Cassini Image Science Subsystem (ISS) Flight Software

Acceptance Test Plan

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November 3, 1994

Jet Propulsion of Technology
Pasadena, California

D-11893 **Final**

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1 INTRODUCTION

1.1 Identification

This Acceptance Test Plan (ATP) provides test descriptions and criteria for accurate and complete evaluation of the Cassini Imaging Science Subsystem (ISS) Flight Software performance.

1.2 ISS Flight Software Overview

The ISS consists of onboard instrumentation and the ISS Flight Software. The onboard ISS instrumentation consists of two main components, the Wide Angle Camera (WAC) and the Narrow Angle Camera (NAC). Each camera has its own set of the optics, the mechanical mountings, the Engineering Flight Computer (EFC), the Bus Interface Unit (BIU) to the central Command and Data System (CDS), the Charge-Coupled Device (CCD), the shutter, the filter wheels, the sensors and the various control electronics. Except for the optics and the filter wheels, the components are identical in the NAC and the WAC cameras.

The ISS Flight Software resides in the Solid State Recorder (SSR) onboard the spacecraft. The SSR, managed by the CDS, uploads the ISS Flight Software into the ISS EFC at Power-On Reset (POR).

The ISS Flight Software accepts, as primary input, command sequences from Earth originating from Cassini Mission Operations and the Instrument Operations Teams, together with the Instrument Science Team. These commands are translated by the ISS Flight Software from Major Commands into Minor Commands that are recognizable by the camera device drivers. The camera device drivers then further process the Minor Commands into single directives called Micro Commands.

The camera devices, controlled by the ISS Flight Software in the image acquisition activities, include:

1) Sensor Head
2) Filter Wheels
3) Shutter
4) Flood Lights
5) Optical Heaters
6) Temperature Control Electronics
7) WAC Calibration Lamp
8) CDS Bus/BIU

9) Housekeeping Data Electronics

The ISS Flight Software functions fall into the following eight categories:

1) Command Management

2) Device Driver Management

3) Program Control

4) Program Management

5) Fault Control

6) Health Maintenance

7) Image Acquisition

8) Communication and Packets

For a more detailed description of the ISS Flight Software functions and requirements, refer to the ISS Flight Software Requirements Document (SRD) listed in paragraph 1.6 .

1.3 Document Scope

This document provides for the ISS Flight Software the acceptance test planning , the acceptance test objectives and test procedures (in Section 4). Test scripts which provide specific parameters, test settings and values for running each test are to be provided in a separate document.

This ATP is designed to provide descriptions of the acceptance tests and success criteria for every requirement listed in the ISS Flight Software SRD. Appendix A provides traceability matrices of ISS SRD requirements to ATP tests and from ATP tests to ISS SRD requirements. In addition to validating specific software requirements, this document also provides regression tests to ensure that changes to delivered software have not degraded software performance.

This document adopts the tailored format of JPL D-4000 guidelines for ATP. This is done to adequately present the tests designed for the verification of the required ISS Flight Software capabilities.

1.4 Testing Method

The tests provided in this document will be automated in both performance and in the recording and evaluation of results. In performance, script-driven tests allow easy test invocation and make test repetition practical. In recording and evaluation of results, test logs will be automatically generated and then either differenced against a standard test log or verified with database-driven programs to determine if the test results meet the success criteria.

The automation of the test performance and the test evaluation will be achieved in a closed loop approach, where the Ground Support Equipment (GSE) initiates and controls the test, receives the test results, and makes automatic comparisons of the results against expected results. Option of using a database-driven tool to verify results will also be available.

1.5 Notation

Glossary and acronym lists are provided in Appendices B and C of this document. No other special notations are used in this document.

1.6 Controlling Documents

Document Name	Doc. No.
Cassini Orbiter Functional Requirements Book, Telemetry Measurements and Formats	CAS-3-281
Cassini S/C Sequencing and Command Formats	CAS-3-291
Cassini S/C Data System Intercommunication Formats	CAS-3-271
Cassini Orbiter Functional Requirements Book, Imaging Science Subsystem (ISS)	CAS-4-2036
Cassini Imaging Science Subsystem (ISS) Subsystem Description Document	CAS-5-2036
Cassini ISS Flight Software SRD	D-10750
Cassini Spacecraft Imaging Science System EFC Startup ROM Program, Software Specifications	D-11894

1.7 Applicable Documents

Document Name	Doc. No.
Cassini Spacecraft Imaging Science Subsystem Electronic Ground Support Equipment, Command Reference Manual	D-11895

2 TEST PLANNING

2.1 Testing Process

The integration and acceptance testing of the ISS Flight Software will be performed at the same time, with tests to be performed in the order of increasing test complexity. Section 3 provides the test categories and the recommended test groups in increasing order of test complexity for the purpose of test planning. The term "acceptance testing" is used throughout this document to refer to integration and acceptance testing.

The acceptance testing will be conducted in 3 phases:

Phase 1. Create test scripts and perform test runs.

Phase 2. Conduct all tests, log results, and document test anomalies using the JPL Failure Report (FR) form.

Test logs will be used for test result comparison in Phase 3 testing and in subsequent regression testing.

The tracking of the FRs will be performed by the JPL Problem Failure Operation Center (PFOC). The ISS Flight Software Cognizant Engineer (CogE) will have the authority over the FR closures.

Phase 3. Conduct all tests again, when the anomalies from Phase 2 testing have been appropriately closed.

Test anomalies from phase 3 will be tracked for closure using the same problem tracking mechanism used in Phase 2. The ISS Electronics Task Manager will have the authority over the FR closures for Phase 3 of the ATP testing.

At the end of Phase 3 testing, all tests will have been successfully tested or the appropriate work arounds provided for functionalities or features not completely verified by the tests.

2.2 Testing Policy

2.2.1 Software Configuration Control

The Source Code Control System (SCCS) provided with the Sun OS will be used for configuration management of the software. Each software build will be identified by its unique version number provided by the SCCS.

2.2.2 Test Baseline

The integration/acceptance test baseline will be established at the successful completion of Phase 3 testing. At this point, the full functionality of the ISS Flight Software will have been executed and the implementation of the required capabilities verified. The newly baselined ISS Flight Software will be ready to be placed under the Project's configuration control. The

test scripts, test logs, and any test verification programs will be placed in computer test archive folders.

2.2.3 Software Changes and Regression Testing

Changes to the baselined software will require: 1. Validation of the modified portions of the ISS Flight Software (FSW) through unit testing and related ATP test(s), and 2. Successful regression testing of the ISS FSW.

Regression testing is performed to ensure that the desired changes are appropriately implemented and that the overall software functionalities are not unintentionally altered with the software changes. Regression tests are a subset of the acceptance tests, and they are presented in Section 3 of this document.

Test logs and any modified test scripts and verification programs will be placed in computer test archive folders, as well as on the appropriate backup disks.

2.3 GSE Testing Support

The GSE will be used to conduct the integration and acceptance tests. In most cases, it will be used to initiate and control the test, receive the test results, and make automatic comparisons of the results against expected results.

To achieve the level of test automation desired for this integration and acceptance testing, the GSE test language must have two capabilities, 1) to send ISS Flight Software commands in some syntax and 2) to issue GSE test directives. These two capabilities are described in the following paragraphs.

2.3.1 ISS Commands Issued by GSE Test Language

The GSE test language will have the capability to issue all ISS Flight Software minor and major commands in some syntax.

2.3.2 GSE Test Directives Issued by GSE Test Language

The GSE test language will have the following capabilities:

1) Control of the ISB

   a) read designated addresses

   b) log ISB output into designated files

2) Control Log Files - Determine which files are written to; turn log files on/off.

3) Control Image Files - Determine which files are written to, turn image files on/off. (Image files are generated in pairs, one containing direct access data, the other containing ISS Flight Software data)

The GSE commands and syntax are described in the Cassini Spacecraft Imaging Science Subsystem, Electronic Ground Support Equipment, Command Reference Manual.

2.4 Test Environment

2.4.1 Test Equipment

Table 2-1 lists the Test Equipment required to perform the ISS Flight Software Acceptance Tests.

Table 2-1. Test Equipment List

Item
Breadboard Flight Cameras NAC and WAC with cooling apparatus
Engineering Test Analyzer (ETA)
Filter Wheel Simulator
Filter Wheel Breakout Box (for SUROM test)
Shutter Simulator
Calibration Lamp Simulator
Flood Light Simulator
Optics Heater Simulator
Temperature Control Electronics (TCE) State Indicator
Logic Analyzer with interface to GSE
GSE Station
CDS Simulator
Housekeeping Data Electronics (HDE) Simulator: TCE (4 potentiometer controls) Optics Temperature Control
Direct Access Link for Image Acquisition
RS 6000
Optical Disk Drive and Disk for GSE

Ramp CCD Simulator

2.4.2 Test Software

Table 2-2 lists the Test Software required to perform the ISS Flight Software Acceptance Tests.

Table 2-2. Test Software List

Software	Platform
TLD Development System	SUN
TLD Debugger	RS6000
IBM Development System	RS6000
GSE Software System[1] with: a) Test script capability b) Test log file c) Housekeeping display d) Image difference e) Test log comparison capability f) VICAR file generation g) Housekeeping storage h) Memory dump storage i) Error display j) CDS simulator	SUN Sparc Station
CDS Simulator Software	
ALF Packet Converter Program	

[1] Refer to D-11895, "Cassini Spacecraft Imaging Science Subsystem Electronic Ground Support Equipment, Command Reference Manual", for more information.

3 TEST GROUPS AND REGRESSION TESTS

The following tables provide test categories, test groups and regression test information. Tests are classified by their functional categories in Table 3.1 for ease of locating tests.

Table 3.2 presents acceptance tests in test orders. Tests are placed in groups of increasing order of functional complexity being tested. This order grouping is suggestive in nature and is to be used as an aid in test planning with considerations of other factors involved, such as software/hardware readiness. Some tests require successful verification of one or more other ATP tests (test precedents) before they can be tested. Test precedents are also listed in Table 3.2.

Table 3.3 summarizes test classification information, including regression tests. Tests to be performed in Regression testing are indicated with "Y" in the column labeled "Regression Test".

Table 3.1 Acceptance Tests by Functional Category

Category [2]	**ATP Test**	**Test Title**
Minor CMD	1	MOVE FILTER WHEEL Command Test
Minor CMD	2	SHUTTER Command Test
Minor CMD	3	LIGHT FLOOD Command Test
Minor CMD	4	HEATER Command (Optics) Test
Minor CMD	5	TEMPERATURE CONTROL ELECTRONICS Command Test
Minor CMD	6	CAL LAMP Command Test
Minor CMD	7	HDE Command Test
Minor CMD	9	HDE Static Test
FSW Init	30	Flood Light and Erase Test
FSW Init	37	Cold Start Test
FSW Init	38	Warm Start Test
FSW Init	67	Warm Start/Command Test
FSW Init	68	BIU Reset Test

[2] Minor CMD: Minor Command
Major CMD: Major Command
HKP & SCI: Housekeeping and Science packets
FSW Init: Flight Software Initialization

FSW Init	69	HALT/WAKE Command Test
FSW Init	70	SLEEP Bit Test
FSW Init	85	SET CAMERA Command Test
FSW Init	90	SUROM Test
FSW Init	91	Initialization Test
Memory	13	LOAD MEMORY Test
Memory	26	Upload Memory Size Test
Memory	41	Memory Protection Test
Memory	51	MONITOR MEMORY Static Test
Memory	52	MONITOR MEMORY Dynamic Test
Memory	53	MONITOR MEMORY On/Off Test
Memory	59	READ MEMORY Test
Memory	81	XSUBS Test
Memory	98	Memory Scrub Test
Packet Headers	23	Verification of Extended Science Header Occurrence Test
Packet Headers	28	Parity Bit Test on Image Line Header
Packet Headers	29	Extended and Overclocked Pixel Test in Line Header
Packet Headers	35	Housekeeping Image Summary Test A
Packet Headers	36	Housekeeping Image Summary Test B
Packet Headers	42	Cassini Science Header Test
Packet Headers	43	Cassini Housekeeping Packet Header Test
Packet Headers	44	Cassini HDE Monitor Packet Header Test
Packet Headers	45	Cassini Memory Monitor Packet Header Test
Packet Headers	46	Cassini Memory Dump Packet Header Test
Packet Headers	47	EFC States Test
Packet Headers	48	High Rate Memory Header Test
Packet Headers	61	Line Header Line Length Test
Packet Headers	62	Science Header Auxiliary Test
Packet Headers	93	Housekeeping/Science Packet Agreement Test
Major CMD	11	WAIT Command Test

Major CMD	12	PORT Command Test
Major CMD	14	NOOP Test
Major CMD	15	LOAD MACRO Test
Major CMD	16	LOAD PMACRO Test
Major CMD	50	TRIGGER in all Command Memory Locations Test
Major CMD	69	HALT/WAKE Command Test
Major CMD	71	INSTANTANEOUS Command Test
Major CMD	83	LOAD MACRO/PMACRO Comprehensive Test
Major CMD	84	SET COMPUTER Command Test
Major CMD	85	SET CAMERA Command Test
Heater	33	Heater Table Test
Heater	34	Heater Table Output Test
Timing Issues	18	Watchdog Timeout Test
Timing Issues	24	Loss of RTI/DTS Test
Timing Issues	27	Verify SCLK Sync Test
Timing Issues	49	TRIGGER Timing Test
Timing Issues	79	RTI, DTS Interrupt Test
Timing Issues	95	Clock Out to RAM Test
Timing Issues	96	BIU Swap Test
Image Event	19	Image Event Delay Test
Image Event	20	Image Event Wait/Count Test
Image Event	30	Flood Light and Erase Test
Image Event	31	Inactive Optics Heaters During Filter Movement Test
Image Event	55	Image Event Device Driver Sequence Test
Image Event	56	Image Event Full Exposure Test
Image Event	57	Image Event 12:8 LUT Test
Image Event	58	Image Event Combinatorial Test
Image Event	63	8-LSB Test
Image Event	76	Prepare Cycle Duration Table Test
Image Event	77	GAIN Test
Image Event	78	LIGHT FLOOD and ERASE Duration Test
Image Event	80	ITERATION Test

Image Event	87	Null Image Test
Image Event	88	Latter End Exposure Test
Image Event	97	Read Out Table Test
TLM Rate	40	Telemetry Mode Change Test - During Image Event
TLM Rate	54	Telemetry Data Rate Test
HKP & SCI	21	Truncation Test
HKP & SCI	60	Housekeeping Durability Test
HKP & SCI	64	Zero Length Packet Test
HKP & SCI	92	Missing Science Packets Test
HKP & SCI	94	Housekeeping Rate Verification Test
2 cameras	32	Camera Interaction Under Reset Test
2 cameras	72	Two-Camera Prepare Cycle Synchronization Test
2 cameras	73	Two-Camera Read-Out Cycle Synchronization Test
2 cameras	74	Two-Camera Imaging Test
MISC	17	FSW Image Transfer Performance Test
MISC	39	Background Loading Test
MISC	75	Event Upset Test
MISC	82	EFC Processing State Verification Test
MISC	86	FSW Inspection
MISC	89	Comprehensive Error Test

Table 3.2 Acceptance Tests by Test Order

Test Order	ATP Test	Prior Test Verifications Needed (numbers here refer to ATP tests)
1	1	0
1	2	0
1	3	0
1	4	0
1	5	0
1	6	0
1	7	0
1	9	0
1	38	0
1	43	0
1	44	0
1	45	0
1	68	0
1	79	0
1	90	0
2	11	6
2	12 a	1
2	12 a	2
2	12 a	6
2	15	3
2	16	3
2	27	0
3	20	0
3	21	0
3	49	2
3	49	15
3	56	0
3	57	0
3	58	0
3	60	0
3	94	0
4	13	56
4	13	94
4	17	58
4	23	56
4	24	11
4	24	56
4	28	56
4	29	56
4	31	56
4	32	11
4	32	56
4	35	1
4	35	15
4	35	56
4	39	56
4	40	11
4	40	56
4	42	56
4	47	56
4	54	58
4	61	58
4	67	56
4	69	1
4	69	2
4	69	11
4	69	56
4	70	1
4	70	2
4	70	11
4	70	56
4	72	58
4	73	58
4	74	58
4	76	20

4	76	58
4	77	0
4	77	56
4	78	3
4	78	13
4	78	56
4	82	58
4	84	56
4	85	0
4	85	56
4	88	56
4	93	43
4	93	56
4	95	58
4	97	58
5	14	6
5	14	13
5	18	13
5	18	58
5	19	11
5	19	54
5	30	58
5	30	85
5	33	59
5	34	59
5	36	15
5	36	50
5	48	59
5	51	13
5	52	0
5	53	0
5	59	0
5	59	13
5	63	58
5	63	85
5	80	23
5	80	42
5	80	56
5	80	77
5	80	93
5	81	13
5	87	42
5	87	56
5	87	93
5	91	2
5	91	4
5	91	5
5	91	9
5	91	69
5	92	23
5	92	42
5	92	58
5	92	93
5	96	54
5	96	56
5	98	45
5	98	51
5	98	52
5	98	53
6	12 b	81
6	26	6
6	26	14
6	26	15
6	26	16
6	37	12
6	37	51
6	37	52
6	37	53
6	41	13
6	41	45
6	41	51
6	41	52

6	41	53
6	41	81
6	46	59
6	50	12
6	50	14
6	50	15
6	50	16
6	55	33
6	55	34
6	62	58
6	62	59
6	62	84
6	64	58
6	71	6
6	71	11
6	71	12
6	71	53
6	71	59
6	71	69
6	75	59
6	83	1
6	83	2
6	83	3
6	83	4
6	83	5
6	83	6
6	83	7
6	83	12
6	83	13
6	83	14
6	83	15
6	83	16
6	83	51
6	83	52
6	83	53
6	83	56
6	83	59
6	83	84
6	83	85
6	89	1
6	89	14
6	89	15
6	89	16
6	89	35
6	89	36
6	89	43
6	89	69

