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	Subsystem/Office Electronics & DAQ Subsystem	
Document Title <b>LAT FSW Qualification Test Procedure:  FSWINI_003: FSW and LAT Initialization – Multiple Boot Images</b>		

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**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**

#### ***FSWINI***

The Test Suite is a logical grouping of a set of tests based on common functionalities and can be executed as a suite of tests in some order when the pre-conditions and post-conditions for each test within the suite have been met successfully.

This test procedure *FSWINI\_003* belongs in the Test Suite *FSWINI* under the *FST* Project.

### 1.2 **Test ID**

#### ***FSWINI\_003***

Test *FSWINI\_003* contains one main script, *FSWINI\_003*, which can be run when the SIU is unpowered.

#### **Telemetry**

<b>APID</b>	<b>Tlm. Packet (L)</b>	<b>Description (L)</b>
<u>0x200</u>	LBTHKP	Boot housekeeping 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
5.3.1.2.2	Multiple Boot Images	<p>At the start of the boot process, a small section of FSW shall read the checksums of multiple redundant boot images and select the first image with a valid checksum to continue the boot process.</p> <p>Note: This feature mitigates risk associated with potential failure of the SUROM EEPROM.</p>	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
V	Volt
W	Watt
s, sec	seconds

### 2.2 Acronyms

BIST	Built-In Self Test
CAL	Calorimeter
EGSE	Electrical Ground Support Equipment
EMC	Embedded Microcontroller
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

### 3. REFERENCES

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

#### 3.1 **Applicable Documents**

<u>Document Number</u>	<u>Description</u>
<u>SPECIFICATIONS</u>	
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)
<u>PROCEDURES</u>	
N/A	N/A
<u>PLANS</u>	
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
<u>OTHER</u>	
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.

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**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		
1553 cables and couplers	SLAC		
Unix or Linux Host	SLAC		
Power supply for SIU	SLAC		
Corelis crate			
Corelis crate controller PC			

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.

