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	Author(s) Sergio Maldonado	Supersedes
	Subsystem/Office Electronics & DAQ Subsystem	

Document Title

LAT FSW Qualification Test Procedure:

SIUCFG_001: LAT Subsystem Data Collection

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
01	XXXXX	Original

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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

SIUCFG

This suite of tests shall verify the ability of the SIU FSW to communicate with the LAT instrument subsystems for the purposes of configuration and retrieval of housekeeping and low rate science data (rate counters). The tests in this suite also verify the ability of FSW to configure the LAT power systems and the T&DF, TKR, CAL, and ACD subsystems as desired and read back the necessary configuration information to completely determine each subsystem's configuration. Finally, tests in this suite verify that the FSW reports all configuration changes in telemetry.

1.2 Test ID

SIUCFG_001

SIUCFG_001 Verifies that SIU flight software communicates with the hardware subsystems using the LATp protocol (custom LAT CPU-to-CPU serial communications protocol).

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
5.2.1.4	Command, Configuration, and Data Collection Interface to the Instrument Subsystems	[4] (5.3.4-5, 5.5.1-3) The SIU FSW shall communicate with the LAT instrument subsystems for the purposes of configuration and retrieval of housekeeping and low rate science data (rate counters), using the custom command and response hardware and software serial data protocols defined in [18] – [23].	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

CAL	Calorimeter
EGSE	Electrical Ground Support Equipment
GASU	Global trigger Anti-collision Spacecraft Unit
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)
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
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		
Event Processing Unit (EPU): 2 (EPU0 and EPU1)	SLAC		
Global trigger, ACD, DAQ, and 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.

