LAT PROJECT DOCUMENT CHANGE NOTICE (DCN)

DCN No. LAT-XR-07131-01

SHEET 1 **OF** 2

ORIGINATOR: Mike DeKlotz	**PHONE:** 650-926-4752	**DATE:** 8/16/05
CHANGE TITLE: DCN for LAT Flight Software Test Procedures		**ORG.:**

DOCUMENT NUMBER	TITLE	NEW REV.
LAT-TD-07126	LAT FSW Qualification Test Procedure: DCMODE_001: ACD Diagnostics & Calibration	01
LAT-TD-07127	LAT FSW Qualification Test Procedure: DCMODE_002: ACD Diagnostics & Calibration	01
LAT-TD-07128	LAT FSW Qualification Test Procedure: DCMODE_003: TKR Diagnostics & Calibration	01
LAT-TD-07129	LAT FSW Qualification Test Procedure: NBTLMV_001: Narrowband Telemetry Housekeeping & Low-rate Science Data Verificaiton	01
LAT-TD-07130	LAT FSW Qualification Test Procedure: NBTLMV_002: Diagnostic Telemetry Verification	01

CHANGE DESCRIPTION (FROM/TO):

LAT-TD-07132-01- LAT FSW Qualification Test Procedure: FSWINI_001: FSW Initialization-SIU Primary Boot
LAT-TD-07133-01 -LAT FSW Qualification Test Procedure: FSWINI_002: FSW & LAT Initialization- Boot Self-Test & Boot Housekeeping Telemetry
LAT-TD-07134-01- LAT FSW Qualification Test Procedure: FSWINI_003: FSW & LAT Initialization- Multiple Boot Images
LAT-TD-07135-01- LAT FSW Qualification Test Procedure: FSWINI_004: FSW & LAT Initialization- SIU Hardware Reboot in response to the Signal on the Discrete Lines
LAT-TD-07136-01- LAT FSW Qualification Test Procedure: FSWINI_005: FSW Initialization- EPU Primary Boot
LAT-TD-07137-01- LAT FSW Qualification Test Procedure: FSWINI_006: FSW & LAT initialization- Reset Source
LAT-TD-07138-01- LAT FSW Qualification Test Procedure: FSWINI_007: FSW & LAT Initialization- Storage & Retrieval of System Errors During SIU Primary Boot
LAT-TD-07139-01- LAT FSW Qualification Test Procedure: FSWINI_008: FSW & LAT Initialization- Storage & Retrieval of System Errors During EPU Primary Boot
LAT-TD-07140-01- LAT FSW Qualification Test Procedure: FSWINI_009: FSW & LAT Initialization- SIU Boot Status on Discrete Lines & SISU Boot Housekeeping Telemetry
LAT-TD-07141-01- LAT FSW Qualification Test Procedure: FSWINI_010: FSW & LAT Initialization- SIU & EPU Secondary Boot
LAT-TD-07142-01- LAT FSW Qualification Test Procedure: FSWINI_011: FSW & LAT Initialization- SIU & EPU Secondary Boot Error Mitigation
LAT-TD-07143-01- LAT FSW Qualification Test Procedure: FSWINI_012: FSW & LAT Initialization- LAT SEU Protection
LAT-TD-07144-01- LAT FSW Qualification Test Procedure: FSWINI_013: FSW & LAT Initialization- LAT Memory Scrubbing
LAT-TD-07145-01- LAT FSW Qualification Test Procedure: FSWINI_014: FSW & LAT Initialization- Watchdog Management During Boot
LAT-TD-07146-01- LAT FSW Qualification Test Procedure: FSWINI_015: FSW & LAT Initialization- Soft Reset
LAT-TD-07152-01 - LAT FSW Qualification Test Procedure:FECALB_001: Charge Injection Calibration – TOT Measurements
LAT-TD-07153-01- LAT FSW Qualification Test Procedure:FECALB_002: Charge Injection Calibration – TKR Threshold and Charge Scans
LAT-TD-07154-01- LAT FSW Qualification Test Procedure: FECALB_003: Charge Injection Calibration – TKR Trigger Check
LAT-TD-07155-01- LAT FSW Qualification Test Procedure: FECALB_004: Charge Injection Calibration – ACD Charge Injection
LAT-TD-07156-01- LAT FSW Qualification Test Procedure: FECALB_005: Charge Injection Calibration – CAL Charge Injection
LAT-TD-07157-01- LAT FSW Qualification Test Procedure: WBTLMV_001: Wideband Telemetry Verification – Science Data Format and Volume

REASON FOR CHANGE:

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

DISPOSITION OF HARDWARE (IDENTIFY SERIAL NUMBERS):	**DCN DISTRIBUTION:**
☒ **No hardware affected (record change only)**	
☐ **List S/Ns which comply already:**	
☐ **List S/Ns to be reworked or scrapped:**	
☐ **List S/Ns to be built with this change:**	
☐ **List S/Ns to be retested per this change:**	
☐	

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

APPROVALS	DATE	OTHER APPROVALS (specify):	DATE
ORIGINATOR: M. DeKlotz (signature on file)	8/16/05		
ORG. MANAGER: D. Horn (signature on file)	8/16/05		
PSA- K. Burlingham (signature on file)	8/16/05		
DCC RELEASE: Natalie Cramar (signature on file)	8/16/05	Doc. Control Level: ☒ Subsystem ☐ LAT IPO ☐ GLAST Project	

Continuation:

LAT-TD-07158-01- LAT FSW Qualification Test Procedure: FILMGT_001: File Management Verification

LAT-TD-07159-01- LAT FSW Qualification Test Procedure: MEMMGT_002: Memory Load Data

LAT-TD-07160-01- LAT FSW Qualification Test Procedure: NBTLMV_003: ACD HSK Anomaly Response and Alert Telemetry Verification