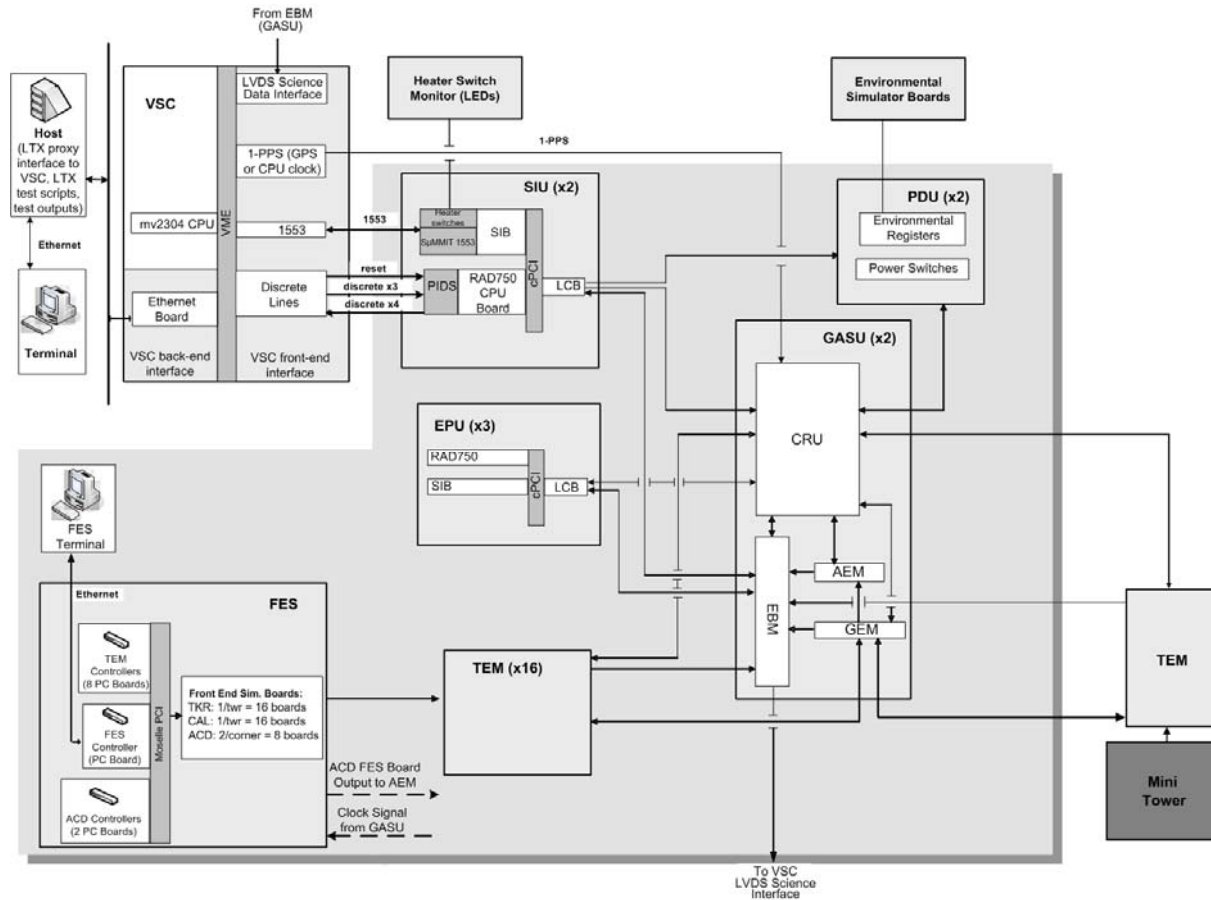


Figure 1. FSW Testbed

## 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		
FMX	File Management Extra		
VSC	Virtual Spacecraft system software		
VPI	VSC Python/Proxy Interface		
Corelis Suite	[[Corelis software]]		
RAD750/emcMap	Boot image linker utility		
emcLd	Corelis image loader (utility in the Corelis Suite)		

**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)
FSWINI_003.py	Main LTX qualification test execution script. This script must be run during the SIU RAD750 crate primary boot. This script verifies the pre-conditions for some tests that need to be conducted in the Boot Mode only.		
FSWINI_003.xml	LTX test description file for test FSWINI_003.		

**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 constituents that are the focus of the test are listed below.

FSW Package	Constituent(s)
PBC	

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	Obtain version numbers of the test tools used to perform this qualification test by running the <b>xxxx</b> script. Pick up and label the hardcopy report generated by the <b>xxxx</b> script and attach it to this test procedure document. Record (1) the label for the attachment in table and (2) the directory location to which an electronic copy of the report was saved in Section 5.2.1.	Complete/ Not Complete
2	Obtain version numbers of the tesc scripts used to perform this qualification test by running the <b>xxxx</b> script. Pick up and label the hardcopy report generated by the <b>xxxx</b> script and attach it to this test procedure document. Record (1) the label for the attachment and (2) the directory location to which an electronic copy of the report was saved in Section 5.2.2.	Complete/ Not Complete
3	Obtain the versions of the FSW packages loaded on the targets by running the <i>version_test</i> script <b>in the Boot mode</b> . Pick up and label the hardcopy report generated by the <i>version_test</i> script and attach it to this test procedure document. Record (1) the label for the attachment and (2) the directory location to which an electronic copy of the report was saved 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 FSWINI 003**

**6.1 Test Objective**

This test verifies that at the start of the boot process, a small section of FSW reads the checksums of multiple redundant boot images and selects the first image with a valid checksum to continue the boot process.

This Test Objective is broken down into the following Test Sub-Objectives:

Number	Test Sub-Objective
1	Verify that boot process starts the first image (image 0) with a valid checksum to continue the boot process.
2	The test confirms the same outcome for boot image 1 (image 0 is corrupted).
3	The test confirms the same outcome for boot image 2, (images 0 and 1 are corrupted).
4	The test confirms the same outcome for boot image 3, (images 0 , 1 and 2 are corrupted)..

## 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)
N/A	N/A	N/A	N/A

## 6.3 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	Power up the Virtual Spacecraft.	Complete/ Not Complete
2	Confirm that 4 primary boot images have been burned into SUROM on the SIU’s RAD750 board.	Complete/ Not Complete

Step No.	Description of Step	Step Outcome
3	Confirm that the SIU crate is ready to power up.	Complete/ Not Complete
4	Start CMX by issuing the following command from the host machine:  <b>\$ cmx start</b>	Complete/ Not Complete
5	On the host machine, change directory to the location of the test scripts by issuing the following command:  <b>\$ cd /afs/slac.stanford.edu/g/glast/flight/FST/source/FSWINI/Vx-x-x/FSWINI_003/</b>	Complete/ Not Complete

The Test Engineer and Quality Assurance Engineer verify that all test preparation steps are complete.

\_\_\_\_\_

Date

\_\_\_\_\_

Time

\_\_\_\_\_

Test Engineer

\_\_\_\_\_

QAE

#### 6.4 Test Procedure

After the test setup has been validated, and test preparation steps are 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); or, “Pass” or “Fail” (for steps involved in verifying completion of test objectives and sub-objectives).

