressure Envelope

Figure 1: Pressure Rate-of-Change During Launch

10.2. Vibro-Acoustic and Shock Loads

Mechanical Systems components and assemblies shall be capable of full operational performance after exposure to the **sinusoidal vibration** loads due to the launch environment shown in Table 5, below, with the CAL, TKR, and ACD loads and interfaces in place, as defined in their respective ICD's. [IRD 3.2.2.8.9, PPG Table 4-7 | Ver: T]

Axis	Frequency (Hz)	Maximum flight levels
Thrust	5 to 6.2 6.2 to 100	1.27 cm (0.5 in.) double amplitude 1.0 g (zero to peak)
Lateral	5 to 100	0.7 g (zero to peak)

Table 5: Payload Planner's Guide Table 4-7. Sinusoidal Vibration Levels

Mechanical Systems components and assemblies shall be capable of full operational performance after exposure to the **random vibration** loads due to the launch environment described in Table 6, below, with the CAL, TKR, and ACD loads and interfaces in place, as defined in their respective ICD's. [same as IRD 3.2.2.8.4 and GEVS Appendix D, Table D-6 | Ver: T]

Freq. (Hz)	ASD Level (G2/Hz)
20	.0016
20-300	+4 dB/oct
300-700	.06
700-2000	-3 dB/oct
2000	.021
Overall	8.7 Grms

Table 6: GEVS Appendix D, Table D-6. Random Vibration Levels

Mechanical Systems components and assemblies shall be capable of full operational performance after exposure to the **acoustic** loads due to the launch environment described in the SPS 3.2.5.2 and reproduced in Table 7, below, with the CAL, TKR, and ACD loads and interfaces in place, as defined in their respective ICD's. [same as IRD 3.2.2.8.5 | Ver: T (TBR)]

One-Third Octave Center Frequency (Hz)	Accept. Test Levels (dB)	Qual. Test Levels (dB)
31.5	121.4	124.4
40	125.5	128.5
50	128.5	131.5
63	131.0	134.0
80	133.0	136.0
100	132.5	135.5
125	132.0	135.0
160	130.5	133.5
200	131.5	134.5
250	132.5	135.5
315	131.5	134.5
400	128.0	131.0
500	125.0	128.0
630	122.0	125.0
800	120.0	123.0
1000	118.0	121.0
1250	117.5	120.5
1600	117.0	120.0
2000	116.7	119.7
2500	116.5	119.5
3150	116.5	119.5
4000	116.0	119.0
5000	114.5	117.5
6300	110.5	113.5
8000	106.5	109.5
10000	103.5	106.5
OASPL	141.8	144.8

Protoflight Levels = Qualification Levels
Test Duration = 60 seconds for acceptance and protoflight tests
Test Duration = 120 seconds for qualification (prototype) tests

Table 7: SPS 3.2.5.2. Acoustic Load Environment for a Delta II 2920H

Mechanical Systems components and assemblies shall be capable of full operational performance after exposure to the **shock** loads due to the launch environment described in Table 8 and Figure 2, below, with the CAL, TKR, and ACD loads and interfaces in place, as defined in their respective ICD's. [same as IRD 3.2.2.8.6, PPG Figure 4-24 | Ver: T (TBR)]

Frequency (Hz)	Shock Response Spectrum	
	Acceptance (G)	Qualification (G)
350	100	140
350-1700	+12.3 dB/oct	+12.3 dB/oct
1700	2500	3500
1700-4000	+5.5 dB/oct	+5.5 dB/oct
4000-5000	5500	7700
5000-10000	-9 dB/oct	-9 dB/oct
10000	2000	2800

