SPECTRUMASTRO

SPECTRUM ASTRO, INC.

HIGH ENERGY SOLAR SPECTROSCOPIC IMAGER (HESSI) PROGRAM

FLIGHT SOFTWARE OPERATIONS MANUAL

CONTRACT NO. PPB005884

PREPARED BY:
SPECTRUM ASTRO, INC.
1440 N. Fiesta Boulevard
Gilbert, Arizona 85233
CAGE Code 0T9D1

INITIAL RELEASE DATE
14 JANUARY 2000

1110-EU-S17595 REV -

14 JANUARY 2000

H:\DOCS\REFERENC.&PF\FLIGHTSO.RNI

SPECTRUM ASTRO, INC.

HIGH ENERGY SOLAR SPECTROSCOPIC IMAGER (HESSI) PROGRAM

FLIGHT SOFTWARE OPERATIONS MANUAL

CONTRACT NO. PPB005884

REVIEWED BY ______________________________

CONFIGURATION/DATA CONTROL, JOE JURHILL DATE

PREPARED BY ______________________________

ENGINEERING, JONATHAN YOUNT DATE

APPROVED BY ______________________________

QUALITY ASSURANCE, JEFF SQUIRES DATE

APPROVED BY ______________________________

SYSTEM ENGINEERING, JOHN JORDAN DATE

APPROVED BY ______________________________

PROGRAM MANAGER, MIKE MATRANGA DATE

REVISION SUMMARY

REV	RELEASE DATE	BRIEF DESCRIPTION/REASON FOR CHANGE	EFFECTIVE PAGES
-	14 January 2000	Initial release.	All

TABLE OF CONTENTS

PAGE
1. SCOPE....1
1.1 Identification....1
1.2 System Overview....1
2. REFERENCED DOCUMENTS....1
2.1 Referenced Documents....1
2.1.1 General....1
3. FLIGHT SOFTWARE BOOT SEQUENCE....2
3.1 FSW Boot Overview....2
3.2 FSW Boot Configuration....2
3.3 Operating System Select....2
3.4 Flight Software Select....3
3.5 Initial Stored Sequence (Mission Mode)....3
3.6 Manually Rebooting....3
4. IN-FLIGHT FILESYSTEM....3
4.1 EEPROM Write Protection....7
4.1.1 SMEEPROMWRITE Telecommand....7
4.1.2 EEPROM Device Level Software Data Protection Mode....8
4.1.3 Example of modifying the EEPROM1 filesystem....10
4.2 Filesystem Content Telecommand....11
5. STORAGE MANAGEMENT SUBSYSTEM....12
5.1 Loading Tables....12
5.2 Dumping Tables....15
5.3 Aborting Table Operations....16
5.4 Loading, Copying and Dumping Memory....18
5.5 PACI Pseudo Non-Volatile Logs....21

5.6 Managing Event Messages 23

TABLE OF CONTENTS (CONTINUED)

PAGE

5.7 In-flight FSW Reprogramming 25

5.8 Spacecraft Clock 29

5.9 VME Interrupt Control 29

5.10 Miscellaneous Housekeeping 30

6. STORED TELECOMMAND SEQUENCES 33

6.1 Absolute-Time Sequences 33

6.2 Relative-Time Sequences 36

6.3 Stored Sequences and the File system 41

6.4 Specific Relative-Time Sequences 41

7. PAYLOAD INTERFACE SUBSYSTEM 42

7.1 Payload Commanding 42

7.2 Payload Telemetry 43

7.3 Science Telemetry 44

7.4 Payload Telecommands 44

8. SSR INTERFACE SUBSYSTEM 45

8.1 SSR Subsystem Initialization 45

8.2 SSR Subsystem 1 Hz Processing 46

8.3 Record and Playback Telecommands 46

8.4 SSR Passthrough Telecommand 51

8.5 SSR SOH Telemetry 53

8.6 SSR Maintenance Telecommands 54

8.7 SSR Housekeeping Telecommands 55

9. ATTITUDE CONTROL SUBSYSTEM 58

9.1 ACS Control Telecommands 58

9.2 ACS Flight Parameters 59
9.3 ACS Telemetry 61

TABLE OF CONTENTS (CONTINUED)