LAT-TD-07161-01- LAT FSW Qualification Test Procedure: OPMODE_001: LAT Operational Mode Control

LAT-TD-07162-01- LAT FSW Qualification Test Procedure: THRMCS_001: LAT Thermal Control System

LAT-TD-07163-01- LAT FSW Qualification Test Procedure: VSGIFV_001: Discrete Signal Interfaces

LAT-TD-07164-01- LAT FSW Qualification Test Procedure: CMDFNC_003: 1553 Interface and Command Functional Verification

LAT-TD-07054-01- LAT FSW Qualification Test Procedure: EVTPMO_001: Event Performance Monitoring and Verification – Software-Related Deadtime

LAT-TD-07055-01- LAT FSW Qualification Test Procedure: EVTPMO_002: Event Performance Monitoring and Verification –Acquisition of VETO Rates from the GEM

LAT-TD-07056-01- LAT FSW Qualification Test Procedure: EVTPMO_003: Event Performance Monitoring and Verification – Level 1 Trigger Rates

LAT-TD-07057-01- LAT FSW Qualification Test Procedure: EVTPMO_004: Event Performance Monitoring and Verification – Monitor CNO Rates

LAT-TD-07112-01- LAT FSW Qualification Test Procedure: EVTFIL_001: Event Filtering – Interface from the Event Builder

LAT-TD-07113-01- LAT FSW Qualification Test Procedure: EVTFIL_002: Event Filtering – Event Filter Rates and Capacity

LAT-TD-07114-01- LAT FSW Qualification Test Procedure: EVTFIL_003: Event Filtering – Event Filter Reprogramming

LAT-TD-07115-01- LAT FSW Qualification Test Procedure: EVTFIL_004: Event Filtering – Event Filter Bypass

	Document #	Date effective
	**LAT-TD-07162-01**	8/16/05
	Author(s) Sergio Maldonado	Supersedes
	Subsystem/Office Electronics & DAQ Subsystem	

Document Title

LAT FSW Qualification Test Procedure:

THRMCS_001: LAT Thermal Control System

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
01	8/16/05	Original

TABLE OF CONTENTS

1. SCOPE

This document describes the procedure followed for qualification testing of the LAT FSW. This Qualification Test Procedure document describes one of the qualification tests executed to verify compliance with the requirements defined in the "Flight Software Specification – Level III" (LAT-SS-00399).

1.1 Test Suite

THRMCS

This suite of tests verifies that the SIU FSW can properly execute the algorithms of the TCS (Thermal Control System) implementation, and that the TCS implementation successfully maintains the LAT within thermal limits.

1.2 Test ID

THRMCS_001

THRMCS_001 verifies FSW support for the LAT thermal control software (LTC) configuration, file handling, command, control, and telemetry.

1.3 Requirement(s) Tested

The Qualification Test Procedure described herein is performed to verify that the FSW satisfies the following requirement(s), quoted from the Flight Software Specification – Level III:

Requirement Number	Requirement Name	Requirement	Level of Requirements Verification in This Test
5.3.19.1.1	Sensor to ADC Mapping	[26] (11.3) The SIU FSW shall receive as input a mapping, stored onboard and updatable by telecommand, of various LAT temperature sensors to physical Analog-to-Digital Converters (ADCs).	Full

Requirement Number	Requirement Name	Requirement	Level of Requirements Verification in This Test
5.3.19.1.2	Set of Sensors to be Read	[26] (11.3) The SIU FSW shall receive as input the set of sensors to be read and reported in telemetry, stored onboard and updatable by telecommand.	Partial (fully verified during LAT thermal testing)
5.3.19.1.3	Set of Sensors for Algorithm	[26] (11.3) The SIU FSW shall receive as input the set of sensors to be used in the TCS control algorithm, stored onboard and updatable by telecommand.	Full
5.3.19.1.4	Raw ADC Data	[26] (11.3) The SIU FSW shall acquire raw data from the ADCs as input to the TCS control algorithm or for telemetry output,.	Partial (fully verified during LAT thermal testing)
5.3.19.1.5	Control Parameters	[26] (11.3) The SIU FSW shall receive as input a set of 5 control parameters, stored onboard and updatable by telecommand, for each of the heat pipes. These parameters are Reservoir Low Temperature, Reservoir High Temperature, Radiator Interface Temperature (RIT) Low Limit, RIT High Limit, and RIT minus Reservoir delta temperature limit.	Full
5.3.19.2	Thermal Control Initialization	[26] (11.3) Upon command, the FSW shall initialize active thermal control by identifying the set of inputs stored onboard (ADC parameters, active sensors & heaters, control & monitoring parameters).	Full
5.3.19.3	Convert ADC to Temperature	[26] (11.3) The SIU FSW shall convert received ADC data into temperature values needed by the TCS control algorithm.	Full

Requirement Number	Requirement Name	Requirement	Level of Requirements Verification in This Test
5.3.19.4	Filter Input	[26] (11.3) The SIU FSW shall filter temperature input for values inconsistent with physically possible temperature variations.	Full
5.3.19.5	Determine Heater Setting	[26] (11.3) The SIU FSW shall determine whether to turn on or off individual heaters, based on the inputs, in accordance with [32].	Full
5.3.19.6	Shut-Down	[26] (11.3) The SIU FSW shall shut down active closed loop control of the TCS, upon receipt of command from the spacecraft.	Full
5.3.19.8	Load Shedding Action	[26] (11.3) Upon receipt of a load shedding command from the spacecraft, the SIU FSW shall stop opening the TCS watchdog switch and send a signal indicating the action taken.	Full
5.3.19.10	Watchdog Open	[26] (11.3) Upon receipt of the appropriate command, the FSW shall open the TCS watchdog switch at a rate greater than 0.1 Hz.	Full
5.3.19.11	Watchdog Stop	[26] (11.3) Upon receipt of the appropriate command, the FSW shall stop opening the TCS watchdog switch.	Full
5.3.19.12	Heater Control Signals	[26] (11.3) The SIU FSW shall output signals, indicating which heaters should be turned on and which should be turned off.	Full

Requirement Number	Requirement Name	Requirement	Level of Requirements Verification in This Test
5.3.19.13	TCS Telemetry	[26] (11.3) At least once every 10 seconds, a telemetry packet shall be composed to monitor the TCS, including: identification of active sensors, identification of active heaters, status for each heat pipe (ok | primary sensor bad | secondary sensor bad | both bad), input temperatures, and algorithm results.	Full

If the requirement(s) quoted above cite external documents (e.g., "…Further details are provided in [11]"), consult LAT-SS-00399 for the list of citations.