Table 8: Payload Planner's Guide Figure 4-24. Shock Response Spectrum

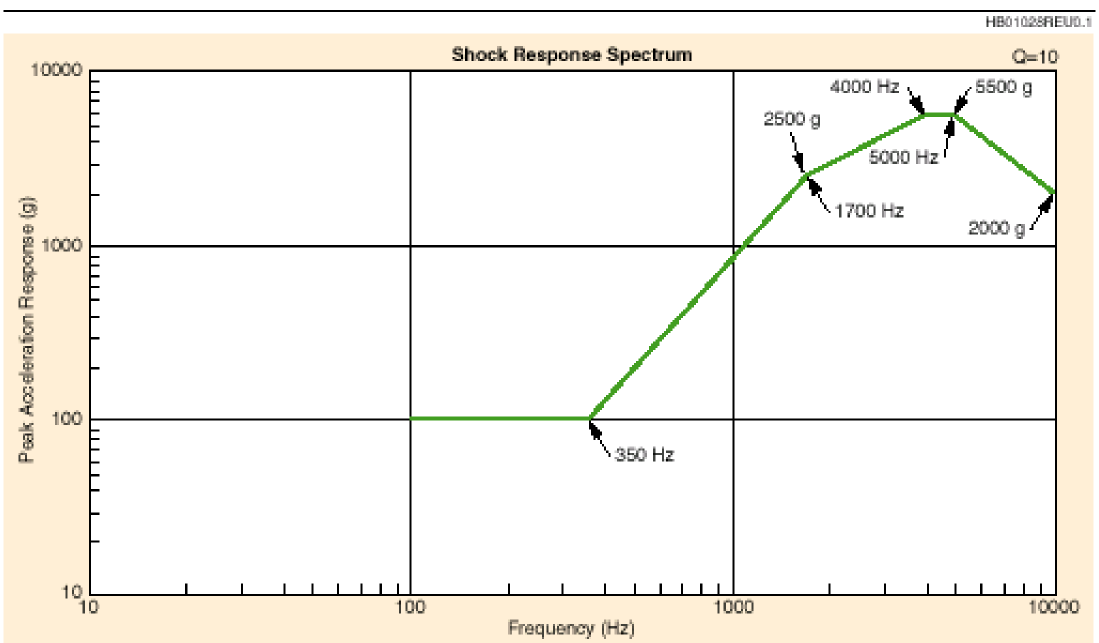

Figure 4-24. Maximum Flight Spacecraft Interface Shock Environment 6019 and 6915 Payload Attach Fitting

Figure 2: Payload Planner's Guide Figure 4-24. Shock Response Spectrum

11. Thermal Environment and Heat Loads

Introduction: The Thermal Control System for the LAT is responsible to maintain the LAT and its subsystems within the required temperature ranges during all modes of operation. Toward that end, it transports and radiates all heat generated from electrical power usage, on-orbit radiation heat sources, and conduction and radiation from the spacecraft. This must be done in an orbital thermal environment which changes depending on operational configuration and orientation, and despite changes in instantaneous power consumption by the LAT electronics.

11.1. Process and Interface Heat Loads

In normal LAT operating modes, Mechanical Systems shall be capable of dissipating up to 650 W of LAT process power, indefinitely. [same as IRD 3.2.4.1.1 | Ver: T, A]

In LAT operating modes, Mechanical Systems shall be capable of dissipating as little as a minimum of 500 W of LAT process power, indefinitely. [derived from LAT-TD-00225 "LAT Dissipated Power" | Ver: T, A]

In normal LAT operating modes, Mechanical Systems shall be capable of dissipating 5 W per Radiator heat conducting in from the spacecraft support struts. [same as IRD 3.2.3.4.3 | Ver: T, A]

In normal LAT operating modes, Mechanical Systems shall be capable of dissipating 750 W (hot-case) LAT process power for 10 minutes, maximum. [same as IRD 3.2.4.1.2 | Ver: T, A]

In normal LAT operating modes, Mechanical Systems shall be capable of normal operation when backloaded by 75 W of heat from the solar arrays to each Radiator. [same as IRD 3.2.3.4.5 | Ver: T, A]

In normal LAT operating modes, Mechanical Systems Radiators shall be capable of normal operation when the view factor to the a solar array from each Radiator is 0.1. [same as IRD 3.2.3.4.5 | Ver: A]

In normal LAT operating modes, Mechanical Systems shall be capable of dissipating 5 W of heat conducting in from the spacecraft through the LAT-SC mounts, at the worst combination of temperature extremes. [same as IRD 3.2.3.3 | Ver: T, A]

In normal LAT operating modes, Mechanical Systems shall be capable of dissipating heat due to radiative leakage in from the spacecraft through 2 layers of MLI, with the spacecraft temperature extremes of –10 degC to + 50 degC. [same as IRD 3.2.3.3 | Ver: T, A]

11.2. Interface Temperatures

In normal LAT operating modes, Mechanical Systems shall be capable of maintaining the temperatures at the CAL, TKR, and ACD interfaces to the operational ranges established in the their respective ICD's. [derived from (TBD) ICD's | Ver: T, A]

