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GLAST LAT	Subsystem/Office Systems Engineering	
Document Title LAT Program Instrument Performance Verification Plan		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT) Program

Instrument Performance Verification Plan

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
1		Initial Release	
2	4/1/04	Post CDR update	

CONTENTS

Index of Tables and Figures

1 PURPOSE

This document represents the collective program plan for GLAST LAT instrument test. It addresses the testing to be performed at the unit/subsystem and instrument level for flight qualification, proto-flight and acceptance testing phases. Also addressed and referenced are the necessary processes/procedures and systems assurance activities to insure test performance.

2 SCOPE

The scope of this document covers the processes supporting testing of the delivered LAT flight hardware and software. This encompasses the LAT verification testing from subsystem components to the completed LAT instrument. Covered within this document is design verification at subsystem component, subsystem and Integrated LAT levels. Also within this scope is science verification and calibration of the LAT instrument.

It is the objective of the LAT test program to perform all testing in configurations which are as close as is practical to the flight configuration. Determination of the final test configuration will be made by evaluating the available resources and the physical requirements for test which may make achieving the actual flight configuration impossible.

For the purpose of this document, all references to flight hardware or software include the following process level elements:

- Qualification
- Proto Flight
- Flight
- Flight Spare
- Refurbished Qualification hardware

This document is organized into sections dealing with the major elements of the test program as follows:

- System Performance which covers the test infrastructure, process and process control elements of the test program
- Verification Plan that outlines the top level Test and Verification Program and provides details of the elements which make up each program
- Subsystem Test Plans presents summaries of the test plans for each subsystem

3 ACRONYMS and DEFINITIONS

3.1 Acronyms

Below are some of the LAT acronyms referenced in this document. A complete list is contained in lAT-MD-01153-01, the LAT Acronym List.

A/T	***Acceptance Test***
ACD	***Anticoincidence Detector***
ASIC	***Application Specific Integrated Circuit***
CAL	***Calorimeter***
CI	***Configuration Item***
CPT	***Comprehensive Performance Test***
DAQ	***Data Acquisition System***
EGSE	***Electrical Ground Support Equipment***
EM	***Engineering Model***
EMC	***Electromagnetic Compatibility***
EMI	***Electromagnetic Interference***
EPU	***Event Processor Unit***
FLT	***Flight/Acceptance***
GLAST	***Gamma-ray Large Area Space Telescope***
GTE	***Global Trigger Electronics***
ISOC	***Instrument/Science Operations Center***
I&T	***Integration and Test***
I/F	***Interface Test***
LAT	***Large Area Telescope***
L1T	***Level 1 Trigger***
LPT	***Limited Performance Test***
MGSE	***Mechanical Ground Support Equipment***
MOC	***Mission Operations Center***
PFQ	***Proto-flight Qualification***
PDU	***Power Distribution Unit***
PSR	***Pre-Shipment Review***
SAS	***Science Analysis Software***
S/C	***Spacecraft***
SIU	***S/C Interface Unit***
T/C	***TKR/CAL, Thermal Cycle***
TEM	***Tower Electronics Module***
T/V	***Thermal Vacuum***
TBD	***To Be Determined***
TKR	***Tracker***
TRR	***Test Readiness Review***

3.2 Definitions

The following abbreviations and definitions apply within the context of this document:

Flt	***Flight***
Proto	***Prototype***
Qual	***Qualification***
Vib	***Vibration***

Acceptance Tests: The validation process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

Assembly: See Level of Assembly.

Audit: A review of documentation or hardware to verify that it complies with project requirements.

Collected Volatile Condensable Material (CVCM): The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time.

Component: See Level of Assembly.

Configuration: The functional and physical characteristics of the payload and all its integral parts, assemblies and systems that are capable of fulfilling the fit, form and functional requirements defined by performance specifications and engineering drawings.

Configuration Control: The systematic evaluation, coordination, and formal approval/disapproval of proposed changes and implementation of all approved changes to the design and production of an item the configuration of which has been formally approved by the contractor or by the purchaser, or both.

Configuration Management: The systematic control and evaluation of all changes to baseline documentation and subsequent changes to that documentation which define the original scope of effort to be accomplished (contract and reference documentation) and the systematic control, identification, status accounting and verification of all configuration items.

Contamination: The presence of materials of molecular or particulate nature that degrade the performance of hardware.

Derating: The reduction of the applied load (or rating) of a device to improve reliability or to permit operation at high ambient temperatures.

Design Specification: Generic designation for a specification that describes functional and physical requirements for an article, usually at the component level or higher levels of assembly. In its initial form, the design specification is a statement of functional requirements with only general coverage of physical and test requirements. The design specification evolves through the project life cycle to reflect progressive refinements in performance, design, configuration, and test requirements. In many projects the end-item specifications serve all the purposes of design specifications for the contract end-items. Design specifications provide the basis for technical and engineering management control.

Designated Representative: An individual (such as a NASA plant representative), firm (such as assessment contractor), Department of Defense (DOD) plant representative, or other government representative designated and authorized by NASA to perform a specific function for NASA. As related to the contractor's effort, this may include evaluation, assessment, design review, participation, and review/approval of certain documents or actions.

Destructive Physical Analysis (DPA): An internal destructive examination of a finished part or device to assess design, workmanship, assembly, and any other processing associated with fabrication of the part.

Design Qualification Tests: Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either “prototype” or “protoflight” test levels.

Discrepancy: See Nonconformance

Electromagnetic Compatibility (EMC): The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

Electromagnetic Interference (EMI): Electromagnetic energy that interrupts, obstructs, or otherwise degrades or limits the effective performance of electrical equipment.

Electromagnetic Susceptibility: Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

End-to-End Tests: Tests performed on the integrated ground and flight system, including all elements of the payload, its control, stimulation, communications, and data processing to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

Failure: A departure from specification that is discovered in the functioning or operation of the hardware or software. See nonconformance.

Failure Free Hours of Operation: The number of consecutive hours of operation without failure the hardware and/or software (as appropriate) accumulated without an operating problem or anomaly since the last major hardware/software change (as appropriate), problem, or anomaly. Hours may be accumulated over various stages of hardware integration.

Failure Modes and Effects Analysis (FMEA): A procedure by which each credible failure mode of each item from a low indenture level to the highest is analyzed to determine the effects on the system and to classify each potential failure mode in accordance with the severity of its effect.

Flight Acceptance: See Acceptance Tests.

Fracture Control Program: A systematic project activity to ensure that a payload intended for flight has sufficient structural integrity as to present no critical or catastrophic hazard. Also to ensure quality of performance in the structural area for any payload (spacecraft) project. Central to the program is fracture control analysis, which includes the concepts of fail-safe and safe-life, defined as follows:

a. **Fail-safe**: Ensures that a structural element, because of structural redundancy, will not cause collapse of the remaining structure or have any detrimental effects on mission performance.

b. **Safe-life**: Ensures that the largest flaw that could remain undetected after non-destructive examination would not grow to failure during the mission.

Functional Tests: The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

Hardware: As used in this document, there are three major categories of hardware as follows:

a. **Prototype Hardware**: Hardware of a new design which is subjected to a design qualification test program. It is not intended for flight.

b. **Qualification Hardware**: Hardware of a new design which is subjected to a design qualification test program. It is not intended for flight.

c. **Flight Hardware**: Hardware to be used operationally in space. It includes the following subsets:

(1) **Protoflight Hardware**: Flight hardware of a new design; it is subject to a qualification test program that combines elements of prototype and flight acceptance validation; that is, the application of design qualification test levels and duration of flight acceptance tests.

(2) **Follow-On Hardware**: Flight hardware built in accordance with a design that has been qualified either as prototype or as protoflight hardware; follow-on hardware is subject to a flight acceptance test program.

(3) **Spare Hardware**: Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.

(4) **Re-flight Hardware**: Flight hardware that has been used operationally in space and is to be reused in the same way; the validation program to which it is subject depends on its past performance, current status, and the upcoming mission.

Inspection: The process of measuring, examining, gauging, or otherwise comparing an article or service with specified requirements.

Instrument: See Level of Assembly.

Level of Assembly: The following levels of assembly are used for describing test and analysis configurations

a. Part: A hardware element that is not normally subject to further subdivision or disassembly without destruction of design use. Examples include resistor, integrated circuit, relay, connector, bolt, and gaskets.

b. Subassembly: A subdivision of an assembly. Examples are wire harness and loaded printed circuit boards.

c. Assembly: A functional subdivision of a component consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole.

d. Component, Module,Unit or Tower: A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem's operation. Examples are TKR tray, CAL logs, ACD tiles, electronic boxes, e.g., GASU power supplies, SIU, etc. For the purposes of this document, "component" and "unit" are used interchangeably.

e. Subsystem: A functional subdivision of a payload consisting of two or more components. Examples are Structure, TKR, CAL, ACD, Electronics. Also included as subsystems of the payload are the science instruments or experiments.

f. Instrument: A spacecraft subsystem consisting of sensors and associated hardware for making measurements or observations in space. For the purposes of this document, the LAT and GBM are considered to be instruments.

g. Observatory: See Payload.

h. Payload: An integrated assemblage of modules, subsystems, etc., designed to perform a specified mission in space. For the purposes of this document, Payload, Observatory, and Spacecraft are used interchangeably.

i. Spacecraft: See Payload.

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

Verification: The process used to ensure the selected solutions meet specified requirements and properly integrate with interfacing products.

Hardware: As used in this document, the major categories of hardware are:

a. Flight Hardware: Hardware to be used operationally in space. It includes the following subsets:

b. Protoflight Hardware: Flight hardware of a new design; it is subject to a qualification test program that combines elements of prototype and flight acceptance validation; that is, the application of design qualification test levels and duration of flight acceptance tests.

c. Qualification Hardware: Non-flight hardware of a new design; which is used to conduct a flight hardware qualification test program combines to design qualification test levels and durations

d. Follow-On Hardware: Flight hardware built in accordance with a design that has been qualified either as prototype or as protoflight hardware; follow-on hardware is subject to a flight acceptance test program.

e. Spare Hardware: Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.

Tests: As used in this document, the major categories of tests are:

a. Functional Tests: The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

b. Acceptance Tests: The validation process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

c. Design Qualification Tests: Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either “qualification” or “protoflight” test levels.

Limit Level: The not-to-exceed value invoked during flight operations. These levels are typically implemented to set flags for alarms, trending, or review.

Limited Life Items: Spaceflight hardware (1) that has an expected failure-free life that is less than the projected mission life, when considering cumulative ground operation, storage and on-orbit operation, (2) limited shelf life material used to fabricate flight hardware.

Margin: The amount by which hardware capability exceeds mission requirements

Module: See Level of Assembly.

Monitor: To keep track of the progress of a performance assurance activity; the monitor need not be present at the scene during the entire course of the activity, but he will review resulting data or other associated documentation (see Witness).

Nonconformance: A condition of any hardware, software, material, or service in which one or more characteristics do not conform to requirements. As applied in quality assurance, nonconformance’s fall into two categories--discrepancies and failures. A discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

Off gassing: The emanation of volatile matter of any kind from materials into a manned pressurized volume.

Out gassing: The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

Part: See Level of Assembly.

Payload: See Level of Assembly.

Performance Operating Time/Hours: The number of hours or amount of time that the hardware or software (as appropriated) was operated at any level of assembly or at a particular level of assembly as defined.

Performance Validation: Determination by test, analysis, or a combination of the two that the payload element can operate as intended in a particular mission; this includes being satisfied that the design of the payload or element has been qualified and that the particular item has been accepted as true to the design and ready for flight operations.

Protoflight Testing: See Hardware.

Prototype Testing: See Hardware.

Qualification: See Design Qualification Tests.

Redundancy (of design): The use of more than one independent means of accomplishing a given function.

Repair: A corrective maintenance action performed as a result of a failure so as to restore an item to op within specified limits.

Rework: Return for completion of operations (complete to drawing). The article is to be reprocessed to conform to the original specifications or drawings.

Section: See Level of Assembly.

Similarity, Validation By: A procedure of comparing an item to a similar one that has been verified. Configuration, test data, application, and environment should be evaluated. It should be determined that design-differences are insignificant, environmental stress will not be greater in the new application, and that manufacturer and manufacturing methods are the same.

Single Point Failure: A single element of hardware whose failure would result in loss of mission objectives, hardware, or crew, as defined for the specific application or project for which a single point failure analysis is performed.

Spacecraft: See Level of Assembly.

Subassembly: See Level of Assembly.

Subsystem: See Level of Assembly.

Temperature Cycle: A transition from some initial temperature condition to temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

Temperature Stabilization: The condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified test tolerance for the necessary duration or where further change is considered acceptable.

Thermal Balance Test: A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

Thermal-Vacuum Test: A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test, including the gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

Torque Margin: Torque margin is equal to the torque ratio (defined below) minus one.

Torque Ratio: Torque ratio is a measure of the degree to which the torque available to accomplish a mechanical function exceeds the torque required.

Total Mass Loss (TML): Total mass of material outgassed from a specimen that is maintained at a specified constant temperature and operating pressure for a specified time.

Tower: See Level of Assembly.

Unit: See Level of Assembly.

Vibroacoustics: An environment induced by high-intensity acoustic noise associated with various segments of the flight profile; it manifests itself throughout the payload in the form of directly transmitted acoustic excitation and as structure-borne random vibration.

Workmanship Tests: Tests performed during the environmental validation program to verify adequate workmanship in the construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Thus random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted parts, etc. Cycling between temperature extremes during thermal-vacuum testing and the presence of electromagnetic interference during EMC testing can also reveal the lack of proper construction and adequate workmanship.

Witness: A personal, on-the-scene observation of a performance assurance activity with the purpose of verifying compliance with project requirements (see Monitor).

4 APPLICABLE DOCUMENTS

Documents relevant to the development of the LAT Program Instrument Performance Verification plan include:

4.1 Project

433-IRD-0001, LAT Instrument – Spacecraft Interface Requirements Document
433-MAR-0001, LAT Instrument Mission Assurance Requirements Document
433-SPEC-0001, GLAST Project Mission Systems Specification
433-SRD-0001, GLAST Science Requirements Document
433-RQMT-0005, EMI Requirements
1196-EI-Y46311-000 GLAST LAT to Spacecraft (SC) Interface Control Document
1196-EO-E46315-000, GLAST Observatory EMI Test Requirements

4.2 LAT

LAT-SS-00010, GLAST LAT Performance Specification
LAT-MD-00039, LAT Performance Assurance Plan
LAT-MD-00068-01, LAT Configuration Management Plan
LAT-MD-00091, LAT Quality Management Plan
LAT-MD-00404, LAT Contamination Control Plan
LAT-SS-00778, LAT Environmental Specification
LAT-MD-00895, LAT Survey and Alignment Plan
LAT-MD-00999, LAT EEE Parts Program Control Plan
LAT-MD-01153-01, LAT Acronym List
LAT-MD-01196, LAT Dynamics Test Plan
LAT-MD-01600, LAT Thermal Test Plan
LAT-TD-02084, LAT requirements Tracking Report
LAT-MD-02726, LAT EMI/EMC Test Plan
LAT-MD-02730, LAT Performance and Operations Test Plan.