Table 3.3 Acceptance Tests and Regression Tests

Test	Category	Group	Regression Test
1	Minor CMD	1	Y
2	Minor CMD	1	
3	Minor CMD	1	Y
4	Minor CMD	1	Y
5	Minor CMD	1	Y
6	Minor CMD	1	Y
7	Minor CMD	1	Y
8	deleted	-	
9	Minor CMD	1	
10	deleted	-	
11	Major CMD	2	
12	Major CMD	2,6	Y
13	Memory	4	Part 1
14	Major CMD	5	Y
15	Major CMD	2	Y
16	Major CMD	2	Y
17	MISC	4	
18	Timing Issues	5	Y
19	Image Event	5	Y
20	Image Event	3	Y
21	HKP & SCI	3	Y
22	deleted	-	
23	Packet Headers	4	Y
24	Timing Issues	4	Y
25	deleted	-	
26	Memory	6	Y
27	Timing Issues	2	Y
28	Packet Headers	4	Y
29	Packet Headers	4	Y
30	FSW Init	5	
30	Image Event	5	
31	Image Event	4	
32	2 cameras	4	Y

33	Heater	5	Y
34	Heater	5	
35	Packet Headers	4	Y
36	Packet Headers	5	Y
37	FSW Init	6	Y
38	FSW Init	1	Y
39	MISC	4	
40	TLM Rate	4	Y
41	Memory	6	Y
42	Packet Headers	4	Y
43	Packet Headers	1	Y
44	Packet Headers	1	Y
45	Packet Headers	1	Y
46	Packet Headers	6	Y
47	Packet Headers	4	Y
48	Packet Headers	5	Y
49	Timing Issues	3	
50	Major CMD	6	Y
51	Memory	5	Y
52	Memory	5	Y
53	Memory	5	Y
54	TLM Rate	4	Y
55	Image Event	6	
56	Image Event	3	Y
57	Image Event	3	
58	Image Event	3	Y
59	Memory	5	Y
60	HKP & SCI	3	Y
61	Packet Headers	4	Y
62	Packet Headers	6	Y
63	Image Event	5	Y
64	HKP & SCI	6	Y
65	deleted	-	
66	deleted	-	
67	FSW Init	4	Y
68	FSW Init	1	Y

69	FSW Init	4	Y
69	Major CMD	4	Y
70	FSW Init	4	Y
71	Major CMD	6	Y
72	2 cameras	4	
73	2 cameras	4	
74	2 cameras	4	
75	MISC	6	Y
76	Image Event	4	
77	Image Event	4	Y
78	Image Event	4	
79	Timing Issues	1	
80	Image Event	5	Y
81	Memory	5	Y
82	MISC	4	Y
83	Major CMD	6	Y
84	Major CMD	4	Y
85	FSW Init	4	Y
85	Major CMD	4	Y
86	MISC	4	
87	Image Event	5	Y
88	Image Event	4	
89	MISC	6	Y
90	FSW Init	1	Partial
91	FSW Init	2	Y
92	HKP & SCI	5	Y
93	Packet Headers	4	Y
94	HKP & SCI	3	Y
95	Timing Issues	4	
96	Timing Issues	5	
97	Image Event	4	
98	Memory	5	Y

4 ACCEPTANCE TESTS

The acceptance tests for the ISS Flight Software are described in this section. Tests are grouped in increasing order of the functional complexity being tested (see section 3). This grouping is suggestive in nature and is to be used as an aid in test planning with considerations of other factors involved, such as software/hardware readiness. Section 3 of this document contains the test grouping information for testing purposes.

Each test should produce its own test log. The success criteria for each of these tests are that the verification steps in each test procedure have been performed and that the results are correct as specified in the procedure.

The requirements for both NAC and WAC cameras are identical. Therefore, both cameras share the same software, with certain distinctions specific to the camera type being implemented with simple IF statements in the code. When a specific camera is to be tested in a test, the type of the camera will be specified in the test procedure. In tests where no camera types are specified, the use of either NAC or WAC in those tests will suffice.

Test 1 MOVE FILTER WHEEL Command Test

Test Objective: Verify correctness of the MOVE FILTER WHEEL command and its parameters.

The following procedure is to be carried out for both wheels in the NAC and the WAC.

Step	Action	Housekeeping Packet	I S B Monitor	Visual Inspection
1	Command filter wheel to position 1, absolute	Verify wheel at position 1		
2	Command filter wheel to position 2, absolute	Verify wheel at position 2 Check number of recoverable and fatal errors	Verify wheel at position 2 Δt from 1st to 2nd position < 3 sec Count number of steps	Verify wheel moved to position 2

3	Command filter wheel +1, relative	Verify wheel at position 3 Check number of recoverable and fatal errors	Verify wheel at position 3 Δt from 2nd to 3rd position < 3 sec Count number of steps	Verify wheel moved to position 3
4	Command filter wheel -2, relative	Verify wheel at position 1 Check number of recoverable and fatal errors	Verify wheel at position 1 Note Δt from 3rd to 1st position < 3 sec Count number of steps	Verify wheel moved to position 1
5	Command filter wheel to position 8, absolute Use ISB command to monitor Home LED and Home sensor	Verify wheel at position 8 Check number of recoverable and fatal errors	Verify wheel at position 8 Δt from 1st to 8th position < 3 sec Verify that the Home LED and sensor are activated at the expected position Count number of steps	Verify wheel moved to position 8

6	Command filter wheel to home position	Verify wheel at home position Check number of recoverable and fatal errors	Verify wheel at home position Δt from 8th to home position < 3 sec Count number of steps	Verify wheel moved to home position
7	Command filter wheel long way to position 10, absolute	Verify wheel at position 10 Check number of recoverable and fatal errors	Verify wheel at position 10 Δt from home to 10th position < 3 sec Count number of steps	Verify wheel moved to position 10
8	Command filter wheel to position home	Verify wheel at home position Check number of recoverable and fatal errors	Verify wheel at home position Δt from 10th to home position < 3 sec Count number of steps	Verify wheel moved to home position

9a for NAC:	Command filter wheel to position 7.	Verify wheel at position 7 Check number of recoverable and fatal errors	Verify wheel at position 7. Δt from 1st to 7th position Count number of steps	Verify wheel moved to position 7.
9b for WAC:	Command filter wheel to position 5.	Verify wheel at position 5 Check number of recoverable and fatal errors	Verify wheel at position 5. Δt from 1st to 5th position < 3 sec Count number of steps	Verify wheel moved to position 5.

Test 2 SHUTTER Command Test

Test Objective: Verify correctness of the SHUTTER command and its parameters.

Camera type does not matter for this test.

Step	Action	I S B Monitor	Visual Inspection
1	Command reset of shutter blades A and B		
2	Command 5 ms exposure	Shutter address shows A and B activated $\Delta t \cong 5$ ms	Verify shutter clicks

3	Command reset shutter blades A and B		
4	Command exposure for 60 seconds	Shutter address shows A and B activated $\Delta t \cong 60$ seconds	$\Delta t \cong 60$ seconds
5	Command reset of shutters A and B		
6	Command 1200-second exposure	Shutter address shows A and B activated $\Delta t \cong 1200$ seconds	$\Delta t \cong 1200$ seconds
7	Command reset of shutters A and B		

Test 3 LIGHT FLOOD Command Test

Test Objective: Verify correctness of the FLOOD LIGHT command and its parameters.

Camera type does not matter for this test.

Step	Action	Housekeeping Packet	I S B Monitor	Visual Inspection
1	Ensure flood light is off (system initial state)			
2	Command to turn on flood light for 2 seconds	Verify flood light is on	Verify flood light address is activated $\Delta t \cong 2$ seconds	Verify flood light is on
3	Command to turn flood light off for 2 seconds	Verify flood light is off	Verify flood light address is deactivated $\Delta t \cong 2$ seconds	Verify flood light is off
4	Command to turn flood light on for 10 seconds	Verify flood light is on	Verify flood light address is activated $\Delta t \cong 10$ seconds	Verify flood light is on

Test 4 HEATER Command (Optics) Test

Test Objective: Verify correctness of the HEATER (Optics) command and its parameters.

HEATER Command (Optics) Test - Part I

Step	Action	Housekeeping Packet	I S B Monitor
1	Set ISB to monitor heater address.		
2	Log Housekeeping heater field.		

3	Issue HEATER Command ON. WAIT 2 seconds.	Heater field = ON.	Heater address = ON.
4	Issue HEATER Command OFF.	Heater field = OFF.	Heater address = OFF.
5	Repeat steps 1 through 4 for second NAC heater.		
6	Perform steps 1 through 5 for WAC heater.		

HEATER Command (Optics) Test - Part II

Step	Action	Housekeeping Packet	I S B Monitor
1	Set ISB to monitor heater address.		
2	Log Housekeeping heater field.		
3	Issue HEATER Command with interval T = 10 seconds.	T1: Heater field = ON. T2: Heater field = OFF ΔT = 10 sec ± 125 ms.	T1: Heater address = ON. T2: Heater address = OFF. ΔT = 10 sec ± 125 ms.
4	Repeat steps 1 through 3 for second NAC heater.		
5	Perform steps 1 through 4 for WAC heater.		

HEATER Command (Optics) Test - Part III

Step	Action	Housekeeping Packet	I S B Monitor
The following test is for the WAC and is based on the following algorithm where T1 is lower temperature boundary and T2 is higher temperature boundary: **If T > T2 then heater off** **If T < T1 then heater on**			
1	Issue HEATER REGULATE Command.		
2	Set ISB to monitor heater address.		
3	Log Housekeeping heater field.		
4	Adjust optics temperature sensor on HDE to just less than T2.		
5	Manually turn T sensor up beyond T2.	Indicates heater off.	Indicates heater off value.
6	Manually turn T sensor below T1.	Indicates heater on.	Indicates heater on value.
7	Manually turn T sensor up beyond T2.	Indicates heater off.	Indicates heater off value.

Test 5 Temperature Control Electronics (TCE) Command Test

Test Objective: Verify correctness of the TCE command and its parameters.

Step	Action	Housekeeping Packet	I S B Monitor	Visual Inspection
1	Command TCE to turn ON	Verify TCE bit is ON	Verify access of TCE ISB address and value of bit is TCE ON	TCE Simulator LED lights
2	Command TCE to turn OFF	Verify TCE bit is OFF	Verify access of TCE ISB address and value of bit is TCE OFF	TCE Simulator LED extinguishes
3	Set temperature dial on HDE test unit to an appropriate low temperature			
4	Command TCE to REGULATE	Verify TCE bit is REGULATE	Verify access of TCE ISB address and value of bit is TCE REGULATE	TCE Simulator LED lights
5	Set temperature dial on HDE test unit to an appropriate high temperature			TCE Simulator LED extinguishes

Test 6 CAL LAMP Command Test

Test Objective: Verify correctness of the CAL LAMP command and its parameters.

Step	Action	Housekeeping Packet	I S B Monitor	Visual Inspection
1	Command calibration lamp to turn ON	Verify calibration lamp ON bit is 1	Verify address for calibration lamp is accessed	Calibration lamp simulator LED lights
2	Command calibration lamp to turn OFF	Verify calibration lamp ON bit is 0	Verify address for calibration lamp is accessed	Calibration lamp simulator LED extinguishes
3	Command calibration lamp to turn ON for 10 seconds	Verify calibration lamp bit is ON for duration of 10 housekeeping packets (rate of housekeeping packets is 1/sec)	Verify ISB access at start and end of interval. Verify 10-second interval ± 5ms	Calibration lamp simulator LED lights for 10 seconds

Test 7 HDE Command Test

Test Objective: Verify that the HDE can report on all the values of HDE measurements through the HDE Housekeeping Packet.

Step	Action	HDE Packet	I S B Monitor
1	Set camera to NAC		
2	Set housekeeping dials on HDE Simulator to different settings.		
3	Issue HDE Command and select measurement X corresponding to code Y.	Verify that: a. All measurements have same value, "X" b. Code field = Y c. Count = 63 d. Camera = 0 (NAC)	Verify value for HDE ISB address is only "X". Measure Æt between start and end of the pulse Verify: Æt Å 20 µs For HDE ports, all values are sampled in one cycle. Verify that ISB values match the HDE values by ± 2 DN.
4	Turn "X" dial up to higher setting (only for 4 optics temperatures).	Verify new value is recorded	Verify that ISB values match the new HDE values by ± 2 DN.
5	Repeat steps 1-4 for the remaining 17 HDE values.	Verify as specified in steps 1-4	Verify as specified in steps 1-4
6.	Repeat 1 iteration for WAC.	Verify as for NAC, except that Camera = WAC.	

Test 8 Deleted

Test 9 HDE Static Test

Test Objective: Verify that the HDE values returned in the housekeeping packet matches the values read over the ISB.

Step	Action	Housekeeping Packet	I S B Monitor
1	Verify Flight Software is operating with housekeeping packets returning at 1 per sec.	Note values for 17 housekeeping addresses. Verify values are equal to ISB values.	Note values for 17 housekeeping addresses. Verify values are equal to Housekeeping packet values.
2	Repeat step 1 with rate at 1 per 64 sec.		

Test 10 Deleted

Test 11 WAIT Command Test

Test Objective: Verify that the WAIT command causes the FSW to stop executing subsequent commands for a specified period of time.

Step	Action	I S B Monitor	Visual Inspection
1	Issue CAL LAMP command to turn calibration lamp on.		
2	Issue WAIT Command for 1 second.		
3	Issue CAL LAMP Command to turn calibration lamp off.	Verify interval between calibration lamp on and calibration lamp off is 1 second.	Verify calibration lamp illuminates for 1 second.

4	Repeat steps 1-3 setting WAIT Command interval for 5, 30, 60, and 120 second intervals.	Verify interval between calibration lamp on and calibration lamp off is the appropriate value.	Verify calibration lamp illuminates for 1 second.

Test 12 PORT Command Test

Test Objective: Verify the correctness of the PORT command and its parameters. PORT command can be used to place an arbitrary value in the ISB address.

Part 1. Port to Unprotected Area

Step	Action	Housekeeping Packet	I S B Monitor	Visual Inspection
1	Command filter wheel to move an appropriate number of steps from a specified position (p1) to another position (p2)	Verify a series of accesses to the filter wheel port address with the appropriate bits set	Filter wheel moves the commanded number of steps from position p1 to position p2	
2	Actuate blade A of shutter, then blade B one second later. Then reset A, then B	Verify housekeeping address and values were adjusted	Shutter opens then closes	
3	Turn CAL lamp on for 2 seconds then shut lamp off	Verify housekeeping address and values were adjusted		Verify lamp lights, then extinguishes

Part 2. Port to Protected Area

Note: This test is similar to XSUBS Test.

Step	Action	Housekeeping Packet
1	Set ISB to monitor LED address.	
2	Issue LOAD MEMORY Command to put a subroutine at address b in memory; subroutine will increment the image count number continuously.	
3	Issue PORT Command changing jump address at call to XSUB1 to address b in memory.	Verify Image Count increments continuously (once per RTI).
4	Restore Flight Software.	

Test 13 LOAD MEMORY Test

Test Objective: Verify the action of the LOAD MEMORY command by using LOAD MEMORY to modify the housekeeping rate and the exposure table.

Step	Action	Housekeeping Packet	I S B Monitor
1	Modify housekeeping rate in memory from once per second, to once per 64 seconds, to once per second	Verify housekeeping address and rate values were adjusted Verify rate change on GSE display as input	
2	Load entire exposure table with new values a) Command IMAGE EVENT with exposure index 1 b) Command IMAGE EVENT with exposure index 31 c) Command IMAGE EVENT with exposure index 62		Verify exposure interval between shutter open and shutter close matches exposure index 1 Verify exposure interval between shutter open and shutter close matches exposure index 31 Verify exposure interval between shutter open and shutter close matches exposure index 62

Test 14 NOOP Test

Test Objective: Verify the correctness of the NOOP command and its parameters.

Step	Action	Housekeeping Packet	I S B Monitor	Visual Inspection
1	Issue five NOOP Commands with 10-, 20-, 40-, 80- and 110-word lengths	Verify number of commands goes up by 5.		
2	Issue TRIGGER Command for first NOOP.	Verify number of commands executed increases by 1.	LED for TRIGGER Received is indicated.	
3	Repeat steps 1-2 for remaining four NOOP commands.			
4	Issue LOAD MEMORY to overlay a CAL LAMP ON Command over a 40-word NOOP Command			
5	Issue TRIGGER Command.	Verify CAL LAMP Indicator is on.	Verify CAL LAMP ISB address was accessed.	CAL LAMP illuminates.

Test 15 LOAD MACRO Test

Test Objective: Verify the correctness of the LOAD MACRO command and its parameters by loading and triggering macros with simple commands in them; also verify that the subsequent upload of a new MACRO will replace the old MACRO.