In normal LAT operating modes, Mechanical Systems shall be capable of controlling the rate of temperature change at the CAL, TKR, and ACD interfaces to the operational limits established in the their respective ICD's. [derived from (TBD) ICD's | Ver: T, A]

In normal LAT operating modes, Mechanical Systems shall be capable of controlling the rate of temperature change at the Radiator interfaces to not more +/- 3 degC (TBR) over the period of an orbit. [derived from (TBD) | Ver: T, A]

When the LAT is in "Off" or "Stand-By" mode, Mechanical Systems shall be capable of controlling the orbit-average temperature at the Grid side of the Radiator interface to the survival ranges of –20 deg C to +15 degC (TBR). [derived from TBD ICD's | Ver: T, A]

11.3. Environment Heat Loading and Orbital Parameters

The LAT shall be in an initial orbit of 550 km [MSS 3.1.1.4.1], with a range of 450 km, min to 575 km, max [MSS 3.1.1.4.4], a maximum inclination of 28.5 degrees [MSS 3.1.1.4.2] and a maximum eccentricity of 0.01 [MSS 3.1.1.4.3]. Mechanical Systems components and assemblies shall be capable of operation within the full phase-space allowed by these orbital parameters and the fluxes defined in the table below. [derived from MSS 3.1.1.4 | Ver: A]

Mechanical Systems shall provide thermal control of the LAT to allow it to be pointed anywhere, at any time, for any duration, during any normal LAT operating mode. [derived from MSS 3.3.2.3 | Ver: T, A]

Mechanical Systems shall be capable of maintaining thermal control of the LAT during exposure to any and all combinations of the fluxes shown in Table 9, below, for each thermal case (survival, cold, nominal, and hot). [see Table 9 for source of Requirement | Ver: T, A]

Parameter	Surv.	Cold-Case	Nom	Hot-Case	Units	Source
Earth IR on any exposed surface	208	208	265	265	W/m^2	IRD 3.2.3.5, Table 3-3
Earth Albedo on any exposed surfaces	0.25	0.25	0.4	0.4		IRD 3.2.3.5, Table 3-3
Solar Flux on surfaces exposed to +X direction	1286	1286	1419	1419	W/m^2	IRD 3.2.3.5, Table 3-3
Solar flux due to 1 deg glancing view of the sun on +/- Y surfaces	0	0	0	6	W/m^2	SPS 3.4.5.1
Orbit-average absorbed solar flux on one Radiator due to re-pointing	0	0	27	0	W	SPS 3.4.5.1

Table 9: Environmental Heat Loads on the LAT

When the LAT is in "Off" or "Stand-By" mode, Mechanical Systems shall be capable of controlling the orbit-average temperature at the Grid side of the Radiator interface to the survival ranges defined in Section 11.2 while one Radiator panel is subjected to sustained full exposure to the solar thermal flux environment, as defined in Table 9. [derived from (TBD) | Ver: T, A]

11.4. Thermal Hardware Configuration

All Mechanical Systems external surfaces shall be insulated with MLI, except dedicated radiating surfaces. [same as IRD 3.2.3.3 | Ver: I]

All Mechanical Systems MLI blankets shall have an effective emissivity of less than 0.03. [same as IRD 3.2.3.3 | Ver: T]

12. On-Orbit Environment

Mechanical Systems material, components, and assemblies shall be capable of normal operation in the space **radiation** environment for the life of the mission, as defined in MSS 3.3.6, with no loss of performance. [same as MSS 3.3.5.1.1 | Ver: S]

Mechanical Systems material, components, and assemblies shall be capable of normal operation in the TBD **atomic oxygen** environment for the life of the mission, as defined in MSS 3.3.6, with no loss of performance. [same as MSS 3.3.5.1.2 | Ver: S]

Mechanical Systems material, components, and assemblies shall be capable of normal operation in the **micrometeoroid** environment for the life of the mission, as defined in MSS 3.3.6, with no loss of performance. [same as MSS 3.3.5.1.3 | Ver: A]

Mechanical Systems material, components, and assemblies shall be capable of normal operation in the **debris** environment for the life of the mission, as defined in MSS 3.3.6, with no loss of performance. [same as MSS 3.3.5.1.4 | Ver: A]

13. Electrical System

13.1. Grounding and Shielding

Grounding req's for Mech Systems (TBD)

TCS components shall meet EMI requirements per 433-RQMT-0005. [same as IRD 3.2.4.3 | Ver: D]

