

Software Test Plan and Procedures for the **Core Flight System SP0-VxWorks6.9 Platform Support Package**

Engineering Directorate
Software, Robotics and Simulation Division

Availability:

NASA & NASA contractor employees as required

May 2022
Baseline



National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 2 of 14

Change Record

<i>Revision</i>	<i>Date</i>	<i>Originator</i>	<i>Description</i>
N/A	Oct 2021	Tam Ngo	Initial draft
N/A	May 2022	Tam Ngo	Baseline

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 3 of 14

Table of Contents

1	INTRODUCTION.....	5
1.1	PURPOSE AND SCOPE	5
1.2	RESPONSIBILITY AND CHANGE AUTHORITY.....	5
2	APPLICABLE AND REFERENCE DOCUMENTS	5
2.1	APPLICABLE DOCUMENTS.....	5
2.2	REFERENCE DOCUMENTS	6
2.3	ORDER OF PRECEDENCE.....	6
3	TEST PLAN	6
3.1	TESTING ACTIVITIES	6
3.2	REQUIREMENT TRACEABILITY	7
4	VERIFICATION AND VALIDATION PROCESS	7
4.1	VERIFICATION AND VALIDATION MANAGEMENT RESPONSIBILITIES	7
4.2	VERIFICATION METHODS	7
4.3	VALIDATION METHODS	7
4.4	CERTIFICATION PROCESS	7
4.5	ACCEPTANCE TESTING.....	7
5	SP0-VXWORKS6.9 PSP TEST PROCEDURES	7
5.1	STATIC CODE ANALYSIS	7
5.2	FULL CODE COVERAGE UNIT TESTING	8
5.2.1	<i>Assumptions, Dependencies and Constraints</i>	<i>8</i>
5.2.2	<i>Building the SP0-VxWorks6.9 PSP unit tests</i>	<i>8</i>
5.2.3	<i>Running the SP0-VxWorks6.9 PSP unit tests.....</i>	<i>9</i>
5.2.4	<i>Verifying the SP0-VxWorks6.9 PSP unit test results against the provided test results</i>	<i>9</i>
5.3	FUNCTIONAL TESTING.....	9
5.3.1	<i>Setting up the test rig</i>	<i>9</i>
5.3.2	<i>Building the SP0-VxWorks6.9 PSP functional tests</i>	<i>10</i>
5.3.3	<i>Running the SP0-VxWorks6.9 PSP functional tests.....</i>	<i>10</i>
5.3.4	<i>Verifying the SP0-VxWorks6.9 PSP functional test results against the provided test results</i>	<i>10</i>
6	SP0-VXWORKS6.9 PSP CERTIFICATION ARTIFACTS	10
7	APPENDICES	11
7.1	ABBREVIATIONS AND ACRONYMS	11
7.2	DEFINITION OF TERMS	12
8	NOTES	14

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 4 of 14

List of Tables

Table 2-1: Applicable Documents	6
Table 2-2: Reference Documents.....	6
Table 6-1: Certification Artifacts	10

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 5 of 14

1 INTRODUCTION

1.1 Purpose and Scope

This document defines the test plan and procedures for the “certifiable” version of the Core Flight System SP0-VxWorks6.9 Platform Support Package (PSP). The intent of the “certifiable” version of the software is to provide the users with the necessary certification artifacts (i.e., documentations, test procedures, test suites and the expected test results) to perform a formal certification (i.e., the “run-for-record”) of the SP0-VxWorks6.9 PSP on a specific platform.

For clarification, “certified” software and “certifiable” software are defined as follow:

- “Certified” software would have already been verified and validated on a target platform with the documented specifications and configurations for the followings:
 - Processor - model, version, etc.
 - Operating system - vendor, version, kernel configurations & image, etc.
 - Hardware drivers - vendor, version, configurations, et.
 - Software configurations - per component, per build, per execution with all the required data files, etc.
 - Other factors as required by the mission/project

Note: Any changes in the above after the official “run-for-record”, regardless of the criticality of the changes, can invalidate the certification claim if certification is not performed again with the new changes.