Step	Action	I S B Monitor	Visual
1	Upload 3 LOAD MACRO Commands, A, B, and C in that order as described in the table below.		
2	Send TRIGGER Command with ID = 13 to initiate macro A.	Verify Cal Lamp ISB values of 2, 3, and 5 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 2, 3, and 5 sec.
3	Send TRIGGER Command with ID = 14 to initiate macro B.	Verify Cal Lamp ISB values of 7, 11, and 13 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 7, 11, and 13 sec.
4	Send TRIGGER Command with ID = 15 to initiate macro C.	Verify Cal Lamp ISB values of 14, 17, and 19 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 14, 17, and 19 sec.
5	Upload 3 LOAD MACRO Commands, C, A, and B in that order.		
6	Send TRIGGER Command with ID = 13 to initiate macro C.	Verify Cal Lamp ISB values of 14, 17, and 19 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 14, 17, and 19 sec.
7	Send TRIGGER Command with ID = 14 to initiate macro A.	Verify Cal Lamp ISB values of 2, 3, and 5 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 2, 3, and 5 sec.
8	Send TRIGGER Command with ID = 15 to initiate macro B.	Verify Cal Lamp ISB values of 7, 11, and 13 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 7, 11, and 13 sec.

CAL LAMP Command Intervals in Macros A, B and C

Macro	Intervals
A	Command 1 = 2 sec Command 2 = 3 sec Command 3 = 5 sec
B	Command 1 = 7 sec Command 2 = 11 sec Command 3 = 13 sec
C	Command 1 = 14 sec Command 2 = 17 sec Command 3 = 19 sec

Test 16 LOAD PMACRO Test

Test Objective: Verify the correctness of the LOAD PMACRO command and its parameters by loading and triggering PMACROs with simple commands in them; also verify that the subsequent upload of a new PMACRO will replace the old PMACRO.

Step	Action	I S B Monitor	Visual
1	Upload 3 LOAD PMACRO Commands, A, B, and C with ID numbers 1, 2, and 3, respectively.		
2	Send TRIGGER Command with ID = 1 to initiate macro A.	Verify Cal Lamp ISB values of 2, 3, and 5 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 2, 3, and 5 sec.

3	Send TRIGGER Command with ID = 2 to initiate macro B.	Verify Cal Lamp ISB values of 7, 11, and 13 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 7, 11, and 13 sec.
4	Send TRIGGER Command with ID = 3 to initiate macro C.	Verify Cal Lamp ISB values of 14, 17, and 19 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 14, 17, and 19 sec.
5	Upload 3 LOAD PMACRO Commands, A, B, and C with ID numbers 4, 5, and 6 respectively.		
6	Send TRIGGER Command with ID = 4 to initiate macro A.	Verify Cal Lamp ISB values of 2, 3, and 5 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 2, 3, and 5 sec.
7	Send TRIGGER Command with ID = 5 to initiate macro B.	Verify Cal Lamp ISB values of 7, 11, and 13 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 7, 11, and 13 sec.
8	Send TRIGGER Command with ID = 6 to initiate macro C.	Verify Cal Lamp ISB values of 14, 17, and 19 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 14, 17, and 19 sec.
9	Upload 3 LOAD PMACRO Commands, C, A, and B with ID numbers 1, 2, and 3 respectively.		
10	Send TRIGGER Command with ID = 1 to initiate macro C.	Verify Cal Lamp ISB values of 14, 17, and 19 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 14, 17, and 19 sec.

11	Send TRIGGER Command with ID = 2 to initiate macro A.	Verify Cal Lamp ISB values of 2, 3, and 5 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 2, 3, and 5 sec.
12	Send TRIGGER Command with ID = 3 to initiate macro B.	Verify Cal Lamp ISB values of 7, 11, and 13 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 7, 11, and 13 sec.
13	Upload 3 LOAD PMACRO Commands, A, B, and C with ID numbers 1, 2, and 3 respectively.		
14	Send TRIGGER Command with ID = 1 to initiate macro A.	Verify Cal Lamp ISB values of 2, 3, and 5 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 2, 3, and 5 sec.
15	Send TRIGGER Command with ID = 2 to initiate macro B.	Verify Cal Lamp ISB values of 7, 11, and 13 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 7, 11, and 13 sec.
16	Send TRIGGER Command with ID = 3 to initiate macro C.	Verify Cal Lamp ISB values of 14, 17, and 19 sec. respectively.	Verify Cal Lamp turns on for approximate intervals of 14, 17, and 19 sec.

CAL LAMP Command Intervals in Macros A, B and C

Macro	Intervals
A	Command 1 = 2 sec Command 2 = 3 sec Command 3 = 5 sec
B	Command 1 = 7 sec Command 2 = 11 sec Command 3 = 13 sec
C	Command 1 = 14 sec Command 2 = 17 sec Command 3 = 19 sec

Test 17 FSW Image Transfer Performance Test

Test Objective: Test the worst case performance of the FSW in returning images as the computer speed is varied.

Step	Action	Difference Log
1	Set EFC to .64 mips.	
2	Using Direct Access (DA), send an image event for a single picture, 1x1 with lossy compression and 12:8 conversion.	

3	Uncompress GSE received image.	Compare with Direct Access (DA) image. Success is that images match. Test fails if images do not match or if decompression fails.
4	Repeat test with EFC set at .32 mips. Repeat again with EFC set at .16 mips.	Compare with DA image. Success is that images match. Test fails if images do not match or if decompression fails.

Test 18 Watchdog Timeout Test

Test Objective: Verify that the FSW can warm start correctly after the watchdog timeout.

Step	Action	Housekeeping Packet	Visual
1	Initiate Flight Software startup.	Microprocessor state is in idle. Image field = a*. * a represents current value of the field.	
2	Command LOAD_MEMORY to put a specified number of noop instructions over the shutter wait's watchdog update.		

3	Command image event with 10-second exposure, 3-second filter movement, and other appropriate parameters.	Microprocessors in active state, then goes to idle. Image field = a. Check software field. Verify warm start bit (a reset indication).	Housekeeping stops for an appropriate number of seconds.
4	Command LOAD_MEMORY to restore overwritten instruction.		
5	Command image event with same parameters as step 3.	Microprocessor is in active state, then goes to idle. Image field = a + 1	

Test 19 Image Event Delay Test

Test Objective: Verify that the time delay parameter of the IMAGE EVENT works correctly.

Step	Action	Secondary Header	Visual
1	Using GSE, set telemetry rate in Flight Software to 6 pkts / RTI.		
2	Upload 2 image events with following data: 1) Δ T = 0 seconds 4 x 4 image with conversion with compression 2) Δ T = 60 seconds 4 x 4 image with conversion with compression Command TRIGGER	Note the shutter time (let S = shutter time).	GSE image display field increments by 1.
3	Wait 60 seconds	Shutter time = S + 60 $\pm$ 1 seconds.	GSE image display field increments by 1 again.
4	Upload 2 image events with same parameters as step 2, but second image Δ T = 120 seconds. Command TRIGGER	Shutter time = S seconds.	GSE image display field increments by 1.
5	Wait 120 seconds.	Shutter time = S + 120 $\pm$ 1 second	GSE image display field increments by 1 again.

6	Upload 2 image events with same parameters as step 2, but second image Δ T = 180 seconds. Command TRIGGER	Shutter time = S seconds.	GSE image display field increments by 1.
7	Wait 180 seconds.	Shutter time = S + 180 ± 1 second.	GSE image display field increments by 1 again.

Test 20 Image Event Wait/Count Test

Test Objective: Verify that the WAIT/COUNT fields of the IMAGE EVENT work correctly.

Step	Action	ISB	Image Header/Cassini Header 2
1	Upload and Trigger 4 x 4 image event with lossless compression, conversion, and the following parameters: prepare cycle = 4 sec. no filter movement exposure = 5 ms. readout cycle = 6 sec. Total image event = 6 sec. Iteration count = 16 Event wait = 60 sec Count = 5	Check shutter address and verify shutter blade reset time stamps are the following: 66 sec. interval between events 4 and 5 9 and 10 14 and 15 6 sec. interval between all other events.	Verify shutter close times equal the following: 66 sec. interval between events 4 and 5 9 and 10 14 and 15 6 sec. interval between all other events.

Test 21 Truncation Test

Test Objective: Verify that the line truncation algorithm of the image event command works correctly for an image that is losslessly compressed.

Step	Action	GSE Image Files	Visual
1	Prepare a target object image comprised of white noise.		
2	Turn direct access on.		
3	Upload and Trigger a single image event, 1x1 with lossless compression and other appropriate parameters.	Compare two image files, test.da (direct access file) with test.fsw (flight software file). Test is successful if images match with 0 difference.	Verify test.da and test.fsw files have partial even line dropout on the right.

Test 22 Deleted

Test 23 Verification of Extended Science Header Occurrence Test

Test Objective: Verify that the Extended Science Header appears at the first, last, and every 50th packet.

This test is to be performed once each for NAC and WAC.

Step	Action	GSE Science Header File
1	Using GSE, set telemetry rate in Flight Software to 6 pkts / RTI.	
2	Upload and Trigger a single image event, 1x1 with no compression, no conversion and other appropriate parameters.	
3	Check science header file.	Verify that: a. First, last and every fifty packets has an extended header. b. NAC/WAC indicator is correct in the header c. The header type value is correct d. The last packet bit is set in the last packet header.
4	Repeat steps 1-3 for 4x4 image with lossy compression and conversion.	

Test 24 Loss of RTI/DTS Test

Test Objective: Verify that the FSW is robust to the loss of RTI and DTS while taking an image.

Step	Action	Housekeeping Packet	Visual
1	Using GSE, set telemetry rate in Flight Software to 6 pkts / RTI. Turn direct access on.		
2	Upload and Trigger a single image event, 1x1 with no compression, no conversion and other appropriate parameters.		
4	Stop RTI and DTS in the middle of the IMAGE EVENT.		
5	Resume RTI/DTS		
6	Wait for image transfer to finish.		
7	Check image.		Image has no miss lines. Image matc direct access imag
8	Check the Housekeeping Packet for errors	RTI/DTS error is logged in the Housekeeping Packet	
9	Repeat steps 1-8 for image with lossy compression and conversion.		

Test 25 Deleted

Test 26 Upload Memory Size Test

Test Objective: Verify that the temporary and permanent command memories are of the correct size.

Step	Action	ISB	Visual
1	Prepare 10 LOAD_MACROS (LM) as follows: LM1 = has 5 second CAL LAMP Command and an appropriate number of NOOPs for total of 2K words. LM2-9 = 2K words each. LM10 = has 10 second CAL LAMP Command and an appropriate number of NOOPs for total of 2K words.		

2	Prepare 12 LOAD_PMACROS (LPM) as follows: LPM1 = has 15 second CAL LAMP Command and an appropriate number of NOOPs for total of 1K words. LPM2-11 = 1K words each. LPM12 = has 20 second CAL LAMP Command and an appropriate number of NOOPs for total of 1K words.		
3	Upload MACROs and PMACROs for total upload of 32K words.		
4	TRIGGER LM1	CAL LAMP address is on then off for 5 second duration.	Calibration Lamp LED lights for 5 seconds.
5	TRIGGER LM10	CAL LAMP address is on then off for 10 second duration.	Calibration Lamp LED lights for 10 seconds.
6	TRIGGER LPM1	CAL LAMP address is on then off for 15 second duration.	Calibration Lamp LED lights for 15 seconds.

7	TRIGGER LPM12	CAL LAMP address is on then off for 20 second duration.	Calibration Lamp LED lights for 20 seconds.

Test 27 Verify SCLK Sync Test

Test Objective: Verify that the FSW will synchronize with the CDS Spacecraft clock time.

Part I:

Step	Action	Housekeeping Packets
1	Verify Flight Software is in idle.	SCLK = a* * a represents current value of the field.
2	Initiate GSE command to set SCLK to 12,000 seconds.	
3	Check housekeeping packets.	SCLK = a + 12,000 seconds. Verify recoverable error field = 33 (SCLK_MISMATCH)

Part II:

Step	Action	Housekeeping Packets
1	Put Flight Software in SLEEP state	
2	Use GSE to stop SCLK update for 10 sec.	Success: Fatal error type: FATAL_SCLK_DROP

3	With Flight Software in SLEEP state, use GSE to stop SCLK update for 9 sec	Success: No FATAL_SCLK_DROP message Recoverable error field = 33: SCLK_MISMATCH

Test 28 Parity Bit Test on Image Line Header

Test Objective: Verify that the parity bit in the image line header which determines the parity of the line length count is correct.

Step	Action	Log File
1	Upload and Trigger an image event, 1 x 1, no compression, no conversion.	
2	Dump first ten image line headers in a log file.	Verify parity bit for both fields of each line is consistent with each corresponding line length.
3	Repeat steps 1 and 2 using a 2 x 2 image with no compression, no conversion, with line size of 512.	Verify parity bit for both fields of each line is consistent with each corresponding line length.
4	Repeat steps 1 and 2 using a 2 x 2 image with lossless compression.	Verify parity bit for both fields of each line is consistent with each corresponding line length.
5	Repeat steps 1 and 2 using 4 x 4 with no compression.	Verify parity bit for both fields of each line is consistent with each corresponding line length.

Test 29 Extended and Overclocked Pixel Test in Line Header

Test Objective: Verify that the extended and overclocked pixels are correctly included in the image line header.

Step	Action	Log File
1	Turn on CCD Simulator with ramp	
2	Upload and Trigger an image event, 1 x 1 with no compression and no conversion.	
3	Dump first ten lines in a log file.	Verify that extended DN = 4 and Overclocked DN = 1036.
4	Upload and Trigger an image event, 2 x 2 with no compression and no conversion.	
5	Dump first ten lines in a log file.	Verify that extended DN = 1 and Overclocked DN = 517.
6	Upload and Trigger an image event, 4 x 4 with no compression and no conversion.	
7	Dump first ten lines in a log file.	Verify that extended DN = 0 and Overclocked DN = 258.

Test 30 Flood Light and Erase Test

Test Objective: Verify that the time windows allocated for flood and erase are correct.

Step	Action	ISB
1	Begin test with Power-On Reset (POR)	
2	Upload an image event with appropriate parameters. Exposure equals 5 ms.	Monitor the following: Flood Light port address Erase port address Blade A port address
3	Trigger image event.	Verify the following: Flood Light is on for 100 ms. Erase is on for 750 ms (The erase window is a constant). Blade A opens within 5 ms of Erase OFF.

Test 31 Inactive Optics Heaters During Filter Movement Test

Test Objective: Verify that the Optic Heaters are turned off during the Filter Wheel movement.

Step	Action	ISB	GSE Current
1	Adjust HDE Simulator so that the Optic Heaters will always be on.	Verify that the heaters are on by checking ISB heater address.	Verify current is consistent with condition of both heaters on.
2	Upload and Trigger an image event with appropriate parameters, with 1 sec. filter movements for the image.	Verify that just before filters move the Optic Heaters are turned off. Verify when filters stop that Optic Heaters are turned on.	

Test 32 Camera Interaction Under Reset Test

Test Objective: Verify that the WAC will continue to execute properly when the NAC is being reset and vice versa.

Step	Action	WAC Housekeeping Packet	Extended Science Header	GSE Images
1	Upload a 5-image event sequence in each camera with identical parameters such that the sequence will execute for 2 minutes or more.			
2	After 1 minute cause the NAC to reset.	Verify WAC completes the 5 images by checking parameters in the image summary.	Verify WAC completes the 5 images by checking that the following parameters are as expected: Summation Compression Conversion Filter Position	Verify WAC completes the 5 images by checking that GSE displays all five.

3	Upload a 5-image event sequence in each camera with identical parameters such that the sequence will execute for 2 minutes or more.			
4	After 1 minute cause the WAC to reset.	Verify NAC completes the 5 images by checking parameters in the image summary.	Verify NAC completes the 5 images by checking that the following parameters are as expected: Summation Compression Conversion Filter Position	Verify NAC completes the 5 images by checking that GSE displays all five.

Test 33 Heater Table Test

Test Objective: Verify that the optic heater tables, based on external temperatures, are correct by comparing them with external algorithm.

Step	Action	Housekeeping Packet
1	Set T1 and T2 on HDE Simulator to an appropriate setting	Obtain T1 and T2 indications from housekeeping packet
2	Issue READ_MEMORY Command to obtain Table 1 and Table 2 resident in RAM.	

3	Input T1 and T2 obtained in step 1 to obtain Ground Table 1 and Ground Table 2	
4	Verify RAM Table 1 matches Ground Table 1. Verify RAM Table 2 matches Ground Table 2	
5	Repeat steps 1-4 for 5 pairs of temperature values	

Test 34 Heater Table Output Test

Test Objective: Verify that the FSW is turning on and off the heaters according to the tables.

Step	Action	I S B Monitor
1	Set T1 and T2 on the HDE Simulator to an appropriate setting	
2	Issue READ_MEMORY Command to obtain Table 1 and Table 2 resident in RAM.	
3	Obtain data from Logic Analyzer (LA) for a 24-second interval	ISB outputs the following: LED Start-of-second ISB Heater 1 ISB Heater 2

4	Verify RAM Table 1 matches ISB Heater 1. Verify RAM Table 2 matches ISB Heater 2.	
5	Repeat steps 1-4 for 5 pairs of temperature values	

Test 35 Housekeeping Image Summary Test A

Test Objective: Verify that the image summary field of the housekeeping is correct.

Step	Action	Housekeeping Packet
1		Verify following values in housekeeping packet: Image Number = a* Trigger ID = b* Note the values of the six sub-fields of twenty image fields. * a and b represent current values of these fields.

2	Send UPLOAD Command with two LOAD_MACRO Image Event Commands with IDs 13 and 14. The following two tables (tables titled "Image Event 1 Settings - Images 1-10 and Images 11-20") provide the settings for the twenty images in Image Event 1 and the table "Image Event 2 Settings" provides the settings for four images in Image Event 2.	
3	Send Trigger 13	Verify following values in housekeeping packet: Image Number = a + 20 Trigger ID = 13 Six sub-fields of twenty image fields match values of Image Event 1
4	Send Trigger 14	Verify following values in housekeeping packet: Image Number = a + 24 Trigger ID = 14 Values of the six sub-fields of twenty image fields have changed and now match the values of Image Event 1, except that values for the four oldest images have been replaced by values in Image Event 2.