4.3 ACD

ACD-PLAN-000050, LAT ACD Verification Plan
LAT-TD-04349, ACD Subsystem Acceptance Test Data Package Contents

4.4 Tracker

LAT-TD-00155, GLAST Tracker Tower Vibration Test Plan
LAT-TD-00191, GLAST Tracker Tower Electrical Test Plan
LAT-TD-01840, Tracker Thermal Vacuum Test Plan
LAT-TD-04350, Tracker Subsystem Acceptance Test Data Package Contents

4.5 Calorimeter

LAT-SS-00262, GLAST LAT Calorimeter Module Assembly and Test Plan
LAT-SS-01345, GLAST LAT Calorimeter Verification Environmental Test Plan
LAT-TD-04351, Calorimeter Subsystem Acceptance Test Data Package Contents

4.6 Electronics, T&DF, Flight Software

LAT MD-00104, LAT Software Management Plan
LAT-TD-00296, LAT Electronics Test Plan
LAT-SS-00297, GLAST-LAT- T&DF Electrical System Test Plan
LAT-TD-00786, LAT Flight Software Test Plan
LAT-MD-01055, LAT Electrical Performance Test Plan
LAT-TD-04353, Trigger and Data Flow Subsystem Acceptance Test Data Package Contents

4.7 Mechanical & Thermal

LAT-SS-00115, LAT Mechanical Systems Subsystem Specification
LAT-SS-00493, LAT Mechanical Subsystem Test Plan
LAT-TD-04352, Mechanical and Thermal Control Subsystems Acceptance Test Data Package Contents

4.8 I&T and Science

LAT-TD-00440, LAT Particle Test Plan
LAT-MD-00446, LAT Science Verification and Calibration Plan, (SVAC)
LAT-MD-01376, LAT Integration & Test Plan
LAT-MD-01587, LAT SVAC Test Requirements Plan

4.9 Military Specifications

Mil-Std-461E, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

5 LAT Test Plan Overview and General Information

The GLAST project requires verification of the Large Area Telescope (LAT) instrument against design and engineering requirements, mission assurance requirements, science requirements and quality assurance requirements. For each of these verifications, there are tests and subsequent analyses of the produced test data. This data will be used to verify that the article being evaluated meets the requirements and specifications necessary for that article.

This Verification Plan identifies the tests and analyses required to demonstrate compliance with requirements of the GLAST LAT instrument. This document and other documents that are referenced herein have been put under SLAC document configuration control.

The performance verification is accomplished primarily by testing. Analysis is used in place of or to supplement testing when performance verification cannot be adequately accomplished by test alone. Performance verification and acceptance is performed at the component, subsystem, and system levels of assembly. Table 5-1 provides the LAT test requirements for tests that must be conducted on the LAT per the LAT Mission Assurance Requirements, 433-MAR-0001. The environmental test levels are specified in the in LAT-SS-00778 , LAT Environmental Specification These are summarized in Table 5-2 with the appropriate test levels.

A Performance Verification Matrix which is provided in LAT-TD-02084, the LAT Requirements Tracking Report provides the verification method for each requirement in the LAT Level II b and Level III specifications with references to the locations of the test or analysis descriptions. When verification is by test, the references are located in this plan. Descriptions of analyses are located in this plan or in subsystem test plans.

For each of these verifications, there are tests and subsequent analysis of the produced test data. This data will be used to verify that the article being evaluated meets the requirements and specifications necessary for that article. The process by which the data is acquired and evaluated is a tightly controlled one that will allow repeatable verification and the production of credible data for evaluation.

A program directive, LAT-MD-01312, LAT Test Plan Directive, established a process where test plans are developed across the disciplines and functional responsibilities within the program. Using this document as the initiator, test-planning documents have been spawned for LAT subsystems, disciplines and functional activities. These all focus on the Integration and Test operation, which is responsible for performing the respective tests, operations and analysis.

The LAT test process as shown in Figure 5-2 will be used to take requirements, develop test plans, conduct reviews, analyze data and evaluate performance. The conclusion of this process results in components, units, subsystems and a full instrument which are qualified and certified for space flight which meet the requirements set out in the program specification documents.

The Test flow for the LAT program is shown in Figure 5-3 and represents the execution of the LAT test program.

Table 5-1LAT Test Requirements

Referenece LAT 433-MAR-0001

Electrical	Mechanical	Environmental	Software
Electrical Interface - Isolation - Insulation Resistance - Hi-Pot - Power Distribution - Command Distribition	**Static Load**	**Thermal Vacuum (8 cycles)**	**Fault Tree Analysis**
Aliveness	**Mass Properties** - Mass - CG	**Thermal Balance (LAT)**	**Unit (Level 0)**
Limited Performance	**Sine Sweep Vibration**	**EMI/EMC**	**Component (Level 1)**
Comprehensive Performance	**Random Vibration** (component level)		**System (Level 2)**
Burn- In / Failure Free Performance	**Modal Survey**		**Formal Qualification Testing**
	Vibro- Acoustic (LAT, ACD, Radiators)		**Independant Verification and Validation (IV&V)**
	Mechanical Shock (OBS)		

Table 5-2 LAT Environmental Test Levels and Durations

Test Factors/Durations			
Test	**Qual**	**Protoflight**	**Acceptance**
Structural Loads[1]			
Test Level	1.25 x Limit Load	1.25 x Limit Load	1.0 x Limit Load
Analysis	1.4 x Limit Load	1.4 x Limit Load	1.4 x Limit Load
(show positive margins for all ultimate failure modes)			
Acoustics			
Level[2]	Limit Level + 3 dB	Limit Level + 3 dB	Limit Level
Duration	2 minutes	1 minutes	1 minutes
Random Vibration			
Level[2]	Limit Level + 3 dB	Limit Level + 3 dB	Limit Level
Duration	2 minutes/axis	1 minute/axis	1 minute/axis
Sine Vibration[3]			
Level	1.25 x Limit Level	1.25 x Limit Level	Limit Level
Duration[4]	2 oct/min	4 oct/min	4 oct/min
Pressure Profile			
Level	As Specified For Mission	Same	Same
Mechanical Shock			
Actual Device	2 actuations	2 actuations	1 actuation
Simulated	1.4 x Limit Level	1.4 x Limit Level	Limit Level
	2 x Each Axis	1 x Each Axis	1 x Each Axis
Thermal Vacuum Cycling			
Temperature[5]			
Normal Operation	Max/Min Predict ±10° C	Max/Min Predict ±10° C	Max/Min Predict ±5° C
Survival	Max/Min Predict ±10° C	Max/Min Predict ±10° C	Max/Min Predict ±5° C
Vacuum	<1X10^{-5} Torr	<1X10^{-5} Torr	<1X10^{-5} Torr
# of Cycles	12	4	4
Rate[6]	<20°C/Hour	<20°C/Hour	<20°C/Hour
Radiation	As Specified For Mission	Same	Same
EMC & Magnetics	See Doc. 433-RQMT-0005	Same	Same

1- If qualified by analysis only, positive margins must be shown for load factors of 2.0 on yield and 2.6 on ultimate. Composite materials cannot be

2- As a minimum, the test level shall be equal to or greater than the workmanship level.

requirements, rather than to simulate an oscillatory mission environment, a faster sweep rate may be considered, e.g., 6-8 oct/min to reduce the potential for pogo-like vibration.

5- Normal operating temperature for the LAT is –10° C to 25° C. Survival temperature is –20° C to 40° C.

6-The CAL module must not exceed a 10° C per hour rate

Figure 5-1 LAT Verification Plan Flow

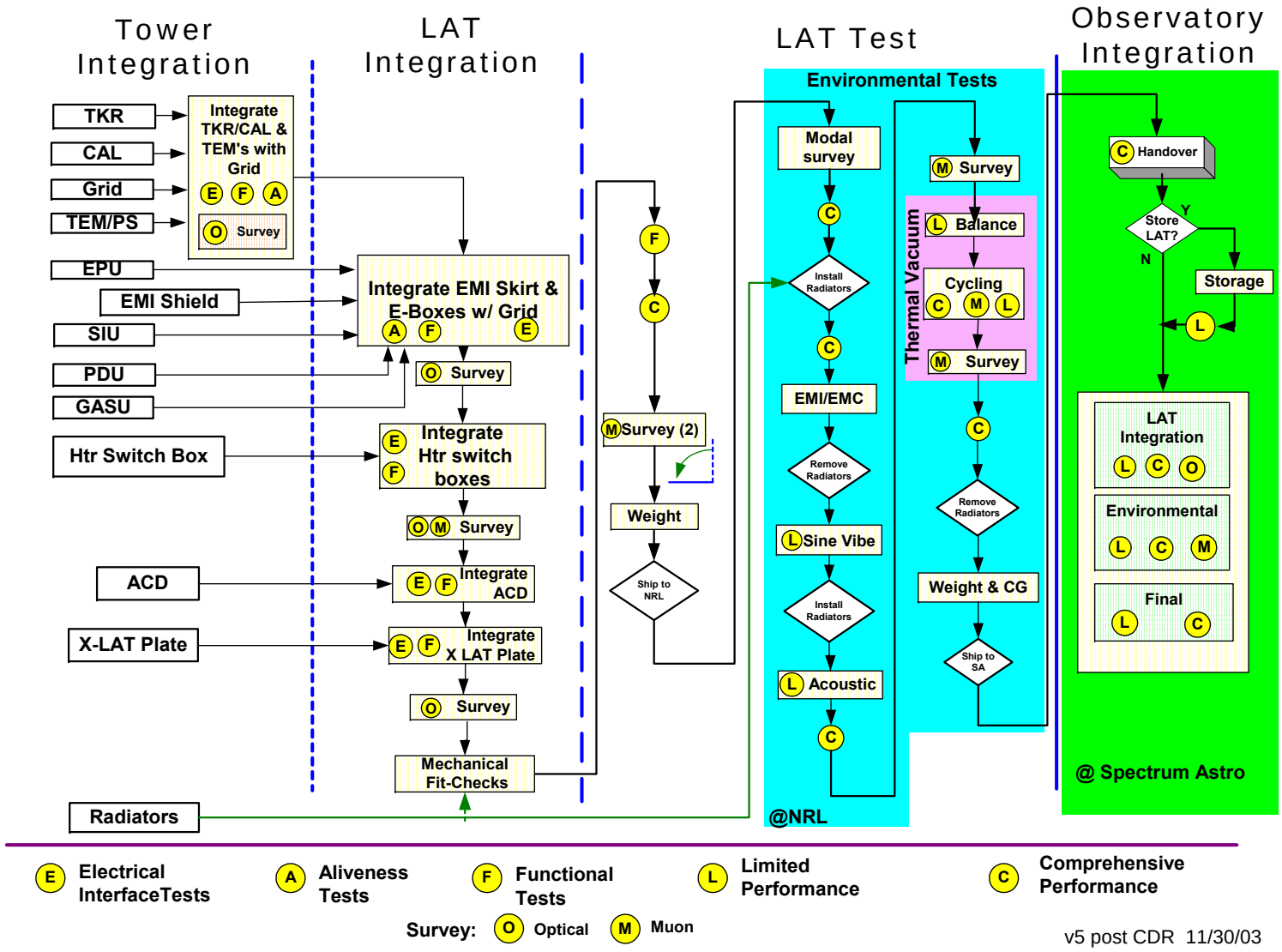
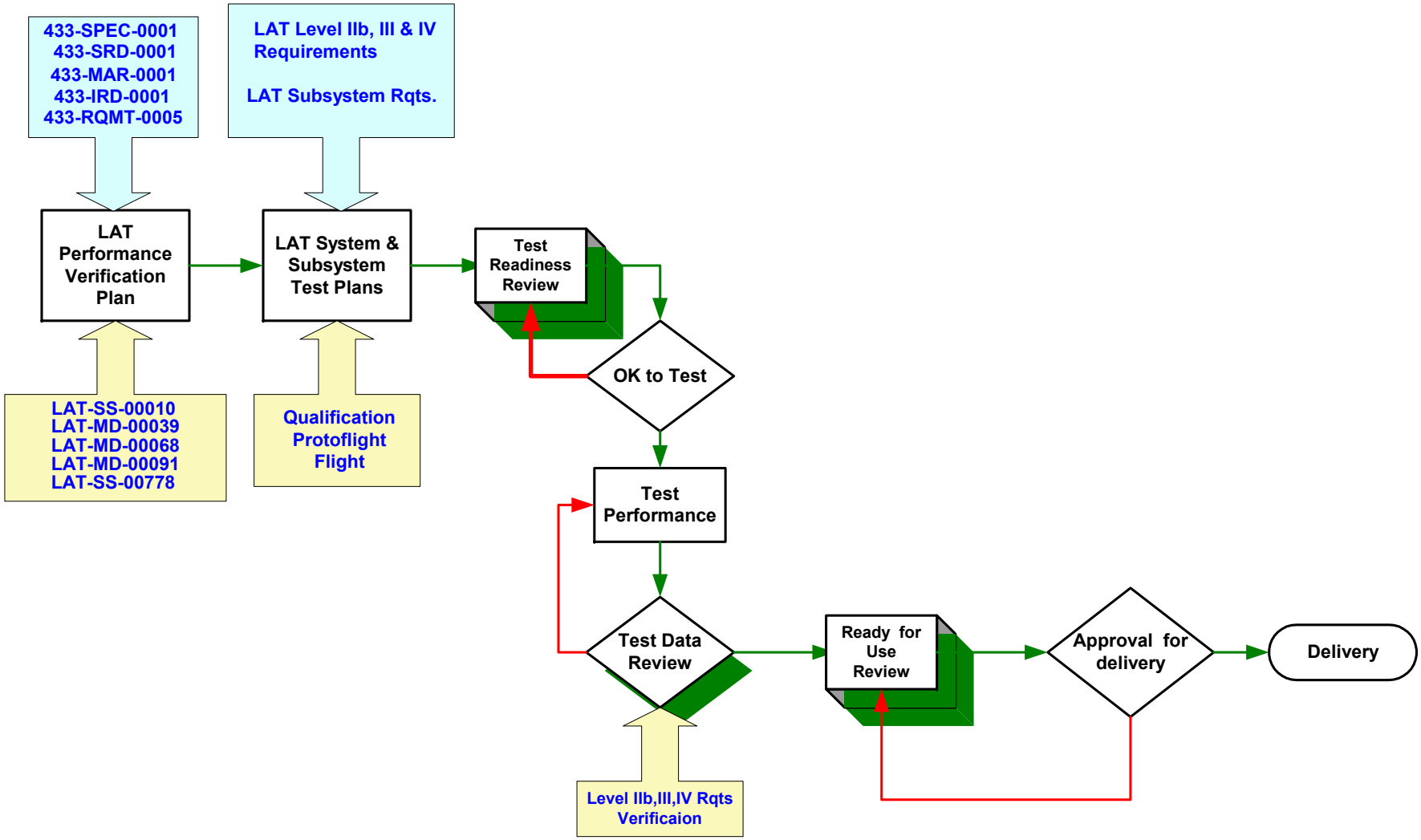


Figure 5-2 Performance Verification Flow



6 Systems Performance Assurance

6.1 Required Documentation

The GLAST Program requires the following documents to delineate the processes and procedures for the verification and test of LAT hardware and software.

6.1.1 Requirements Documents

Each article of flight hardware or software developed for the LAT must have traceability to a requirements document that details the performance specifications of the article. Any tests which are performed for the GLAST program must reference a requirements document.

All components, units, subsystems and the LAT itself must be tested against a released performance specification. This specification must contain requirements for verification to determine acceptable performance.

6.1.2 Test Plans

All testing or analysis that provides verification of a requirement for the LAT program must be contained in a test plan. The test plan must provide the following information:

- Test plan objectives
- Performance requirements being met by test
- Verification method for each requirement
- Table of environmental test limits for each test
- Specifications to be tested
- Purpose and description of tests to be performed
- Facility requirements
- Data collection and test records
- Test configuration
- Limitations
- Analysis activities

When required, test plan will show traceability to Mission Assurance Requirements contained in 433-MAR-0001 for tests performed.

6.1.2.1 Analytical Verification

When a requirement is verified by analysis, the test plan must include the supporting information of the analytical verification. This material shall include the analysis objective, descriptions of mathematical models and any assumptions made. The expected output must also be identified for use in evaluation of results.

6.1.3 Test Procedures

Each article of flight hardware or software tested for the GLAST/LAT program will use released test procedures. These test procedures will be under configuration management and subject to review and acceptance by subsystem engineering, systems engineering and mission assurance.