2. DEFINITIONS AND ACRONYMS

The following terms, abbreviations, and acronyms are used in this document:

2.1 Definitions

Hz	Hertz, unit of frequency
s, sec	Seconds
V	Volt
W	Watt

2.2 Acronyms

ADC	Analog-to-Digital-Converter
CAL	Calorimeter
EGSE	Electrical Ground Support Equipment
GASU	Global trigger Anti-collision Spacecraft Unit
LIM	LAT Instrument Manager (Mode Controller)
LHK	LAT Housekeeping
LTC	LAT Thermal Control
PTR	Post Test Review
TEM	Tower Electronics Module
TKR	Tracker
TPS	Tower Power Supply
TRR	Test Readiness Review
QAE	Quality Assurance Engineer
TE	Test Engineer
1 PPS	One Pulse per Second

3. REFERENCES

The list below provides documents that are to be used as references for this procedure:

3.1 Applicable Documents

Document Number	Description
SPECIFICATIONS	
LAT-SS-00399	LAT Flight Software Level III Specification
1196 EI-S46310-000	GLAST 1553 Bus Protocol Interface Control
LAT-TD-02659	LAT Flight Software Telecommand and Telemetry Formats
LAT-TD-0561	The Virtual Spacecraft (VSC)
LAT-TD-05956	GLAST LAT Radiator VCHP Reservoir Heater Control Algorithm Description
PROCEDURES	
N/A	
PLANS	
LAT-MD-00039	Performance Assurance Implementation Plan
LAT-MD-00078	GLAST LAT System Safety Program Plan
LAT-MD-00404	LAT Contamination Control Plan
LAT-MD-00408	LAT Program Instrument Performance Verification Plan
LAT-SS-00296	T & DF Test Plan
LAT-TD-00297	LAT Electronics Test Plan
LAT-TD-00786	LAT Flight Software Test Plan
LAT-MD-00104	LAT FSW Management Plan
DRAWINGS	
N/A	
OTHER	
LAT-MD-00091	GLAST Quality Manual
LAT-MD-00471	Control of Nonconforming Product
LAT-MD-00472	Corrective and Preventative Action

4. REQUIREMENTS

This section lists the requirements that shall be followed during the LAT FSW Qualification Testing process.

The Performance Assurance Implementation Plan, LAT-MD-00039, shall be utilized to ensure that the products produced by the GLAST LAT project intended for design qualification, flight and critical ground support equipment usage meet the required levels of quality and functionality for their intended purposes.

The LAT Program Instrument Performance Verification Plan, LAT-MD-00408, shall be utilized to address the testing to be performed at the unit/subsystem and instrument level for flight qualification, proto-flight and acceptance testing phases. Also included are the necessary processes/procedures and systems assurance activities.

4.1 Test Data, Equipment and Software

This procedure shall follow the requirements found in the Control of Nonconforming Product, LAT-MD-00471. This document establishes the method to identify and control nonconforming product developed by the LAT project team.

4.2 Quality Assurance

This procedure shall follow the requirements found in the Corrective and Preventative Action document, LAT-MD-00472 and the GLAST Quality Manual, LAT-MD-00091.

The Corrective and Preventative Action document establishes the method to be used to initiate, implement, evaluate and record corrective and preventive actions. The GLAST Quality Manual defines the methods implemented by the GLAST LAT project to ensure consistent quality of all processes for procurement, design, development and production of flight hardware, flight software and all associated ground support equipment interfacing with flight hardware and software.

4.3 Safety

This procedure shall follow the requirements found in the GLAST LAT System Safety Program Plan, LAT-MD-00078. This document defines all phases of the LAT program including: design, development, fabrication, handling, transportation, storage, test, assembly and operation.

WARNING: When high voltages are present extreme care should be exercised.

4.4 Warnings, Cautions, and Notes

The following SAFETY ALERTS are intended to create awareness of the potential safety hazards and the steps that must be taken to avoid accidents. These same alerts are used throughout this document to identify specific hazards that may endanger personnel and/or equipment.

Identification of every conceivable hazardous situation is impossible. Therefore, all personnel have the responsibility to diligently exercise safe practices whenever exposed to this equipment.

WARNING: Indicates a potential hazardous situation which, if not avoided, could result in death or injury.

CAUTION: Indicates a potential hazardous situation which, if not avoided, could result in damage to equipment.

Note: Indicates a notification of information that is important, but not hazard related.

4.5 General Instructions

This qualification test procedure shall be conducted on a formal basis to its latest approved and released version. The designated Software QAE shall be notified 24 hours prior to the start of this procedure. Software QAE may monitor the execution of all or part of this procedure should they elect to do so.

The Test Engineer conducting this test shall read this document in its entirety and resolve any apparent ambiguities before beginning the procedures described herein.

Deviations from the procedures described in this document and breaks in hardware or software configuration can only be initiated by the Test Engineer, must be approved by QA, and must be documented in Appendix A.

Any nonconformance/defect/anomaly is to be reported in JIRA. Refer to the LAT Flight Software Test Plan LAT-TD-00786 for guidance. Do not alter or break configuration if a failure occurs. Notify Software Quality Assurance.