Image Event 1 Settings - Images 1-10

	Image									
Field	1	2	3	4	5	6	7	8	9	10
Compression										
Filter 1	1	1	1	1	2	2	2	2	3	3
Filter 2	1	2	3	4	5	1	2	3	4	5
Gain										
Summation										
Conversion										

Image Event 1 Settings - Images 11-20

	Image									
Field	11	12	13	14	15	16	17	18	19	20
Compression										
Filter 1	3	3	4	4	4	4	1	1	1	1
Filter 2	1	2	3	4	5	1	2	3	4	5
Gain										
Summation										
Conversion										

Image Event 2 Settings

	Image			
Field	1	2	3	4
Compression				

Filter 1	6	7	8	9
Filter 2	6	7	8	9
Gain				
Summation				
Conversion				

Test 36 Housekeeping Image Summary Test B

Test Objective: Verify the following fields of the housekeeping are correct: command summary, last macro ID, last upload ID, # of commands received, number of commands executed.

Step	Action	Housekeeping Packet
1		Verify following values in housekeeping packet: Command Opcodes = 8 appropriately specified values Last Macro ID = a* Upload ID = b* Command No. Received = c* Command No. Executed = d* * a,b,c and d represent current values of these fields.
2	Send UPLOAD (designated #33) with two LOAD MACRO Commands, with IDs 13 and 14, as shown in Macro Table below.	Verify following values in housekeeping packet: Command Opcodes = same values as listed in step 1 Last Macro ID = a Upload ID = 33 Command No. Received = c + 2 Command No. Executed = d

3	Send Trigger 13	Verify following values in housekeeping packet: Command Opcodes = Values in Macro 1 Last Macro ID = 13 Upload ID = 33 Command No. Received = c + 2 Command No. Executed = d + 8
4	Send Trigger 14	Verify following values in housekeeping packet: Command Opcodes = Values in Macro 2 Last Macro ID = 14 Upload ID = 33 Command No. Received = c + 2 Command No. Executed = d + 16

Macro Table for Test 36

Macro 1	Macro 2
NOOP	NOOP
CAL LAMP	NOOP
FLOOD LIGHT	NOOP
FILTER	NOOP
NOOP	CAL LAMP
FLOOD LIGHT	CAL LAMP
FILTER	CAL LAMP
NOOP	NOOP

Test 37 Cold Start Test

Test Objective: Verify that the FSW will be downloaded and restart correctly under a Cold Start condition.

Step	Action	Housekeeping Packet	Memory Monitor Packet
1	Initiate Flight Software startup.		
2	Put FSW to IDLE state		
3	Use PORT to overwrite the number of PMACRO slots with the value AAAA (HEX).		
4	Press EFC reset button		
5	Load FSW program when BIU status = 1D		
6	Wait until program is loaded	Success: Microprocessor State = IDLE	
7	Use MONITOR MEMORY to examine the number of PMACRO constant		Success: Number of PMACRO slots = 12 Verify that the BIU status reports checksum error with error code = 28 in HEX.

Test 38 Warm Start Test

Test Objective: Verify that the FSW will restart correctly under Warm Start condition.

Step	Action	Housekeeping Packet	Visual	BIU Status
1	Initiate Flight Software startup.	Verify Flight Program is in idle state. Verify Warm Start bit is set in the first Housekeeping Packet.		
2	Press reset button on EFC breadboard.	Momentary pause in housekeeping packets.	GSE pauses for a moment, but does not pause for one minute for Flight Software load.	Verify the BIU status = 2, and never = 15 (there should be no Flight Software loading status).
3	Check housekeeping and visual after five seconds.	Verify Flight Software is in idle state.	GSE resumes functioning.	

Test 39 Background Loading Test

Test Objective: Verify that no more than 30% of any 5-ms period is spent in the background.

Part 1: FSW in Idle State

Step	Action	Logic Analyzer
1	Put FSW in idle state	
2	Setup LA for address B0000 (LED address) for values 0 - 49	

3	Delay 2 sec after starting LA	
4	Readout LA results	Compare results of LA pairs: LA pairs: (0, 25), (1, 26), (2, 27), ..., (24, 49) Success: No time value > 1.67 ms in a 5 ms interval.

Part 2: FSW in Most Demanding Stage

Step	Action	Logic Analyzer
1	Upload an IMAGE EVENT with: no filter wheel movements 5 ms exposure readout = 45 sec 1X1, no compression 12 bit	
2	Trigger IMAGE EVENT	
3	Delay 5 sec	
4	Setup LA for address B0000 (LED address) for values 0 - 49	
5	Delay 2 sec after starting LA	

6	Readout LA results	Compare results of LA pairs: LA pairs: (0, 25), (1, 26), (2, 27), ..., (24, 49) Success: No time value > 1.67 ms in a 5 ms interval.

Test 40 Telemetry Mode Change Test - During Image Event

Test Objective: Verify that the FSW detects telemetry mode change during an image event.

Step	Action	Extended Science Header	Visual
1	Using GSE, set telemetry rate in Flight Software to 2 pkts / RTI.		
2	Upload image event with following data: 2 x 2 image no conversion no compression prepare cycle = 4 readout cycle = 3 Command Trigger	Verify 2 pkt / RTI in rate field.	
3	Wait 20 seconds after Trigger and using GSE, set telemetry rate to 6 pkts / RTI.	After 5 seconds, verify 6 pkts / RTI in rate field.	

4	Verify output image from GSE is complete.		Verify output image to GSE is recorded about 32 seconds after Trigger.

Test 41 Memory Protection Test

Test Objective: Verify that the memory protection feature is working correctly**.**

Step	Action	Housekeeping Packet
1	Start with FSW in idle state	
2	Use LOAD MEMORY to upload an XSUBs routine that: 1. Increment the image count field once per RTI (an un-protected area) 2. Increment the recoverable error count field (a protected area)	
3	Examine HKP output	Success: 1. Image count field changes per RTI. 2. Error count field does not change. 3. Machine error increments 8 per sec (once per RTI) as second update fails due to memory protect.

Test 42 Cassini Science Header Test

Test Objective: Verify that the Cassini Science header of the Cassini Science packet is correct.

This test is to be performed once each for NAC and WAC.

Step	Action	Cassini Science Packet
1	Take an image	
2	Capture extended header in a log.	
3	Perform steps 1 through 2 for the following modes: 1 x 1 no conversion 1 x 1 with conversion 2 x 2 no conversion 2 x 2 with conversion 4 x 4 no conversion 4 x 4 with conversion	

4	Examine Cassini primary and secondary headers	Verify the following: version # = 000 type = 0 secondary header flag = 1 subsystem id = 01100 segment flag = 11 CDS error flag = 0 camera type* is correct for the type of camera being tested packet id* = 0010 packet length = 945 source sequence field = a) increments from start to end b) final value matches the value listed in the table below. * Camera type and packet id are sub fields of application process ID (ref. CAS-3-281)

Image Modes and Packet Number for Test 42

Summation	Conversion	# of Packets
1X1	None	2277
1X1	12:8	1143
2X2	None	572
2X2	12:8	288
4X4	None	144

4X4	12:8	74

Test 43 Cassini Housekeeping Packet Header Test

Test Objective: Verify that the Cassini header for the Housekeeping Packet is correct.

Step	Action	Housekeeping Packet	Visual
1	Log 10 packets from NAC	Verify the following: version # = 000 type = 0 secondary header flag = 1 subsystem id = 01100 segment flags = 11 CDS error flags = 0 camera type* = NAC packet id* = 0001 packet length = 133 Verify that spacecraft time increments 1 second for each consecutive packet Verify that in the Housekeeping body, camera type = NAC	Verify that first packet seconds field is Remote Terminal Interface Unit (RTIU) time +1±1 sec.

2	Log 10 packets from WAC	Verify the following: version # = 000 type = 0 secondary header flag = 1 subsystem id = 01100 segment flags = 11 CDS error flags = 0 camera type* = WAC packet id* = 0001 packet length = 133 Verify that spacecraft time increments 1 second for each consecutive packet Verify that in the Housekeeping body, camera type = WAC * Camera type and packet id are sub fields of application process ID (ref. CAS-3-281)	Verify that first packet seconds field is RTIU time +1±1 sec.

Test 44 Cassini HDE Monitor Packet Header Test

Test Objective: Verify that the Cassini HDE Monitor Packet header is correct.

Step	Action	HDE Monitor Packet	Visual
1	Log 10 packets from NAC	Verify the following: version # = 000 type = 0 secondary header flag = 1 subsystem id = 01100 segment flags = 11 CDS error flags = 0 camera type* = NAC packet id* = 1101 packet length = 133 source sequence field = 1 Verify that spacecraft time increments 1 second for each consecutive packet	Verify that first packet seconds field is RTIU time +1±1 sec.

2	Log 10 packets from WAC	Verify the following: version # = 000 type = 0 secondary header flag = 1 subsystem id = 01100 segment flags = 11 CDS error flags = 0 camera type* = WAC packet id* = 1101 packet length = 133 source sequence field = 1 Verify that spacecraft time increments 1 second for each consecutive packet * Camera type and packet id are sub fields of application process ID (ref. CAS-3-281)	Verify that first packet seconds field is RTIU time +1±1 sec.

Test 45 Cassini Memory Monitor Packet Header Test

Test Objective: Verify that the Cassini Memory Monitor Packet header is correct.

Step	Action	Memory Monitor Packet	Visual
1	Log 10 packets from NAC	Verify the following: version # = 000 type = 0 secondary header flag = 1 subsystem id = 01100 segment flags = 11 CDS error flags = 0 camera type* = NAC packet id* = 1110 packet length = 133 source sequence field = 1 Verify that spacecraft time increments 1 second for each consecutive packet	Verify that first packet seconds field is RTIU time +1±1 sec.

2	Log 10 packets from WAC	Verify the following: version # = 000 type = 0 secondary header flag = 1 subsystem id = 01100 segment flags = 11 CDS error flags = 0 camera type* = WAC packet id* = 1110 packet length = 133 source sequence field = 1 Verify that spacecraft time increments 1 second for each consecutive packet * Camera type and packet id are sub fields of application process ID (ref. CAS-3-281)	Verify that first packet seconds field is RTIU time +1±1 sec.

Test 46 Cassini Memory Dump Packet Header Test

Test Objective: Verify that the Cassini header for memory dump is correct.

Step	Action	Memory Dump Packet
1	Acquire 1024 words (3 packets from NAC)	Verify the following: camera type = NAC packet id = 0111 packet length = 945 source sequence field = increments from 1 to 3
2	Acquire 1024 words (3 packets from WAC)	Verify the following: camera type = WAC packet id = 0111 packet length = 945 source sequence field = increments from 1 to 3
3	Observe spacecraft time in : a. Cassini Secondary header (spacecraft time field holds the memory dump time) b. Housekeeping packet	Verify the following: a. Memory dump time for the first memory dump packet is within 2 seconds of housekeeping time b. The change in the times of 2 consecutive memory dump packets is consistent with the data rate (e.g. for 6 packets per 1 RTI or 125 ms => 20 ms per packet)

Test 47 EFC States Test

Test Objective: Verify that the microprocessor state field in the housekeeping is correct.

Part I:

Step	Action	Housekeeping Packet
1	Put Flight Software in idle state (bit is set to 1).	Verify in housekeeping log that microprocessor state is set to idle.
2	Send an image event with exposure of 1 minute.	Verify in housekeeping log that microprocessor state is set to active.
3	Use RTIU to set sleep bit to 0.	Verify in housekeeping log that microprocessor state is set to sleep.
4	Use RTIU to set sleep bit to 1.	Verify in housekeeping log that microprocessor state is set to idle.

Part II:

Step	Action	Console
1	Put Flight Software in SLEEP state	
2	Run special user console function to determine processor speed code	Success: code = 01 (binary), indicating 1/4 speed.
3	Put Flight Software in IDLE state	
4	Run special user console function to determine processor speed code	Success: code =10 (binary)

Test 48 High Rate Memory Header Test

Test Objective: Verify that the High Rate Memory Header is correct.

Step	Action	Memory Packet Header
1	Issue READ_MEMORY Command on NAC to obtain 2048 words. Specify appropriate Start Address (S) and End Address.	
2	Acquire Memory Dump of 5 packets in a log file and examine.	Verify the following: camera type = NAC packet 1 start address = S end address = S + 463 packet 2 start address = S+464 end address = S+927 packet 3 start address = S+928 end address = S+1391 packet 4 start address = S+1392 end address = S+1855 packet 5 start address = S+1856 end address = S+2047

Test 49 TRIGGER Timing Test

Test Objective: Verify that the command is triggered within one second of commanding.

Step	Action	I S B Monitor	Visual Inspection
1	Using LOAD MACRO load a macro into Command Memory. Macro contains minor commands, SHUTTER, to open shutter for 5 seconds, close shutter and reset		

2	Using GSE, send trigger to the Flight Software with ID of macro loaded in step 1	Using LA, record LED event and shutter address on ISB. Verify shutter opens at RTI-0.	Shutter opens less than one second after LED event
3	Repeat step 2 for each of the remaining 7 RTI's, waiting for an appropriate number of seconds between each test	Same as above	Same as above

Test 50 TRIGGER in all Command Memory Locations Test

Test Objective: Verify that the commands in all permanent slots can be triggered, and that up to 200 commands in temporary memory can be triggered.

Step	Action	I S B Monitor
1	Using the LOAD PMACRO Command, load 12 macros into permanent Command Memory, each macro having a single PORT command addressing a specific LED address	
2	Using GSE, successively send triggers 1 - 12 to activate corresponding permanent memory locations 1 - 12	LA records corresponding value set for each trigger command

3	Using the LOAD MACRO Command, load 200 commands into temporary memory using NOOPs for intervening commands.	
4	Beginning with command 13 and , successively send triggers 13 - 212 to activate corresponding temporary memory locations 13 - 212	LA records corresponding value set for each trigger command

Test 51 MONITOR MEMORY Static Test

Test Objective: Verify that the monitor memory command can read a non-changing variable.

Step	Action	Housekeeping Packet
1	Use LOAD_MEMORY Command to load an appropriate value into a specified address in RAM.	
2	Command MONITOR_MEMORY for that address	Observe 61 repeated values at specified address Verify that: a. Count = 61 b. Address = Commanded address c. Camera = NAC

3	Repeat for 9 other specified addresses	
4	Repeat test for WAC, use only one address	

Test 52 MONITOR MEMORY Dynamic Test

Test Objective: Verify that the monitor memory command can monitor a changing variable.

Part I:

Step	Action	Memory Monitor Packet
1	Determine address of sub-rti_count.	
2	Set monitor memory rate to once per 5 ms.	
3	Issue MONITOR_MEMORY Command for sub-rti_count address. Repeat three times	Verify the value increments for each measurement.
4	Repeat steps 1 - 3 for the following: rti_count DTS_interrupt_count	 Verify one rti_count increment for every 25 housekeeping packet entries. Verify one DTS_interrupt _count increment for every 25 housekeeping packet entries.

Part II:

Step	Action	Memory Monitor Packet
1	Repeat Part I, steps 1 - 3, with the following change: Run at sampling interval of 5 (in units of 5 ms)	Success: rti_count increments by 1 per sample DTS_interrupt_count increments by 1 per sample

Test 53 MONITOR MEMORY On/Off Test

Test Objective: Verify that memory monitor can be turned on and off.

Step	Action	Housekeeping Packet
1	Issue MONITOR_MEMORY ON Command with a specified address and an appropriate value.	Observe the value at the specified address
2	Issue MONITOR_MEMORY OFF Command.	Observe housekeeping packet returns to normal output format.
3	Repeat steps 2 and 3 two times.	

Test 54 Telemetry Data Rate Test

Test Objective: Verify that 1. the number of packets per second matches the selected TLM rate, 2. the total time of an image transfer is as expected, and 3. FSW adjusts to the changing TLM mode.

Step	Action	Housekeeping Packet	Visual
1	Upload 8 Image Events as listed in the table below.		
2	Set telemetry data rate to 1.		
3	Trigger Image Event 1	Verify that the value in the Housekeeping data rate field is as specified in step 2.	Verify that the image transfer time (in the test log) matches the value in the table below.
4	Write down 5 consecutive packet counts from the GSE TLM window		Verify that the # of packets/sec matches the TLM mode
5	Repeat steps 3 and 4 for remaining 7 images.		
6	Repeat steps 2 through 5 for remaining data rates.		

Image Event Table for Telemetry (TLM) Data Rate Test

Image Event	Summation	Conversion	# of Packets	Image Transfer Time in Seconds for the Following TLM Rates in packets/RTI **					
				6	5	4	3	2	1
1	1 x 1	none	2277	53.44	62.93	77.16	100.88	148.31	290.63
2	1 x 1	12:8	1143	29.81	34.58	41.72	53.63	77.44	148.88
3	2 x 2	none	572	17.92	20.30	23.88	29.83	41.75	77.5
4	2 x 2	12:8	288	12.00	13.2	15.00	18.00	24.00	42.00
5	4 x 4	none	144	9.00	9.60	10.50	12.00	15.00	24.00

6	4 x 4	12:8	74	7.54	7.85	8.31	9.08	10.63	15.25

** The Image transfer time includes the 4 seconds for prepare cycle and 2 seconds for flood light, erase and padding. The equation used for the calculation is: Image Transfer time = ((# of packets) / (48 packets/sec for TLM rate = 6)) • (6 / current TLM rate) + 4 sec + 2 sec.

Test 55 Image Event Device Driver Sequence Test

Test Objective: Verify that the sequence of device driver events are correct.