PAGE

9.4 ACS Housekeeping Telecommands 62
10. STATE OF HEALTH SUBSYSTEM 63
11. UPLINK SUBSYSTEM 64
11.1 CCSDS COP-1 Protocol Control 64
11.2 Uplink Subsystem CRC Commands 65
11.3 Resetting the CIB Device FPGAs 68
11.4 Switching CIB Uplink Channel 69
11.5 Uplink Subsystem Housekeeping 69
12. DOWNLINK SUBSYSTEM 70
12.1 Transmitter and Bypass 71
12.2 Managing Stored Telemetry 72
12.3 CIB Device Downlink Bit Rate 77
12.4 Downlinked Housekeeping 77
13. PCB INTERFACE SYSTEM 78
13.1 Power Switches 78
13.1.1 Transmitter Switch 80
13.2 Torque Rods 80
13.3 Inertial Adjustment Device 81
13.4 Solar Array Releases 82
13.5 Mission Mode 84
13.6 PCB Miscellaneous Telecommand 84
13.7 PCB Interface Housekeeping Telecommands 86
14. SCHEDULER SUBSYSTEM 87

15. FAULT MANAGEMENT 88
15.1 Interrupts 88
15.2 Fault Monitors 89

TABLE OF CONTENTS (CONTINUED)

PAGE

15.2.1 Analog Sensors 89
15.2.2 ACS Sun Pointing Fault 90
15.2.3 Loss of Telecommanding 91
15.2.4 Clearing Fault Response Indications 91
15.3 CPU EDAC RAM Scrubbing 92
15.4 PACI EDAC RAM Scrubbing 93
15.5 CIB Watchdog Timer 93
15.6 FSW O/S Task Monitor 94
15.7 FSW Program Text Segment Corruption Monitor 94
15.8 Fault Management Housekeeping 94
16. FLIGHT PARAMETERS 95
16.1 Changing Flight Parameters 101
17. UTILITY APPLICATIONS 101
17.1 binToTableLoad 101
17.2 gen_itos_report 102
17.3 hessiChecksum 102
17.4 hessiLogTool 102
17.5 sendbin 102
17.6 default 103

LIST OF TABLES

Table 4-1. Filenames and Maximum File Length 5

Table 6-1. Special Purpose Relative-Time Sequences....................42
Table 7-1. Spacecraft Status Segment Sources....................43
Table 8-1. SSR Subsystem Initial Vaules....................44
Table 8-2. SSR Telemetry to Monitor....................52
Table 9-1. ACS Flight Parameters....................60

LIST OF TABLES (CONTINUED)

PAGE

Table 9-2. ACS Telemetry....................61
Table 12-1. Stored Telemetry APIDs....................71
Table 14-1. Subsystem Wakeup Schedule....................87
Table 15-1. Interrupt Monitors....................88
Table 15-2. FSW Interrupt Telemetry Points....................89
Table 15-3. Analog Sensor Fault Monitors....................90
Table 15-4. ACS Fault Monitor....................91
Table 15-5. Loss of Telecommand Fault Response....................89
Table 16-1. Flight Parameters....................95

LIST OF ACRONYMS

ACS	Attitude Control Subsystem
ADB	Auxiliary Driver Board
APID	Application Identifier
ATS	Absolute Time Sequence
CCB	Charge Control Board
CCSDS	Consultative Committee for Space Data System
CIB	Communication Interface Board
COP-1	Command Operation Procedure, version 1
CPU	Central Processing Unit
CRC	Critical Command
EDAC	RAM with single bit upset immunity
EEPROM	Electrically Erasible Programmable ROM
EFC	Engineering Flight Software
FARM-1	Frame Acceptance and Reporting Mechanism, version 1
FSS	Fine Sun Sensor
FSW	Flight Software, which is defined as the non-ACS software
GSFC	Goddard Space and Flight Center
HCD	Hardware Command Decoder
HESSI	High Energy Solar Spectroscopic Imager
IAD	Inertial Adjustment Device
IDPU	Instrument Data Processing Unit
ITOS	Integration and Test Operations System
MB	Mega Bytes
MIPS	Million Instructions Per Second

O/S	Operating System

LIST OF ACRONYMS (CONTINUED)

PACI	Payload and Attitude Control Interface
PCB	Power Control Board
PNVRAM	PACI Pseudo Non-Volatile RAM
RAM	Random Access Memory
ROM	Read-Only Memory
RTS	Relative Time Sequence
SCLK	Spacecraft Clock
SDP	Software Data Protection, for EEPROM
SMEX	Small Explorer, NASA program
SAS	Solar Aspect System
SOH	State Of Health
SSR	Solid State Recorder
SUROM	Startup ROM
TC	Telecommand
TLM	Telemetry
TTL	Transistor-Transistor Logic
VC0	Virtual Channel 0
VC1	Virtual Channel 1
VME	VersaModule Eurocard bus, a 32-bit data bus

1. SCOPE

1.1 Identification

This document is the High Energy Solar Spectroscopic Imager (HESSI) spacecraft flight software operations manual.