All success conditions for a test must be met for the test to pass.

5. SETUP

This section describes the hardware and software configuration used for the qualification test described later in this document. Any break from configuration or deviation from a particular procedure must be authorized by the Quality Assurance Engineer and documented in Appendix A.

5.1 Hardware Setup

The list below indicates the equipment that is used to execute the tests described in this document.

Hardware Unit	Manufacturer	GLAT Number (and Hardware Sub-Units by GLAT Number)	Firmware Version (where applicable)
Virtual Spacecraft (VSC)	SLAC		
Spacecraft Interface Unit (SIU)	SLAC		
Global Trigger AEM Signal Distribution Unit (GASU)	SLAC		
Power Distribution Unit (PDU)	SLAC		
1553 cables and couplers	SLAC		
Unix or Linux Host Establishes connection between VSC and the terminal from which the test is run.			
Power supply for SIU	SLAC		

The Figure below depicts the Testbed on which this qualification test is performed. The particular hardware units utilized in this test are itemized by GLAT number and firmware version in the

preceding table.

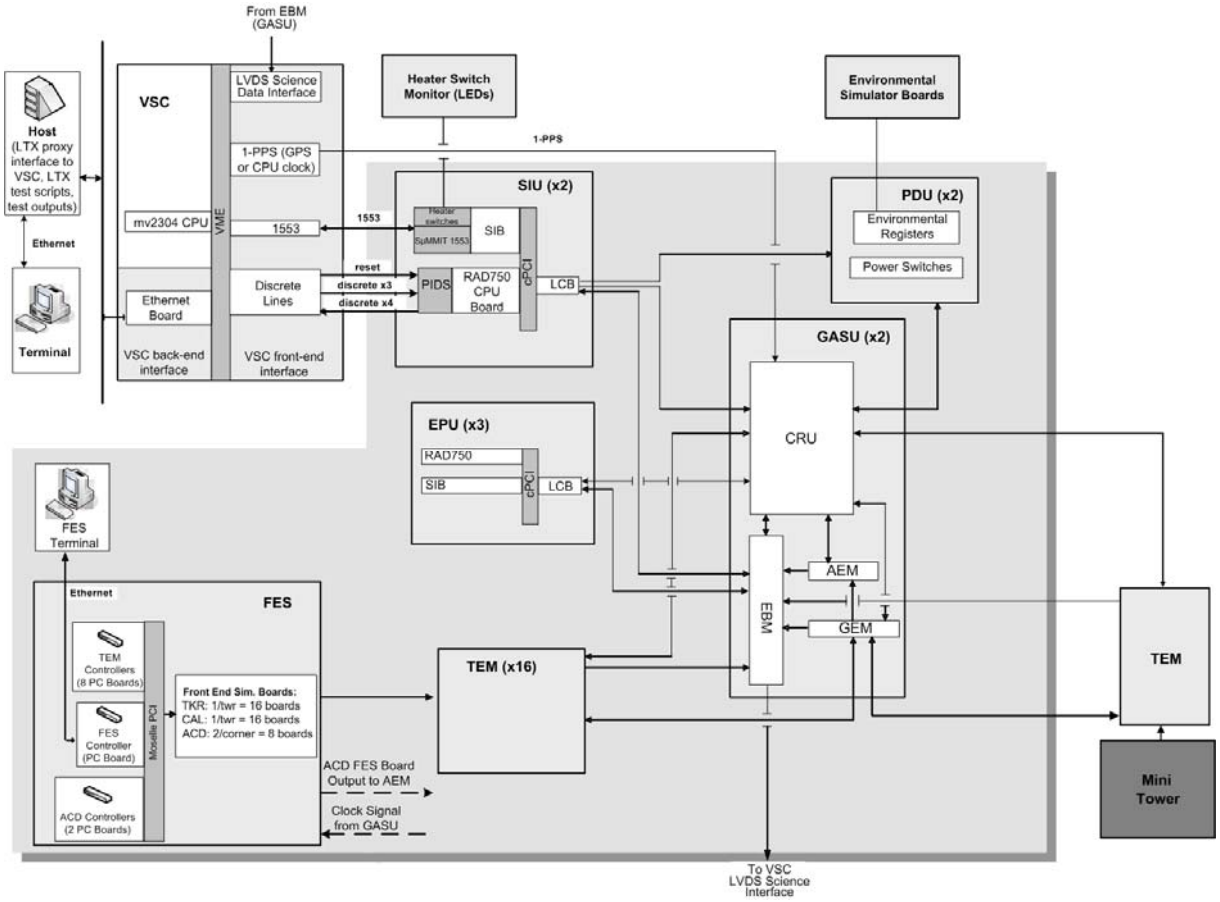

Figure 1. FSW Testbed

5.2 Software Setup

The software required to prepare for and execute the tests described in this Qualification Test Procedure document is itemized in this section.

5.2.1 Test Tools

The following table specifies the test executive used to run this qualification test, and identifies the other software tools used to support the execution of the test. The “Software Version Number” column identifies the version number of the test tool being used; alternatively, this column identifies the hardcopy attachment to this document that records the version of the tool being used (e.g., “Attachment 1”). The “Path to Attachment” column identifies the directory in which the electronic copy of any hardcopy attachment is saved (if applicable).

Software	Description of Software	Software Version Number (or Specify Attachment Number)	Path to Attachment (If Applicable)
LTX	LAT Test Executive		
VSC	Virtual Spacecraft system software		
VPI	VSC Python/Proxy Interface		
ADCSIM	ADC simulator software. Simulates raw ADC values read from the TEM, PDU, and ACD hardware by intercepting LCB command lists and encoding the data in the corresponding result lists.		