- “Certifiable” software can become “certified” by using the provided certification artifacts to perform the official “run-for-record” with the user-specified configurations on the user-selected platform. Unlike “certified” software, “certifiable” software is not associated with any specific certification platform, configurations or builds, other than those that are used in development and testing of the software.

The development of this “certifiable” software product followed the NPR 7150.2 requirements for a class A, safety-critical software product, as documented in the cFS Certification Software Development Plan. Hence, the certification artifacts that come with a “certifiable” version of this product could be used to formally certify it as class A, safety-critical software, which is the highest software classification and criticality, as defined by the NPR 7150.2.

1.2 Responsibility and Change Authority

This document is prepared in accordance with EA-WI-025, “GFE Flight Project Software and Firmware Development”. The responsibility for the development of this document lies with the Engineering Directorate Software, Robotics, & Simulation Division (SR&SD), Spacecraft Software Engineering Branch/ER6. Change authority is the Software, Robotics and Simulation Division of the Johnson Space Center.

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

The following documents, of the exact issue and revision shown, form a part of this VDD to the extent specified herein.

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 6 of 14

Table 2-1: Applicable Documents

<i>Document Number</i>	<i>Document Title</i>	<i>Revision / Release Date</i>
NPR 7150.2	NASA Software Engineering Procedural Requirements	Rev C / Aug 2019
EA-WI-025	GFE Flight Project Software and Firmware Development	Rev D / Sep 2013
GP-10021	cFS Certification Software Development Plan	Baseline / May 2020

2.2 Reference Documents

The following documents are reference documents utilized in the development of this VDD. These documents do not form a part of this VDD and are not controlled by their reference herein.

Table 2-2: Reference Documents

<i>Document Number</i>	<i>Document Title</i>	<i>Revision / Release Date</i>
N/A	SP0-VxWorks6.9 PSP Software Design Document	Baseline / May 2022
N/A	SP0-VxWorks6.9 PSP Software User's Guide	Baseline / May 2022

2.3 Order of Precedence

In the event of a conflict between the text of this specification and an applicable document cited herein, the text of this specification takes precedence.

3 TEST PLAN

It is expected that the users will document the overall test plan and procedures for their overall software system. This document provides the test plan and procedures specifically for the SP0-VxWorks6.9 PSP, as a software component of that overall system.

SP0-VxWorks6.9 PSP's development and testing were done on an SP0-S processor running VxWorks6.9 RTOS. Partial regression testing was done with Gitlab Continuous Integration: static code analysis and target build. And integrated vertical validation testing was done on an SP0-S platform running VxWorks6.9 RTOS. All tests were built with the default configurations defined for the SP0-VxWorks6.9 PSP.

3.1 Testing Activities

The following activities were performed against the code base of the SP0-VxWorks6.9 PSP:

- Static code analysis, both internal and independent
- Formal code inspection via peer review
- Full code coverage unit testing
- Functional testing
- Integrated vertical validation testing

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 7 of 14

Items (a) & (b) have been performed by the cFS development team, and the associated metrics are reported to and tracked by a software engineering authority, the JSC Spacecraft Software Engineering Team (SSET). Items (c) & (d) can be repeated by the users. And item (e) is also expected to be performed by the users, with user-defined configurations, as part of their validation of their integrated software system.

3.2 Requirement Traceability

The SP0-VxWorks6.9 PSP is implemented as a library, which provides a set of public functions that can be used by other cFE/cFS components. These public functions are essentially its “requirements”. For purpose of certification, there will not be requirement traceability for libraries. And hence, this section is not applicable to the SP0-VxWorks6.9 PSP.

4 VERIFICATION AND VALIDATION PROCESS

4.1 Verification and Validation Management Responsibilities

The users are ultimately responsible for the Verification and Validation of their overall software system. The SP0-VxWorks6.9 PSP should be treated as a software component of that overall software system. The users can use the provided certification artifacts to satisfy their verification and validation requirements. It is up to the users how these artifacts are integrated and/or can be used to satisfy their system requirements.