1.2 System Overview

The Flight Software(FSW) executes on a RAD6000 Flight Central Processing Unit (CPU) and supports control and access to all the spacecraft functions through sending spacecraft commands and receiving spacecraft telemetry from the Integration and Test Operations System (ITOS) ground station. The HESSI FSW interfaces with six VME hardware boards: directly access to RAD6000 CPU, Payload and Attitude Control Interface (PACI), Communications Interface Board (CIB), the Power Control Board (PCB), and the Auxiliary Driver Board (ADB), and indirect access to the Charge Control Board (CCB).

FSW communicates to the Instrument Data Processing Unit (IDPU), and Solid State Recorder (SSR) via the PACI board. The PACI board is responsible for decoding and providing all analog and digital telemetry. The PACI board is also responsible for the real-time State Of Health (SOH) telemetry frame.

The CIB board has three telemetry input paths: VersaModule Eurocard bus, a 32-bit data bus (VME) for FSW telemetry, PACI serial for real-time SOH, and Solid State Recorder (SSR) serial for science data.

The CPU board has 128 Mega Bytes (MB) (Random Access Memory (RAM) and 3 MB Electrically Erasible Programmable ROM (EEPROM), with a CPU is running at 10 Million Instructions Per Second (MIPS).

To support in-flight reprogramming, FSW is partitioned into 24 separate files that are loaded into an EEPROM filesystem. At power up, a boot program (one file) is loaded and run. The boot program loads and runs the Operating System (O/S) (one file). After the O/S boots, it loads flight software (22 files).

Flight software has access to two absolute-time sequence-stored telecommand sequences and sixty-four relative-time sequenced stored telecommand sequences.

2. REFERENCED DOCUMENTS

2.1 Referenced Documents

Unless otherwise specified, the following documents in their current issue form a part of this document to the extent specified herein.

2.1.1 General

a. 1110-EW-T17552 HESSI Telecommand and Telemetry Database Specification

b. 1110-EW-S16620 HESSI Attitude Control Subsystem Flight Software Specification

3. FLIGHT SOFTWARE BOOT SEQUENCE

3.1 FSW Boot Overview

On power up, or as a result of a processor reset, the RAD6000 CPU starts reading instructions and starts executing out of its Start-Up ROM (SUROM). The SUROM sets up the initial state of the processor, various hardware devices, and clears all 128 MB of EDAC RAM. The SUROM then copies a predefined region of code from EEPROM into RAM, and jumps to a predefined location.

The code that the Startup ROM(SUROM) copies is the first 4096 bytes of the bootrom.bin file from the in-flight filesystem in EEPROM. The in-flight filesystem will be described in detail in Section 4. IN-FLIGHT FILESYSTEM starting on page 3. In brief, the are three in-flight filesystems: one read-only filesystem in EEPROM, one read-write filesystem in EEPROM, and one read-write filesystem in RAM.

The bootrom.bin is called the O/S Boot ROM program. The purpose of the O/S Boot ROM program is the allow for the flexibility of loading the Operating System (O/S) and FSW from different filesystems. When the O/S Boot ROM program starts executing, it copies its entire contents from EEPROM into RAM, and continues execution. The O/S Boot ROM reads various input configuration parameters, and then loads and starts executing the O/S from a filesystem.

The O/S provides access to various device resources and provides the real-time task scheduling capabilities. After the O/S has initialized, it reads various input configuration parameters and then loads FSW from twenty-two files in the in-flight filesystem. After all files have been loaded, the boot filesystem is copied into RAM as the working filesystem. FSW is then started.

After FSW has been started, an initial stored sequence of telecommands is started.

3.2 FSW Boot Configuration

The various files that are loaded at boot time is configurable:

a. The O/S file load with the SMREBOOT telecommand.

b. The FSW files loaded with the CRC22 bit or with the SMREBOOT telecommand

c. The initial stored sequence executed with the PCBMISSNMODE telecommand

The default boot configuration on power-up or after a VME SYSRESET signal is: O/S is loaded from the EEPROM1 (read-only) filesystem, FSW is loaded from the based on FSW select Critical Command (CRC), the stored sequence selected by Mission Mode is started.