13.2. Thermal Control Operations

All Mechanical Systems electrical components, and the TCS system shall be able to tolerate instantaneous removal of electrical power, without damage or subsequent loss of functionality. [derived from IRD 3.2.4.1.6.5 | Ver: D]

Survival heater power shall not be required during normal operations of the LAT. [same as IRD 3.2.4.1.7 | Ver: D]

Survival power shall be used only for heaters and associated passive control circuitry that maintain the LAT at a minimum turn-on temperature. [same as IRD 3.2.4.1.7.2 | Ver: D]

The TCS shall be capable of handling continuous simultaneous power to all redundant power buses with no failure or loss of function. [same as IRD 3.2.4.1.7.3 | Ver: D]

TCS survival heaters shall be electrically isolated from each other and the chassis. [same as IRD 3.2.4.1.7.4 | Ver: I]

The TCS shall passively (TBR) control the manner by which the survival heater circuit is closed. [same as IRD 3.2.4.1.7.7 | Ver: D]

The TCS shall tolerate without damage or loss of function DC voltages from 0 to 42 V on the survival busses. [same as IRD 3.2.4.1.3.2 | Ver: D]

The TCS shall be capable of transitioning from any mode to safe mode in less than 10 seconds (TBR). [derived from IRD 3.2.8.2 | Ver: D]

14. Venting, Volatiles, and Particulates

Mechanical Systems shall be designed such that all air and particulates be vented down and away from the LAT Interface Plane (LIP) during depressurization on ascent. [derived from (TBD) | Ver: I]

Mechanical Systems components and assemblies shall be designed, fabricated, and tested to meet all requirements of LAT-MD-00404, "LAT Contamination Control Plan." [derived from CCP | Ver: I]

15. Reliability and Redundancy

Mechanical Systems components and assemblies shall be capable of fully functioning for five years after launch (10 year goal). [derived from MSS 3.1.1.2.2 | Ver: A]

The probability of a failure which renders the LAT thermal control system non-functional shall be no greater than 0% (TBR). [TBD | Ver: A]

Except for structural assemblies and pressure vessels, no single-point failure mechanism of any kind in Mechanical Systems components and assemblies shall jeopardize the mission. Components shall be fully redundant or sufficiently oversized to carry the loss of a neighboring component. [derived from IRD 3.2.8.1, MSS 3.3.1.5.1 | Ver: A]

No two credible failures of any Mechanical Systems component or assembly shall result in loss of life or damage to surrounding facilities (Note: this does NOT apply to the SC support joint, since this is outside the purview of this specification). [derived from MSS 3.3.1.5.1 | Ver: A]

The TCS shall have redundant survival heaters. [same as IRD 3.2.4.1.7.1 | Ver: D]

Mechanical Systems design, fabrication, and testing shall meet all requirements of the MAR [derived from MAR | Ver: I]

16. Analytical Modeling

Steady-state and transient thermal analysis shall use only TSS and SINDA analysis software. [same as IRD 3.2.3.6.1 | Ver: I]

Mechanical Systems shall develop and maintain hot-case and cold-case thermal models whose parameters bound the thermal performance of the LAT. [derived from IRD 3.2.3.6.2 | Ver: I]

Mechanical Systems shall generate a reduced thermal model of the LAT, with less than 400 nodes, for delivery as needed. [derived from IRD 3.2.3.6.2 | Ver: I]

Mechanical Systems shall be responsible for the design, analysis, and performance of the LAT thermal system. [derived from IRD 3.2.3.1 | Ver: I]

Structural factors of safety for all mechanical analysis shall be in accordance with GEVS-SE Rev A. [same as IRD 3.2.2.8.3 | Ver: I]

All design and analysis models shall use SI units. [same as IRD 3.2.1.4 | Ver: I]

Mechanical Systems shall observe current NASA Policy Directive NPD 8010.2C "Use of the Metric System of Measurement in NASA Programs." [derived from IRD 3.2.1.6 | Ver: I]

All interchanges external to the LAT shall use the Spacecraft Coordinate System, as defined in the SPS 3.1.7 and MSS 3.3.1.6.2. [same as IRD 3.2.1.1, MSS 3.3.1.6.2 | Ver: I]

17. Verification Matrix

The tables on the following pages list all requirements in this Specification, and the method by which they will be verified. Below is a glossary of the terms used in the tables:

Analysis: existing analysis shows that requirement can be met

Design: existing design is compliant with requirement

Plan: Current fabrication/test plans will lead to compliance with requirement

Y: Design is shown to be compliant

P: Design is partially compliant, but compliance has not been fully demonstrated

A, Analysis: A quantitative evaluation of a complete system and /or subsystems by review/analysis of collected data.