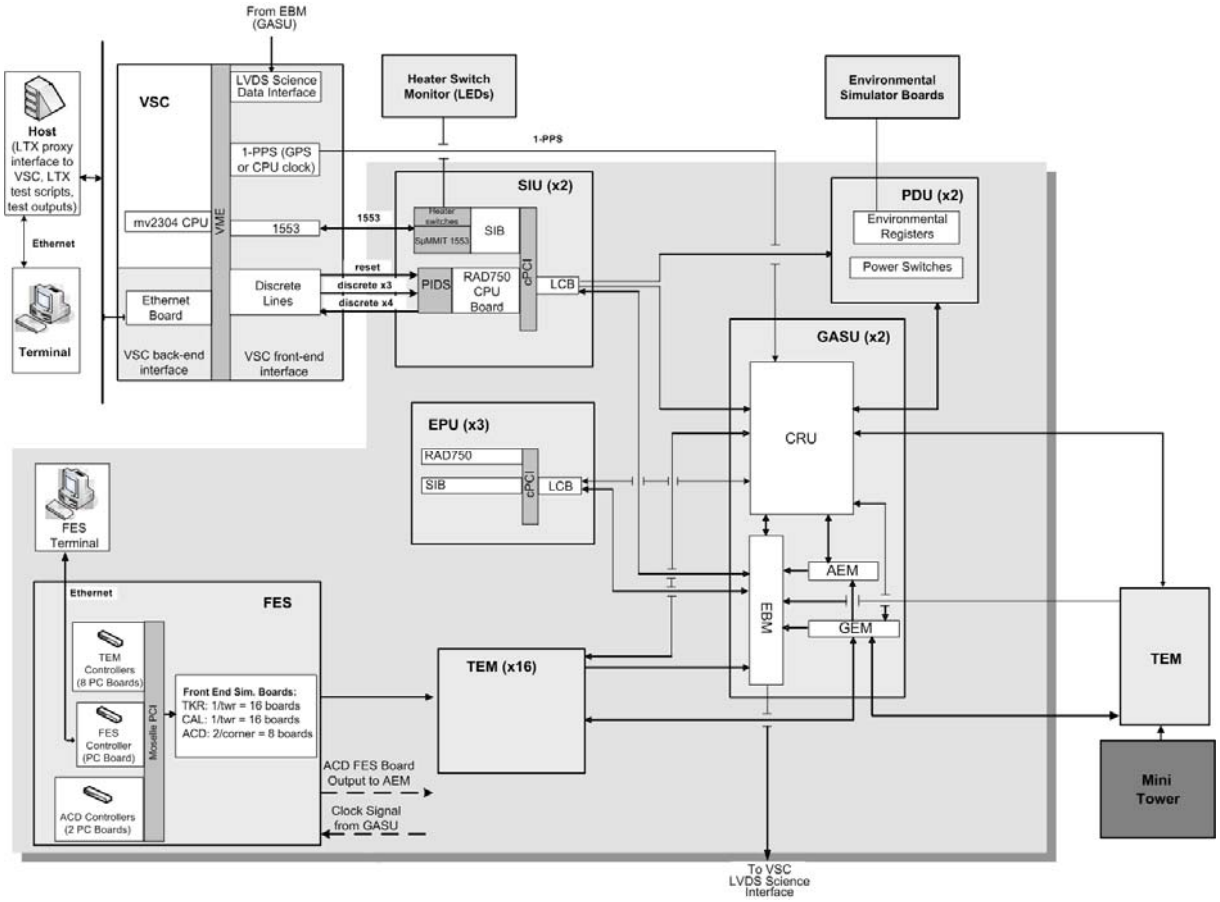

Figure 1. FSW Testbed

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		

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)
SIUCFG_001.py	This script, the main test execution script, tests FSW operating in Application Mode. It executes tests of SIU FSW, EPU0 FSW, and EPU1 FSW. The script controls the entire test process, detecting the state of the hardware and FSW and advancing SIU and EPU FSW through the different necessary operational modes required to execute the test.		
SIU_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)
LHK	

FSW Package	Constituent(s)
LMC	

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

Step No.	Description of Step	Step Outcome
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 SIUCFG_001

6.1 Test Objective

The SIU flight software delegates the transfer of data between the SIU and instrument subsystems. The data format of this exchange is defined by the custom CPU-to-CPU serial message protocol call the LATp hardware protocol. The transfer is physically enabled by the LCB device hardware. Flight software provides the hardware driver, the routing and delivery service layer, and the packet formatting/parsing utilities.

Due to the fact that LATp is a protocol enforced by hardware, all packets sent across the LCB must conform to the specification. If a LATp packet has an incorrect format, it will be rejected by the hardware, not the software. The flight software does not provide the capability to externally monitor the contents of raw LATp packets. Nor does it provide a mechanism that allows for direct manipulation of a LATp packet.

Since direct validation cannot be achieved, only indirect methods can be used to verify proper usage of the LATp protocol. By using telemetry to confirm the presence of message traffic between the SIU and instrument subsystems, and confirm the absence of any hardware error reports, implicit verification of LATp protocol conformance is achieved.

The specific messaging classes that will be utilized are described in Test Sub-Objectives table:

Number	Test Sub-Objective
1	Verify successful delivery of data from the TEM instrument subsystems to the SIU

Number	Test Sub-Objective
2	Verify successful delivery of data from the CAL instrument subsystems to the SIU
3	Verify successful delivery of data from the TKR instrument subsystems to the SIU
4	Verify successful delivery of data from the ACD instrument subsystem to the SIU
5	Verify successful delivery of data from the GASU instrument subsystem to the SIU
6	Verify successful delivery of data from the PDU instrument subsystem to the SIU
7	Verify the absence of any hardware error reports in 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)
lhk_mne.txt	VPI input file to configure archiving of LHK specific mnemonics		
lmc_mne.txt	VPI input file to configure archiving of LMC diagnostic specific mnemonics		
error_mne.txt	VPI input file to configure archiving of error message specific mnemonics		

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.

Input File	Description of Input File	Input File Version Number (or Specify Attachment Number)	Path to Attachment (If Applicable)
VPI_lhk_mne_mmddyy_hhmmss.csv	Telemetry data file output from VSC/Python interface for LHK specific mnemonics.		
VPI_lmc_mne_mmddyy_hhmmss.csv	Telemetry data file output from VSC/Python interface for LMC specific mnemonics.		
VPI_error_mne_mmddyy_hhmmss.csv	Telemetry data file output from VSC/Python interface for error message specific mnemonics..		

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
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).