3.3 Operating System Select

The SMREBOOT telecommand writes configuration parameters to a specific region in RAM to be read after a reboot. One specific parameter indicates to the O/S Boot ROM the name of the O/S file in the in-flight filesystem. The options for this parameter is either the O/S file in EEPROM1 or the O/S file RAM.

3.4 Flight Software Select

One specific parameter that the SMREBOOT telecommand writes to a specific region in RAM indications the filesystem from which to read flight software. This filesystem can be any three of the in-flight filesystems.

If the FSW filesystem is not specified in that specific region in RAM, then the CRC22 bit is read from the CIB. If the CRC22 bit is zero, then FSW is read from the EEPROM1 filesystem; if the bit is one, the FSW is read from the EEPROM2 filesystem. The selected filesystem is then copied to the RAM filesystem so that 'working' copies are available for modification.

3.5 Initial Stored Sequence (Mission Mode)

The initial stored sequence that is started is after boot-up is selectable with the Mission Mode indicator. The Mission Mode indicator is output as two bits from the PCB. If either of the bits is zero, then the Mission Mode is the 'Launch', and the RTS00 stored sequence will be started. If both bits are one, then the Mission Mode is 'Nominal', and the RTS01 stored sequence will be started.

3.6 Manually Rebooting

The SMREBOOT telecommand allows the operator to manually reboot the CPU. The SMREBOOT telecommand has two parameters, OSBOOTDEVICE and FSBOOTDEVICE, for selecting the filesystem from which to load the O/S and FSW files. Keep in mind that the Watchdog Timer (CRC19) must be disabled when manually rebooting as otherwise it expire and send a VME SYSRESET signal to reset the CPU.

SMREBOOT Reboots the flight software from the image in EEPROM or RAM OSBOOTDEVICE (UB) Selects the device from which load 'vxWorks' O/S Range: 0 to 2 0 = OS_EEPROM1 EEPROM1 OS boot: /hessiFs/eeprom1/vxWorks 2 = OS_RAM RAM OS boot: /hessiFs/ram/vxWorks FSBOOTDEVICE (UB) Selects the device from which to load FSW Range: 0 to 2 0 = FSW_EEPROM1 EEPROM1 FSW /hessiFs/eeprom1/ 1 = FSW_EEPROM2 EEPROM2 FSW /hessiFs/eeprom2/ 2 = FSW_RAM RAM FSW /hessiFs/ram/
Telemetry: After reboot, the following telemetry points will be set appropriately: TFSWVERSION (U1234) Flight Software Version TFMBOOTDEV (UB) The current boot device (0=default boot EEPROM1, commanded 1=EEPROM1, 2=EEPROM2, 3=RAM) TFMBOOTTIMEI (TIME40) FSW Boot Time

4. IN-FLIGHT FILESYSTEM

There are three in-flight filesystems:

Filesystem Name	Filesystem Type	Filesystem Size
/hessiFs/eeprom1/	Read-only EEPROM	2036 Kbytes
/hessiFs/eeprom2/	Read-write EEPROM	1024 Kbytes
/hessiFs/ram/	Read-write RAM	2048 Kbytes

Each filesystem has a fixed size, a fixed number of 104 files, a maximum length for each file, a checksum for each file directory entry, and a checksum for the contents of each file. Table 4-1, Filenames and Maximum File Length lists the names of the files in each filesystem with their respective maximum file length. Some files can be referenced by more than one name. For example, the bootrom.bin file can also be referenced as 'fsw00'. The files are organized as:

fsw00 – fsw31	Flight software files
ats00 – ats01	Absolute-time sequenced stored telecommand sequences
rts00 – rts63	Relative-time sequenced stored telecommand sequences
param	Flight parameters
file00 – file03	General purpose files
directory	Filesystem information about each file

In ITOS, files are referred to as tables. All files get loaded, and can be dumped, using the SMTBLLOAD and SMTBLDUMP telecommands described in Section 4.2, Filesystem Content Telecommand. A listing of the contents of a filesystem can be retrieved using the SMTBLDESCDMP telecommand, and displayed using the ITOS SMFSWFILES and SMSEQFILES pages.

Each file in the RAM filesystem has a corresponding telemetry point that indicates whether a file contains data. In ITOS terms, when a file contains data it is considered 'loaded'; when a file contains no data (file length of zero), then the file is considered 'not loaded'. These telemetry points are named TSMTBLNUM000 – TSMTBLNUM103, and are displayed on the REPROGRAMMING page.