Test procedures will include the following information as well as the necessary steps and operations to gather data in a repeatable fashion for a given test article. Test procedures for the LAT program will contain:

- Purpose
- Scope
- Applicable documents
- Test Support requirements
    - Environment
    - Equipment
    - Systems Assurance
    - Quality Assurance Provisions
    - Safety
    - Special Requirements
    - Certifications
- Test Performance Requirements
- Test Configuration & set-up
- Test Performance Procedure
- Alarm/High/Low/Halt limits
- Pass/Fail Criteria
- Test Data Records & Data Sheets

The Test Performance Requirements include test readiness conditions, support personnel requirements, test environmental conditions, and required test equipment. The test procedures shall provide guidance on process for determining if the test should be suspended or continued when a nonconformance occurs.

6.1.4 Mate/De-mate Log

A mate/de-mate log will be kept on each flight connector. This log will travel with the flight hardware and be used to track the mating of flight connectors.

6.1.5 Hardware Installation Log

A hardware installation log will be kept on each flight unit. This log is part of each units end item data package and will be used to document the installation and removal of flight hardware from mechanical interfaces. These installations include but are not limited to cold plates, vibration fixtures, handling fixtures and other fixtures which flight hardware may be mounted.

The log will also provide information on the use of fasteners for attaching the flight hardware as required by LAT mechanical systems.

6.1.6 Software Installation Log

A software installation log will be kept on the LAT flight instrument. This log will be used to track the installation of flight software onto the LAT. It will show each software component and the current version/revision level installed on the LAT. This log will be matched to a software revision report prior to testing to insure that the latest released version of software is being used.

6.1.7 Configuration Log

A configuration log will be kept which identifies the current configuration of the LAT instrument. This log will be used to verify the hardware and software configuration prior to test.

6.1.8 Power On Log

A log indicating when and for how long the unit has been powered will be kept. An additional log of power on failure-free performance will be maintained on each piece of flight hardware.

6.1.9 Contamination Control

All LAT verification activities must be performed in compliance with the LAT Contamination Control Plan, LAT-MD-00404. Conformance with this plan will be prescribed in all test plans and test procedures used for the verification of LAT flight hardware.

6.1.10 Environmental Log

All LAT hardware shall be supported by an Environmental Log which tracks the temperature, humidity and Helium exposure of flight hardware.

6.1.11 Database Log

A database log will be kept that supports the use of the telemetry and command database versions and releases against the performance verification of flight hardware.

6.1.12 Test Data Packages

6.1.12.1 Flight Hardware Acceptance Test Data Package

All tests performed on LAT qualification, proto-flight and flight hardware (including flight spares) will have unit support information and the corresponding test data collected by the test conductor. All collected data will be assembled into an Acceptance Test Data Package and retained per the LAT Performance Assurance Implementation Plan, LAT-MD-00039.

The Acceptance Test Data Package is the collection of all pertinent test data taken in support of certifying an item for flight and is deliverable with each unit. This data package will be permanently retained and portions of it will be sent with the flight unit as required for use in higher level test assemblies.

The original Acceptance Test Data Package will be retained at the supplier's facility. A copy of this package will be duplicated and maintained by the LAT program.

6.1.12.2 Test Records

A test record containing the performance detail information of each test and the step by step procedural execution log will be made and retained for each test performed on each test article. This record will be included in the Acceptance Test Data Package.

6.1.12.3 Test Data Sheets

Test data sheets will be used to record pass/fail data and to record performance metrics as required by the test procedure. These data sheets will be used to support the certification that an item is ready for flight. The test data sheets will be included in the End Item Test Data Package.

6.1.12.4 Recording

Test support material such as photographs, electronic data files and other support material will be collected and included in the Acceptance Test Data Package.

6.1.12.5 Data Identification Requirements

Data recoded in support of a test of qualification level or flight hardware or software shall be identified with the following information:

- Test procedure number
  - Test Procedure Revision number
- Telemetry & Command Database Version
- Test paragraph number
- Unit under test identification
- Unit serial number
- Date and time
- Test software name
- Test software version number & revision date
- Data approvals
- Test conductor

6.1.12.6 Acceptance Test Data Summary Package

This package is delivered to LAT Program and is made available to Integration, Test & Calibration (IT&C), and Systems Engineering. This package is delivered with all flight units. It provides the information necessary to integrate and operate the unit at the next higher level of assembly. A typical package will contain:

- Identification Information
- Unit Performance Data
- Mechanical Summary Data
- Electrical Interface & Summary Data
- Unit Support Data
- Quality Assurance Data

The contents of the data package for each subsystem shall be coordinated between the subsystem and LAT IT&C and Systems Engineering. A Technical Note will be generated by SLAC Systems Engineering to document the agreed upon contents.

6.1.12.7 Science Calibration and Trending Data

Data supporting science verification and calibration will be acquired and maintained. This is delivered to and maintained by the IT&C organization per the Science Verification and Calibration Plan.

6.2 Configuration Management

6.2.1 General

All elements of the LAT program which support the manufacture, test, handling or support of flight or qualification level hardware/software will be under configuration control. This control will be exercised per the LAT Configuration Management Plan (LAT-MD-00068).

Items under configuration control will be subjected to a formal review and release process, which is managed by systems engineering.

Items that are under configuration control within the scope of this document are:

- Test support documents
- Commands & Command Groups
- Telemetry Database Configuration
- Electrical hardware
- Mechanical hardware
- Test support firmware
- Test support software
- Test equipment
- Flight Hardware
- Flight Software

6.2.2 Documents

All documents which support the design, assembly, test or handling of flight hardware or software including “as built” documentation will be under configuration control. These items will be subject a formal review/release process.

Documents under configuration control are:

- Test procedures
- Test plans
- Test requirements
- Test configurations & ICD’s
- Test equipment design documents
- Test equipment drawings

6.2.3 Ground Support Equipment (GSE)

The GSE hardware and software are considered configuration items and are subject to design review and CCB management.

The following items will be subject to configuration control in support of the test of flight hardware:

- Electrical ground support equipment (EGSE)
- Mechanical ground support equipment (MGSE)
- Test cables & harnesses
- EGSE support software
- Test software
- Equipment test procedures

The hardware and software associated with Ground Support Equipment (GSE), which is used to test or verify design, engineering, mission requirements and specifications to flight hardware or software, will be under configuration control.

All GSE hardware are considered configuration items (CIs) and will be built to released drawings and tested against released procedures.

Test software and GSE firmware will be managed and controlled as released CIs and be subject to program release and configuration management practices.

All GSE hardware, software and firmware will be subjected to acceptance tests before being placed into service.

All GSE hardware, software and firmware will be subjected to validation tests prior to use in a specific configuration. The validation test will be repeated when the configuration is changed, external electrical interfaces are broken or other configurations are modified which compromises the previous validation test.

6.2.4 Software Configuration Items

Software CIs will be maintained per the LAT Software Management Plan, LAT MD-00104. Software CIs will be tracked per this plan.

6.3 Quality Assurance Provisions

6.3.1 Test Configuration

6.3.1.1 Documentation

All tests involving flight hardware will be tested to released test configuration drawings. These drawings will call out the required MGSE, EGSE, Cable Assemblies, Test Software and Flight software builds required to successfully perform the test.

These configurations may be contained in a released test procedure or may be independent released documents referenced from a test procedure.

6.3.1.2 Certification

Prior to beginning any test involving flight hardware, a certification of the test configuration will be performed by the appropriate quality assurance personnel. This certification to proceed will be noted in the respective test data sheets and will be part of the record of the test.

6.3.2 Test Performance

Test performance will be witnessed on an as need basis. The need for a Quality Assurance witness will be at the discretion of program Quality Assurance, Subsystem Quality Assurance or any other members of the collaboration with cognizance over hardware being produced by the LAT program.

When witnessing of a test is required, the test procedure will call out the need for a witness in the Quality Assurance Provision Section.

6.3.3 Test Results Documentation

Quality Assurance will certify the following for each test

- Test records are complete and correct

- Correct version of the Test procedure is being used
- Test procedure steps have all been properly executed
- Test data sheets are all complete and present
- Photo and chart records required are included
- Data has been taken and identified

6.3.4 Data Review

GLAST Performance Assurance will review all test data packages for completeness. The Performance Assurance organization will certify that all tests required have been performed, that the data has been collected and is available for review. Performance Assurance will also review the End Item Test Data Packages for Non Conformance issues as required.

6.3.5 Software Quality Assurance Program

A Software Quality Assurance Program will be conducted on the flight software per LAT-MD-00104, LAT Flight Software Management Plan.

6.4 Safety

Safety representatives will conduct evaluations of all LAT test plans to certify that they meet the requirements of the GLAST LAT System Safety Program Plan, LAT MD-00078. LAT Program Safety is also part of the Test Readiness Review Panel and will have reviews of test procedures as required.

6.5 Test Equipment

6.5.1 MGSE

All MGSE will be built to released drawings. All MGSE used on the GLAST program will be qualified and mechanically certified for its purpose and will be subject to periodic re-evaluation as determined by design and safety engineering. Qualification of MGSE shall include compliance with the following standards:

- Lifting Devices and Equipment, NASA-STD-8719.9
- Ground Support Equipment, NASA-STD-5005A
- AMSE B30.1, Jacks

Qualification of MGSE that will, or could, be used at NRL, observatory level testing, or launch base, shall include compliance with the following standard:

- East-West Range Safety Requirements, EWR-127.1

Qualification of MGSE that will, or could, be used at SLAC shall include compliance with the following standard:

- Specification for Seismic Design at SLAC, SLAC-I-720-0A24E-001

Personnel operating and using MGSE will be trained and certified for the operating this equipment. This includes lifting and transport devices such as overhead cranes, forklifts and other equipment used for handling high value hardware.

6.5.2 EGSE

All EGSE, interconnect cables and test cables will be built to released drawings. All EGSE will be certified for use on flight hardware by means of a released Acceptance Test procedure and the performance of an acceptance test against that procedure.

6.5.2.1 Acceptance Tests

EGSE will be subjected to acceptance tests using an approved and released EGSE Acceptance Test procedure after completion of initial assembly and prior to use on flight hardware.

An Acceptance Tests or an abbreviated acceptance test will be conducted after any upgrade or repair where components internal to the equipment have been repaired, replaced or exchanged and after any break of internal configuration.

6.5.2.2 Validation Tests

EGSE will be subjected to validation tests prior to first use in a given configuration validating use of the equipment in that configuration. Validation tests will also be performed after breaking the external electrical configuration, transportation, and/or relocation of the equipment.

Validation tests will include the cables intended for use on the flight hardware and any other electrical devices which will be connected to the test article.

6.5.3 Support Equipment& Systems

Equipment and systems that support the operation of the EGSE, the collection of data and the analysis of performance will be considered part of the EGSE and will be subjected to the same documentation and release requirements that flight hardware test equipment complies.

6.5.4 Equipment Calibration

All measurement equipment must be in a calibration and maintenance program. All equipment used for testing of flight hardware shall be in current calibration and shall be noted external to the equipment by a tag or sticker.

All equipment, fixtures and facilities must show conformance to test requirements prior to conducting tests on qualification or flight hardware. All items used in performance of a test must be capable of maintaining the test conditions for the duration of the test. Performance of a test facility or piece of test equipment must be demonstrated prior to use with flight hardware.

6.5.5 Measurements

All measurements to flight hardware will be made with tools and equipment which are under calibration control and in their current calibration cycle.

6.5.6 Measurement Accuracy

Measurement accuracy unless otherwise noted will be per will be per 433-MAR-0001.

6.5.7 Equipment Substitutions

Where necessary, equipment which has been specified in a test procedure will be substituted with another piece of equipment of equal or better performance. These substitutions are permitted deviations from test plans provided the changes are identified to and concurred with by subsystem engineering management.

6.6 Test Performance Requirements

6.6.1 Test Readiness Review

A test readiness review will be conducted prior to commencing a flight level test program as required in the Systems Engineering Management plan, LAT-MD-00066. This review will be imposed upon all subsystem and system level qualification and flight level test programs. Topics to be addressed at the review are:

- Significant changes since CDR
- Test Requirements
- Planned tests
- Test Entry / Exit Criteria
- Test facilities
- Equipment calibration
- Test configurations
- Test procedure status
- Staffing plans
- System performance review
- Quality program review
- Problem / failure reports
- Risk assessment
- System safety
- Test schedule
- Issues and concerns
- Reference document list with implemented revisions

6.6.1.1 Release to Test

The Test Readiness Review will produce a Release to Test authorization. A review panel comprised of Program Management, Systems Engineering, Performance Assurance, Systems Safety, Subsystem Engineering and other members of the collaboration as required will approve the release of hardware to be tested to the flight test program which was evaluated.

For a test program to begin testing, all open issues from the Test Readiness Review will have been addressed and closed to the satisfaction of the review panel.

6.6.2 Test Data Review

Test data sheets and the detailed test data will be reviewed by the appropriate subsystem engineering, GLAST Performance Assurance and GLAST Systems Engineering.

Before flight hardware will be delivered, the data package will be certified by the reviewers that it is correct and that the item is good for flight.

If the item is not capable of being certified for flight it will be handled per LAT-MD-00471, Control of Non-Conforming Product.

6.6.3 Pre Ship Review

After completion of a Qualification or Acceptance test program, a pre-Ship review will be conducted prior to delivering any flight level deliverables. This review will be imposed upon all subsystem and system level qualification and flight level test programs.

Topics to be addressed at the review are:

- Unit Revision status
- Tests Performed and Summary Report
- Performance Review Summary
- Quality Review Summary
- Test Data summary
- Problem / Failure Reports & Status
- Issues and Concerns
- Recommendations

The unit may be released for use after a successful RFU review with all open items closed. A unit may be released for use with open issues as long as there is a plan in place for closure and the open issues do not affect the higher-level integration.

The Pre-ship review panel is comprised of representatives from Program Management, Systems Engineering, Performance Assurance, Subsystem Engineering, the other members of the collaboration as required. The panel will approve the release of the hardware for use on the LAT.

7 Verification Plan

7.1 Verification Plan Overview

The GLAST LAT program plans a comprehensive performance verification program in which the LAT performance and science requirements are verified by a combination of testing and analysis. This verification program is conducted at component, subsystem, and system integration levels. Qualification of flight hardware is accomplished through either qualification test programs or proto-flight test programs. In the qualification test programs, a qualification unit which is not flown is built and subjected to the prescribed series of tests. Where the hardware is qualified with a proto flight program, a unit is built and subjected to a less stringent program but, the hardware is also flown. In all cases, production units are qualified for flight by similarity to either the Qual or Proto flight units. This section provides an overview of the verification program and the approach taken to satisfy each requirement specified in the LAT Performance Specification.

7.1.1 Subsystem Qualification

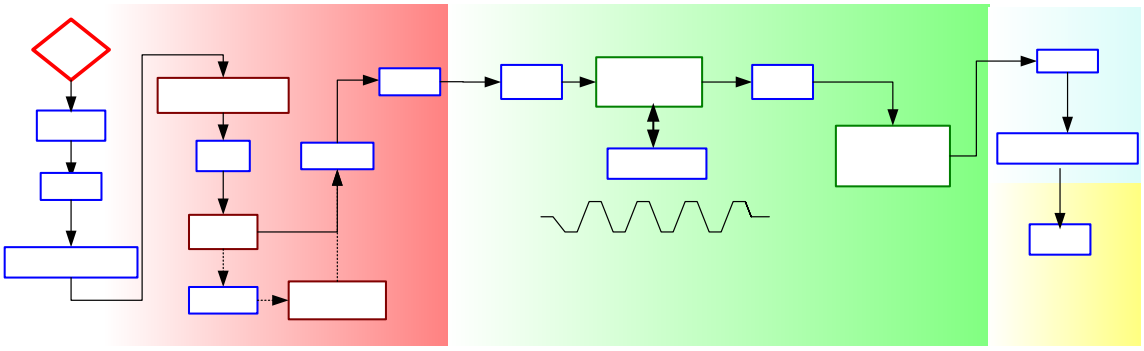
The objective is to qualify for flight all subsystem components. All LAT components, subsystems, and system will complete a Qualification or Proto-Flight test program.