Step	Action	ISB Monitor
1	Adjust optics temperature on GSE to ensure algorithm turns heaters on.	
2	Upload an Image Event with the following parameters: filter wheel 1 = a filter wheel 2 = b exposure index = c summation = d	
3	Set ISB to monitor the following: shutter optics heater filter wheels light flood erase CCD integration clockout	
4	Trigger Image Event	

5	Record ISB output into log file.	Success is that addresses are accessed in the following order and values: shutter blades a & b = reset optics heater 1 & 2 = off filter wheels movement = consistent with a & b optics heater 1&2 = on light flood on then off, ΔT = 100 ms erase start, stop ΔT = <750 ms integration on shutter a actuation = consistent with c shutter b actuation = consistent with c ΔT between first shuttering and integration shuttering >= 2 sec integration off clockout begin repeat clockout time is consistent with d no filter wheel or shutter actuation during readout

Test 56 Image Event Full Exposure Test

Test Objective: Verify that all exposures in the exposure table produce the right shutter time.

Step	Action	Science Packet	ISB Monitor
1	Cross filters.		

2	Upload 64 Image Events with exposure indices from 0 to 63 and the following parameters: prepare cycle of each image is consistent with exposure time. summation = 4 x 4 compression = 2:1 conversion = 12:8 readout time < 6 sec all other parameters as appropriate		
3	Set ISB to monitor shutter address. Log 1 science packet.		
4	Trigger Image Event 1.		
5	Log ISB output and exposure time from science packet.	Success is: Exposure index in science packet matches commanded exposure index.	Success is: The difference between the actual exposure time and the exposure time indicated by the index is ² 1 ms .
6	Repeat for remaining 63 values.		

Test 57 Image Event 12:8 LUT Test

Test Objective: Verify that the image event is calling the 12:8 lookup table (LUT) correctly.

Step	Action	CCD Simulator
1	Obtain Cornell 12:8 LUT.	
2	Upload 1 Image Event with the following parameters: 1 x 1 no compression conversion = 12:8 other parameters as appropriate	
3	Turn on CCD Simulator. Input ramp 0 - 1023.	
4	Trigger Image Event.	
5	Dump first line in image.	Success is that the line matches values in Cornell file.
6	Change CCD Simulator to a random value "a" above 1023.	
7	Trigger Image Event.	
8	Dump first line in image.	Success is that the line matches values in Cornell file.
9	Repeat steps 6 through 8 for 10 other values.	

Test 58 Image Event Combinatorial Test

Test Objective: Verify that the correct packet sizes and correct number of packets are produced, while varying the summation, compression, conversion and exposure.

Step	Action	Extended Science Header	Housekeeping Packets	DA Compare
1	Create Upload of 37 Image Events as listed in Table below.			
2	Trigger Image Event 1.			
3	Delay 1 second.	Check 1 packet header and verify values match table values.	Check 2 packets and verify values match table values.	
4	Difference Flight Software image and DA image. Verify images match.	Verify first and last headers are extended. Verify every 50th header is extended.		Verify that images match.
5	Repeat steps 1 through 4 for remaining 36 images.			

Image Event Table for Combinatorial Test

Image Event	Filter 1	Filter 2	Summation	Compression	Conversion	Exposure
1	a	x	2 x 2	lossless	none	T1
2	a	y	2 x 2	lossless	none	T1
3	a	z	2 x 2	lossless	none	T1
4	b	x	2 x 2	lossless	none	T1
5	b	y	2 x 2	lossless	none	T1
6	b	z	2 x 2	lossless	none	T1

7	c	x	2 x 2	lossless	none	T1
8	c	y	2 x 2	lossless	none	T1
9	c	z	2 x 2	lossless	none	T1
10	a	x	2 x 2	lossless	none	T1
11	a	x	2 x 2	lossless	none	T2
12	a	x	2 x 2	lossless	none	T3
13	a	x	2 x 2	lossless	none	T4
14	a	x	1 x 1	none	none	T2
15	a	x	1 x 1	none	12-8	T2
16	a	x	1 x 1	none	LSB	T2
17	a	x	1 x 1	lossy	12-8	T2
18	a	x	1 x 1	lossy	LSB	T2
19	a	x	1 x 1	lossless	none	T2
20	a	x	1 x 1	lossless	12-8	T2
21	a	x	1 x 1	lossless	LSB	T2
22	a	x	2 x 2	none	none	T2
23	a	x	2 x 2	none	12-8	T2
24	a	x	2 x 2	none	LSB	T2
25	a	x	2 x 2	lossy	12-8	T2
26	a	x	2 x 2	lossy	LSB	T2
27	a	x	2 x 2	lossless	none	T2
28	a	x	2 x 2	lossless	12-8	T2
29	a	x	2 x 2	lossless	LSB	T2
30	a	x	4 x 4	none	none	T2
31	a	x	4 x 4	none	12-8	T2
32	a	x	4 x 4	none	LSB	T2
33	a	x	4 x 4	lossy	12-8	T2
34	a	x	4 x 4	lossy	LSB	T2
35	a	x	4 x 4	lossless	none	T2
36	a	x	4 x 4	lossless	12-8	T2
37	a	x	4 x 4	lossless	LSB	T2

Test 59 READ MEMORY Test

Test Objective: Verify that the READ MEMORY Command is working correctly.

READ MEMORY Test - Part I

Step	Action	Memory Dump Packet	Cassini Secondary Header
1	Initiate Flight Software and put into idle state.		
2	Issue Upload Command with READ MEMORY with exposure table addresses = a.		
3	Collect READ MEMORY into a log file.	Success is: Memory dump packet returns. Check camera ID = NAC in the memory dump header. Verify start and end addresses in the memory dump header = a. Verify that exposure table is in data portion.	Success is: Time field in Memory Dump Packet = SCLK field in Cassini Secondary Header. (This check is for Time field in Memory Dump Packet)

READ MEMORY Test - Part II

Step	Action	Memory Dump Packet
1	Initiate Flight Software and put into idle state.	
2	Issue LOAD MEMORY Command which puts 10 words of value x at address m in the middle of memory.	
3	Issue an Upload with 3 READ MEMORY Commands: 1) first 1/3 of memory 2) second 1/3 of memory 3) third 1/3 of memory	
4	Collect READ MEMORY output into a log file.	Success is: First 1/3 of memory: Locate prepare table, readout tables and verify to code listing. Second 1/3 of memory: Locate in memory dump packets address m. Verify 10 words = x. Third 1/3 of memory: Locate the warm start pattern in last page of memory dump. Verify 10 words.

READ MEMORY Test - Part III

Step	Action	Memory Dump Packet
1	Initiate Flight Software and put into idle state.	
2	Issue LOAD MEMORY Command with 1 word = X'BBBB' at address "m".	

3	Upload READ MEMORY with 1 word address "m".	Success is: Output is single memory dump packet Starting address in header = m and ending address = m. Data = X'BBBB'.

READ MEMORY Test - Part IV

Step	Action	Memory Dump Packet
1	Set TLM mode such that 48 packets per sec is the High Rate value.	
2	Perform Part II of Test 59	Success: TLM display window on the GSE shows 48 packets/sec being returned. Statistics on TLM window show zero new zero-length packets.
3	Repeat steps 1 and 2 with 40 packets/sec	Success: TLM display window on the GSE shows 40 packets/sec being returned. Statistics on TLM window show zero new zero-length packets.
3	Repeat steps 1 and 2 with 16 packets/sec	Success: TLM display window on the GSE shows 16 packets/sec being returned. Statistics on TLM window show zero new zero-length packets.

4	Repeat steps 1 and 2 with 8 packets/sec	Success: TLM display window on the GSE shows 8 packets/sec being returned. Statistics on TLM window show zero new zero-length packets.

Test 60 Housekeeping Durability Test

Test Objective: Verify the stability of the FSW in sleep state.

Step	Action	Housekeeping Packet
1	Initiate Flight Software in Sleep state. Set housekeeping rate to once per sec.	
2	Monitor housekeeping for 1 hour.	Examine the following constant fields and verify no variation: Summation Compression Conversion CAL Lamp state Filter 1 position Filter 2 position Shutter Light flood Upload number Image number Commands received Commands executed Data rate
3	Upload and trigger command to turn on Cal Lamp	Success: Cal Lamp does not turn ON. Value in command_executed field does not increment.

Test 61 Line Header Line Length Test

Test Objective: Verify that the line header in the science packet is correct.

Step	Action	Log File
1	Upload and TRIGGER an image event: 1x1 with no compression, and other appropriate parameters.	
2	Dump first 10 and last 10 image line headers in a log file. Examine line headers (using READ_TLM and READ_SCI programs).	Sum headers for line: 1 = 1024 1024 = 1024 Sum of all headers and data = 476 words per packet.
3	Upload and TRIGGER an image event: 2x2 with no compression and other appropriate parameters.	
4	Dump first 10 and last 10 image line headers in a log file. Examine line headers.	Sum headers for line: 1 = 512 1024 = 512
5	Upload and TRIGGER an image event: 4X4 with no compression and other appropriate parameters.	
6	Dump first 10 and last 10 image line headers in a log file. Examine line headers.	Sum headers for line: 1 = 256 1024 = 256

Test 62 Science Header Auxiliary Test

Test Objective: Verify that eight fields of the standard and extended headers are correct.

PART 1 (Continuation bit, image line, light flood/erase, prepare index, readout index):

Step	Action	Science Data Packets
1	Upload and trigger an IMAGE EVENT with: no conversion no compression summation = 2X2 prepare index = b readout index = a other parameters as appropriate	
2	Dump 4 packets of the following fields: continuation bit image line field light flood/erase prepare index readout index	Success: 1. For the 1st packet, the continuation bit = 0; for all others, the continuation bit = 1 2. Values in the image line fields for the 1st 4 packets = 1,1,2,3, respectively. 3. Light flood/erase = 1 (ON) 4. Readout index = a 5. Prepare index = b

PART 2 (Anti-blooming):

Step	Action	Science Data Packets	ISB
1	Use SET COMPUTER to set anti-blooming on.		
2	Upload and trigger an IMAGE EVENT with same parameters as in Part 1.		
3	Dump 4 packets of the anti-blooming field	Success: anti-blooming = ON for all 4 packets	Success: anti-blooming is ON for all 4 packets
4	Use SET COMPUTER to set anti-blooming off.		
5	Trigger the same IMAGE EVENT as in step 2		
6	Dump 4 packets of the anti-blooming field	Success: anti-blooming = OFF for all 4 packets	Success: anti-blooming is OF for all 4 packets
7	Use SET COMPUTER to set anti-blooming on.		
8	Trigger the same IMAGE EVENT as in step 2		
9	Dump 4 packets of the anti-blooming field	Success: anti-blooming = ON for all 4 packets	Success: anti-blooming is ON for all 4 packets

PART 3 (Table data): Verify that the table data field correctly dumps the preparation , readout, and exposure tables.

Step	Action	Extended Science Data Packet
1	Upload a READ MEMORY command to dump the preparation, readout, and exposure tables	
2	Upload an IMAGE EVENT with: summation: 1X1 no compression no conversion iteration count = 10 other parameters as appropriate	
3	Trigger IMAGE EVENT	
4	Collect the table data fields of extended science headers	
5	Compare header table data with memory dump from step 1.	Success: Table values are the same in memory dump and in the table data fields of the Extended Science Headers

Test 63 8-LSB Test

Test Objective: Verify that the conversion by selecting eight least significant bits (8-LSB) is being recorded, packed and sent properly.

Step	Action	Housekeeping Packets	Science Data Packets	Visual Inspection
1	Turn CCD simulator on, using a 0-1040 ramp			
2	Upload a SET CAMERA with: conversion type = 8-LSB compression = none other parameters as appropriate			
3	Upload an IMAGE EVENT with: summation = 1X1 other parameters as appropriate			
4	Trigger SET CAMERA and IMAGE EVENT	Success: conversion field = 8-LSB		

5	Use READ_TLM and READ_SCI programs to list packets		Success: Verify the 1st 10 lines: 1. Pixels are packed 2 to a word 2. 256th, 512th, and 768th pixels = 0 3. Look for 0-255 ramp pattern	Success: GSE display shows 4 dark to white ramps.

Test 64 Zero Length Packet Test

Test Objective: Verify that the correct number of zero length packets are emitted when no science data is being returned.

Step	Action	GSE
1	Set telemetry mode to 6 packets / RTI	
2	Upload an IMAGE EVENT with exposure index = 63, other parameters as appropriate	
3	Trigger IMAGE EVENT	
4		Examine GSE output for one second interval Success: 48 zero length packets are returned in one second interval

Test 65 Deleted

Test 66 Deleted

Test 67 Warm Start/Command Test

Test Objective: Verify that it is possible to re-trigger a command load after a Warm Start.

Step	Action	Housekeeping Packet	GSE
1	Upload image event with exposure = 1 minute.		
2	Trigger image event.		
3	Delay for 10 seconds.		
4	Press reset EFC button.		
5	Record number of images in housekeeping	Number of images = a	
6	Trigger image event.		Verify direct access and reconstructed images match.
7	Record number of images in housekeeping.	Number of images = a+1	

Test 68 BIU Reset Test

Test Objective: Verify that the FSW can recover from a BIU reset.

Step	Action	Housekeeping Packet
1	Initiate Flight Software in IDLE state. Log Housekeeping.	Verify housekeeping packets are returning.
2	Use GSE to stop the RTIU for 2 seconds.	
3	Use GSE to restart the RTIU.	
4	Delay for 1 second.	Verify housekeeping packets are returning.

Test 69 HALT/WAKE Command Test

Test Objective: Verify that the Halt and WAKE commands work correctly.

HALT/WAKE Command Test - Part I

Step	Action	Housekeeping Packet	ISB	GSE
The following test is for the NAC				
1	Put Flight Software into IDLE state with shutter closed.	Flight Software State = IDLE. Blade B = Reset. Blade A = Reset		
2	Set LA to monitor Shutter and SHE sleep.			
3	Issue HALT Command.			

4	Wait 1 second.	Flight Software State = SLEEP. Blade B = Activate Blade A = Reset	Shutter blade A is activated.	Note the amount of current decrease from GSE housekeeping display
5	Issue WAKE Command.			
6	Wait 1 second.	Flight Software State = IDLE. Blade B = Reset. Blade A = Reset Filter Wheels = Home	Shutter blade A is reset.	Current increases in approximately same amount as it decreases in step 4.

Step	Action	Housekeeping Packet	ISB	GSE
The following test is for the WAC				
1	Put Flight Software into IDLE state with shutter closed.	Flight Software State = IDLE. Blade B = Reset. Blade A = Reset		
2	Set LA to monitor Shutter and SHE sleep.			
3	Issue HALT Command.			
4	Wait 1 second.	Flight Software State = SLEEP. Blade A = Activate. Blade B = Reset. 50V HDE = 2.5 ± 1 V. 30V HDE = 0 to 1 V. ±12V HDE = 0 to 1 V.	Shutter blade A is activated. SHE Sleep bit = SLEEP.	Note the amount of current decrease from GSE housekeeping display
5	Issue WAKE Command.			

6	Wait 1 second.	Flight Software State = IDLE. Blade B = Reset. Blade A = Reset Filter Wheels = Home 50V HDE does not equal to 2.5 ± 1 V. 30V HDE does not equal to 0 to 1 V. ±12V HDE does not equal 0 to 1 V.	Shutter blade A is reset. SHE Sleep bit = WAKE.	Current increases in approximately same amount as it decreases in step 4.

HALT/WAKE Command Test - Part II

(Verify that HALT will interrupt exposure activity.)

Step	Action	Housekeeping Packet
The following test is for the NAC		
1	Upload and Trigger an image event with exposure equal to 1 minute, and other appropriate parameters .	
2	Wait for 15 seconds	Flight Software State = ACTIVE.
3	Issue HALT Command.	
4	Wait 1 second.	Flight Software State = SLEEP.
5	Issue WAKE Command.	
6	Wait 1 second.	Flight Software State = IDLE.

HALT/WAKE Command Test - Part III

(Verify that HALT will interrupt filter wheel movement.)

Step	Action	Housekeeping Packet
The following test is for the NAC		
1	Upload and Trigger an image event with filter wheel movements of 6 positions. Other parameters don't matter.	
2	Wait 1 second.	Flight Software State = ACTIVE.
3	Issue HALT Command.	
4	Wait 1 second.	Flight Software State = SLEEP.
5	Issue WAKE Command.	
6	Wait 1 second.	Flight Software State = IDLE.

HALT/WAKE Command Test - Part IV

Step	Action	Housekeeping Packet	GSE Packet Window
The following test is for the NAC			
1	Upload and Trigger an image event with the following parameters: exposure = 0 filter wheel movement = 0 readout = 1 minute other parameters don't matter.		
2	Wait for 1 second.	Flight Software State = ACTIVE.	
3	Wait for 20 seconds		
4	Issue HALT Command.		Image transfer stops.
5	Wait 1 second.	Flight Software State = SLEEP.	
6	Issue WAKE Command.		
7	Wait 1 second.	Flight Software State = IDLE.	

HALT/WAKE Command Test - Part V

Step	Action	Housekeeping Packet	GSE Packet Window
The following test is for the WAC			
1	Upload and Trigger an image event with the following parameters: exposure = 0 filter wheel movement = 0 readout = 1 minute other parameters as appropriate.		
2	Wait for 1 second.	Flight Software State = ACTIVE.	
3	Wait for 20 seconds		
4	Issue HALT Command.		
5	Wait 1 second.	Flight Software state = SLEEP.	Image transfer stops.
6	Issue WAKE Command.		
7	Wait 1 second.	Flight Software state = IDLE.	

Test 70 SLEEP Bit Test

Test Objective: Verify that the FSW responds to sleep bit.