Step No.	Description of Step	Step Outcome
1	From the test terminal, run the test script by issuing the following command:  \$ ltx run FSWINI_003	Complete/ Not Complete

Step No.	Description of Step	Step Outcome
2	<p>Boot the SIU from image 0. There are four redundant images of the Primary Boot Code stored within the RAD750 SUROM. At the beginning of each image is a 32-byte header that contains the image's length and Adler32 checksum (along with other, unused information). Following the completion of PPCI BIST, the EMC finds a valid PBC image and begins executing it. The EMC does this by verifying the checksums of the images and executing the first valid image that it finds. If it finds no valid image, the EMC executes the first image by default.</p> <p>The EMC stores the status of the image selection process in its General-Purpose Register 10. The bits within this 32-bit status value have the following meaning:</p> <p>bits 0-15: Number of EMC vectors handled while verifying images.</p> <p>bits 16-26: Unused.</p> <p>bit 27: Set if no valid image was found and the default image was selected.</p> <p>bit 28: Set if the 4th image was checked because the first 3 images were invalid.</p> <p>bit 29: Set if the 3rd image was checked because the first 2 images were invalid.</p> <p>bit 30: Set if the 2nd image was checked because the first image was invalid.</p> <p>bit 31: Set if the 1st image was checked (should always be set).</p> <p>At reset, the EMC's Vector Anchor Register points to a default vector table located at address FFF00000. When the EMC begins executing the selected PBC image, however, it changes the value of the Vector Anchor Register so that it points to a vector table within the selected image.</p>	Complete/ Not Complete
3	Power down the SIU.	Complete/ Not Complete
4	Remove the SIU's RAD750 board.	Complete/ Not Complete
5	Insert the RAD750 board into the Corelis crate.	Complete/ Not Complete
6	Connect the RAD750 board to the Corelis PC.	Complete/ Not Complete
7	Boot the Corelis crate.	Complete/ Not Complete

Step No.	Description of Step	Step Outcome
8	<p>Corrupt primary boot image 0 according to the following steps.</p> <ul style="list-style-type: none"> <li>- At the test terminal, create a 4 byte file named “dummy.in” with the following UNIX command: echo ABC &gt; dummy.in</li> <li>- At the test terminal, view the contents of “dummy.in” by executing the following command: more dummy.in</li> <li>- Confirm “dummy.in” was saved to the current host directory. At the test terminal, execute the following command: ls -l dummy.in</li> <li>- At the test terminal, link the data in “dummy.in” to a primary boot image to generate the “corrupt” image “bad_sum_0.obj”, using the following command: emcMap -b dummy.in 0x0140c -o bad_sum_0.obj</li> <li>- At the Corelis PC, issue the following command to load the “corrupt” image back to the RAD750 board as image 0:  /cygdrive/c/emcTools/emcLd -b -f bad_sum_0.obj</li> </ul>	N/A
9	Power down the Corelis crate.	Complete/ Not Complete
10	Remove the RAD750 board from the Corelis crate.	Complete/ Not Complete
11	Move the RAD750 board back to the SIU crate and reinsert it.	Complete/ Not Complete
12	Resume execution of FSWINI_003 script by booting the SIU from image 1	Complete/ Not Complete
13	Repeat steps 3-12 for other 3 images. Note: use different object files bad_sum_1.obj-bad_sum_3.obj to corrupt the images.	Complete/ Not Complete
14	<p>LTX automatically sends several output files to the nfs file space. Print the /nfs/slac/g/glast/ltx000/ltx_repos/FST/FSWINI/Vx-x- x/FSWINI_0xx/mmdyy_hhmmss log file, retrieve it from the printer, label it, and attach it to this test procedure.</p> <p>Record the label written on the printed log file: _____</p> <p>Record the full nfs path and filename of the soft copy of this output file:  _____ _____</p>	



**7. TEST POST-CONDITIONS AND OVERALL OUTCOME**

**7.1 Test Post-Conditions**

The expected state of the FSW and/or Testbed at the conclusion of this qualification test is indicated in the following table.

No.	Post-Condition	Post-Condition Met? (Yes/No)
1	Primary boot is complete and the SIU is ready for the secondary boot process.	

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 FSWINI\_003**

Based on the analysis of the test results, the overall outcome of Test FSWINI\_003 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)

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**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).

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**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.

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**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., “MEMMGT\_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.

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