A complete Qualification (Qual) Test Program will be executed on the following LAT subsystem components. The objective of this test program is to qualify for flight all subsystem components prior to production. The Qualification units will be tested as flight hardware but will not be flown without refurbishment and re-testing.

- Tower Electronics Modules
  - TEM
  - TEM Power Supplies
- Electronics Boxes (SIU, EPU, GASU,PDU)
- Grid Box Assembly

The general flow of the Qualification Test Program is shown in Figure 7-1.

Figure 7-1 Unit Qualification Test Flow

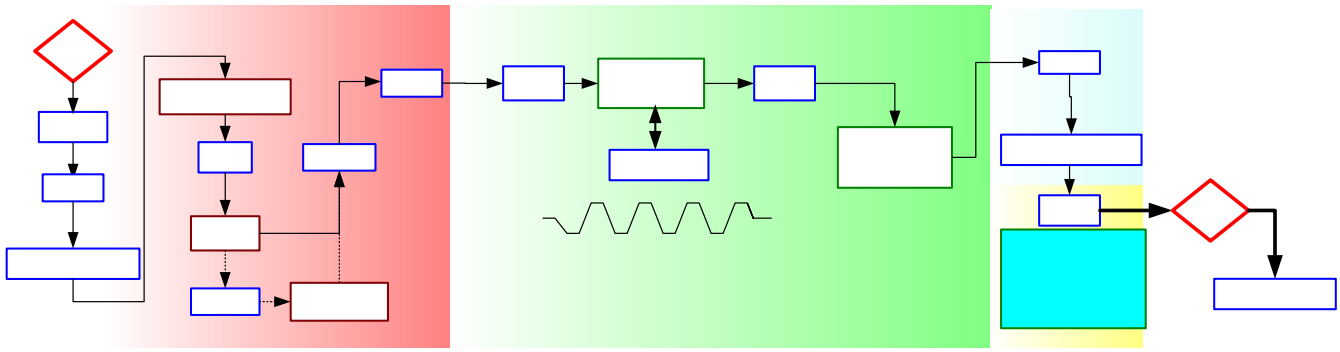


Units that are not qualified via a Qualification Test Program will be subjected to a Proto Flight Test program for qualification. These tests will be conducted to the qualification test levels outlined in the LAT Environmental Specification, LAT-SS-00778. The following unit level assemblies will have listed Qual/PF test programs:

- Calorimeter modules
- Tracker Tower Assemblies
- Anticoincidence Detector
- Radiators
- X-LAT Plate
- Grid Box Assembly
- LAT Thermal Control System

The general flow of the Proto Flight Test Program is shown in Figure 7-2.

Figure 7-2 Unit Proto Flight Test Flow



7.1.1.1 Comprehensive Performance Tests

Comprehensive performance tests as appropriate will be conducted prior to, during and after each environmental test. These tests will exercise all unit operating modes as well as primary and redundant circuits and paths. Parameters will be varied over their specification ranges to insure that the unit performs as designed.

7.1.1.2 Electrical Interface Tests

Electrical interface tests are conducted to insure integrity of the electrical interfaces. Depending on the circumstances, one or more of the following tests will be performed:

- Signal distribution
- Power Distribution
- Command Distribution
- Grounding

- Isolation
- Insulation Resistance
- Hi-Pot

7.1.1.3 Functional / Limited Performance Tests

LPTs will be performed during, and between environmental tests, as appropriate, to demonstrate that the functional capability of the unit has not been degraded by an environmental test.

7.1.1.4 Strength Tests

Strength tests will be conducted on the Grid Box Assembly which is the main structural component of the LAT. A targeted qualification test program will be conducted which will focus on interfaces and specific regions of the Grid Box. Preliminary analysis of the design has shown that stresses are very low except in specific discrete areas so qualification testing will be performed on those areas where there are expected to be high stresses. Tests on the grid box will be conducted as listed in table 7-1.

Table 7-1 Strength Test Qualification Test Matrix

Component / Assembly / Interface	Analysis	Test	Comp Test	Similarity	Other	Test Name
SC-Grid connection	√	√				Grid Static Pull
EMI Skirt	√	√				Grid Static Pull
Heat Pipe Patch Panel	√	√				Grid Static Pull
ACD-Grid connection	√	√				Corner Static Pull
Radiator Mount Bracket	√	√				Corner Static Pull
TKR-Grid corner mount	√	√				Top Flg Strength Qual
TKR-Grid mid-side mount	√	√				Top Flg Strength Qual
CAL-Grid bolted joint	√	√				Grid Static Pull
Grid Assembly	√					
CAL-Grid Shear Plates						
Mid-Side Shear Plate	√		√		√	Shear Pl strength qual
Interior Shear Plate	√			√		
Qtr-Point Shear Plate	√			√		
Corner Shear Plate	√			√		
TFHP potting into groove			√		√	
DSHP mounting to Grid					√	

7.1.1.5 Vibro-Acoustic

The LAT Instrument and the ACD subsystem will be subjected to Vibro Acoustic testing to satisfy the random vibration requirement. The vibro-acoustic levels and durations are defined in LAT-SS-00778, LAT Environmental Specification.

7.1.1.6 Random Vibration

All Qualification and Proto-Flight hardware units will be subjected to a random vibration test to the appropriate qualification levels. The Random vibration levels are defined in LAT-SS-00778,

LAT Environmental Test Specification. Test durations are provided in Table 7-2 for Qualification and Proto Flight Hardware.

Table 7-2 Random Vibration Test Durations

Qualification	Proto Flight
2 Minute / Axis	1 Minute / Axis

7.1.1.7 Sine Vibration

Sine vibration tests will be conducted on all Qualification and Proto-Flight hardware. The Sine vibration qualification levels are defined in LAT-SS-00778, LAT Environmental Specification Test durations are provided in Table 7-3 for Qualification and Proto Flight Hardware. Low level sine vibration test shall be performed to identify/characterize responses up to 150 Hz.

Table 7-3 Sine Vibration Test Duration

Qualification	Proto Flight
2 octaves / minute	4 octaves / minute

Note: Lower sweep rates shall be used in appropriate frequency bands as required to match the duration and rate of change of frequency of any flight sustained, pogo-like vibration.

7.1.1.8 Mechanical Shock Test

Mechanical shock tests will be performed at observatory level if required. The mechanical shock qualification levels will be defined after analysis of transfer of shock through the spacecraft. The LAT has no shock inducing components.

7.1.1.9 Thermal Vacuum

Thermal vacuum testing with thermal cycling will be performed on all components. All components in a qualification program will be subjected to 12 cycles at unit/component level for qualification. All components in a Proto Flight program will be subjected to 4 cycles to qualification levels followed by an additional 4 cycles at LAT level integration and, 4 cycles at Observatory level. The 4 cycles at component /unit level will be to qualification level temperatures. A soak/dwell of 4 hours minimum at each temperature extreme will be observed.

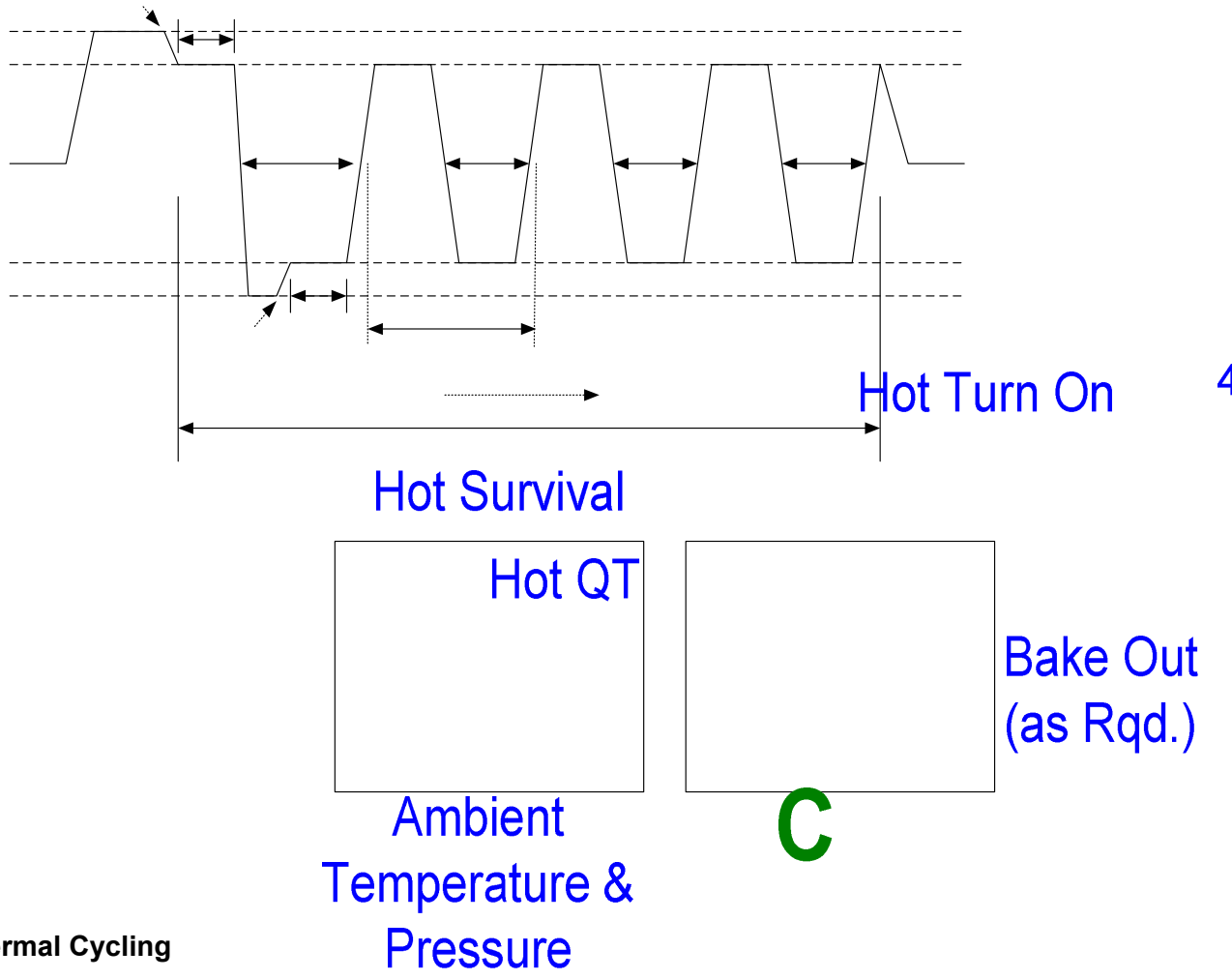
One hot and cold turn on sequence will be performed at the appropriate dwell points.

Comprehensive Performance tests will be performed at each dwell point.

Limited performance tests will be performed during transitions for the purpose of monitoring the instrument systems for failures and intermittent operations.

The Thermal Vacuum Cycle profile for Qualification is shown in Figure 7-3.

Figure 7-3 Qualification Thermal Vacuum Profile



7.1.1.10 Thermal Cycling

Thermal cycling at ambient pressure will be performed on a case by case basis as workmanship tests.

7.1.1.11 Humidity /Storage Tests

The LAT program will use analysis supported by test when necessary to demonstrate that the hardware produced for flight use meets the storage and humidity requirements set for the program. The results of the test or analysis will become part of the qualification data package.

7.1.1.12 Failure Free Operation

All proto-flight hardware will have the required 150 hours of failure free power on time prior to delivery to LAT integration. All proto-flight units will be delivered with a recorded minimum of 150 hours of failure free operation within the proto-flight test program.

7.1.2 Subsystem Acceptance Test Program

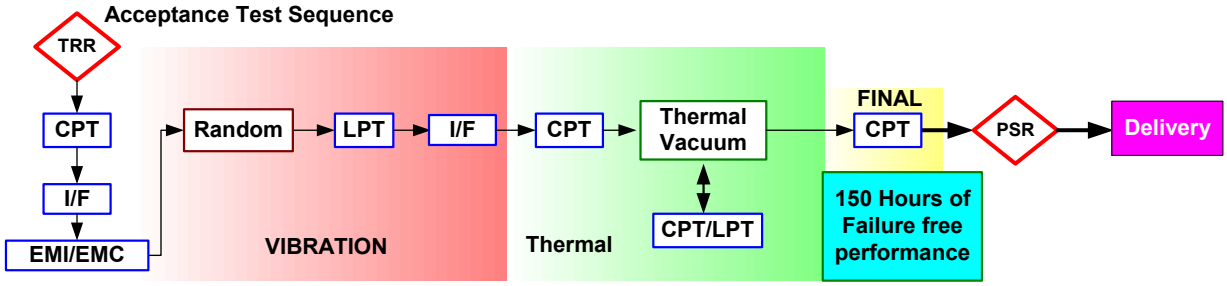
An acceptance test programs will be conducted on LAT components which are represented by an appropriate qualification program,. These components are:

- Tracker Tower Assemblies
- Calorimeter modules
- Tower Electronics Modules
- Electronics Boxes (SIU, EPU, GASU,PDU)
- Tower Power Supplies

The objective of the acceptance test program is to provide a production test program for components and units which are manufactured in quantity for use on the LAT.

The flow of the Acceptance Test Program will be as shown in Figure 7-4.

Figure 7-4 LAT Unit level Acceptance Test Flow



7.1.2.1 Comprehensive Performance Tests

Comprehensive performance tests as appropriate will be conducted prior to, during and after each environmental test. These tests will exercise all unit operating modes as well as primary and redundant circuits and paths. Parameters will be varied over their specification ranges to insure that the unit performs as designed.

7.1.2.2 Functional / Limited Performance Tests

LPTs will be performed during, and between environmental tests, as appropriate, to demonstrate that the functional capability of the unit has not been degraded by an environmental test.

7.1.2.3 Thermal Vacuum

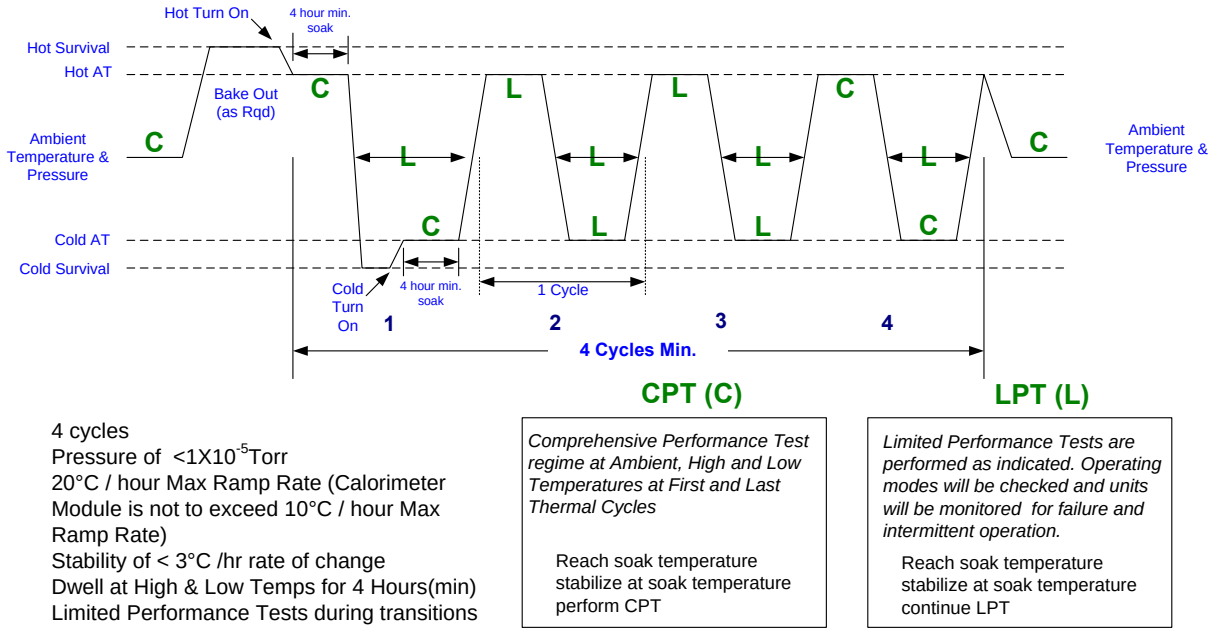
Thermal vacuum testing will be performed on all components. To verify a previously qualified component for the LAT, it will be subjected to 4 Thermal Vacuum cycles to acceptance temperature limits. A soak/dwell of 4 hours minimum at each temperature extreme will be observed.