SLEEP Bit Test - Part I

Step	Action	Housekeeping Packet	ISB	GSE
The following test is for the NAC				
1	Put Flight Software into IDLE state with shutter closed.	Flight Software State = IDLE. Shutter A = Reset. Shutter B = Reset.		
2	Set LA to monitor Shutter and SHE sleep.			
3	Set SLEEP Bit to ON.			
	Wait 1 second.	Flight Software State = SLEEP. Shutter A = Activate. Shutter B = Reset.	Shutter blade A is activated.	Current decreases appropriately.
4	Set SLEEP Bit to OFF.			
5	Wait 1 second.	Flight Software State = IDLE. Shutter A = Reset. Shutter B = Reset Filter Wheels = Home	Shutter blade A is reset.	Current increases appropriately.

Step	Action	Housekeeping Packet	ISB	GSE
The following test is for the WAC				
1	Put Flight Software into IDLE state with shutter closed.	Flight Software State = IDLE. Shutter A = Reset. Shutter B = Reset.		
2	Set LA to monitor Shutter and SHE sleep.			
3	Set SLEEP Bit to ON.		Verify SHE is idle.	

4	Wait 1 second.	Flight Software State = SLEEP. Shutter A = Activate. Shutter B = Reset. 50V HDE = 0. 30V HDE = 0.	Shutter blade A is activated. SHE Sleep bit = SLEEP.	Current decreases appropriately.
4	Set SLEEP Bit to OFF.			
5	Wait 1 second.	Flight Software State = IDLE. Shutter A = Reset. Shutter B = Reset Filter Wheels = Home 50V HDE not equal to 0. 30V HDE not equal to 0.	Shutter blade A is reset. SHE Sleep bit = WAKE.	Current increases appropriately.

SLEEP Bit Test - Part II

Step	Action	Housekeeping Packet
The following test is for the NAC		
1	Upload and Trigger an image event with exposure equal to 1 minute. Other parameters as appropriate.	
2	Wait for 15 seconds	Flight Software State = ACTIVE.
3	Set SLEEP Bit to ON.	
4	Wait 1 second.	Flight Software State = SLEEP.
5	Set SLEEP Bit to OFF.	

6	Wait 1 second.	Flight Software State = IDLE.

SLEEP Bit Test - Part III

Step	Action	Housekeeping Packet
The following test is for the WAC		
1	Upload and Trigger an image event with filter wheel movements of 6 positions. Other parameters as appropriate.	
2	Wait 1 second.	Flight Software State = ACTIVE.
3	Set SLEEP Bit to ON.	
4	Wait 1 second.	Flight Software State = SLEEP.
5	Set SLEEP Bit to OFF.	
6	Wait 1 second.	Flight Software State = IDLE.

SLEEP Bit Test - Part IV

Step	Action	Housekeeping Packet	GSE Packet Window
The following test is for the NAC			
1	Upload and Trigger an image event with the following parameters: exposure = 0 filter wheel movement = 0 readout = 1 minute other parameters as appropriate.		
2	Wait for 1 second.	Flight Software State = ACTIVE.	
3	Wait for 20 seconds		
4	Set SLEEP Bit to ON.		Image transfer stops.
5	Wait 1 second.	Flight Software State = SLEEP.	
6	Set SLEEP Bit to OFF.		
7	Wait 1 second.	Flight Software State = IDLE.	

SLEEP Bit Test - Part V

Step	Action	Housekeeping Packet	GSE Packet Window
The following test is for the WAC			
1	Upload and Trigger an image event with the following parameters: exposure = 0 filter wheel movement = 0 readout = 1 minute other parameters as appropriate.		
2	Wait for 1 second.	Flight Software State = ACTIVE.	
3	Wait for 20 seconds		
4	Set SLEEP Bit to ON.		
5	Wait 1 second.	Flight Software state = SLEEP.	The display in the GSE Packet Window shows that Image transfer has stopped.
6	Set SLEEP Bit to OFF.		
7	Wait 1 second.	Flight Software state = IDLE.	

Test 71 INSTANTANEOUS Command Test

Test Objective: Verify that the instantaneous packet works.

Step	Action	Housekeeping Packet	Visual
1	Upload READ MEMORY Command. Size of Command must require 10 seconds to complete.		
2	Wait for 1 second.	Fight Software state = ACTIVE	
3	Wait 4 seconds.		
4	Send INSTANTANEOUS Command with MONITOR MEMORY with appropriate parameters.	MONITOR MEMORY packet will replace normal housekeeping packet.	
5	Send INSTANTANEOUS Command with MONITOR MEMORY off.	Normal housekeeping packets return.	
6	Upload packet with WAIT Command of 60 seconds.		

7	Send INSTANTANEOUS Command with PORT Command CAL LAMP On. Wait 10 seconds.	CAL LAMP On.	CAL LAMP On.
8	Send INSTANTANEOUS Command with PORT Command CAL LAMP off.	CAL LAMP Off.	CAL LAMP Off.

Test 72 Two-Camera Prepare Cycle Synchronization Test

Test Objective: Verify that when two cameras are operating simultaneously, the prepare cycle events are synchronized.

Step	Action	ISB / Prepare Cycle Table
1	Set Logic Analyzer (LA) to examine LED ISB addresses for WAC and NAC.	
2	Upload one IMAGE EVENT to both cameras with: prepare cycle index = 0 include NAC and WAC blocks all other parameters as appropriate	
3	Trigger IMAGE EVENT	
4	Record LA results	

5		Compare following LA results: start of prepare cycle start of NAC filter wheel end of NAC filter wheel start of WAC filter wheel end of WAC filter wheel start of exposure window end of exposure window end of prepare cycle Success: 1. The difference between NAC time and WAC time for each of the above LED measurements = 0 ± 10 ms 2. NAC filter wheel window and WAC filter wheel window do not overlap
6	Repeat steps 1 through 5, substituting the prepare cycle index parameter for the IMAGE EVENT command with index = 2 and then 6.	

Test 73 Two-Camera Read-Out Cycle Synchronization Test

Test Objective: Verify that when two cameras are operating simultaneously, the read-out cycle events are synchronized.

Step	Action	ISB / Read-Out Cycle Table
1	Set Logic Analyzer (LA) to examine LED ISB addresses for WAC and NAC.	

2	Upload one IMAGE EVENT to both cameras with: read-out cycle index = 0 include NAC and WAC blocks summation = 4X4 with compression 12:8 bit conversion all other parameters as appropriate	
3	Trigger IMAGE EVENT	
4	Record LA results	
5		Compare following LA results: start of read-out cycle start of NAC read-out cycle end of NAC read-out cycle start of WAC read-out cycle end of WAC read-out cycle end of read-out cycle Success: 1. The difference between NAC time and WAC time for each of the above LED measurements = 0 ± 10 ms 2. NAC is readout before WAC

6	Repeat steps 1 through 5, substituting the read-out index parameter for the IMAGE EVENT command with index = 2 and then 6.	

Test 74 Two-Camera Imaging Test

Test Objective: Verify that two cameras can shutter, acquire and return two images simultaneously.

Step	Action	Direct Access
1	Upload one IMAGE EVENT to both cameras with: include NAC and WAC blocks 2:1 compression 12:8 bit conversion 5 blocks with summations as follows: Summation: WAC NAC 1X1 1X1 1X1 2X2 1X1 4X4 2X2 1X1 4X4 1X1 gain as appropriate for the summation modes all other parameters as appropriate	
2	Turn Direct Access ON for NAC	
3	Trigger IMAGE EVENT	

4		Compare images returned. Success: 5 NAC images and 5 WAC images are returned from FSW 5 NAC Direct Access images are returned Differences between each of the 5 set of NAC and Direct Access images = 0
5	Repeat steps 1 through 4, with the following changes: In step 2: Turn Direct Access ON for WAC	Success for step 5: 5 NAC images and 5 WAC images are returned from FSW 5 WAC Direct Access images are returned Differences between each of the 5 set of WAC and Direct Access images = 0

Test 75 Event Upset Test

Test Objective: Verify that 1. FSW reports SEUs and DEUs in the Housekeeping packet, 2. FSW's memory scrub removes SEUs from the Flight Computer RAM.

Step	Action	Housekeeping Packet
1	Put FSW in SLEEP mode	
2	Use READ MEMORY to obtain the values in the following addresses (one at the beginning and the end, and 2 in the middle of the RAM): 100(HEX), 1,000(HEX), 30,000 (HEX), and 7F,000 (HEX)	
3	Note the values in SEU and DEU fields in the HKP packet	Let SEU = a DEU = b

4	Use SEU procedure to corrupt one bit in each of the following addresses: 100(HEX), 1,000(HEX), 30,000 (HEX), and 7F,000 (HEX)	
5	Wait 15 minutes	
6	Note the values in SEU and DEU fields in the HKP packet	Success: SEU = a + 4 DEU = b
7	Use READ MEMORY to obtain the values in the following addresses (one at the beginning and the end, and 2 in the middle of the RAM): 100(HEX), 1,000(HEX), 30,000 (HEX), and 7F,000 (HEX)	Success: All values in the four addresses are restored to the same values obtained in step 2.
8	Repeat steps 1 through 7, with the following exceptions: in Step 4: Use DEU procedure to corrupt one bit in each of the following addresses: 100(HEX), 1,000(HEX), 30,000 (HEX), and 7F,000 (HEX)	Success at Step 6: SEU = a + 4 DEU = b + 4 Success at Step 7: None of the values in the 4 addresses were restored (for DEU case).

Test 76 Prepare Cycle Duration Table Test

Test Objective: Verify that the FSW responds correctly to all prepare cycle times in the Prepare Cycle Table.

Part I: Using NAC with WAC Block

Step	Action	ISB / Prepare Cycle Table
1	Upload one IMAGE EVENT with: prepare cycle index = 0 include WAC block all other parameters as appropriate	
2	Set Logic Analyzer (LA) to examine LEDs for : start of prepare cycle (SP) start of NAC filter wheel (SNAC) end of NAC filter wheel (ENAC) start of WAC filter wheel (SWAC) end of WAC filter wheel (EWAC) start of exposure window (SEXP) end of exposure window (EEXP) end of prepare cycle (EP)	
3	Trigger IMAGE EVENT	
4	Record LA results	

5	Compare LA results with the following Prepare Cycle Table values from code: 1. NAC filter wheel interval (NAC_fw) 2. WAC filter wheel interval (WAC_fw) 3. Exposure interval (EXP)	Success: NAC_fw = ENAC - SNAC ± 10 ms WAC_fw = EWAC - SWAC ± 10 ms EXP = EEXP - SEXP ± 10 ms (EP-SP) = NAC_fw + WAC_fw + EXP + 0.85 ms (flood & erase) + 0.575 ms (pad) ± 10 ms
6	Repeat steps 1 through 5, substituting the prepare cycle index parameter for the IMAGE EVENT command with 1 through 15.	

Part II: Using WAC with NAC Block

Repeat Part I procedure with the following changes:

Run the test with WAC, and in step 1, in the IMAGE EVENT parameter, include NAC block (instead of WAC block).

Part III: Using NAC with No WAC Block

Repeat Part I procedure with the following change:

In step 1, do not include WAC block in the IMAGE EVENT command.

In step 5, the success criteria for WAC_fw = 0 ± 10 ms

Part III: Using WAC with No NAC Block

Repeat Part I procedure with the following change:

Run the test with WAC, and in step 1, do not include NAC block in the IMAGE EVENT command.

In step 5, the success criteria for NAC_fw = 0 ± 10 ms

Test 77 GAIN Test

Test Objective: Verify that the FSW will change the gain state when asked to do so.

GAIN Test - Part I

Step	Action	Housekeeping Packet	Science Packet Header	ISB
1	Upload 4 image events with gain states 0, 1, 2, 3 respectively. Exposure must be determined experimentally. Other parameters as appropriate.			
2	Set ISB to monitor gain address.			
3	Trigger image event 1.	Verify in first packet that gain state = 0.	Verify in first packet header that gain state = 0.	Verify gain state =0.
4	Repeat step 3 for remaining three images.	Verify correct value for gain state.	Verify correct value for gain state.	Verify correct value for gain state.

GAIN Test - Part II

Step	Action
1	Reference Part I above and compute average DN values for 4 images, A1, A2, A3, A4.
2	Verify averages for images such that A1< A2 < A3 < A4.

Test 78 LIGHT FLOOD and ERASE Duration Test

Test Objective: Verify that the Light Flood and Erase durations are correct.

Step	Action	I S B Monitor
1	Put Flight Software into idle state.	
2	Upload LOAD MEMORY Command with Light Flood duration change from 100 ms constant to 200 ms.	
3	Set ISB to monitor Light Flood Address.	
4	Upload and Trigger an Image Event (parameters as appropriate).	**Success Criteria:** ISB listing shows: $\Delta T = 200$ ms between Light Flood ON and Light Flood OFF.
5	Upload LOAD MEMORY Command with ERASE duration change from 750 ms to 850 ms.	

6	Set ISB to monitor Erase Go and Integrate.	
7	Upload and Trigger Image Event (parameters as appropriate).	**Success Criteria:** ISB listing shows: $\Delta T = 850$ ms ± 5 ms for Erase duration. Erase Go is set. Integrate is set.

Test 79 RTI, DTS Interrupt Test

Test Objective: Verify that the FSW is correctly detecting the RTI and DTS interval times.

Step	Action	I S B Monitor
1	Use ISB command to monitor LED address	
2	Detect LED "value" which corresponds to RTI, DTS and sub -RTI	**Success Criteria:** 1. Do detect RTI and DTS values 2. Æt between RTI detections is 125 ms ± 1 ms 3. Æt of RTI-DTS is <=120 ms ± 1 ms

Test 80 ITERATION Test

Test Objective: Verify that the IMAGE EVENT iteration parameter works correctly.

Step	Action	Science Packet Header
1	Upload 1 image event with 6 blocks as shown in table below.	
2	Trigger the image event. Log science packet header data from each image.	Verify 13 images in header. Verify values for 13 images are as follows (see Block Table): Block 1 Block 2 Block 3 Block 3 Block 3 Block 4 Block 5 Block 5 Block 6 Block 6 Block 6 Block 6 Block 6

Image Event Block Table

	Gain	FW1	FW2	Exposure	Iteration
Block 1	0	1	1	1	1
Block 2	1	2	2	2	1
Block 3	2	3	3	3	3
Block 4	3	4	4	4	1
Block 5	0	5	5	5	2
Block 6	1	6	6	6	5

Test 81 XSUBS Test

Test Objective: Verify that a subroutine can be inserted into the FSW while it is running.

Step	Action	ISB
1	Set ISB to monitor LED address.	Verify no activity.
2	Issue LOAD MEMORY Command to put a subroutine at address b in memory; subroutine will write value n at address c.	
3	Issue LOAD MEMORY Command changing jump address at call to XSUB1 to address b in memory.	Verify every 125 ms LED writes value n at address c.
4	Restore Flight Software.	

Test 82 EFC Processing State Verification Test

Test Objective: Verify that in sleep state the EFC is running at 1/4 speed (.32 mips), and in idle/active state the EFC is running at 1/2 speed (.64 mips).

NOTE: This is a manual procedure (no script is available; this test uses a REXX procedure named efc_rate.uc).

Step	Action	User Console
1	POR the computer	
2	Set FSW in sleep sate	
3	Bring up the user console	
4	stop EFC	

5	Execute the REXX procedure named efc_rate.uc	Success: The procedure prints 1/4 speed on the user console window
6	Restart EFC	
7	Using BIU discrete, set FSW to idle	
8	Upload and Trigger an IMAGE EVENT with summation: 1X1 other parameter as appropriate	
9	While the image is being read out, stop EFC	
10	Execute efc_rate.uc from the user console	Success: The procedure prints 1/2 speed on the user console window

Test 83 LOAD MACRO/PMACRO Comprehensive Test

Test Objective: Verify that LOAD MACRO/PMACRO commands can contain the full set of commands.

Step	Action	Housekeeping Packet
1		Verify that the upload empty condition is set in the housekeeping
2	Upload MACRO Command with the following commands: SET CAMERA IMAGE EVENT NOOP LOAD MEMORY READ MEMORY SET COMPUTER MONITOR MEMORY MOVE FILTER WHEEL SHUTTER HEATER CAL LAMP LIGHT FLOOD TCE HDE PORT	Note "number of executed commands" field value "a".
3		Verify that the upload full condition is set in the housekeeping
4	Trigger Macro.	Verify "number of executed commands" field is equal to a + 15.
5	Repeat steps 1-4 using PMACRO Command.	

Test 84 SET COMPUTER Command Test

Test Objective: Verify that the SET COMPUTER command works correctly.

Step	Action	Housekeeping Packet	ISB Monitor
1	Set ISB for the parallel clock voltage address and offset voltage address		
2	Send an upload with: SET COMPUTER PCVOL (Parallel Clock Voltage) = V1 SET COMPUTER OFFSET = V2 **Success Criteria:** SET COMPUTER commands executed without a trigger		**Success Criteria:** ISB values for PCVOL address = V1 ISB values for offset address = V2
3	Clear old ISB settings		
4	Set ISB for anti-blooming address, flood address and erase address		
5	Set an upload with: SET COMPUTER to turn off anti-blooming and turn off erase IMAGE EVENT (parameters as appropriate)		

6	TRIGGER IMAGE EVENT	**Success Criteria:** Housekeeping Anti-blooming = OFF	**Success Criteria:** ISB Anti-blooming value = OFF No ISB report for flood and erase
7	Send an upload with: SET COMPUTER to turn anti-blooming ON and turn flood and erase ON IMAGE EVENT (parameters as appropriate)		
8	TRIGGER IMAGE EVENT	**Success Criteria:** Housekeeping Anti-blooming = ON	**Success Criteria:** ISB Anti-blooming value = ON From ISB, value in flood address changes from ON to OFF, and ON appears in erase address.