5.2.2 Test Scripts

The following table identifies the test scripts that are run to execute this qualification test. The "Script Version Number" column identifies which version of the script is being used; alternatively, this column identifies the hardcopy attachment to this document that records the version of the script being used (e.g., "Attachment 1"). The "Path to Attachment" column identifies the directory in which the electronic copy of any hardcopy attachment is saved (if applicable).

Test Script	Description of Test Script	Script Version Number (or Specify Attachment Number)	Path to Attachment (If Applicable)
THRMCS_001.py	This script, the main test execution script, tests FSW operating in Application Mode. It executes tests of SIU FSW. The script controls the entire test process, detecting the state of the hardware and FSW and advancing SIU FSW through the different necessary operational modes required to execute the test.		
THRMCS_001_analyze.py	Post-processing result analysis script.		

5.2.3 Flight Software

This qualification test is performed on a complete, integrated Candidate Release of FSW. All FSW libraries under test are final Flight Unit Candidate versions. The test described in this document is

designed to evaluate the particular FSW packages and constituents listed in the following table; for clarity, only those packages and constituents that are the focus of the test are listed below.

FSW Package	Constituent(s)
LTC	
LHK	
LIM	

The Candidate Release into which these FSW constituents are integrated is identified in the following table. The "Candidate Release Build Number" column specifies the build number of the FSW Candidate Release under test (e.g., "B0-0-1"). The "Candidate Release Attachment Number" column identifies which hardcopy attachment to this document confirms the name and version number of the full set of FSW packages and constituents used in the test (e.g., "Attachment 2"). The "Path to Attachment" column specifies where in the test repository an electronic copy of the hardcopy attachment has been saved.

Candidate Release Build Number	Candidate Release Attachment Number	Path to Attachment

5.3 Setup Validation

5.3.1 Hardware Validation

The following signatures confirm that the Test Engineer and Quality Assurance Engineer have verified the GLAT numbers, firmware version numbers, and the proper connection of all hardware listed in the table in Section 5.1.

_____	_____	_____	_____
Date	Time	Test Engineer	QAE

5.3.2 Software Validation

The Test Engineer performs the following procedure to validate the software setup for this qualification test and records completion of the setup validation steps in the space provided.

Step No.	Description of Step	Step Outcome
1	Record the version numbers of all test tools used to perform this qualification test in the table in Section 5.2.1	Complete/ Not Complete
2	Record the version numbers of all test scripts used to perform this qualification test in the table in Section 5.2.2	Complete/ Not Complete
3	Record the version numbers of the FSW constituents and the Candidate Release on which this test is performed in Section 5.2.3.	Complete/ Not Complete

The following signatures confirm that, using the procedure described in the previous table, the Test Engineer and Quality Assurance Engineer have verified that all versions of test support software, test scripts, and FSW constituents match those identified in Section 5.2.

_____	_____	_____	_____
Date	Time	Test Engineer	QAE

6. TEST PROCEDURE FOR THRMCS_001

6.1 Test Objective

The strategy employed for testing the LAT thermal control software (LTC) involves the usage of an ADC simulator. The testbed hardware setup does not encompass a method for driving specific values directly into the hardware sensors located on the PDU, with any amount of fidelity. This simulator provides such a mechanism by driving the ADC values at the LCB driver level. The simulator intercepts LCB command lists and generates the appropriate result lists, populated with stored ADC values. These ADC values can be programmatically adjusted using the SIU vxworks command line. The usage of this simulator still offers a black box style of testing the thermal control software. The simulator simply overrides the LCB hardware driver, while preserving all other LTC interfaces. The LTC software is not at all compromised or otherwise modified. This method will permit the amount of fidelity required to fully verify the thermal control algorithm, ADC mappings, and heat pipe control.

Exclusive black box testing of the related requirements will be fully satisfied during thermal vacuum testing at NRL, where the hardware sensor input can be directly controlled using a realistic thermal environment, without the use of any software or hardware simulations.

Number	Test Sub-Objective
1	Verify successful input, by file, of temperature sensors to ADC mapping

Number	Test Sub-Objective
2	Verify successful input, by file, of sensors to be read and reported in telemetry
3	Verify successful input, by file, of sensors to be used in the control algorithm
4	Verify successful input, by file, of the 5 control parameters for each of the heat pipes
5	Verify successful initialization by command of thermal control system using input files
6	Verify successful acquisition of raw ADC data as input to the control algorithm and telemetry output
7	Verify successful conversion of acquired ADC data into temperature values
8	Verify successful filtering of inconsistent temperature input values
9	Verify successful heater control in accordance with the provided thermal control algorithm
10	Verify successful shutdown of the active closed loop control
11	Verify successful closing of the thermal control watchdog in response to load shed command
12	Verify successful processing of commands for the thermal control watchdog switch state
13	Verify successful processing of command that opens the thermal control watchdog at rate greater than 0.1 Hz
14	Verify successful reporting of heater on/off states
15	Verify successful delivery and content of thermal control telemetry

Analysis of results is performed as and when data arrives in telemetry. Typically analysis includes verifying the telemetry values against expected values and tagging the sub-objectives as either “PASS” or “FAIL”.

6.2 Test Input Files

The following table identifies all auxiliary files (e.g., Front End Simulator data files, GLEAM data files) used as inputs to this qualification test. Note that not all qualification tests use input data of this type. The “Input File Version Number” column identifies the version number of the auxiliary file being used; alternatively, this column identifies the hardcopy attachment to this document that records the version of the file being used (e.g., “Attachment 1”). The “Path to Attachment” column specifies where in the test repository an electronic copy of the hardcopy attachment has been saved.