One hot and cold turn on sequence will be performed at the appropriate dwell points. This test is used for credit against the LAT level requirements.

Limited Performance tests will be performed at each dwell or soak point as well as during transitions.

The acceptance Test Thermal Vacuum profile is shown in figure 7-5.

Figure 7-5 Acceptance Test Thermal Vacuum Profile



7.1.2.4 Thermal Cycling

No thermal cycling is required since all flight units will have 4 Thermal Vacuum Cycles.

7.1.2.5 Random Vibration

All units will be subjected to a random vibration test.

7.1.2.6 Failure Free Operation

The acceptance test process will be used to achieve the required 150 hours of failure free power on time prior to delivery to LAT integration. All units will be delivered with a minimum of 150 hours of failure free operation on all units which have been acceptance tested.

7.1.3 LAT Test Program

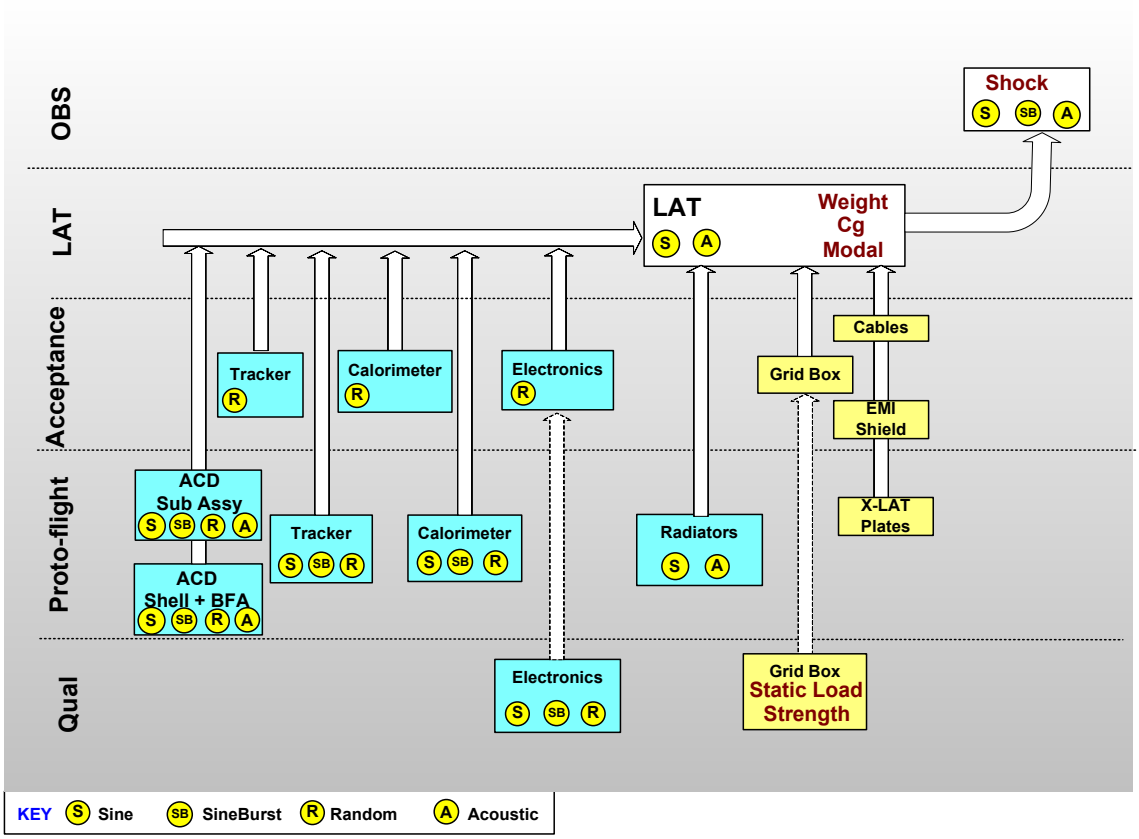
7.1.3.1 Integration and Test Sequence

The LAT integration and test sequence with electrical tests identified is shown in Figure 5-1

7.2 Structural, Mechanical & Alignment Tests

Mechanical tests are performed at successively higher levels of integration to provide the minimum program risk and maximum risk reduction benefit and cost to the program. Tests will be performed to the levels published in the LAT Environmental Specification document, LAT-SS-00778. The diagram in Figure 7-7 shows the flow of the tests during LAT integration onto Observatory testing.

Figure 7-7 LAT Dynamics Tests by Level of Assembly



7.2.1 Proof Tests

Proof tests will be conducted on composite materials used on the LAT as called out in 433-MAR-0001 regarding the use of composites on primary and secondary structures.

7.2.2 Static Load Tests

All LAT subsystem mechanical components will be subjected to static load tests. These tests will be conducted on Qualification and proto-flight level components. The X-LAT Plate will be tested to proto flight test levels prior to integration. The Radiators and their associated hardware will be tested and flown having been tested to qualification levels.

7.2.3 Dynamics Tests

Dynamics tests are to be performed in the mode in which the equipment will observe the environment. The LAT will be launched in a “powered off” mode. All dynamics tests which are for launch environment verification will be performed with the test article powered off.

7.2.3.1 Sine Burst Vibration

7.2.3.1.1 Tracker

The proto-flight Tracker Tower Assembly will be subjected to a sine burst vibration test at the proto-flight level.

7.2.3.1.2 CAL

The Calorimeter will conduct a sine burst vibration test on the proto-flight module.

7.2.3.1.3 ACD

The ACD will conduct a sine burst vibration test on the proto-flight ACD subsystem.

7.2.3.1.4 Electronics

All qualification model electronics units (TEM+TEM-PS, SIU, EPU, GASU, PDU) will be subjected to a sine burst vibration test.

7.2.3.2 Sinusoidal Sweep Vibration

Sine sweep vibration testing will be performed prior to integration on some subsystems to reduce design risk. In addition, low level sine vibration test shall be performed to identify/characterize responses up to 150 Hz

7.2.3.2.1 Tracker

The Tracker will conduct a sine sweep vibration test on proto-flight and flight electronics, tracker trays, and tracker towers at the appropriate levels to the unit.

One Tracker Tower Assemblies will be subjected to a sine sweep vibration test at the proto-flight level. The remaining units will be subjected to a sine sweep vibration test at the acceptance level

7.2.3.2.2 CAL.

One Calorimeter module will be subjected to a sine sweep vibration test at the proto-flight level.

7.2.3.2.3 ACD

The ACD will conduct a sine sweep vibration test as part of its Proto Flight test program.

7.2.3.2.4 Electronics

All qualification electronics units (TEM+TEM-PS, SIU, EPU, GASU, PDU) will be subjected to a sine sweep vibration test at qualification levels.

7.2.3.2.5 LAT

The Lat instrument, without radiators, will be subjected to a sine sweep vibration test at the proto-flight level. The LAT instrument, as a part of the integrated GLAST Observatory will be subjected to a sine sweep vibration test at the proto-flight level.

7.2.3.3 Random Vibration

All subsystem components will be subjected to 3-Axis random vibration tests as a workmanship test. Random vibration will be conducted on both qualification and flight units.
All subsystem components will be subjected to 3-Axis random vibration testing. For qualification and proto-flight hardware this test is to qualify the design for launch. At the acceptance level, this test is used to verify workmanship. The fully assembled LAT will be subjected to an acoustic test, rather than a random vibration test

7.2.3.4 Acoustic Tests

The Acoustic tests will be performed on the integrated LAT. Acoustic levels will be based upon the expected launch environment as published in the LAT Mission Environmental Specification document, LAT-SS-00778.

All subsystems will perform an analysis to support verification at the subsystem level of the acoustic requirements except for the ACD.

7.2.3.4.1 ACD

ACD will conduct vibro-acoustic tests on the ACD subsystem.

7.2.3.5 Modal Survey Test

A modal survey test of the flight LAT will be performed to assess the design against the expected modal frequencies and to reduce the risk of incompatibility of the LAT with environmental conditions.

7.2.3.5.1 ACD

The ACD will conduct a stand-alone Modal Survey test on the ACD subsystem.

7.2.3.6 Mechanical Shock

The LAT will be subjected to mechanical shock testing at the observatory level.

7.2.4 Pressure Profile

Pressure profile verification will be verified by analysis on each subsystem.

7.2.5 Mass Properties

Weight and center of gravity in the x, y, and z planes will be collected where practical on each subsystem component installed on the LAT. A mass properties report will be prepared and submitted as required.

7.2.5.1 LAT

A reference weight measurement will be taken upon completion of LAT integration. A final reference weight and center of gravity measurement will be taken prior to close-out of the LAT and observatory integration.

7.2.6 Dimension & Fit Checks

Dimensions and fit checks will be made on all subsystem components prior to integration with the LAT.

A reference dimension check of the LAT will be made during the I&T flow when the reference mass properties measurement is made.

7.2.7 Alignment Survey

Alignments will be conducted throughout the I&T flow as described in LAT-MD-00895, LAT Survey and Alignment Plan. The occurance of the surveys are shown in Figure 7-8. At the LAT level, a set of reference optical alignment measurements will be made within the I&T flow. Muon surveys will be conducted to establish the alignment and calibration of the detectors. A final set of alignment measurements will made prior to LAT testing as the instrument is closed out the environmental test program. The planned survey and alignment activity is summarized in Table 7-4.

Figure 7-8 LAT Survey activity in the I&T flow

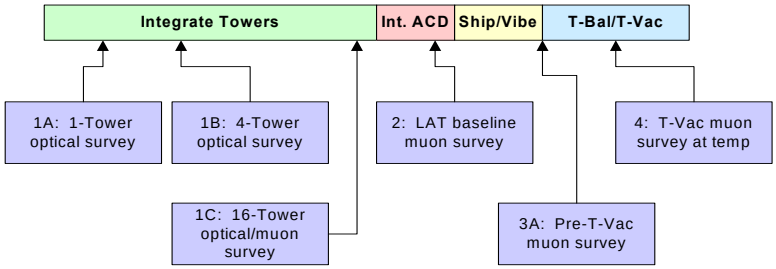
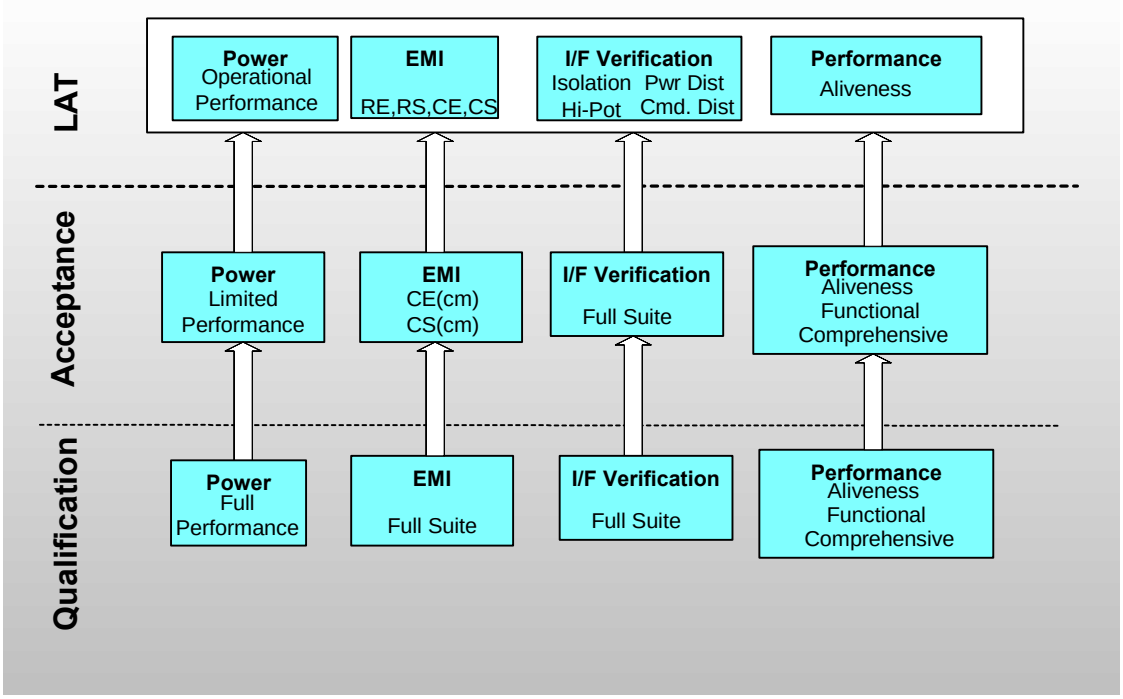


Table 7-4 LAT Alignment & Survey (TBD)

7.3 Electrical Tests

Electrical Tests will be conducted on the LAT at increasing levels of assembly to verify operational performance and compliance with the requirements and specifications of the instrument. The flow of these tests which will be conducted on the LAT subsystem components and the LAT during assembly are shown in Figure 7-9.

Figure 7-9 LAT Electrical Performance Test flow



7.3.1 Interface Verification Tests

Interface verification tests will be performed on all subsystem electrical components prior to integration. Measurements will be made of all interface electrical signals prior to connecting a new subsystem component to an integrated assembly.

Electrical interface cables will be tested for continuity, impedance, isolation and insulation resistance (hi-pot) prior to integration with flight hardware.

7.3.2 LAT Component & Instrument EMI tests

Test which are required to be performed on the LAT and LAT component assemblies are described in this section and are provided with references that trace to the LAT EMI Requirement , 433-RQMT-005.The test numbers called out refer to the test descriptions in Mil-Std.- 461E, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment.

The LAT EMI test performance requirements and specifications are delineated in LAT-SS-00778, the LAT Environmental Specification.

Tests will be conducted on the LAT and LAT hardware components at various levels of assembly to determine compliance with the specifications using the prescribed methods. The test matrix planned for LAT and: LAT component EMI testing is provided in Table 7-5.

Table 7-5 LAT & LAT Component EMI Testing

	Emissions					Susceptability							Other		
	Radiated		Conducted			Radiated		Conducted							
	Electric Field (RE102)	Magnetic Field (RE101)	Conducted Emissions(CE 101/102)	Conducted Emissions Common Mode (CECM)		Radiated Susceptability -Electric Field (RS 103)	Radiated Susceptability Magnetic Field (RS101-Static)	Conducted Susceptability Electric Field (CS101/102)	Conducted Susceptability Common Mode (CSCM)	Instrument Conducted Fuse Blow Transient (CS06)	Perform (Science)/Operate (No Science) CS06		Static Dipole Moment	EMI Safety Margin	EMI Superposition (EMISM)
Subsystem Components															
EM/Prototype	☒	☒	☒	☒		☒	☒	☒	☒	☒					
Proto-flight/Qualification	☒	☒	☒	☒		☒	☒	☒	☒		☒				
Acceptance/Flight *			☒					☒			☒				
LAT Instrument	☒	☒	☒	☒		☒	☒	☒	☒				☒	☒	☒
			☒ Recommended				☒ Required								

* If it is deemed that other tests will provide more insightful data than CE102 and/or CS102, then those tests may be performed in the place of CE102 and/or CS102. Two tests are required.