Test 85 SET CAMERA Command Test

Test Objective: Verify that the SET CAMERA command works correctly.

SET CAMERA Command Test - Part I

Step	Action	Housekeeping Packet
1	Upload image event. Parameters as appropriate.	
2	Log Housekeeping.	
3	Trigger image event.	Verify compression = lossless Conversion = 12:8

SET CAMERA Command Test - Part II

Step	Action	Housekeeping Packet	ISB
1	Monitor the ISB readout for LED Trigger Arrival, Lossy and Lossless fields.		
2	Upload SET CAMERA with compression = none and conversion = none. Upload 2 image events, parameters as appropriate.		
3	Log Housekeeping.		
4	Trigger SET CAMERA Command. Delay 1 second.		
5	Trigger 2 image events with appropriate delay in between triggers.	Verify that for both image events, compression = none. Conversion = none	
6	Upload SET CAMERA, selecting the default configuration indicator.		

7	Upload an image event, parameters as appropriate.		
8	Trigger SET CAMERA. Delay 1 second.		Verify that SET CAMERA command is completed within a sub-rti (SRD Requirement 120)
9	Trigger image event	Verify compression = lossless Conversion = 12:8	
10	Upload SET CAMERA with compression = lossy and conversion = 12:8 LSB. Upload 2 image events, parameters as appropriate.		
11	Trigger SET CAMERA Command. Delay 1 second.		Verify that SET CAMERA command is completed within a sub-rti (SRD Requirement 120)
12	Trigger 2 image events with appropriate delay in between triggers.	Verify that for both image events, compression = lossy Conversion = 12: LSB	
13	Do POR		
14	When FSW is ready, put FSW to IDLE state.		
15	Upload image event. Parameters as appropriate.		
16	Log Housekeeping.		
17	Trigger image event.	Verify compression = lossless Conversion = 12:8	

Test 86 FSW Inspection

Test Objective: Verify by inspection that 1. One bit is used for indicating lossless/lossy selection, 2. FSW is primarily written in Ada, 3. FSW runs on EFC, and 4. LOAD MEMORY function uses as little of other FSW program code as possible.

Step	Action	Success Criteria
1	Inspect parameters of SET CAMERA in FSW	1 bit is used to indicate the lossless/lossy selection
2	Randomly select 60 % of the FSW routines and perform a visual audit	FSW is primarily written in Ada
3	Verify by inspection that the acceptance testing of FSW is performed using EFC.	FSW runs on EFC, a MIL-STD 1750A computer.
4	Inspect the LOAD MEMORY function, and identify external functions used by LOAD MEMORY	LOAD MEMORY uses a minimal set of FSW functions, so that it can modify memory independently of other ISS FSW codes.

Test 87 Null Image Test

Test Objective: Verify that the special index # 63 (indicating null image is to be taken) works.

Step	Action	Science Packets
1	Upload 1 image event with the following: Prepare cycle and readout cycle = a 3 blocks in image event with 2nd block exposure index = 63.	
2	Obtain first science packet.	
3	Trigger image event.	Verify the following: 2 images returned Δ T of shutter times for 2 images = 2a.

Test 88 Latter End Exposure Test

Test Objective: Verify that the exposure occurs in the latter end of the exposure window.

Step	Action	ISB
1	Set ISB to monitor LED address and shutter address.	
2	Upload 1 image event with exposure = a and exposure window > a.	
3	Predict the shutter close time using the prepare cycle index value	

4	Trigger image event.	Note the following values: LED value = n Shutter open = n + x Shutter close = n + y LED value = m Verify the following: Exposure = y - x Exposure Window = m - n n + y = m within 10 ms. The predicted and actual shutter close times as recorded in the Cassini Secondary Header match to within 5 ms.

Test 89 Comprehensive Error Test

Test Objective: Verify that all error flags are raised by their respective error conditions.

Note: Error types that are used for internal software check do not need to be tested in the ATP test and, therefore, are not included in this test.

Part I: Filter Wheel Errors (Error types 8 - 15)

This test only needs to be done using one of the two cameras.

Step	Action	Housekeeping Packet
1	Put FSW in idle	
2	Monitor Housekeeping recoverable error field	
3	Disconnect filter wheel 1	

4	Upload MOVE FILTER WHEEL command to move filter wheel 1 to home position.	Success: Error code = 10 Number of errors incremented by 1
5	Disconnect filter wheel 2	
6	Upload MOVE FILTER WHEEL command to move filter wheel 2 to home position.	Success: Error code = 14 Number of errors incremented by 1
7	Reconnect filter wheels	
8	Command both filter wheels to home position	
9	Upload MOVE FILTER WHEEL command to move both filter wheels to position 9.	
10	Disconnect LED sensors on both filter wheels.	
11	Upload MOVE FILTER WHEEL command to move filter wheel 1 to position 1.	Success: Error code = 11 Number of errors incremented by 1
12	Upload MOVE FILTER WHEEL command to move filter wheel 2 to position 1.	Success: Error code = 15 Number of errors incremented by 1
13	Reconnect LED sensors for both filter wheels	
14	Command both filter wheels to home position with MOVE FILTER WHEEL command	
15	Upload MOVE FILTER WHEEL command to move both filter wheels to position 9.	

16	Disconnect filter wheel 1 LED A and filter wheel 2 LED A.	
17	Upload MOVE FILTER WHEEL command to move filter wheel 1 to position 1.	Success: Error code = 9 Number of errors incremented by 1
18	Upload MOVE FILTER WHEEL command to move filter wheel 2 to position 1.	Success: Error code = 13 Number of errors incremented by 1
19	Upload MOVE FILTER WHEEL command to move filter wheel 1 to home position	Success: Error code = 8 Number of errors incremented by 1
20	Upload MOVE FILTER WHEEL command to move filter wheel 2 to home position	Success: Error code = 12 Number of errors incremented by 1

Part II: Command Memory Errors (Error types 24 - 28)

Step	Action	Housekeeping Packet
1	Put FSW in idle	
2	Monitor Housekeeping recoverable error field	
3	Upload a LOAD PMACRO command that contains 11 100-word NOOP commands	Success: Error code = 27 Number of errors incremented by 1

4	When FSW is back in idle, upload LOAD PMACRO with: macro ID = 13 any legal contents as appropriate	Success: Error code = 28 Number of errors incremented by 1
5	Repeat step 4 for macro ID = 50, 100	
6	When FSW is back in idle, upload a single command that has invalid ID	Success: Error code = 24 Number of errors incremented by 1
7	When FSW is back in idle, upload a sequence of 220 NOOPs, each of 100-word long	Success: Error code = 25 Number of errors incremented by 1
8	When FSW is back in idle, upload a sequence of 260 NOOPs, each of 1-word long	Success: Error code = 26 Number of errors incremented by 1

Part III: Upload Errors (Error types 17, 19, 37, 40, 52)

Step	Action	Housekeeping Packet
1	Put FSW in idle	
2	Monitor Housekeeping recoverable error field	
3	Upload a 20-second WAIT command	

4	Submit an immediate second upload with appropriate contents	Success: Error code = 17 Number of errors incremented by 1
5	When FSW is back in idle, submit an upload with 10 LOAD MACROs, with each macro containing 35 100-word NOOPs.	Success: Error code = 19 Number of errors incremented by 1
6	When FSW is back in idle, use GSE to load an upload with a missing packet	Success: Error code = 37 Number of errors incremented by 1
7	When FSW is back in idle, use GSE to submit an upload without the END UPLOAD (upload content as appropriate)	
8	Send another upload with content as appropriate, and the upload ID different from the previous upload ID	Success: Error code = 40 Number of errors incremented by 1
9	When FSW is back in idle, use GSE to submit an upload with a corrupted checksum	Success: Error code = 52 Number of errors incremented by 1

Part IV: Synchronization Errors (Error types 2, 30, 31, 32, 34, 53)

Step	Action	Housekeeping Packet
1	Put FSW in idle	
2	Monitor Housekeeping recoverable error field	
3	Cause GSE to emit an early RTI	Success: Error code = 2 Number of errors incremented by 1
4	When FSW is back in idle, use GSE to drop one DTS	Success: Error code = 30 Number of errors incremented by 1
5	When FSW is back in idle, use GSE to drop one RTI	Success: Error code = 31 Number of errors incremented by 1
6	When FSW is back in idle, use GSE to send garbled SCLK/TLM message	Success: Error code = 32 Number of errors incremented by 1
7	When FSW is back in idle, cause GSE to stop sending SCLK message	Success: Error arrives [3] 10 seconds after SCLK stops Error code = 34 Number of errors incremented by 1

8	When FSW is back in idle, use GSE to send SCLK message in RTI 1	Success: Error code = 53 Number of errors incremented by 1

Part V: Miscellaneous Errors (Error types 45 - 47, 50, 55)

Step	Action	Housekeeping Packet
1	Put FSW in idle	
2	Monitor Housekeeping recoverable error field	
3	Use GSE/RTIU to send a garbled command to the nominal command subaddress.	Success: Error code = 45 Number of errors incremented by 1
4	When FSW is back in idle, Use GSE/RTIU to send an illegal command to the nominal command subaddress.	Success: Error code = 46 Number of errors incremented by 1
5	When FSW is back in idle, upload and trigger an IMAGE EVENT with: 1X1 summation, no compression, no conversion, and all other parameters as appropriate	
6	In the middle of readout, Use GSE to stop picking up science packets.	Success: Error code = 47 Number of errors incremented by 1

7	When FSW is back in idle, issue a WAIT command as an INSTANTANEOUS COMMAND	Success: Error code = 50 Number of errors incremented by 1
8	When FSW is back in idle, send an UPLOAD with a WAIT for 60 seconds.	
9	Send a HALT command (when machine is in active state)	Success: Error code = 55 Number of errors incremented by 1
10	When FSW is back in idle, issue a WAKE command.	
11	Send an UPLOAD with a WAIT for 60 seconds.	
12	Use GSE to reset sleep bit to 0.	Success: Error code = 55 Number of errors incremented by 1

Test 90 SUROM Test

Test Objective: Verify that SUROM works properly in maintenance mode, non-maintenance mode, and cross filter mode.

Part 1: Cold Start (No maintenance)

Following procedure is performed twice, once each for NAC and WAC.

Step	Action	Log Status/ISB
1	Set maintenance bit = 0 (no maintenance)	
2	Monitor ISB addresses for SHE OFF, filter wheel, shutter, and BIU status.	
3	Do POR	
4	Wait for status bit 3	**Success Criteria:** 1. Status value in Hex = 08 (Verifying FSW) 2. ISB BIU status value = 08
5	Wait for status bit 4,3,2	**Success Criteria:** 1. a. Null SHE ISB for NAC or SHE ISB OFF for WAC b. No filter wheel activity c. No shutter activity 2. a. Status value in Hex = 1D (Waiting for FSW to load) b. ISB BIU status value = 1D
6	Use GSE to load FSW	**Success Criteria:** 1. Status value in Hex = 15 (Loading FSW) 2. ISB BIU status value = 15

7	Wait for status bit 2	**Success Criteria:** 1. Status value in Hex = 18 2. ISB BIU status value = 18
8	Wait for status bit 1	**Success Criteria:** 1. Status value in Hex = 02 (FSW started) 2. ISB BIU status value = 02

Part 2: Cold Start (with maintenance)

Following procedure is performed twice, once each for NAC and WAC.

Step	Action	Log Status/ISB
1	Put Filter Wheel at home.	
2	Set maintenance bit = 1 (maintenance) Set cross filter = 0	
3	Monitor ISB addresses for SHE OFF, filter wheel, shutter, and BIU status.	
4	Do POR	
5	Wait for status bit 3	**Success Criteria:** 1. Status value in Hex = 08 (Verifying FSW) 2. ISB BIU status value = 08

6	Wait for status bit 4,3,2	**Success Criteria:** 1. ISB detects SHE ON both NAC and WAC 2.a. ISB Shutter activities are in the following order: (Note: Simultaneous port access for resets) 1. Blade B reset 2. Blade A reset 3. Blade A activate 4. Blade B activate 5. Blade B reset 6. Blade A reset 7. Blade A activate b. Æt for the following intervals are ³ 2 sec. 1. from activity 2 to activity 3 2. from activity 4 to activity 5 3. from activity 6 to activity 7 3. For each filter wheel, ISB indicates that: a. Activities took in the following order: 1. Filter wheel moves in reverse order 10 steps 2. Filter wheel home forward 3. Filter wheel moves forward 300 steps 4. Filter wheel moves in reverse order 300 steps 5. Filter wheel is at home position b. Time duration for each activity identified above (in 3.a) is 7 ms ± 1 ms. 4. a. Status value in Hex = 1D (Waiting for FSW to load) b. ISB BIU status value = 1D

7	Use GSE to load FSW	**Success Criteria:** 1. Status value in Hex = 15 (Loading FSW) 2. ISB BIU status value = 15
8	Wait for status bit 2	**Success Criteria:** 1. Status value in Hex = 18 2. ISB BIU status value = 18
9	Wait for status bit 1	**Success Criteria:** 1. Status value in Hex = 02 (FSW started) 2. ISB BIU status value = 02
10	Repeat the procedure, this time set: maintenance bit = 1 cross filter = 1	**Success Criteria:** Same success criteria as before, plus: Add to step 6, after the filter wheel activities, the following success criteria: For NAC case: filter wheel 1 = 135 steps in reverse direction filter wheel 2 = 180 steps in forward direction For WAC case: filter wheel 1 = 120 steps in reverse direction filter wheel 2 = 240 steps in reverse direction Total time for steps 8 and 9 should be < 15 sec (per requirement # 327).

Part 3: Warm Start

Following procedure is performed twice, once each for NAC and WAC.

Step	Action	Log Status/ISB
1	Monitor ISB addresses for SHE OFF, filter wheel, shutter, and BIU status.	
2	Do reset	
3	Wait for status bit 3	**Success Criteria:** 1. Status value in Hex = 08 (Verifying FSW) 2. ISB BIU status value = 08
4	Wait for status bit 4,3,2	**Success Criteria:** a. Null SHE ISB for NAC and null SHE ISB OFF for WAC b. No filter wheel activity c. No shutter activity
5	Wait for status bit 2	**Success Criteria:** 1. Status value in Hex = 18 2. ISB BIU status value = 18
6	Wait for status bit 1	**Success Criteria:** 1. Status value in Hex = 02 (FSW started) 2. ISB BIU status value = 02

Part 4: Error Test

Note: Following items are needed for this test: Filter Wheel Breakout Box and GSE FSW-load fault capability to simulate various faults.

Part 4.1 FSW Load Errors

Note: SUROM design ensures that each ALF packet can be tested independently.

Step	Action	LOG Status
1	Power on the instrument	
2	Load SUROM with error case 1 of the table listed below.	**Success Criteria:** BIU Status correspond to case number tested per table listed below.
3	Repeat steps 1 and 2 for the rest of the table entries.	

Table for FSW Load Errors

Case	Command Packet Word Count Wrong	Checksum Error in ALF Packet	ALF Packet Message ID BAD	ALF Packet Out of Sequence	Error Status (in binary)
1				Y	00000100
2			Y	Y	00001100
3		Y	Y	Y	00011100
4	Y	Y	Y	Y	00111100
5			Y		00001000
6		Y	Y		00011000
7	Y	Y	Y		00111000

8		Y			00111000
9	Y	Y			00110000
10		Y		Y	00010100
11	Y	Y		Y	00110100
12	Y		Y		00101000
13	Y		Y	Y	00101100
14		Y			00010000
15	Y				00100000
16	Y			Y	00100100

Part 4.2 Total ALF Packets Error

Step	Action	LOG Status
1	Power on the instrument	
2	Load SUROM with one dropped packet	**Success Criteria:** BIU Status = 01000000 (binary)
3	Repeat steps 1 and 2 with: Step 2: dropping 10 and then 100 packets	

Part 4.3 Command Packet Timeout

Step	Action	LOG Status
1	Power on the instrument	
2	Load SUROM, but dropping last packet	
3	Wait 2 minutes	**Success Criteria:** BIU Status = 10000000 (binary)

Part 4.4 POR Memory Check

Step	Action	LOG Status
1	Power on the instrument	**Success Criteria:** BIU Status = 01000000 (binary) SUROM continues loading

Part 4.5 Filter Wheel Error Test 1

Perform this test for both filter wheels 1 and 2.

Step	Action	LOG Status
1	Set maintenance bit to ON	
2	Do POR	
3	Set the following settings on the Breakout Box: Normal = OFF LED A = OFF LED B = OFF	

4	When the filter wheel moves approximately 300 steps (move off home) set Normal = ON	**Success Criteria:** For filter wheel 1: BIU Status = 00000100 (binary) For filter wheel 2: BIU Status = 00100000 (binary)

Part 4.6 Filter Wheel Error Test 2

Perform this test for both filter wheels 1 and 2.

Step	Action	LOG Status
1	Set maintenance bit to ON	
2	Do POR	
3	Set the following settings on the Breakout Box: Normal = OFF LED A = ON LED B = ON	**Success Criteria:** For filter wheel 1: BIU Status = 00001000 (binary) For filter wheel 2: BIU Status = 01000000 (binary)

Part 4.7 Filter Wheel Error Test 3

Perform this test for both filter wheels 1 and 2.