Input File	Description of Input File	Input File Version Number (or Specify Attachment Number)	Path to Attachment (If Applicable)
TBD0.f	LTC heat pipe configuration file		
TBD1.f	LTC sensor configuration file		

Input File	Description of Input File	Input File Version Number (or Specify Attachment Number)	Path to Attachment (If Applicable)
VPI_ltc_mne.txt	VPI configuration file with LTC telemetry archiving activated		

6.3 Test Output Files

The following table identifies all files used as outputs to this qualification test. Note that not all qualification tests use output data of this type. The "Output File Version Number" column identifies the version number of the auxiliary file being used; alternatively, this column identifies the hardcopy attachment to this document that records the version of the file being used (e.g., "Attachment 1"). The "Path to Attachment" column specifies where in the test repository an electronic copy of the hardcopy attachment has been saved.

Output File	Description of Output File	Output File Version Number (or Specify Attachment Number)	Path to Attachment (If Applicable)
VPI_ltc_mne_mmddyy_hhmmss.csv	Telemetry mnemonic archive file generated by VSC proxy interface (VPI)		

6.4 Test Preparation

After the hardware and software setup has been validated, steps may be required to place the hardware and FSW in an operational mode in which the qualification test can be performed or otherwise complete preparations for the test to begin.

The Test Engineer carries out the following procedure to prepare for qualification testing and records completion of the test preparation steps in the space provided.

Step No.	Description of Step	Step Outcome
1	Confirm that the VSC is powered up.	Complete/ Not Complete

Step No.	Description of Step	Step Outcome
2	Confirm that the SIU and the GASU are powered up: The voltage indicator on the SIU/GASU Xantrex power supply should display 28 ± 0.2V. The SIU feed "POWER ON" switch on the regulated feeds bus protection unit (BPU) should be flipped "ON". The SIU voltage indicator on the BPU should display 28 ± 0.2V. The SIU current as shown by the BPU indicator should be above 0.4A The DAQ feed "POWER ON" switch on the BPU should be flipped "ON". The DAQ voltage indicator on the BPU should display 28 ± 0.2V.	Complete/ Not Complete

6.5 Test Procedure

This section describes the step by step procedure performed once the test preparation is complete. The Test Engineer proceeds with the qualification test procedure itself, as described below, and records the outcome of each step during test execution. The outcome of each step is either "Complete" or "Not Complete" (for steps which involve no analysis or verification).

The following LTC telecommands and telemetry are used in this test:

LTC Telecommands

APID	FC	Cmd. Packet	Description
0x645	1	LTCRESTART	Restart and reinitialize LTC
0x645	2	LTCSTART	Start LTC
0x645	3	LTCSTOP	Stop LTC
0x645	4	LTCSETMODE	Set LTC mode
0x645	5	LTCHTRONOFFCNTL	Set LTC heater control
0x645	6	LTCSETPARAM	Set LTC control parameters

LTC Telemetry

APID	Tlm. Packet	Description
0x22e	LtcData0	LTC Housekeeping Telemetry
0x22f	LtcData1	LTC Housekeeping Telemetry
0x230	LtcData2	LTC Housekeeping Telemetry
0x231	LtcData3	LTC Housekeeping Telemetry

0x2bc DiagLTC LTC Diagnostic Telemetry

Step No.	Description of Step	Step Outcome
1	At the test terminal, run the script *THRMCS_001* under LTX through the VSC with the following command: **$ ltx run THRMCS_001**	Complete/ Not Complete
2	The test script determines whether the SIU is powered on by checking whether SIU boot housekeeping telemetry is being transmitted. Regardless of the SIU's current operational mode, the script sends the SIU the LPBCRESET telecommand to reboot the unit. The script then checks whether the SIU FSW is operating in Boot Mode by detecting if boot housekeeping is being transmitted. If not, the script sends the LPBCRESET command and checks again. If the SIU FSW cannot be placed in Boot Mode, LTX prints an error message to the screen and exits, aborting the test. If the test is NOT aborted, mark "Complete" for the Step Outcome.	Complete/ Not Complete
3	The script initializes the VSC software and starts proxy interface using the input file VPI_ltc_mne.txt telemetry configuration file. Output file VPI_ltc_mne_mmddyy_hhmmss.csv is created in the test session directory and the full path and filename of the soft copy of this output file is recorded in section 6.3 of the procedure document.	Complete/ Not Complete
4	With FSW on the SIU in Boot Mode, send PBCRTOSEXEC telecommand to advance to secondary boot.	N/A
5	After completion of secondary boot, FSW modules are loaded and the SIU is placed in TERMINAL mode. Housekeeping telemetry LHKxxx shows LIM reporting terminal mode. LTC is initialized with default built-in settings.	N/A
6	Send telecommand LIMMAINFEEDON to initialize the LCB, PDU, and GASU. Housekeeping telemetry LHKxxx reports LIM in QUIESCIENT mode.	N/A
7	The ADCSIM constituent adcsim is dynamically loaded from CMX binary tree using the vxworks command: ld <0,1,"/afs/slac.stanford.edu/g/glast/flight/FST/binary/ADCSIM/prod/rad750/adcsim/libadcsim.o" All simulated ADC heat pipe sensor inputs are set to nominal. These values are specified using the vxworks command line interface with the function ADCSIM_setPduEnvData(). The function call takes the group, bank, ADC number, and value corresponding to the nominal values defined to be within limits as specified in TBD0.f.	N/A
8	Telecommand LTCRESTART is issued with file ID parameters consistent with TBD0.f and TDB1.f. This command updates all input values from the default settings to values read from the file stored in the onboard file system.	N/A
9	ADC input sensors are loaded with values inconsistent with nominal temperatures for a duration of 10 to 20 seconds, to enable the LTC smoothing process. These simulated values are loaded using the vxworks command line interface with the function ADCSIM_setPduEnvData(). The function call takes the group, bank, ADC number, and value.	N/A