7.3.2.1 Self Compatibility

The LAT Instrument as a system will demonstrate self-compatibility. This demonstration will insure the LAT itself is evaluated for conditions which are incompatible with it's own subsystems and components. It will also be tested to show compatibility with the intended electromagnetic environment and against the EMI requirements.

7.3.2.2 Emissions Tests

7.3.2.2.1 Radiated Emissions (RE102)

Tests will be conducted to determine compliance with the LAT EMI Radiated Emissions (RE102) requirements. These tests will be conducted on subsystem components and the LAT Instrument as outlined in the LAT Environmental Specification, LAT-MD-00778.

7.3.2.2.2 Magnetic Field Emissions (RE101)

LAT and LAT components shall be tested for magnetic field emissions (RE101). Tests will be conducted on Qualification hardware, proto-flight hardware and the LAT Instrument.

7.3.2.2.3 Conducted Emissions (CE102, CECM)

Conducted Emissions tests will be performed on all qualification, proto flight and acceptance test hardware programs.

LAT and LAT components will be tested for conducted emissions (CE102) and Conducted Emissions in Common Mode (CECM) at the component and instrument level. These tests will be performed as required to determine compliance with LAT-SS-00778, the LAT Environmental Specification.

7.3.2.3 Susceptibility Tests

Susceptibility tests will be performed on LAT hardware in qualification, proto-flight and LAT instrument assembly levels. These tests will be performed as required to determine compliance with LAT-SS-00778, the LAT Environmental Specification.

7.3.2.3.1 Radiated Susceptibility, Electric Fields (RS103)

LAT and LAT components will be tested for Radiated Susceptibility at the component and instrument level. Component level tests will be performed on qualification units. Production units will be qualified by similarity. Radiated susceptibility tests will be conducted on proto flight hardware and the LAT instrument.

7.3.2.4 RF Interference Testing Source Compatibility

The LAT will be tested for susceptibility to RF emissions from the host spacecraft as listed in Table 7-6. The location of the sources is provided in the LA T Environmental Specification.

Table 7-6 Observatory RF Sources

Spacecraft-Generated GLAST RF Sources (TBR)					
Transmitter	**Band**	**Center Frequency (GHz)**	**Modulation Type**	**Bandwidth (MHz)**	**Volts/m @ Inst (E_{peak})**
STDN	-S	2.2875	QPSK	<5[(1)]	38V/m
Science D/L	X	8.485	OQPSK	<20[(1)]	55V/m

(1) Width of main lobe of the transmitter spectrum (null to null).

7.3.2.4.1 Radiated Susceptibility, Magnetic Fields (RS101, Static)

The susceptibility of the instrument to magnetic fields shall be verified by test of the LAT at instrument level. The LAT will be exposed to magnetic fields with the properties specified in the LAT Environmental Specification and the worst case magnetic fields at locations TBS by the spacecraft vendor. Instrument performance shall be measured to determine affect of the fields on the operational LAT

7.3.2.4.2 Conducted Susceptibility (CS101, CSCM, CS06)

LAT and LAT components will be subjected to Conducted Susceptibility tests on the primary input power. Tests will be to levels provided in the LAT Environmental Specification.

7.3.2.4.2.1 Conducted Sine Wave

The instrument will be subjected to conducted sine wave and pulse modulated (CS101) noise injected on the primary power input as detailed in the LAT Environmental Specification.

7.3.2.4.2.2 Common Mode Noise (CSCM)

LAT and LAT components will be subjected to performance tests with common mode noise injected on the primary input power leads.

7.3.2.4.3 Transients (CS06)

Transient Tests will be conducted on the LAT and LAT components. LAT and LAT components shall be subjected to both positive and negative polarity transients in the powered and un-powered conditions. The LAT shall be subjected to transient noise (CS06-Perform) injected on the primary power input.

Non-Flight LAT components shall be subjected to both positive and negative polarity fuse blow/fault transients(CS06- Survive) injected on the primary power input leads (28 V line-to-chassis and return-to-chassis) transients in the powered and un-powered conditions.

7.3.2.5 Instrument Magnetic Properties

The Instrument Magnetic Properties verification shall be performed by Analysis. The report will provide an analysis of each subsystem component and the results of the LAT as a system.

7.3.2.6 Electromagnetic Interference Safety Margin

This requirement shall be verified by analysis of equipment EMI test data.

7.3.2.7 Superposition

This requirement shall be verified by analysis of equipment EMI test data.

7.3.3 Performance Operating Time

All LAT test systems will collect the power on time of each component. This information will be collected in a manner that facilitates the determination of failure free performance. Major hardware or software changes shall be recorded in this log.

Where a subsystem component has a primary and a redundant unit or side, the units will be alternated in use on a periodic basis (i.e. daily). Data will be collected which supports the power on and failure free operation of both primary and redundant units.

Power on data will be collected for each subsystem electrical assembly which is either a flight article or flight spare.

7.3.4 Failure-Free Performance Evaluation

Systems engineering will evaluate the power on data for determination of failure free performance hours from the log of electrical power on time.

7.3.5 Comprehensive Performance Tests (CPT)

Comprehensive performance tests will be developed for use in support of LAT testing. These tests are outlined in LAT-MD-02730, LAT Performance and Operations Test Plan. LAT CPT testing will demonstrate the operation of all primary and redundant circuitry and paths for all operational modes. Parameters will be varied over their specification ranges to ensure that the unit performs as designed. These tests will be performed to provide baseline data for each level of assembly. A CPT will also be conducted during the hot and cold extremes of the temperature test or the thermal-vacuum test and at the conclusion of the environmental test sequence as well as at other times as needed in the verification procedures.

The LAT CPT will demonstrate that the hardware and software meet their performance requirements.

The CPT will also demonstrate that the instrument produces the expected responses. At lower levels of assembly, the test will demonstrate that, when provided with appropriate inputs, internal performance is satisfactory and outputs are within acceptable limits.

7.3.6 Limited Performance Tests (LPT)

LPTs will be performed at the instrument level before, during, and after environmental tests, as appropriate, to demonstrate that the functional capability of the instrument has not been degraded by an environmental test. These tests are outlined in LAT-MD-02730, LAT Performance and Operations Test Plan.

Limited Performance tests will be a subset of the CPT.

Electrical tests include the application of expected voltages, impedance, frequency, pulses, and waveforms at the electrical interfaces.

Mechanical tests shall include application of torque, load, and motion as appropriate.

7.3.7 Aliveness Tests

An aliveness test will be performed to verify that the instrument and its major components are functioning and that changes or degradation have not occurred as a result of environmental exposure, handling, transportation, or faulty installation. These tests are outlined in LAT-MD-02730, LAT Performance and Operations Test Plan.

Aliveness tests will be performed at various locations in the test flow where it is necessary to determine that the test article still functions.

7.3.8 Instrument Calibration Tests

Instrument calibration tests will be performed using the SLAC accelerator beam. These tests are outlined in LAT-MD-00446 the GLAST LAT Calibration Plan. This plan outlines the build up of calibration from component to instrument level. The calibrations are divided into low and high level calibrations that correlate to level of integration of the calibration unit.

A detailed description of all calibration activities is contained in the calibration plan document.

7.4 Optical Tests

The ACD will perform optical performance tests on the flight ACD optical components (PMTs, optical fibers, tiles, etc.). These tests are described in the LAT ACD Subsystem Verification Plan.

7.5 LAT Space Environment Tests

7.5.1 Vacuum, Thermal, and Humidity

The LAT and its components will be subjected to vacuum, thermal and humidity environmental tests at increasing levels of integration to demonstrate compliance with the Mission System Spec and the requirements in the LAT MAR. The GLAST LAT it's components will also be subjected to analysis and modeling of those components which can not be readily tested on the ground or otherwise have difficulty in obtaining verification of requirements.

7.5.2 Thermal-Vacuum

Thermal vacuum testing will be conducted on the LAT and its components in accordance with 433-MAR-0001 and per 433-SPEC-0001. The LAT will be subjected to a total of 12 Thermal Vacuum cycles. The LAT Thermal Vacuum profile is shown in Figure 7-10.

Eight (8) Thermal vacuum cycles will be performed on the LAT. Four (4) Cycles will be performed at component / unit level. An additional four (4) cycles will be performed at integrated LAT level. Soaks at each extreme will be for a total of 16 hours. The warm/cold start cycles will be at a more extreme temperature for 8 of the 16 hours of that particular soak period. The Thermal Vacuum profile is shown in Figure 9

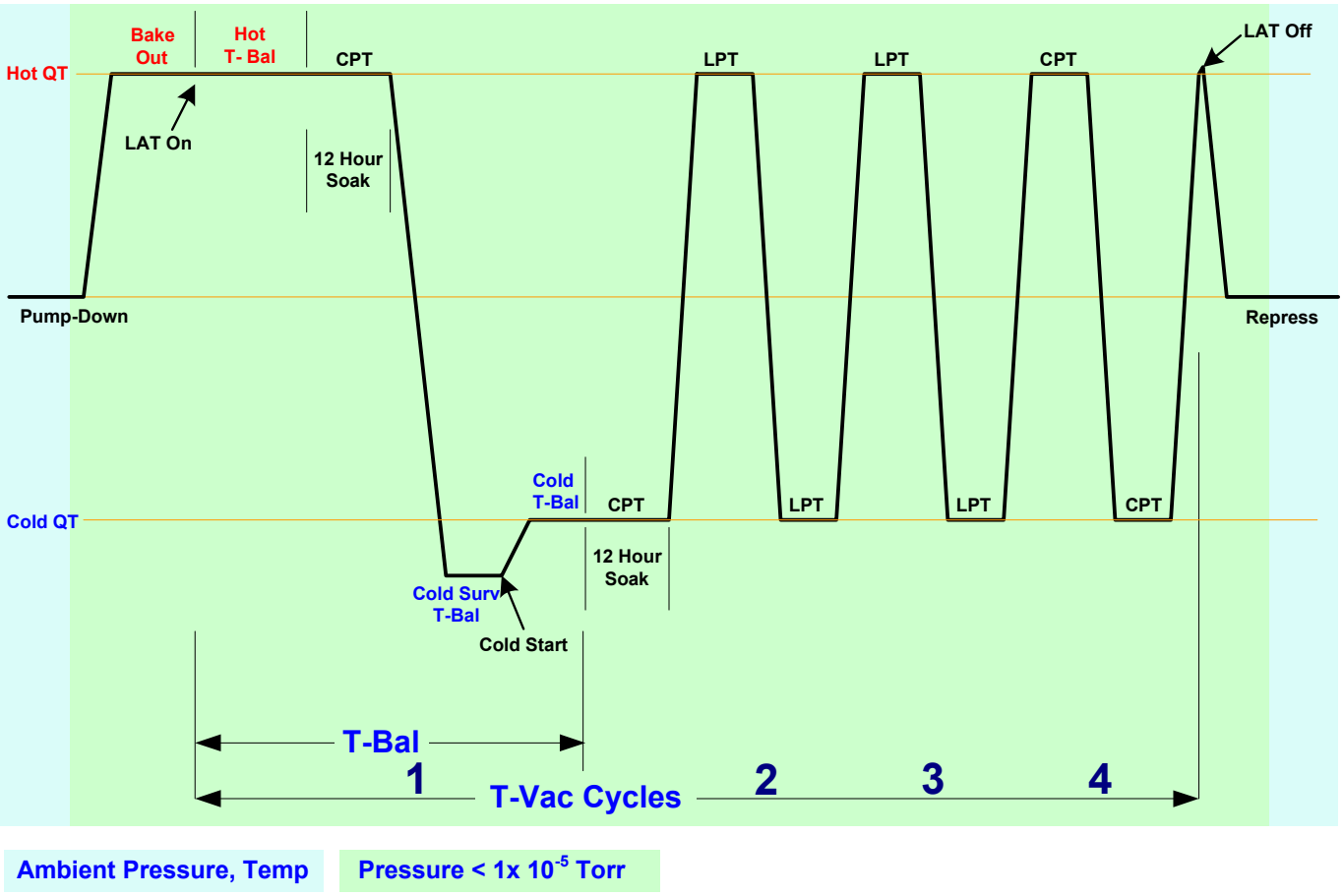
The remaining 4 cycles will occur at the integrated observatory level.

Throughout Thermal Vacuum testing, the hardware will be operated and its performance monitored. Limited functional performance testing of electrical items will be performed to accomplish this operational requirement.

The temperature extremes used for Thermal Vacuum testing, hot /cold soaks as well as hot/cold starts are outlined in the LAT Environmental Specification document, LAT-SS-00778. The Calorimeter Module is not to exceed 10°C / hour Max Ramp Rate during thermal cycling to mitigate the risk of thermal gradiant damage to the CsI crystals.

The LAT Thermal Vacuum Test Program is shown in Figure 7-11

Figure 7-10 LAT Thermal Vacuum Profile



7.5.3 Thermal Balance

A thermal balance test will be conducted during the planned thermal vacuum test program to demonstrate the operational capability of the LAT Thermal control system and the LAT thermal design itself.

The thermal balance test data will be used to validate the LAT thermal models and to predict on-orbit performance.

7.5.4 Thermal Cycle

All thermal cycle testing will be conducted under vacuum as shown in the unit test plans. This testing will be used to verify workmanship of LAT components at integrated subsystem levels.

7.5.5 Temperature/Humidity – Transportation and Storage

LAT components will be analyzed for environmental limits in uncontrolled storage conditions. The LAT program will impose a storage environment requirement that will require all who are in custody of the LAT to maintain the instrument within the limits called out in the LAT Environmental Specification document, LAT-SS-00778.

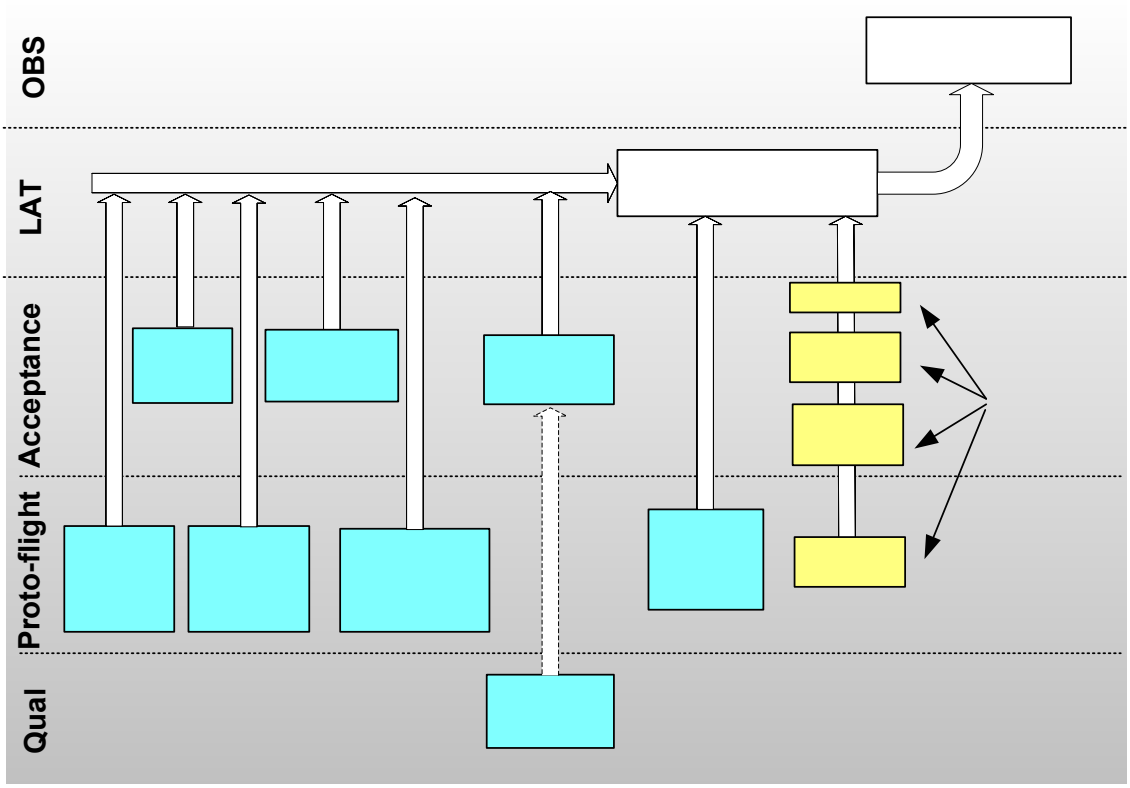
7.5.6 Radiation

Compliance with the requirements for radiation environments as represented by the Total Ionizing Dose (TID) and Single Event Effects (SEE) will be performed by test or analysis. Testing will be conducted at the parts level when the affected part is required to be tested to meet the parts qualification for the program. Unit level qualification will be performed by analysis. Specification for the TID and SEE are contained in the LAT Environmental Specification, LAT-SS-00778.