4.2 Verification Methods

This section is not applicable to the SP0-VxWorks6.9 PSP since there is no requirement associated with a library. See Section 3.2.

4.3 Validation Methods

The validation of the SP0-VxWorks6.9 PSP’s public functions shall be covered by its functional testing. See Section 5.3.

4.4 Certification Process

The certification of cFS products shall be performed by the users in accordance with their software certification process.

4.5 Acceptance Testing

Acceptance testing of cFS products shall be performed by the users in accordance with their software acceptance process.

5 SP0-VXWORKS6.9 PSP TEST PROCEDURES

5.1 Static code analysis

The static code analyzer tool, *Understand*, was used to perform static code analysis on the SP0-VxWorks6.9 PSP code base against the JSC SSET Coding Standards for C programming language. Any deviation from the coding standard is documented in the cFS Certification SDP document. Since the SP0-VxWorks6.9 PSP source

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 8 of 14

code is available, the users can opt to re-run static code analysis using the users' preferred analysis tool and coding standards.

5.2 Full code coverage unit testing

The SP0-VxWorks6.9 PSP code base comes with the source code for unit testing that can be built and run on an SP0-S platform running VxWorks 6.9 OS. All external interfaces are stubbed (including cFE and OSAL interfaces) so that unit tests can be executed as a stand-alone program. This is accomplished with the use of the cFS Unit Test Framework called *ut_assert* that is distributed as part of the OSAL code base.

The SP0-VxWorks6.9 PSP implementation is platform-dependent; hence, its unit tests are intended to be built and run on an SP0-S processor running VxWorks6.9 operating system. The Wind River's code coverage tools are used to obtain the code coverage.

5.2.1 Assumptions, Dependencies and Constraints

5.2.1.1 Assumptions

- The application code base, in its entirety, resides as a sub-directory of the "*psp*" directory of a cFS workspace. See the recommended cFS workspace from the cFS repository at <https://www.github.com/nasa/cfs>.
- There is a target build setup to include the SP0-VxWorks6.9 PSP. See the sample build setup in *cmake/sample_defs* directory and the sample top-level build file, *cmake/Makefile.sample*, from the cFE repository at <https://www.github.com/nasa/cfe>.

5.2.1.2 Dependencies

- cFS build system uses cmake, specifically cmake3.

5.2.1.3 Constraints

The SP0-VxWorks6.9 PSP is a custom implementation of the PSP for the SP0/SP0-S processor running VxWorks6.9 RTOS. And hence, can only be run correctly on such platform.

5.2.2 Building the SP0-VxWorks6.9 PSP unit tests

The SP0-VxWorks6.9 PSP's unit tests and code coverage are built and run at the same time on the SP0 processor running VxWorks 6.9 OS.

It is assumed that

- The SP0 is connected to the local network; and
- The Wind River's Registry service must be able to communicate with the SP0; and
- The location of the kernel image file, i.e., "*vxWorks*", is known.

The build steps are captured in a shell script, *psp/fsw/sp0-vxworks6.9/unit_test/build_psp.sh*.

- From the host computer, enable the Wind River environment.

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 9 of 14

Ex: > sh /<VXWORKS_HOME>/wrenv.sh -p vxworks-6.9

where <VXWORKS_HOME> is the VxWorks installation directory on the host computer, or use the environment variable, \$WIND_HOME, if available.

- b. Execute the script, *psp/fsw/sp0-vxworks6.9/unit_test/build_psp.sh*.

The script will put the executable in *psp/fsw/sp0-vxworks6.9/unit_test/payload* directory.

5.2.3 Running the SP0-VxWorks6.9 PSP unit tests

The execution steps are captured in a shell script, *psp/fsw/sp0-vxworks6.9/unit_test/run_psp.sh*.