Step No.	Description of Step	Step Outcome
10	The telecommand LTCSETTLMFREQ is issued with a value of 1. This will cause an LTC specific diagnostic packet to be emitted once per second. To exercise a 1 Hz watchdog processing rate, ADC input sensors are changed once every second, at values within limits, for 20 seconds.	N/A
11	ADC input sensors are loaded with values that exercise the 28 different combinations specified in the thermal control algorithm document. Each combination is sustained for 5 seconds to allow for sufficient telemetry data to be sent. These simulated values are loaded using the vxworks command line interface with the function ADCSIM_setPduEnvData(). The function call takes the group, bank, ADC number, and value.	N/A
12	Telecommand LTCSETMODE is issued with parameters set to enable PASSIVE mode for all heaters. Telecommand LTCHTRONOFFCNTL is issued with parameters set to turn OFF all heaters. Procedure step 11 is repeated to ensure that the active control loop was disabled, and the heaters remain in the OFF state.	N/A
13	Telecommand LTCSTOP is issued to stop the nominal control loop. Telecommand LTCHTRONOFFCNTL is issued with parameters set to turn OFF all heaters. This enables closing of the watchdog switch. After a duration of 60 seconds, the watchdog times out, and all heaters are set to ON.	N/A
14	Telecommand LTCSTART is issued to restart the nominal control loop with PASSIVE heat pipe control enabled. This opens the watchdog switch at the default rate of 1 second. LTCHTRONOFFCNTL is issued with parameters set to turn OFF all heaters.	N/A
15	Telecommand LTCHTRONOFFCNTL is issued with parameters set to turn OFF all heaters.	N/A
16	Telecommand LIMLOADSHED is issued to force closing of the TCS watchdog. After a duration of 60 seconds, the watchdog times out, and all heaters are set to ON.	N/A

Initial to confirm.

_____	_____	_____	_____
Date	Time	Test Engineer	QAE

6.6 Test Analysis

The analysis for each of the sub-objectives is conducted by the main analysis script THRMCS_xxx. “Pass” or “Fail” is specified for steps involved in verifying completion of test objectives and sub-objectives.

Step No.	Description of Step	Step Outcome
1	At the conclusion of the test run, the analysis script *THRMCS_001_analyze.py* is autonomously executed: Review the terminal output of the analysis script for: **Analyzing test output**	Complete/ Not Complete

Step No.	Description of Step	Step Outcome
2	Telemetry data archive file VPI_ltc_mne_mmddyy_hhmmss.csv is loaded. Mnemonic values for LTCHPxSELRESHPN, LTCHPxSELRITHPN LTCHPxRESTYP, and LTCHPxRITTYP are extracted, where x=[0-11]. These values represent the mapping read from TBD1.f. Each value is compared against the values specified in TBD1.f. All mapped sensor values match exactly to the specified input file, thereby verifying sub-objective 1. Review the terminal output of the analysis script for: **Temperature sensor to ADC mapping data validated: 0: PASS**	Pass/ Fail
3	Telemetry data archive file VPI_ltc_mne_mmddyy_hhmmss.csv is parsed for mnemonic values LTCHPxRAWADCy where x=[0-11] and y=[0-5]. Input file TBD1.f specified all sensors to be read, used in the control algorithm, and reported. Each ADC value is compared against the simulated input values for all specified mnemonics, thereby verifying sub-objectives 2, 3, and 6. Review the terminal output of the analysis script for: **Temperature sensor selection data validated: 0: PASS** **Raw ADC sensor acquisition data validated: 0: PASS**	Pass/ Fail
4	Telemetry data archive file VPI_ltc_mne_mmddyy_hhmmss.csv is parsed for mnemonic values: LTCHPxRITLOLIM, LTCHPxRITHILIM , LTCHPxRESLOLIM , LTCHPxRESHILIM ,LTCHPxDBDLTLIM, where x=[0-11]. Input file TBD1.f specified control parameters for each heat pipe. Each input control parameter is matched to the output telemetry value, thereby verifying sub-objective 4. Review the terminal output of the analysis script for: **Heat pipe control parameter data validated: 0: PASS**	Pass/ Fail
5	Verification of sub-objectives 1 through 4 constitutes a successful initialization of the thermal control system by file, in response to the LTCRESTART telecommand. This verifies sub-objective 5 **Thermal control initialization by file validated: 0: PASS**	Pass/ Fail
6	Telemetry data archive file VPI_ltc_mne_mmddyy_hhmmss.csv is parsed for mnemonic values LTCHPxRITTEMP and LTCHPxRESTEMP where x=[0-11]. These values represent the converted ADC values to temperatures in degrees Celsius. Each raw ADC value extracted in step 3 is converted to a Celsius temperature using the conversion table specified by the PDU/RTD circuit vendor Goodrich Model 0118MF and the PDU/thermistor circuit vendor YSI 44900 resistance-temperature relationship table. Each calculated value is compared to the telemetry output to verify correct conversion of raw ADC values to temperatures, thereby verifying sub-objective 7. Review the terminal output of the analysis script for: **Raw ADC conversion to degrees Celsius verified: 0: PASS**	Pass/ Fail