7.5.7 Atomic Oxygen

Compliance with the requirements for Atomic Oxygen exposure will be performed by test or analysis. Testing will be conducted at the parts level when the affected part is required to be tested to meet the parts qualification for the program. Unit level qualification will be performed by analysis. Specifications for the Atomic Oxygen environment are contained in the LAT Environmental Specification, LAT-SS-00778.

Figure 7-11 LAT Thermal Vacuum Test Program



7.6 Software

Flight Software will be tested as outlined in the LAT Flight Software Test Plan, LAT-TD-00786. A comprehensive test plan using the flight software to support engineering development test bed activities and calibration unit testing is planned. The testing involves four phases, Engineering Model 1, Engineering Model 2, Calibration Unit and Full LAT Release. The Full LAT release will be used in LAT

Thermal Vacuum and Thermal Balance testing. The LAT Flight Software Test and Integration plan showing the software module testing against flight hardware and target processors is shown in Figure 7-12.

The Flight software Test Matrix, showing performance tests against flight software modules is shown in Table 7-7.

Figure 7-12 LAT Flight Software Test & Integration Plan

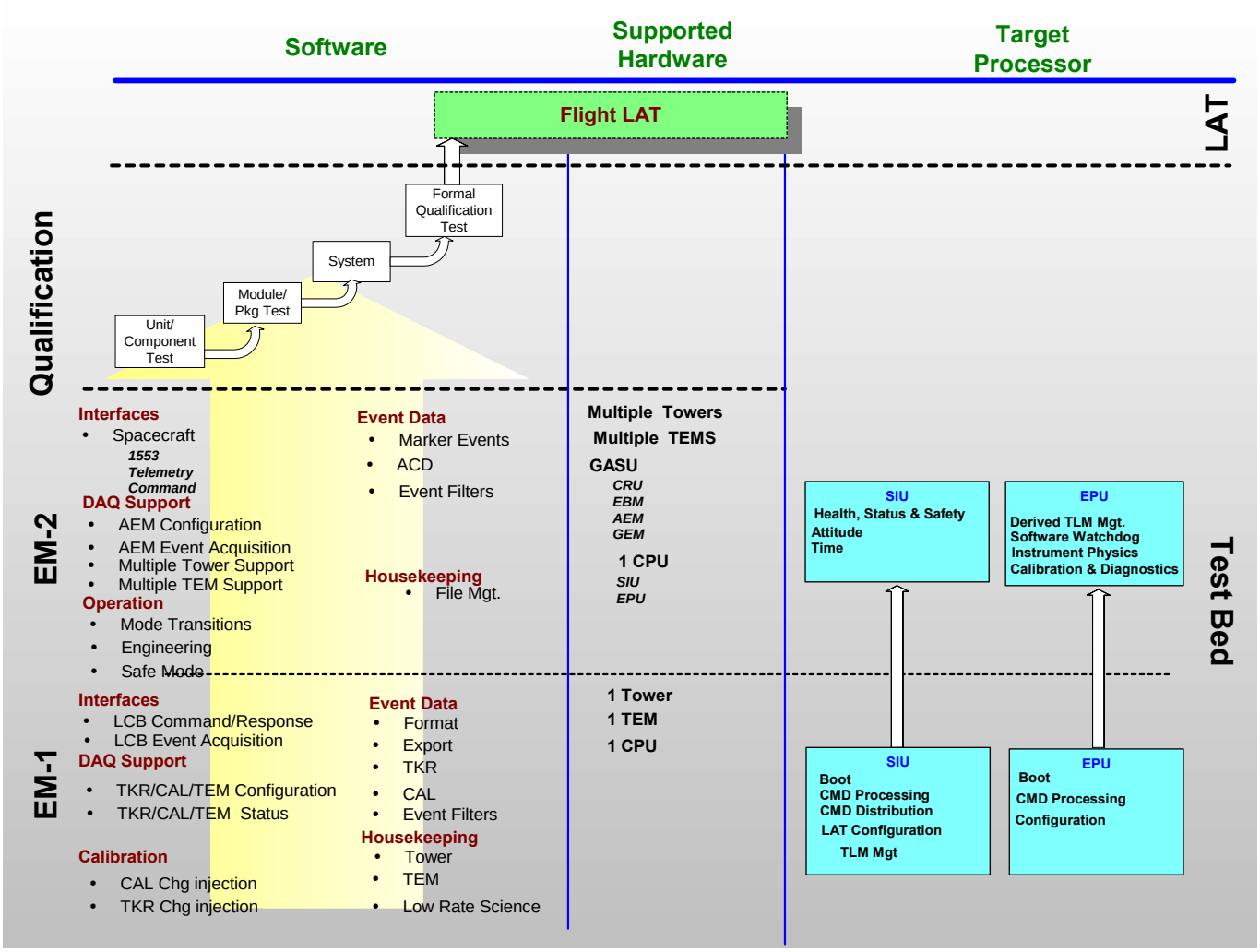


Table 7-7 LAT Flight Software Test Matrix

TEST NUMBER		001	002a	002b	003	004	005	006a	006b	007a	007b	007c	007d	008a	008b	009a	009b	010	011	012a	012b	013a	013b	014	015		100	101	102	103	104		100	101	102	103	104
LAT FSW TESTS **LAT FSW RELEASES AND TEST PHASES**	**COMPONENT-LEVEL**	1553 INTERFACE TEST	COMMAND FUNCTIONAL	MEMORY UPLOAD VERIFICATION	NARROWBAND TELEMETRY VERIFICATION	WIDEBAND TELEMETRY VERIFICATION	VEHICLE SIGNALS INTERFACE VERIFICATION	SIU/EPU CPU-TO-CPU COMM FNCTL TEST	EPU INTERNAL CONFIGURATION TEST	T&DF INTERNAL CONFIGURATION TEST	TKR INTERNAL CONFIGURATION TEST	CAL INTERNAL CONFIGURATION TEST	ACD INTERNAL CONFIGURATION TEST	EVENT FILTERING - ALGORITHM VERIFICATION	ELECTRONIC CALIBRATION	FSW AND LAT INITIALIZATION	FSW AND LAT RE-INITIALIZATION AND RECOVERY	LAT POINTING CALCULATIONS	GRB HANDLING/REPOINTING REQUESTS	ADDL SCI PROC - GRB DETECTION AND LOCATION	ADDL SCI PROC - REPOINTING LOGIC	OPERATIONAL MODES - SAFE MODES	OPERATIONAL MODES - SCIENCE MODES	LAT DIAGNOSTIC AND CALIBRATION MODES	LAT THERMAL CONTROL SYSTEM	**SYSTEM-LEVEL**	LAT ON ORBIT INITIALIZATIONS	NORMAL OPERATIONS – SKY SURVEY MODE	NORMAL OPERATIONS – POINTED OBS MODE	LAT PERFORMANCE VERIFICATIONS	LAT AIRBORNE END-TO-END TEST	**FORMAL QUALIFICATION TESTS**	LAT ON ORBIT INITIALIZATIONS	NORMAL OPERATIONS – SKY SURVEY MODE	NORMAL OPERATIONS – POINTED OBS MODE	LAT PERFORMANCE VERIFICATIONS	LAT AIRBORNE END-TO-END TEST
ENGINEERING MODEL RELEASES																																					
EM1					P			P	P	X	X	X		T	P	P																					
EM2		P	P	X	P	P		X	X	X	X	X		T	P	P			P			P	P	P													
CALIBRATION UNIT RELEASE																																					
AMBIENT		P	X	X	P	X		X	X	X	X	X	X	T	X	X	X	P	P	T	T	P	P	P						X							
VAN DE GRAPH TEST			X		P	X										X													X							
BEAM TEST - POSITRON			X		P	X										X													X							
BEAM TEST - PHOTON			X		P	X										X													X							
BEAM TEST - PROTON			X		P	X										X													X							
FULL LAT RELEASE																																					
AMBIENT		X	X	X	X	X	X	X	X	X	X	X	X	T	X	X	X	X	X	T	X	X	X	X	P		X	X	X				X	X	X		
LAT BEAM TEST			X		X	X										X													X						X	
THERMAL VACUUM HOT			X		X	X										X									X		X	X	X				X	X	X		
THERMAL VACUUM COLD			X		X	X										X									X		X	X	X				X	X	X		
AIRBORNE PERFORMANCE TEST			X		X	X										X														X						X

X = Test is performed P = Partial test is performed T = Test performed on separate testbed w ith simulated data

7.7 Science Verification and Calibration Tests

Science and Calibration verification testing is conducted at increasing levels of assembly. Calibration techniques are developed and baseline data taken on instrument components and the 4 tower Calibration Unit. These techniques and methods are then applied to the full LAT instrument.

The on-ground science verification plan is contained in the LAT Science Verification and Calibration Plan, (SVAC) LAT-MD-00446. Additional Science Verification Tests are performed in the beam test using the 4 tower Calibration Unit. These tests are described in LAT-TD-00440.

7.8 Compatibility Testing

A series of compatibility tests will be performed t ensure compatibility of the LAT with interfacing facilities. These tests will be performed using either the actual facility or simulators. Tests will be performed to validate:

- Instrument Operations Center (IOC) (TBD)
- Science Analysis Software (SAS) (TBD)
- BUS (TBD)
- Mission Operations Center (MOC) (TBD)

8 Subsystem Test Plans

8.1 TKR

Table 8-1 Tracker Test Plan

Hardware				Mechanical							Electrical						Thermal			Other	
Assembly Level	Unit Type	Component (ITEM)	Quantity	Static Load	Sine Burst (static equivalent acc.)	Sinusoidal vibration+modal survey	Random Vibe + modal survey	Acoustic	Pressure Profile	Mass Properties	Interface Verification	EMI/EMC	EDS Compatibility (Grounding)	Stacked Cosmic Ray Test	Functional and Power	Burn-In	Thermal Vacuum	Thermal Balance	Thermal Cycle	Radiation	Comments
C	E	EM Tracker MCMs	8							T	T				T	T			QT		
C	E	Tray panels	24				QT														Vibe z-axis only
C	E	Live trays	5				QT			M					T		QT				Vibe & TV only 1
C	E	EM Mini-Tower	1								T	T	T		T						
C	E	EM Bottom Tray	2	QT						M									QT		Test 1 to destruction
C	E	EM Tracker Std. Trays	18	A			QT												QT		Vibe 5; z-axis only
S	E	EM Tracker Tower	1	A	QT	QT	QT			M	T						QT	T			
C	Q	Mini-MCMs (ASICs)	4												T					QT	
C	Q	Qualification MCMs	38						T	M	T				T	T			QT		2 for DPA
C	Q	QM Tracker MCMs	36								T				T	T			QT		
C	Q	Tray panels	19				QT														Vibe z-axis only
C	Q	QM Bottom Tray	1	QT						M	T			T	T				QT		
C	Q	QM Tracker Std. Trays	18	A						M	T			T	T				QT		
S	Q	QM Tracker Tower	1	A	QT	QT	QT	A		M	T	T	T		T		QT	T			
C	F	Flight Tracker MCMs	612								T				T	T			T		
C	F	Tray panels	323			AT	AT														Vibe z-axis only
C	F	Flight Bottom Trays	17	AT							T			T	T				AT		
C	F	Flight Tracker Std. Trays	306								T			T	T				AT		
S	F	Flight Tracker Towers	17		AT	AT	AT			M	T	QS	QS		T		AT	QS			

Assembly Level
S= Subsystem
C= Component

Unit Type
F= Flight
Q= Protoflight
E= Engineering Model

Verification Method:
T= Test
A= Analysis
M= Measurement
QS= Qual by Similarity
QT= Test, Protoflight Level
AT= Test, Acceptance Level

8.2 CAL

Table 8-2 Calorimeter Verification Matrix

CALORIMETER VERIFICATION MATRIX

HARDWARE				MECHANICAL							ELECTRICAL					THERMAL				OTHER					
COMPONENT (ITEM)	QUANTITY	TYPE	SUPPLIER	STATIC LOAD	SINE BURST	SINE VIBRATION	RANDOM VIB	LOW LEVEL RANDOM VIB	PRESSURE PROFILE	MASS PROPERTIES	INTERFACE VERIF	EMC/EMI	ESD COMPATABILITY (GNDING)	MAGNETICS	FUNCTIONAL	THERMAL VACUUM	THERMAL BALANCE	THERMAL CYCLE	HUMIDITY	RADIATION	BAKEOUT	BEAM TEST – EM SHOWERS	BEAM TEST - HADRONS	BEAM TEST – HEAVY IONS	COMMENTS
2 CsI Det Elements (CDE)	12	Q	F	A			A			M	T	A	A		T	TQ		TQ		T					
2 PreElect Modules (PEM)	1	Q	F	T	TQ	TQ	TQ			M	T				T	TQ		TQ							
Electronics Prototype	1	Q	N												T										
CsI Det Elements (CDE)		Q	N							M	T				T			TQ	M	TQ					TQ applies to sample batches
Composite Structure	1	Q	F		TQ		TQ	T		M	T				T				M						
Front End Elect (AFEE)	4	Q	N	A	A	A	A			M	T	A	A		T			TQ	M	A					
CAL Module	1	Q	N		TQ	TQ	TQ	T	A	M	T	T	T		T	TQ	TQ	TQ	M	A		T	T	T	
M CsI Det Elements (CDE)		PF	N							M	T				T			TQ	M	TQ					TQ applies to sample batches
M Composite Structure	1	PF	F		TQ		TQ	T		M	T				T				M						
M Front End Elect (AFEE)	4	PF	N	A	A	A	A			M	T	A	A		T			TQ	M	A					
M CAL Module	1	PF	N		TP	TP	TP	T	A	M	T	T	T		T	TP	QS		M	A					
CsI Det Elements (CDE)		F	N							M	T				T				M	TQ					TQ applies to non-flight samples
Composite Structure		F	F		TQ		TQ	T		M	T				T				M						
Front End Elect (AFEE)		F	N	QS	QS	QS	QS			M	T	QS	QS		T			TQ	M	A					
CAL Module	17	F	N		QS	QS	TA	T	A	M	T	TA	QS		T	TA	QS		M	A					

rimeter Verification plan & Environmental Specification
tamination Control Plan, LAT-MD-00228
unding checked for each component prior to S/C integration

LEVEL OF ASSEMBLY:
S = Subsystem
C = Component

SUPPLIER:
F = France
N = NRL

UNIT TYPE:
PF = ProtoFlight
F = Flight
S = Spare
Q = Qual. unit

VERIFICATION METHOD:
T = Test
A = Analysis
M = Measurement
I = Inspection
QS = Qual by Similarity
TQ = Test, Qual level
TP = Test, ProtoFlight level
TA = Test, Acceptance level