Step No.	Description of Step	Step Outcome
1	At the test terminal, run the script *SIUCFG_001* under LTX through the VSC with the following command: **$ ltx run SIUCFG_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	Initialize the VSC software and start proxy interface.	N/A
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.	N/A
6	Send telecommand LIMMAINFEEDON to initialize the LCB, PDU, and GASU. Housekeeping telemetry LHKxxx reports LIM in QUIESCIENT mode. Send telecommand LIMPOWERON with parameters set to enable power to all instrument subsystems.	N/A
7	Initialize and start the FES run using input file XYZ to generate data for CAL, TKR, and ACD.	Complete/ Not Complete
8	Send telecommand LMCCALLRS to initiate collection of CAL low-rate science data	N/A
9	Send telecommand LMCTKRLRS to initiate collection of TKR low-rate science data	N/A
10	Send telecommand LMCACDTILEALL to initiate collection of ACD low-rate science data	
11	Wait xx minutes to allow for accumulation of telemetry data.	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 SIUCFG_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 *SIUCFG_xxx* is autonomously executed:	N/A
2	The values for mnemonics LHKT<n>TEM33V and LHKT<n>TEM33V ST are extracted from the housekeeping archive file VPI_lhk_mne_mmddyy_hhmmss.csv, where <n>=0 through 15 for all TEMs. Prior to the powering of the TEMs, the status mnemonics have the value 1, which denotes an unsuccessful attempt at reading the specified TEM registers. Once the power on command was issued, the status values change to a value of 0, which denotes a successful read. The voltage values become non-zero, indicating a successful read of the TEM registers using the LATp protocol, and thereby verifying sub-objective 1.	Pass/ Fail
3	The values for mnemonics LMCCALCNTR<n>VAL are extracted from the diagnostic archive file VPI_lmc_mne_mmddyy_hhmmss.csv, where <n>=0 through 15 for all CALs. The counter values are zero until the FES run is started, and then become non-zero, indicating a successful read of the CAL specific registers using the LATp protocol and thereby verifying sub-objective 2.	Pass/ Fail
4	The values for mnemonics LMCTKRCNTR<n>VAL are extracted from the diagnostic archive file VPI_lmc_mne_mmddyy_hhmmss.csv, where <n>=0 through 31 for all TKRs. The counter values are zero until the FES run is started, and then become non-zero, indicating a successful read of the TKR specific registers using the LATp protocol and thereby verifying sub-objective 3	Pass/ Fail
5	The values for mnemonics LHKAEMFR<n>PWRST are extracted from the diagnostic archive file VPI_lmc_mne_mmddyy_hhmmss.csv, where <n>=0 through 11 for all AEM free boards. Prior to the powering of the ACD and free boards, the status mnemonics have the value 0, which denotes a powered off state for each free board. Once the power on command was issued, the status values change to a value of 1, which denotes a powered on status, and a successful read of the ACD registers using the LATp protocol, and thereby verifying sub-objective 4.	Pass/ Fail
6	The values for mnemonics LMCACDCNT<n>VAL are extracted from the diagnostic archive file VPI_lmc_mne_mmddyy_hhmmss.csv, where <n>=0 through 26 for all sampled tiles present in the packet. The counter values are zero until the FES run is started, and then become non-zero, indicating a successful read of the ACD specific registers using the LATp protocol. Since these registers are located in the GEM, successful LATp communication is demonstrated for the GASU, thereby verifying sub-objective 5.	
7	The values for mnemonics LHKP0TEM<n>PWRST are extracted from the diagnostic archive file VPI_lhk_mne_mmddyy_hhmmss.csv, where <n>=0 through 15 for all TEMs. Prior to the powering of the TEMs, the status mnemonics have the value 0, which denotes a powered off state for each TEM. Once the power on command was issued, the status values change to a value of 1, which denotes a powered on status, and a successful read of the TEM specific PDU registers using the LATp protocol, and thereby verifying sub-objective 6.	
8	The telemetry archive file VPI_error_mne_mmddyy_hhmss.csv parsed for the presence of MSG code 0xabcd denoting any LATp related format errors. If no entries are found, no LATp errors were detected, thereby verifying sub-objective 7.	

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	None	

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 SIUCFG_001

Based on the analysis of the test results, the overall outcome of Test SIUCFG_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., “SIUCFG_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.