D, Demonstration: To prove or show, usually without measurement of instrumentation, that the project/product complies with requirements by observation of results.

I, Inspection: To examine visually or use simple physical measurement techniques to verify conformance to specified requirements.

S, Similarity: To shown capability of functioning based on heritage for similar components or materials

T, Testing: A measurement to prove or show, usually with precision measurements or instrumentation, that the project/product complies with requirements.

Sect	Requirement	Status	Date	Comply	Compliance Verif. dPDR	Final	Req Source
8	Configuration						
8.1.	**Mass**						
	The total mass of Mechanical Systems < 323 kg	Rev	May-02	Y	analysis	I	same as LAT-TD-00125-1
8.2.	**Center of Gravity**						
	C.G. of Mechanical Systems less than z = -530.2 mm	Rev	May-02	Y	analysis	I	derived from IRD 3.2.2.5
8.3.	**Stay-Clear Volume and Dimensions**						
	Mechanical Systems shall stay, and keep other subsystems within the IRD envelope	NC		Y	analysis	I	same as IRD 3.2.2.1
	Max Radiator area shall be 5.4 m2	NC		Y	design	I	same as IRD 3.2.3.4.1
	Radiators configured as 2 separate Radiators	NC		Y	design	I	same as IRD 3.2.3.4.1
	Each Radiator no wider than 1.85 m	New	May-02	Y	design	I	same as IRD 3.2.3.4.1
	Radiators positioned according to IRD Appendix A	New	May-02	Y	design	I	same as IRD 3.2.2.3
	Mount point for SC support as shown in IRD Appendix A	Rev	May-02	Y	design	I	same as IRD 3.2.2.3
8.4.	**Power**						
	When on, Radiator VCHP heater power < 48 W	NC		Y	analysis	D	derived from LAT-TD-00125-1
	When off, orbit-average survival heater power < 300 W AT 27 V min	Rev	May-02	Y	analysis	D	derived from IRD 3.2.4.1.7.6
	When off, orbit-average survival heater power < 350 W AT 29 V max	Rev	May-02	Y	analysis	D	derived from IRD 3.2.4.1.7.6
	When off, survival heater peak power < 350 watts	New	May-02	Y	analysis	D	same as IRD 3.2.4.1.7.6
	LAT main bus voltage range of 27 V – 29 V, DC	New	Jun-02	Y	plan	D	same as IRD 3.2.4.1.3.1
	LAT survival bus voltages (2 buses) in the range of 27 V – 29 V, DC	New	Jun-02	Y	plan	D	same as IRD 3.2.4.1.7.2
8.5.	**Stiffness**						
	Fixed-base first-mode > 50 Hz	NC		Y	analysis	T	same as IRD 3.2.2.8.1.2
8.6.	**Provisions for Integration and Test**						
	LAT Integration Accommodations						
	Provide purge plena to allow constant inside-out purging of the LAT	New	May-02	Y	design	D	TBD
	Ground Environment						
	Components capable of being stored and operated in a class 100,000 environment	New	May-02	Y	plan	A	same as IRD 3.2.1.5.4
	Components capable of functioning and being stored in ground ambient environments	NC		Y	plan	D	same as IRD 3.2.1.5
	Test Provisions						
	During Obs t-vac, TCS capable of full functionality "lying on its side"	Rev	May-02	Y	design	T, A	same as IRD 3.2.3.7
	Observatory Integration Provisions						
	After Obs int., connectors capable of de-/re-mating w/out requiring other de-mates	New	May-02	P	plan	I	same as IRD 3.2.4.6.3
	LAT capable of mating/de-mating to the SC without de-mating any internal LAT cables	New	May-02	Y	design	I	same as IRD 3.2.4.6.4
	LAT ground test connectors easily accessible for de-/mating after LAT integration	New	May-02	P	plan	I	same as IRD 3.2.4.6.5