Step No.	Description of Step	Step Outcome
7	The Celsius temperature values extracted from telemetry in step 6 are compared against the simulated inconsistent ADC input values. None of the inconsistent input values were used as input in the conversion, demonstrating filtering of bad values, thereby verifying sub-objective 8. Review the terminal output of the analysis script for: **ADC bad value filtering validated: 0: PASS**	Pass/ Fail
8	In order to verify successful thermal control algorithm execution, all 28 possible heater outcome states, as defined in the thermal control algorithm document, were exercised for each heat pipe. The temperature values extracted in step 6 are used to verify that the input read by the LTC is consistent with the input specified for all 28 possible states. Telemetry data archive file VPI_ltc_mne_mmddyy_hhmmss.csv is parsed for mnemonic values LTCACTVHP, which represents the on/off status of each heat pipe. For each of the 28 combination, this mnemonic value is verified to be consistent with the expected outcome of the algorithm, thereby verifying sub-objective 9. Reporting of the active heat pipe states in telemetry also verifies sub-objective 14. Review the terminal output of the analysis script for: **Thermal control algorithm execution validated: 0: PASS** **Heater on/off state telemetry validated: 0: PASS**	Pass/ Fail
9	Procedure step 12 commanded all heaters to the OFF state and commanded the control loop processing to PASSIVE mode. Telemetry LTCACTVHP, which represents the on/off status of each heat pipe, is verified to report all heaters OFF. Telemetry LTCHTRCMD is validated to report a value of 0 for all heat pipes, which denotes PASSIVE mode for all heaters. These telemetry items were verified to not change state for the duration of repeated algorithm input exercised in procedure step 11. This demonstrates that the active control loop was successfully disabled by command, thereby verifying sub-objective 10. Review the terminal output of the analysis script for: **Commanded shutdown of active heater control validated: 0: PASS**	Pass/ Fail
10	In response to the LTCSTOP telecommand issued in procedure step 13, all thermal control processing was terminated, which closed the watchdog switch after 60 seconds. This was verified by telemetry LTCACTVHP reporting all heaters OFF prior to the LTCSTOP command being issued, and reporting ON 60 seconds after the command was issued. In response to the LTCSTART telecommand, all thermal control processing was reactivated, thereby reopening the watchdog switch. After 60 seconds, telemetry LTCACTVHP is validated to report a value of 0 or OFF for all heaters, which verifies that the watchdog did not expire, and the thermal control system is actively opening the watchdog switch at a rate grater than 0.1 Hz, thereby verifying sub-objectives 13 and 14. Review the terminal output of the analysis script for: **Watchdog open/close validated: 0: PASS** **Watchdog rate validated: 0: PASS**	Pass/ Fail

Step No.	Description of Step	Step Outcome
11	In response to the LIMLOADSHED command, the watchdog is closed after 60 seconds, and all heaters are turned ON. Telemetry LTCACTVHP is validated to report the transition of all heaters from the OFF state prior to issuing the command, to the ON state, 60 seconds after the command was issued. This transition validates the watchdog close response to the load shed command, thereby verifying sub-objective 11. Review the terminal output of the analysis script for: **Load shed heater control response validated: 0: PASS**	Pass/ Fail
12	The timestamp for each thermal control telemetry packet received is extracted and all values are compared to demonstrate that each set of 4 packets were delivered at least every 10 seconds. Successful verification of steps 1 through 13 demonstrates that the telemetry packet content contains identification of active sensors, identification of active heaters, status for each heat pipe (ok | primary sensor bad | secondary sensor bad | both bad), input temperatures, and algorithm results, thereby verifying sub-objective 15. Review the terminal output of the analysis script for: **Telemetry content and delivery rate validated: 0: PASS**	Pass/ Fail

7. TEST POST_CONDITIONS AND OVERALL OUTCOME

7.1 Test Post-Conditions

The following post-conditions are analyzed and verified by the test script as described in "Test Procedure and Test Analysis":

No.	Post-Condition	Post-Condition Met? (Yes/No)
1	LAT flight software is in QUIESCIENT mode as reported by telemetry apid 0x30f mnemonic LIMTOPMODE Terminal displays **LAT MODE: QUIESCIENT**	

The Test Engineer and Quality Assurance Engineer verify that all test post-conditions are met.

_____	_____	_____	_____
Date	Time	Test Engineer	QAE

7.2 Overall Outcome of THRMCS_001

Based on the analysis of the test results, the overall outcome of Test THRMCS_001 is as follows:

☐ **Passed** - all of the expected outcomes for the test were confirmed

☐ **Failed** - one or more of the test outcomes were not confirmed

_____	_____	_____	
	Date	Test Engineer	QAE

8. CERTIFICATION

I certify that the information obtained under this test procedure is as represented and the information recorded in this document is complete and correct. Any deviations from test procedures described herein are identified in Appendix A.

_____ _____ _____

Date Test Engineer (Print Name) Test Engineer (Signature)

I certify that the information obtained through execution of this test procedure is as represented and the information recorded in this document is complete and correct. Execution of the test, storage of the results, and verification of outcomes were carried out in accordance with quality standards defined in the GLAST Quality Manual (LAT-MD-00091).

_____ _____ _____

Date Software QA Engineer (Print Name) Software QA Engineer (Sign)

I certify that the information obtained under this test procedure is as represented and the information recorded in this document is complete and correct. The test procedure, as designed and executed, does indeed verify that the FSW functionality under test satisfies the corresponding requirements from the Flight Software Specification – Level III.

_____ _____ _____

Date FSW Manager (Print Name) FSW Manager (Signature)

APPENDIX A: DEVIATIONS FROM THE QUALIFICATION TEST PROCEDURE

This section details any deviations from the hardware configuration, software configuration, or test procedure followed during the execution of the test or tests described in this Qualification Test Procedure document. All deviations from the approved procedure are agreed to by the Test Engineer and the Software Quality Engineer during the test execution session. All deviations must be reported during the Post Qualification Test Review, where their impact on the test results will be evaluated.

Hardware Deviations

Describe any deviations from the hardware configuration defined in Section 5.1. Name the hardware that was modified and describe the modifications. If hardware is *replaced* during execution of the test, name the replaced hardware, the manufacturer, and list an identification number (e.g., GLAT ID number).

Software Deviations

Describe any changes made to the software configuration under test or the software configuration used to support test execution, as defined in Section 5.2. Give version numbers of all FSW packages and test packages that were modified. Describe how the contents of the modified software load were verified. Describe these deviations for each test that was modified.

Procedural Deviations

Specify any deviations from the test procedure for the test being executed. If this document contains more than one test procedure, list the procedure by number (e.g., “THRMCS_001”). List by number the steps modified or skipped. Provide a numbered sequence listing any added steps. Describe these deviations for each test that was modified.