Step	Action	LOG Status
1	Set maintenance bit to ON	
2	Do POR	

3	Set the following settings on the Breakout Box: Normal = ON LED A = OFF LED B = OFF	**Success Criteria:** For filter wheel 1: BIU Status = 00001000 (binary) For filter wheel 2: BIU Status = 01000000 (binary)
4	When the filter wheel moves approximately 300 steps (move off home), set: Normal = OFF	**Success Criteria:** For filter wheel 1: BIU Status = 00010000 (binary) For filter wheel 2: BIU Status = 10000000 (binary)

Test 91 Initialization Test

Test Objective: Verify that initial conditions are met at POR for the following: instrument state, shutter, SHE, optics heaters, and TCE.

Part I: Instrument State after POR

Step	Action	Housekeeping Packets
1	Set SLEEP bit to 0 (sleep)	
2	Do Power On	
3		Check housekeeping FSW state Success: fsw_state = sleep
4	Set SLEEP bit to 1	
5	Power off then on (via GSE)	

6		Check housekeeping FSW state Success: fsw_state = idle

Part II: Shutter, SHE, Optics Heaters, TCE States (NAC)

Step	Action	Housekeeping Packets
1	Set SLEEP bit to 1	
2	Do Power On	
3		Check housekeeping for: shutter state, the 50V HDE value, optics heater field, and TCE field Success: shutter blade a = reset shutter blade b = reset 50 V Å 50V optics heater = regular TCE = regular

Part III: Shutter, SHE, Optics Heaters, TCE States (WAC)

Step	Action	Housekeeping Packets
1	Set SLEEP bit to 1	
2	Do Power On	

3		Check housekeeping for: shutter sate, the 50V HDE value, optics heater field, and TCE field Success: shutter blade a = reset shutter blade b = reset 50 V = 0V optics heater = regular TCE = regular

Test 92 Missing Science Packets Test

Test Objective: Verify that image can be reconstructed even when there are dropped packets

Step	Action	Extended Science Header	Housekeeping Packets
1	Create Upload of 37 Image Events as listed in Table below.		
2	Request GSE to drop off 10% of packets (e.g., Select "many" option in the ISS Image Process Window to drop off approximately 10% of randomly selected packets.)		
3	Trigger Image Event 1.		

4	DELAY 1 second.	Check 1 packet header and verify values match table values.	Check 2 packets and verify values match table values.
5	Difference Flight Software image and DA image. Verify images match except for missing lines due to dropped packets.	Verify first and last headers are extended. Verify every 50th header is extended.	
6	Repeat steps 1 through 5 for remaining 36 images.		

Image Event Table for Combinatorial Test

Image Event	Filter 1	Filter 2	Summation	Compression	Conversion	Exposure
1	a	x	2 x 2	lossless	none	T1
2	a	y	2 x 2	lossless	none	T1
3	a	z	2 x 2	lossless	none	T1
4	b	x	2 x 2	lossless	none	T1
5	b	y	2 x 2	lossless	none	T1
6	b	z	2 x 2	lossless	none	T1
7	c	x	2 x 2	lossless	none	T1
8	c	y	2 x 2	lossless	none	T1
9	c	z	2 x 2	lossless	none	T1
10	a	x	2 x 2	lossless	none	T1
11	a	x	2 x 2	lossless	none	T2
12	a	x	2 x 2	lossless	none	T3
13	a	x	2 x 2	lossless	none	T4

14	a	x	1 x 1	none	none	T2
15	a	x	1 x 1	none	12-8	T2
16	a	x	1 x 1	none	ISB	T2
17	a	x	1 x 1	lossy	12-8	T2
18	a	x	1 x 1	lossy	ISB	T2
19	a	x	1 x 1	lossless	none	T2
20	a	x	1 x 1	lossless	12-8	T2
21	a	x	1 x 1	lossless	ISB	T2
22	a	x	2 x 2	none	none	T2
23	a	x	2 x 2	none	12-8	T2
24	a	x	2 x 2	none	ISB	T2
25	a	x	2 x 2	lossy	12-8	T2
26	a	x	2 x 2	lossy	ISB	T2
27	a	x	2 x 2	lossless	none	T2
28	a	x	2 x 2	lossless	12-8	T2
29	a	x	2 x 2	lossless	ISB	T2
30	a	x	4 x 4	none	none	T2
31	a	x	4 x 4	none	12-8	T2
32	a	x	4 x 4	none	ISB	T2
33	a	x	4 x 4	lossy	12-8	T2
34	a	x	4 x 4	lossy	ISB	T2
35	a	x	4 x 4	lossless	none	T2
36	a	x	4 x 4	lossless	12-8	T2
37	a	x	4 x 4	lossless	ISB	T2

Test 93 Housekeeping/Science Packet Agreement Test

Test Objective: Verify that fields of the science and housekeeping packets agree.

Step	Action	Extended Science Header	Housekeeping Packets
1	Create Upload of 37 Image Events as listed in Table below.		
2	Trigger Image Event 1.		
3	Delay 1 second.	Check 1 packet header and verify values match table values.	Check 2 packets and verify values match table values.
4	Compare following fields in Housekeeping and Extended Science Headers. Verify that values match: Summation Compression Conversion Gain Filter 1 Filter 2 CAL lamp TCE Optics heater 1 Optics heater 2 6 HDE voltages ± 5 DN 8 HDE temperatures ± 5 DN Current ± 5 DN Last trigger Number of commands Current upload number Software field	Verify values match Housekeeping.	Verify values match Extended Science Headers.
5	Repeat steps 1 through 4 for remaining 36 images.		

Image Event Table for Combinatorial Test

Image Event	Filter 1	Filter 2	Summation	Compression	Conversion	Exposure
1	a	x	2 x 2	lossless	none	T1
2	a	y	2 x 2	lossless	none	T1
3	a	z	2 x 2	lossless	none	T1
4	b	x	2 x 2	lossless	none	T1
5	b	y	2 x 2	lossless	none	T1
6	b	z	2 x 2	lossless	none	T1
7	c	x	2 x 2	lossless	none	T1
8	c	y	2 x 2	lossless	none	T1
9	c	z	2 x 2	lossless	none	T1
10	a	x	2 x 2	lossless	none	T1
11	a	x	2 x 2	lossless	none	T2
12	a	x	2 x 2	lossless	none	T3
13	a	x	2 x 2	lossless	none	T4
14	a	x	1 x 1	none	none	T2
15	a	x	1 x 1	none	12-8	T2
16	a	x	1 x 1	none	ISB	T2
17	a	x	1 x 1	lossy	12-8	T2
18	a	x	1 x 1	lossy	ISB	T2
19	a	x	1 x 1	lossless	none	T2
20	a	x	1 x 1	lossless	12-8	T2
21	a	x	1 x 1	lossless	ISB	T2
22	a	x	2 x 2	none	none	T2
23	a	x	2 x 2	none	12-8	T2
24	a	x	2 x 2	none	ISB	T2
25	a	x	2 x 2	lossy	12-8	T2
26	a	x	2 x 2	lossy	ISB	T2
27	a	x	2 x 2	lossless	none	T2
28	a	x	2 x 2	lossless	12-8	T2

29	a	x	2 x 2	lossless	ISB	T2
30	a	x	4 x 4	none	none	T2
31	a	x	4 x 4	none	12-8	T2
32	a	x	4 x 4	none	ISB	T2
33	a	x	4 x 4	lossy	12-8	T2
34	a	x	4 x 4	lossy	ISB	T2
35	a	x	4 x 4	lossless	none	T2
36	a	x	4 x 4	lossless	12-8	T2
37	a	x	4 x 4	lossless	ISB	T2

Test 94 Housekeeping Rate Verification Test

Test Objective: Verify that housekeeping can be set back at the rate of once per 64 seconds.

Step	Action	Housekeeping Packets
1	Set Housekeeping rate to 1 packet/64 seconds.	
2	Collect 5 consecutive Housekeeping packets.	Verify Cassini second header spacecraft time field shows ÆT for packets = 64 seconds ± 1 second.

Test 95 Clock Out to RAM Test

Test Objective: Verify that the FSW is reading CCD into the EFC RAM at rates limited by the CCD readout and the BIU readout.

Step	Action	ISB
1	Upload an IMAGE EVENT with : 1X1 summation, no compression, no conversion other parameters as appropriate	
2	Set up Logic Analyzer to look at the first word of the CCD RAM address	
3	Trigger IMAGE EVENT	
4	Record Logic Analyzer results	Success: Æt for the CCD RAM readout = 16 ms ± 1 ms for the first 200 lines (This part is CCD limited) Æt for the CCD RAM readout = 45 ms ± 2 ms for the remaining lines (This part is BIU limited)

Test 96 BIU Swap Test

Test Objective: Verify that BIU swaps correctly while taking pictures.

Step	Action	Direct Access	Extended Science Header
1	Upload an image event to NAC and WAC with simultaneous shuttering. Other parameters as appropriate.		
2	Direct RTIU to pick up science packets from address 17 only.		
3	Turn on Direct Access.		
4	Set telemetry mode to 6 packets / RTI.		
5	Trigger NAC and WAC in the same second.	Verify Direct Access and packet images are identical.	Verify that the shutter close times from NAC and WAC extended headers are the same ± 10 ms.
6	Repeat this procedure (steps 1 through 5) 49 times, with the following excepting: In step 5: only do Direct Access compare, and don't need to verify shutter close times in the Extended Science Header		

Test 97 Read Out Table Test

Test Objective: Verify that the expected readout time intervals (per Readout Cycle Duration Table) of an image event are correct.

Part 1a. NAC

Step	Action	ISB
1	Obtain a copy of the Readout Cycle Duration Table	
2	Upload an Image Event with: Readout index = 0 4X4 summation, lossless compression, and 12:8 conversion for NAC, readout NAC first, Other parameters don't matter	
3	Trigger the Image Event	Monitor the ISB readout for the following: (a) NAC Readout LED 1 (b) NAC Readout LED 2 (c) WAC Readout LED 1 (d) WAC Readout LED 2 (e) Pad Readout LED 1 (f) Pad Readout LED 2 **Success Criteria:** Æt's between (a) and (b), and (c) and (d) = values in Readout Cycle Duration Table ± 10 ms. Æt between (b) and (c) < 5 ms. Æt between (e) and (f) < 500 ms ± 10 ms. NAC is readout before WAC

4	Repeat steps 2 and 3, replacing in step 2 the Readout Indices from 1 - 15	

Part 1b. NAC

Repeat Part 1a with the following change:

In step 2, set Image Event to readout WAC first.

In step 3, the success criteria changes to: WAC is readout before NAC.

Part 2. WAC

In this test, Part 1 test is repeated with the following modification to step 2:

Replace "4X4, lossless compression, and 12:8 conversion for NAC" with "1X1 no compression, no compression for WAC".

Note: Because no compression is opted in Part 2, some image cut-offs are expected for certain Readout Indices. Success Criteria for the image cut-off case (in addition to those specified in Part 1): Image is cut off properly.

Step	Action	ISB
1	Obtain a copy of the Readout Cycle Duration Table	
2	Upload an Image Event with: Readout index = 0 1X1 summation, no compression, no compression for WAC, Other parameters don't matter	

3	Trigger the Image Event	Monitor the ISB readout for the following: (a) NAC Readout LED 1 (b) NAC Readout LED 2 (c) WAC Readout LED 1 (d) WAC Readout LED 2 (e) Pad Readout LED 1 (f) Pad Readout LED 2 **Success Criteria:** Æt's between (a) and (b), and (c) and (d) = values in Readout Cycle Duration Table ± 10 ms. Æt between (b) and (c) < 5 ms. Æt between (e) and (f) < 500 ms ± 10 ms. For image cut-off case: Image is cut off properly.
4	Repeat steps 2 and 3, replacing in step 2 the Readout Indices from 1 - 15	

Part 3. NAC Test with Zero WAC Count

Repeat Part 1 test with the following modification:

Add to step 2: WAC Count = 0

Note success criteria: Æt between (c) and (d) =0 ms.

Step	Action	ISB
1	Obtain a copy of the Readout Cycle Duration Table	
2	Upload an Image Event with: Readout index = 0 4X4 summation, lossless compression, and 12:8 conversion for NAC, WAC Count = 0 Other parameters don't matter	

3	Trigger the Image Event	Monitor the ISB readout for the following: (a) NAC Readout LED 1 (b) NAC Readout LED 2 (c) WAC Readout LED 1 (d) WAC Readout LED 2 (e) Pad Readout LED 1 (f) Pad Readout LED 2 **Success Criteria:** Æt's between (a) and (b) = values in Readout Cycle Duration Table ± 10 ms. Æt between (c) and (d) =0 ms. Æt between (b) and (c) < 5 ms. Æt between (e) and (f) < 500 ms ± 10 ms. For image cut-off case: Image is cut off properly.
4	Repeat steps 2 and 3, replacing in step 2 the Readout Indices from 1 - 15	

Part 4. WAC Test with Zero NAC Count

Repeat Part 2 test with the following modification (similar to Part 3 test):

Add to step 2: NAC Count = 0

Note success criteria: Æt between (a) and (b) =0 ms.

Step	Action	ISB
1	Obtain a copy of the Readout Cycle Duration Table	
2	Upload an Image Event with: Readout index = 0 1X1 no compression, no compression for WAC, NAC Count = 0 Other parameters don't matter	
3	Trigger the Image Event	Monitor the ISB readout for the following: (a) NAC Readout LED 1 (b) NAC Readout LED 2 (c) WAC Readout LED 1 (d) WAC Readout LED 2 (e) Pad Readout LED 1 (f) Pad Readout LED 2 **Success Criteria:** Æt between (a) and (b) =0 ms. Æt's between (c) and (d) = values in Readout Cycle Duration Table ± 10 ms. Æt between (b) and (c) < 5 ms. Æt between (e) and (f) < 500 ms ± 10 ms.

4	Repeat steps 2 and 3, replacing in step 2 the Readout Indices from 1 - 15	

Test 98 Memory Scrub Test

Test Objective: Verify that the memory scrub algorithm operates properly.

Step	Action	Memory Monitor Packet
1	FSW is in idle state.	
2	Issue MONITOR MEMORY command: monitor memory scrub pointer variable (2 words).	
3	Delay 5 seconds	Examine contents of memory monitor packets. Success: Memory monitor does not return a changing value.
4	Put FSW in sleep state	
5	Delay 5 seconds	Examine contents of memory monitor packets. Success: 2-word values in the memory monitor packets increment by 10 per entry.
6	Delay 5 min.	Examine contents of memory monitor packets. Success: The 2-word value runs from 0 to 512,000 ± 200 words

Appendix A Traceability Matrices

Various traceability tables to and from the requirements are presented in this appendix. Table A-1 is a trace of each requirement in the ISS Flight Software SRD to the acceptance test(s) that verify that requirement. Table A-2 is the reverse of Table A-1, where the acceptance tests are traced to ISS Flight Software SRD requirement(s). In addition, tests tracing to various header fields are presented in this appendix.

In summary, traceability tables included in this appendix are:

Table A-1: SRD Requirements to Tests

Table A-2: Tests to SRD Requirements

Table A-3: CCSDS Primary Header to Tests

Table A-4: Cassini Secondary Header to Tests

Table A-5: Normal Housekeeping to Tests

Table A-6: HDE Monitor Housekeeping Packet to Tests

Table A-7: Memory Monitor Housekeeping Packet to Tests

Table A-8: High Rate Memory Header to Tests

Table A-9: Standard ISS Science Header to Tests

Table A-10: Extended ISS Science Header to Tests

Table A-11: ISS Science Contents to Tests

Notations used in the following trace tables are:

E*: Requirement is deleted.

None: No requirement is associated with this number

X: Test deleted.

Appendix B Glossary

1553B bus	The spacecraft bus connecting the instrument and the subsystems to the CDS.
BIU Address	Each camera within the ISS instrument has a unique address on the spacecraft bus so that the central computer of the spacecraft can select one instrument and camera to read and write. Hs is the BIU address.
Lossless Compression	An optional compression step that will nominally reduce the number of bits representing an image by a factor of 2. The resulting compressed image may be decompressed and the original image reconstructed perfectly.
Lossy Compression	A compression scheme employing an algorithm that may effect compression a factor greater than the lossless chip. Images may not be reconstructed exactly.
Macro	A collection of instrument commands collected into a single unit with a unique identifier that may be collectively sorted and invoked.
Packet	A unit of transmission of commands to the spacecraft and of data from the spacecraft to the ground.
Sub-RTI	A partitioning of the 125 ms RTI interval into 125 1 ms sub-intervals. This sub-interval of the RTI is the sub-RTI.

Appendix C Acronyms

ATP.....Acceptance Test Plan
BIU.....Bus Interface Unit
CCD.....Charge-Coupled Device
CDS.....Command and Data System
CogE.....Cognizant Engineer
CMD .....Command
DA.....Direct Access
DTS .....Dead-Time Start
EFC .....Engineering Flight Computer
ETA.....Engineering Test Analyzer (Provided by IBM for use with EFC
.....software development)
FR.....Failure Report
FSW.....Flight Software
GSE .....Ground Support Equipment
HDE .....Housekeeping Data Electronics
HKP .....Housekeeping Packet
ISB.....Imaging Science Bus
ISS.....Imaging Science Subsystem
LA .....Logic Analyzer
LED.....Light Emitting Diode
LSB.....Least Significant Bits
LUT.....Lookup Table
NAC .....Narrow Angle Camera
OS .....Operating System
PCVOL.....Parallel Clock Voltage
PFOC.....Problem Failure Operation Center
POR.....Power-On Reset
RAM.....Computer's random access memory
RTI.....Real-Time Interrupt
RTIU .....Remote Terminal Interface Unit

SCLK ..... Spacecraft Clock Time
SHE ..... Sensor Head Electronics
SHS ..... Sensor Head Simulator
SRD ..... Software Requirements Document
SSR ..... Solid State Recorder
SUROM ..... Start Up Read-Only Memory
TCE ..... Temperature Control Electronics
WAC ..... Wide Angle Camera