Sect	Requirement	Status	Date	Comply	Compliance Verif.		Req Source
					dPDR	Final	
9	LAT Alignment						
9.1.	Alignment						
	Maintain subsystem alignment to 30 arc-minutes after ground testing and launch	NC		P	design	I	derived from (TBD)
	During launch, maintain subsystem alignment to less than 5 arc-minutes	NC		Y	analysis	A	derived from (TBD)
	During launch, prevent subsystem modules from colliding or touching each other	NC		Y	analysis	A	derived from (TBD)
9.2.	Alignment Stability						
	Maintain TKR alignment to < 7 arc-seconds, 1 s radial, during normal LAT operation	NC		Y	analysis	T (TBR), A	same as MSS 3.3.1.11.1.2
	Maintain TKR alignment to < 7 arc-seconds, 1 s radial, during all slews	NC		Y	analysis	A	same as MSS 3.1.4.2.1.1
10	Structural Load Environment						
10.1.	Structural Loads						
	Capable of exposure to static launch loads	Rev	May-02	Y	analysis	T, A	same as IRD 3.2.2.8.2
	Capable of withstanding static loads in thrust and lateral axes simultaneously	NC		Y	analysis	A	same as IRD 3.2.2.8.2
	Capable of withstanding the time rate of change of pressure in the LV fairing	NC		P	design	A	same as PPG 4.2.2
10.2.	Vibro-Acoustic and Shock Loads						
	Capable of exposure to sinusoidal vibration launch loads	NC		Y	analysis	T	IRD 3.2.2.8.9, PPG Table 4-7
	Capable of exposure to random vibration launch loads	NC		P	analysis	T	same as IRD 3.2.2.8.4
	Capable of exposure to acoustic launch loads due	Rev	May-02	P	analysis	T (TBR)	same as IRD 3.2.2.8.5
	Capable of exposure to shock launch loads	NC		P	design	T (TBR)	same as IRD 3.2.2.8.6

					Compliance Verif.		
Sect	Requirement	Status	Date	Comply	dPDR	Final	Req Source
11	**Thermal Environment and Heat Loads**						
11.1.	**Process and Interface Heat Loads**						
	Capable of dissipating up to 650 W of LAT process power, indefinitely	NC		Y	analysis	T, A	same as IRD 3.2.4.1.1
	Capable of dissipating as little as 500 W of LAT process power, indefinitely					T, A	derived from LAT-TD-00225
	Capable of dissipating 5 W per Radiator heat conducting in from the SC supports	NC		Y	analysis	T, A	same as IRD 3.2.3.4.3
	Capable of dissipating 750 watts LAT process power for 10 minutes, maximum	NC		Y	analysis	T, A	same as IRD 3.2.4.1.2
	Capable of normal operation when loaded by 75 W/Rad of heat from SC solar arrays	Rev	May-02	Y	analysis	T, A	same as IRD 3.2.3.4.5
	Capable of normal operation with Rad-Solar Array view factor = 0.1	NC		Y	analysis	A	same as IRD 3.2.3.4.5
	Capable of dissipating 5 watts of heat conducting through LAT-SC mounts	NC		Y	analysis	T, A	same as IRD 3.2.3.3
	Capable of dissipating heat from the SC through 2 layers of MLI [-10C<T(SC)<+50C]	NC		Y	analysis	T, A	same as IRD 3.2.3.3
11.2.	**Interface Temperatures**						
11.3.	**Environment Heat Loading and Orbital Parameters**						
	The LAT shall be in an initial orbit of 550 km	NC		Y	analysis	A	derived from MSS 3.1.1.4
	Orbit range of 450 km min to 575 km max	New	May-02	Y	analysis	A	derived from MSS 3.1.1.4
	Maximum inclination of 28.5 degrees	NC		Y	analysis	A	derived from MSS 3.1.1.4
	Maximum eccentricity of 0.01	NC		Y	analysis	A	derived from MSS 3.1.1.4
	Provide thermal control with LAT pointed 2pi/24/7/365 during any normal LAT mode	NC		Y	analysis	T, A	derived from MSS 3.3.2.3
	Capable of maintaining thermal control during exposure to IR, Albedo, Solar fluxes	Rev	May-02	Y	analysis	T, A	derived from IRD 3.2.3.5
	Capable of maintaining thermal control when exposed to solar flux from SC re-points	Rev	May-02	Y	analysis	T, A	derived from SPS 3.4.5.1
	Capable of maintaining survival temp's while one Radiator is fully exposed to sun	Rev	May-02	Y	analysis	T, A	derived from (TBD)
11.4.	**Thermal Hardware Configuration**						
	All Mechanical Systems external surfaces shall be insulated with MLI	New	May-02	Y	design	I	same as IRD 3.2.3.3
	All Mechanical Systems MLI blankets shall have an effective emissivity < 0.03	New	May-02	Y	design	S	same as IRD 3.2.3.3
12	**On-Orbit Environment**						
	Capable of operation in radiation environment for the life of the mission	NC		P	design	S	same as MSS 3.3.5.1.1
	Capable of operation in the TBD atomic oxygen environment for the life of the mission	New	May-02	P	design	S	same as MSS 3.3.5.1.2
	Capable of normal operation in micrometeoroid environment for the life of the mission	NC		Y	design	A	same as MSS 3.3.5.1.3
	Capable of operation in the debris environment for the life of the mission	NC		Y	design	A	same as MSS 3.3.5.1.4