- a. Execute the script, *psp/fsw/sp0-vxworks6.9/unit_test/run_psp.sh*, like below:

```
$ sh psp/fsw/unit_test/run_psp.sh <SP0-IP> <kernel-image-file>
```

where <SP0-IP> is the IP address of the SP0, and <kernel-image-file> is the full path to the kernel image.

Ex: > sh psp/fsw/sp0-vxworks6.9/unit_test/run_psp.sh 192.110.22.10
~/VxWorks6.9/prebuilt-kernels/VxWorks

The script will establish a connection to the SP0 using the Wind River's Registry service, "*wtxregd*". Then the executable, as described in section 5.2.2, is loaded and executed on the SP0. A timer of 25 seconds is set, waiting for the unit test to complete. Once done, the results are obtained using the Wind River tool, "*coverageupload*", and get converted to HTML using the Wind River tool, "*coverageconvert*".

- b. To view the code-coverage results in a browser in the *psp/fsw/sp0-vxworks6.9/unit_test/html* directory,

```
$ firefox index.html
```

5.2.4 Verifying the SP0-VxWorks6.9 PSP unit test results against the provided test results

Once built and run, the test results can be verified against the provided test results. See Table 6-1 below for the file name and location of the provided unit test and code coverage results.

5.3 Functional testing

For libraries, functional testing is done in place of verification testing. Functional testing is intended to verify the intended side effects and/or behaviors post execution. For example, upon executing a function to create a file, aside from checking the function return status and argument validations, a check for the existence of the new file should also be done.

5.3.1 Setting up the test rig

The test rig used to perform functional testing for the SP0-VxWorks6.9 PSP is documented in the [cFS Test Rig](#) charts.

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 10 of 14

5.3.2 Building the SP0-VxWorks6.9 PSP functional tests

TBD.

5.3.3 Running the SP0-VxWorks6.9 PSP functional tests

TBD

5.3.4 Verifying the SP0-VxWorks6.9 PSP functional test results against the provided test results

Once built and run, the test results can be verified against the provided expected results. See Table 6-1 below for the file name and location of the provided functional test results.

6 SP0-VXWORKS6.9 PSP CERTIFICATION ARTIFACTS

Table 6-1 lists the available certification artifacts for the SP0-VxWorks6.9 PSP.

Table 6-1: Certification Artifacts

<i>Testing Type</i>	<i>Artifact Description</i>	<i>Artifact Location</i>
Unit testing with code coverage	Unit test source code and build file	psp/fsw/sp0-vxworks6.9/unit_test/*
	Unit test results	Release Artifacts package: psp_sp0-vxworks6.9_ut_results.log
	Code coverage results	Release Artifacts package: psp_sp0-vxworks6.9_ut_coverage.zip
	Functional test source code and build file	psp/fsw/sp0-vxworks6.9/functional_test/*
	Functional test results	Release Artifacts package: psp_sp0-vxworks6.9_ft_results.log

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 11 of 14

7 APPENDICES

7.1 Abbreviations and Acronyms

<i>Term</i>	<i>Definition</i>
API	Application Programming Interface
CBCS	Computer Based Control System
CDS	cFE Critical Data Storage
cFE	Core Flight Executive
cFS	Core Flight System
ES	cFE Executive Services
EVS	cFE Event Services
GFE	Government Furnished Equipment
GSFC	Goddard Space Flight Center
ICD	Interface Control Document
ISR	Interrupt Service Routine
JSC	Johnson Space Center
LRO	Lunar Reconnaissance Orbiter
MDT	SCH_TT Message Definition Table
Msg	Message
NASA	National Aeronautics and Space Administration
PMP	Project Management Plan
SB	cFE Software Bus
SBNG	Software Bus Network for Gateway cFS application
SCH_TT	Time-Triggered Ethernet Scheduler cFS application
SDD	Software Design Document
SDP	Software Development Plan
SDT	SCH_TT Schedule Definition Table
SRS	Software Requirements Specification
SR&SD	JSC Engineering Directorate Software, Robotics & Simulation Division
SSET	JSC Spacecraft Software Engineering Team
STP	Software Test Plan
SUG	Software User's Guide
TTE	Time-Triggered Ethernet
TTE_LIB	Time-Triggered Ethernet cFS Library
TTE_MGR	Time-Triggered Ethernet Manager cFS application
VDD	Version Description Document