8.3 ACD

Table 8-3 ACD Test Plan

Hardware Description				Structural/Mechanical											Electrical					Thermal		
Item	Level of Assembly	Unit Type	Supplier	Qualification Status	Modal Survey (low level sine survey)	Static Loads	Sine Burst	Sine Vibration	Random Vibration	Acoustics	Mechanical Function	Performance Testing (Optical)	Mass Properties	Interface Verif.	EMC/EMI	ESD Compatibility (Grounding)	Magnetics	Functional / Performance	No. of Thermal-Vacuum Cyc	Thermal Cycle	Thermal Balance	Remarks
ACD Subsystem	S	F	GSFC	4	X		X	X	X	X		X	X	X	X	X		X	4		X	Acceptance Levels
ACD Mechanical Subsystem	S	F	GSFC	1	X-e		X-e	X-e	X-e	X-e	X		X						2 ?			ACD Structure w/mass sims
Tile Shell Assembly	SA	F	GSFC	2									X-e									
Tile Shell Assembly - partial	SA	D	GSFC	1				X	X				X						4			
Shell	C	F	TBD	2		X-a							X									
Shell - partial	P	D	TBD	2		X-a							X									
TDA Tiedown	P	F	GSFC	3		X-c							X									Test bonded joint
TDA Tiedown	P	EM	GSFC	2		X-c							X									Test bonded joint
TDA Tiedown	P	D	GSFC	1	X	X-b	X	X	X		X		X					X?	8			Characterize flexures
Tile Detector Assembly	SA	F	Fermilab	3								X-d	X									117 Flt TDAs (28 Flt spares)
Tile Detector Assembly	SA	EM	Fermilab	2				X-c	X-c			X-d	X						4-c			20 TDAs
Tile Detector Assembly	SA	D	Fermilab	1		X	X	X	X			X-d	X						8-d			Functional testing code660
WSF/Clear Fiber Connector	C	F	GSFC	3								c	X									
WSF/Clear Fiber Connect	C	EM	GSFC	2		X		X	X		X	c	X							4-c		
WSF/Clear Fiber Connect	C	D	GSFC			X		X	X		X	X-d	X							8-d		Several dvlpmnt models
Base Frame	C	F	GSFC	2	X-e-c	X-e-c		X-e-c	X-e-c				X									
Base Frame - partial	C	D	GSFC	2		X		X-e	X-e				X									
Shield & Thermal Blanket	C	F	GSFC	3									X									Similarity to dev. model
Shield & Thermal Blanket	C	EM	GSFC	3									X									Similarity to dev. model
Shield & Thermal Blanket	C	D	JSC, GSFC	2																		Characterize thermal perf.
Clear fiber cable assembly	SA		GSFC																			
PMT/Fiber Connector	C	F	GSFC	3								c	X									
PMT/Fiber Connector	C	EM	GSFC	2		X		X	X		X	c	X							4-c		
PMT/Fiber Connector	C	D	GSFC	1		X		X	X		X	X-d	X							8-d		Several dvlpmnt models
ACD Electrical Subsystem	S	F	GSFC	1																		
Base Electronics Assembly	SA	F	GSFC	2				X	X				X	X				X		X?		
Partial Electronics Assembly	SA	D	GSFC			X?																
FREE Board with PMT	C	F	GSFC	4				X	X					X				X		X		12 Units
FREE Board with PMT	C	S	GSFC	4				X	X					X				X		X		2 Units
FREE Board with PMT	C	EM	GSFC	1				X	X					X	X	X		X	4-?	X		4 Units
FREE Board Parts	P	F,S	Multiple	2														X-s				Using NASA approved flight parts
PMTs	P	F	H	2				X-s?	X-s?									X-s				
PMTs	P	EM	H	2				X-s?	X-s?									X-s				
PMT with Res Sh	P	EM	H, GSFC	2				X?	X?					X?				X?		X?		
HVBS	C	F	GSFC	4				X	X					X				X		X		12 Units
HVBS	C	EM	GSFC	1				X	X					X	X	X		X		X		4 Units
HVBS	C	S	GSFC	4				X	X					X				X		X		2 Units

LEGEND:

LEVEL OF ASSEMBLY	UNIT TYPE	QUALIFICATION STATUS	NOTES:
S - Subsystem	D - Development Model	1 - Complete qual req	a. Composite structure, see Sec.4.3
SA - Subassembly	EM - Engineering Model	2 - Partial qual req (see remarks)	b. Test-to-failure
C - Component	F - Flight	3 - Otherwise qual (see remarks)	c. May be tested at next higher ass'y
P - Part	S - Spares	4 - Acceptance	d. Test for light yield and repeatability
			e. Test with mass models
			s. Tested by supplier

8.4 Electronics

8.4.1 Tower Electronics Module

Table 8-4 TEM Test Plan

Tower Electronics Module

Hardware				Mechanical							Electrical				Environmental			Comments
Assembly Level	Unit Type	Component (ITEM)	Quantity	Static Load	Sine Burst	Sine Sweep	Random Vib	Acoustic	Pressure Profile	Mass Properties	Interface Verification	EMI/EMC	ESD Compatibility (Grnding)	Functional/Performance	Thermal Vacuum	Thermal Cycle	Radiation	
C	E	TEM DAQ Board	1	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	Q	TEM DAQ Board	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	Q	TEM Enclosure	1	A	A	A	A	-	-	M	AT	-	-	AT	-	AT	A	
C	F	TEM DAQ Board	17	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	-	
C	F	TEM Enclosure	17	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	-	
S	Q	TEM	1	QT	QT	QT	QT	A	A	M	QT	QT	QT	QT	QT	-	-	
S	F	TEM	16	AT	-	-	AT	-	-	M	AT	-	-	AT	AT	-	-	4 cycle T/V
S	S	TEM	1	AT	-	-	AT	-	-	M	AT	-	-	AT	TA	-	-	8 cycle T/V

Assembly Level
S= Subsystem
C=Component

Unit Type
PF=Proto Flight
F=Flight
S=Spare
Q=Qual
E=Engineering / VerificationModel

Verification Method
T=Test
A=Analysis
M=Measurement
I=Inspection

QS= Qual by Similarity
QT= Test, Qual or Protoflight Level
AT= Test, Acceptance Level

8.4.2 Tower Power Supply

Table 8-5 Tower Power Supply Test Plan

Tower Power Supply

Hardware				Mechanical							Electrical				Environmental			Comments
Assembly Level	Unit Type	Component (ITEM)	Quantity	Static Load	Sine Burst	Sine Sweep	Random Vib	Acoustic	Pressure Profile	Mass Properties	Interface Verification	EMI/EMC	ESD Compatibility (Grnding)	Functional/Performance	Thermal Vacuum	Thermal Cycle	Radiation	
C	E	Twr PS Board	1	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	Q	Twr PS Board	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	Q	Twr PS Enclosure	1	A	A	A	A	-	-	M	AT	-	-	AT	-	AT	A	
C	F	Twr PS Board	17	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	-	
C	F	Twr PS Enclosure	17	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	-	
S	Q	Twr PS	1	QT	QT	QT	QT	A	A	M	QT	QT	QT	QT	QT	-	-	
S	F	Twr PS	16	AT	-	-	AT	-	-	M	AT	-	-	AT	AT	-	-	4 cycle T/V
S	S	Twr PS	1	AT	-	-	AT	-	-	M	AT	-	-	AT	AT	-	-	8 cycle T/V

Assembly Level
S= Subsystem
C=Component

Unit Type
PF=Proto Flight
F=Flight
S=Spare
Q=Qual
E=Engineering / VerificationModel

Verification Method
T=Test
A=Analysis
M=Measurement
I=Inspection

QS= Qual by Similarity
QT= Test, Qual or Protoflight Level
AT= Test, Acceptance Level

8.4.3 Spacecraft Interface / Event Processor Unit

Table 8-6 SIU/EPU Test Plan

Spacecraft Interface & Event Processing Unit

Hardware				Mechanical							Electrical				EnvironmenATI			Comments
Assembly Level	Unit Type	Component (ITEM)	Quantity	Static Load	Sine Burst	Sine Sweep	Random Vib	Acoustic	Pressure Profile	Mass Properties	Interface Verification	EMI/EMC	ESD Compatibility (Grnding)	Functional/Performance	Thermal Vacuum	Thermal Cycle	Radiation	
C	E	Storage Interface Board (SIB)	1	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	E	LAT Communication Board (LCB)	1	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	E	Crate Backplane (CBP)	1	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	E	Crate Power Supply (CPS)	1	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	Q	Storage Interface Board*	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	Q	RAD 750 CPU Card	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	Buy-Tested at supplier
C	Q	LAT Communication Board	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	Q	Crate Power Supply Board	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	Q	Crate Backplane*	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	Q	SIU Enclosure	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	E	Storage Interface Board	6	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	E	RAD 750 CPU Card	6	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	Buy-Tested at supplier
C	F	LAT Communication Board	6	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	F	Crate Power Supply	6	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	F	Crate Backplane	6	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
C	F	SIU Enclosure	6	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
S	Q	SIU / EPU Crate	1	QT	QT	QT	QT	A	A	M	QT	QT	QT	QT	QT	-	-	
S	F	SIU	2	-	-	-	AT	-	-	M	AT	-	-	AT	AT	-	-	4 Cycle T/V
S	F	EPU	3	-	-	-	AT	-	-	M	AT	-	-	AT	AT	-	-	5 Cycle T/V
S	S	SIU / EPU Crate	1	-	-	-	AT	-	-	M	AT	-	-	AT	AT	-	-	8 Cycle T/V
		* Qualified for program																

Assembly Level
S= Subsystem
C=Component

Unit Type
PF=Proto Flight
F=Flight
S=Spare
Q=Qual
E=Engineering/Verification Model

Verification Method
T=Test
A=Analysis
M=Measurement
I=Inspection
QT=Test, Qual Level
AT=Test, AccepATnce Level

8.4.4 *G*lobal trigger *A*CD *S*ignal distribution *U*nit (GASU)

Table 8-7 GASU Test Plan

GASU

Hardware				Mechanical							Electrical				Environmental			Comments
Assembly Level	Unit Type	Component (ITEM)	Quantity	Static Load	Sine Burst	Sine Sweep	Random Vib	Acoustic	Pressure Profile	Mass Properties	Interface Verification	EMI/EMC	ESD Compatibility (Grnding)	Functional/Performance	Thermal Vacuum	Thermal Cycle	Radiation	
C	E	GASU DAQ	1	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	E	GASU-PS	1	-	-	-	-	-	-	-	AT	-	-	AT	-	AT	A	
C	Q	GASU DAQ	2	-	-	-	-	-	-	M	TQ	-	-	TQ	-	TQ	A	
C	Q	GASU-PS	2	-	-	-	-	-	-	M	TQ	-	-	TQ	-	TQ	A	
C	Q	GASU Enclosure	1	-	-	-	-	-	-	M	TQ	-	-	TQ	-	TQ	A	
C	F	GASU DAQ	2	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	-	
C	F	GASU-PS	2	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	-	
C	F	GASU Enclosure	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	-	
S	Q	GASU Box	1	QT	QT	QT	QT	A	A	M	QT	QT	QT	QT	QT	-	-	
S	F	GASD Box	1	-	-	-	AT	-	-	M	AT	-	-	AT	AT	-	-	

Assembly Level
S= Subsystem
C=Component

Unit Type
PF=Proto Flight
F=Flight
S=Spare
Q=Qual
E=Engineering/Verification Model

Verification Method
T=Test
A=Analysis
M=Measurement
I=Inspection

QT=Test, Qual Level
AT=Test, AccepATnce Level

8.4.5 Power Distribution Unit

Table 8-8 PDU[2] Test Plan

Pwr Distribution Unit[2]

Hardware				Mechanical							Electrical				Environmental			Comments
Assembly Level	Unit Type	Component (ITEM)	Quantity	Static Load	Sine Burst	Sine Sweep	Random Vib	Acoustic	Pressure Profile	Mass Properties	Interface Verification	EMI/EMC	ESD Compatibility (Grnding)	Functional/Performance	Thermal Vacuum	Thermal Cycle	Radiation	
C	Q	PDU DAQ Board	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	Buy-Test at supplier
C	Q	PDU Enclosure	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	Use qualified chassis
C	F	PDU DAQ Card	2	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	Buy-Test at supplier
C	F	PDU Enclosure	1	-	-	-	-	-	-	M	AT	-	-	AT	-	AT	A	
S	Q	Pwr Dist Box	1	QT	QT	QT	QT	A	A	M	QT	QT	QT	QT	QT	-	-	
S	F	Pwr Dist Box	2	-	-	-	AT	-	-	M	AT	-	-	AT	AT	-	-	4 Cycle T/V

Assembly Level
S= Subsystem
C=Component

Unit Type
PF=Proto Flight
F=Flight
S=Spare
Q=Qual
E=Engineering/VerificationModel

Verification Method
T=Test
A=Analysis
M=Measurement
I=Inspection

QT=Test, Qual Level
AT=Test, AccepATnce Level

8.5 Mechanical

Table 8-9 Mechanical Test Plan

Hardware						Mechanical										Electrical				Environmental					Comments
Assembly Level	Unit Type	Qualification Level	Component	Quantity	Flight Spares	Static Load	Sine Burst	Sine Sweep	Random Vibe	Acoustic	Mech shock	Pressure	Mass, C.G.	Fit / Dim Chk	Alignment	Interface Verif	EMI/EMC	ESD (Grounding)	Functional	Thermal Vacuum	Thermal Balance	Thermal Cycle	Thermal Performance	Non-Condensible Gas	
			Grid Assembly																						
A	E	Q	Grid Top Flange Heat Pipe Bonding	1		TQ								M								TQ			Validates HP bonding process
C	E	Q	CAL-Grid Joint Shear Test	3		TQ																			EM testing of CAL-Grid joint design
C	E	Q	Grid Mock-up	1										I											Validates Grid fab processes
C	E	Q	Heat Pipe Thermal Interface Test	3																TQ					Qual's HP thermal joint design
C	F	A	Grid Structure	1									M	M											
C	F	A	Top Flange Heat Pipe	5	1							P	M	M									TA	TA	HP's qual'd by similarity
C	F	A	Down Spout Heat Pipe	12	2							P	M	M									TA	TA	HP's qual'd by similarity
A	PF	A	Grid Box Base Assembly	1									M	M		I			TA						Grid #1
A	PF	Q	Grid Box Assembly	1		TQ							M	M											Grid #2
			X-LAT Thermal Plate																						
A	E	Q	X-LAT Heat Pipe EM	1								P								TQ					
C	F	A	X-LAT Heat Pipes	6	1							P	M	M									TA	TA	HP's qual'd by similarity
A	F	A	X-LAT Thermal Plate(Assembly)	1									M	M						TQ					
			Radiator Assemblies																						
C	PF	A	Radiator VC Heat Pipes	12	2							P	M	M									TQ	TQ	New Design Requires Qualification
A	PF	Q	Radiator Ass'y (individual)	2				TQ		TQ			M	M		I			TQ	TQ					
			Thermal Control System																						
C		Q	Controller Unit	2	1				TQ				M	M		I	TQ	TQ	TQ	TQ		TQ			
C	PF	Q	Heater Control Box	2	1				TQ				M	M		I	TQ	TQ	TQ	TQ		TQ			
S	PF	Q	Radiator Pair w/ TCS	1															TQ	TQ	TQ				

Ass'y Level	Unit Type		Verification Method
S = Subsystem	PF = Proto Flight	Q = Qual	T = Test
A = Assembly	F = Flight	E = Engineering Model	A = Analysis
C = Component	S = Spare	V = Verification Model	M = Measurement
			I = Inspection