Sect	Requirement	Status	Date	Comply	Compliance Verif. dPDR	Final	Req Source
13	**Electrical System**						
11.5.	**Grounding and Shielding**						
	TCS components shall meet EMI requirements per 433-RQMT-0005	NC		P	design	D	same as IRD 3.2.4.3
11.5.	**Thermal Control Operations**						
	Elec components and the TCS able to tolerate instantaneous removal of power	NC		P	design	D	derived from IRD 3.2.4.1.6.5
	Survival heater power not required during normal operations of the LAT	New	May-02	Y	design	D	same as IRD 3.2.4.1.7
	Survival power used only for heaters and associated passive control circuitry	New	May-02	Y	design	D	same as IRD 3.2.4.1.7.2
	TCS capable of handling continuous simultaneous power to all redundant power buses	NC		P	analysis	D	same as IRD 3.2.4.1.7.3
	TCS survival heaters electrically isolated from each other and chassis	New	May-02	Y	design	I	same as IRD 3.2.4.1.7.4
	TCS passively controls survival heaters	New	May-02	Y	design	D	same as IRD 3.2.4.1.7.7
	TCS tolerates survival bus DC voltages from 0 to 42 V	New	May-02	P	design	D	same as IRD 3.2.4.1.3.2
	TCS capable of transitioning from any mode to safe mode in less than 10 seconds	New	May-02	P	design	D	derived from IRD 3.2.8.2
14	**Venting, Volatiles, and Particulates**						
	All air and particulates vented down and away from the LIP during ascent	NC		Y	plan	I	derived from (TBD)
	Components, assemblies to meet LAT-MD-00404, "LAT Contamination Control Plan."	NC		Y	plan	I	derived from CCP
15	**Reliability and Redundancy**						
	Components and assemblies capable of functioning for five years after launch	NC		Y	design	S	MSS 3.1.1.2.2
	Probability of a fatal failure of TCS shall be no greater than 0%					A	derived from (TBD)
	No single-point failure of any kind shall jeopardize the mission	NC		Y	design	A	derived from IRD 3.2.8.1
	Components shall be fully redundant	NC		Y	design	A	derived from IRD 3.2.8.1
	No two credible failures shall result in loss of life or damage	New	May-02	P	design	A	derived from MSS 3.3.1.5.1
	The TCS shall have redundant survival heaters	New	May-02	Y	analysis	D	same as IRD 3.2.4.1.7.1
	Design, fabrication, and testing shall meet all req's of the MAR					I	derived from MAR
16	**Analytical Modeling**						
	Steady-state and transient thermal analysis shall use only TSS and SINDA	New	May-02	Y	plan	I	same as IRD 3.2.3.6.1
	Develop and maintain hot-case and cold-case thermal models	NC		Y	plan	I	derived from IRD 3.2.3.6.2
	Generate a reduced thermal model of the LAT	New	May-02	P	plan	I	derived from IRD 3.2.3.6.2
	Responsible for the design, analysis, and performance of the LAT thermal system	NC		Y	plan	I	derived from IRD 3.2.3.1
	Structural factors of safety in accordance with GEVS-SE Rev A.	NC		Y	design	I	same as IRD 3.2.2.8.3
	All design and analysis models shall use SI units	NC		Y	plan	I	derived from IRD 3.2.1.4
	Use metric system	NC		Y	plan	I	derived from IRD 3.2.1.6
	All interchanges external to the LAT shall use the Spacecraft Coordinate System	New	May-02	P	plan	I	same as IRD 3.2.1.1