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 12 of 14

7.2 Definition of Terms

<i>Terms</i>	<i>Definition</i>
<i>V&V Terms</i>	
Certification	The audit process by which the body of evidence that results from the verification activities presented are provided to the appropriate certifying authority to indicate all requirements are met.
Deviation	Written authorization issued “before the fact” to develop a product that departs from established requirements.
HSI1	Hardware/software integration (HSI) that is performed prior to PDR. This testing establishes confidence that the hardware and software design concepts are adequate to meet functional interfaces.
HSI2	Hardware/software integration that is performed prior to CDR on engineering unit or DVTU hardware. This testing establishes confidence that the hardware and software detailed designs meets requirements.
Validation	The process that ensures a system meets the customer/sponsor’s expectations for intended use. Unique validation activities may not be required if validation is satisfied through verification or acceptance testing activities.
Verification	A formal process, using the method of test, analysis, inspection or demonstration, to confirm that a system and its hardware and software components satisfy all specified performance and operational requirements.
Waiver	Written authorization to temporarily accept an item that departs from a particular performance or design requirement of a specification, drawing, or other contract document. The authorization is granted for a specific number of items and/or a specific period of time. The item(s) is/are considered suitable for use “as is” for a specified period of time or quantity of items, until reworked by approved method..
<i>Types of V&V Methods</i>	
Test	A method of verification wherein formal project requirements (performance, environment, etc.) are verified by measurement or functional test during or after the controlled application of functional and/or environmental stimuli. These measurements may require the use of laboratory equipment, recorded data, procedures, test support items, or specialized software.
Analysis	A verification method utilizing techniques and tools such as math models, prior test data, simulations, analytical assessments, etc. Verification by similarity is acceptable if the subject article is similar or identical in design, manufacturer, manufacturing process, and quality control to another article that has been previously verified to equivalent or more stringent criteria.
Inspection	A method of verification of physical characteristics that determines compliance without the use of special laboratory equipment, procedures, test

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 13 of 14

	support items, or services. Inspection uses standard methods such as visual gauges, etc. to verify compliance with design requirements.
Demonstration	A qualitative method of verification that evaluates the properties of the subject end item. Demonstration is used with or without special test equipment or instrumentation to verify required characteristics such as operational performance, human engineering features, service and access features, transportability, and displayed data.
Testing Levels	
Development Testing	
Qualification Testing	
Acceptance Testing	
System Level Testing	
End-to-End Testing	
Types of Test Articles	
Prototype Unit	The breadboard, generic component or developmental assembly of hardware and software that roughly performs the basic functions of the engineering unit but is not fully functional equivalent. This unit is used for proof of concept testing of the preliminary design.
Engineering Unit	The hardware, firmware, and software unit that is functionally equivalent to the qualification unit, but not necessarily form and fit equivalent. This unit is used for proof of concept testing of the detailed design. It may be used for software verification credit after CDR with quality controls as defined in the Software Development Plan.
Design Verification Test Unit (DVTU)	The hardware, firmware, and software unit which is form, fit and functional equivalent to the flight unit, but may not be manufactured using the exact flight parts. This unit is used for design proof of concept.
Qualification Unit	
Flight Unit	
Proto-flight Unit	
Ground Support Equipment	

Verify this is the correct version before use

Johnson Space Center Engineering Directorate	Title: Software Test Plan and Procedures for the Core Flight System SP0-VxWorks6.9 Platform Support Package	
	Doc. No. N/A	Baseline
	Date: May 2022	Page 14 of 14

8 NOTES

None.

Verify this is the correct version before use