Table 4-1. Filenames and Maximum File Length

Filename	Max Length	Filename	Max Length	Filename	Max Length
bootrom.bin (fsw00)	204800	rts01	304	rts36	304
vxWorks (fsw01)	835584	rts02	304	rts37	304
vxWorks.load (fsw02)	1024	rts03	304	rts38	304
fsw_fswLoad.o (fsw03)	5120	rts04	304	rts39	304
fsw_fswStart.o (fsw04)	8192	rts05	304	rts40	304
fsw_acs.o (fsw05)	87040	rts06	304	rts41	304
fsw_autocode.o (fsw06)	41984	rts07	304	rts42	304
fsw_commandProcessor.o (fsw07)	95232	rts08	304	rts43	304
fsw_devices.o (fsw08)	37888	rts09	304	rts44	304
fsw_downlink.o (fsw09)	45056	rts10	304	rts45	304
fsw_eventtask.o (fsw10)	13312	rts11	304	rts46	304
fsw_faultmgmt.o (fsw11)	41984	rts12	304	rts47	304
fsw_hessiRoot.o (fsw12)	0	rts13	304	rts48	304
fsw_idpuInterface.o (fsw13)	25600	rts14	304	rts49	304
fsw_infrastructure.o (fsw14)	111616	rts15	304	rts50	304
fsw_interrupts.o (fsw15)	9216	rts16	304	rts51	304
fsw_pcbinterface.o (fsw16)	43008	rts17	304	rts52	304
fsw_reprogramming.o (fsw17)	111616	rts18	304	rts53	304
fsw_scheduler.o (fsw18)	17408	rts19	304	rts54	304
fsw_simdevices.o (fsw19)	49152	rts20	304	rts55	304
fsw_soh.o (fsw20)	19456	rts21	304	rts56	304
fsw_ssrInterface.o (fsw21)	89088	rts22	304	rts57	304
fsw_tcmessagemap.o (fsw22)	6144	rts23	304	rts58	304
fsw_tcrouter.o (fsw23)	11264	rts24	304	rts59	304
fsw_uplink.o (fsw24)	44032	rts25	304	rts60	304
fsw25	0	rts26	304	rts61	304
fsw26	0	rts27	304	rts62	304
fsw27	0	rts28	304	rts63	304
fsw28	0	rts29	304	params	2048
fsw29	0	rts30	304	file00	24576
fsw30	0	rts31	304	file01	7168
fsw31	0	rts32	304	file02	4096
ats00	35004	rts33	304	file03	4096
ats01	35004	rts34	304	. (directory)	2496
rts00	304	rts35	304		

4.1 EEPROM Write Protection

The EEPROM filesystems have write protection mechanisms that need to be disabled before the user can successfully change. The following three methods ensure that the EEPROM will not be inadvertently written to in flight:

a. FSW Filesystem Write Enable.
On boot, FSW considers both EEPROM filesystems to be read-only. The SMEPROMWRITE telecommand allows the ground to change the filesystem write mode between read-only and read-write. When a filesystem is read-only, writes attempts return an error.

b. Hardware EEPROM Write Enable.
The EEPROM device write-enable signal enable/disables writing to all 3MB of EEPROM. This signal is tied to CIB HCD/CRC 21. When CRC21 is clear, this signal prevents inadvertent and explicit writes from programming EEPROM.

c. EEPROM Device Level Software Data Protection (SDP) Mode.
The first 2 MB of EEPROM, which is the first EEPROM filesystem, will be protected using the device level Software Data Protection mode of the EEPROM multi-chip modules. The EEPROM device level write protection configuration is set during I&T and retained in the EEPROM devices during the remainder of I&T and in flight. This feature will allows the top 1 MB portion of EEPROM to be reprogrammed in flight while protecting the lower 2MB containing the primary boot FSW image.
The device level data protection mode still allows the protected portion of EEPROM to be reprogrammed, but in order to write to the protected portion of the EEPROM a special write sequence must be followed for each data byte written. The FSW will not contain the code that can write this special sequence, so the protected portion of EEPROM is prevented from being inadvertently reprogrammed. To reprogramming this portion of EEPROM, additional software must be uploaded and executed.

4.1.1 SMEEPROMWRITE Telecommand

The SMEPROMWRITE telecommand is used to change the filesystem write mode between read-only and read-write:

SMEPROMWRITE Enable/Disable various mechanisms to write to EEPROM ENABLESELECT (UB) Select mechanism to enable/disable writing Range: 1 to 2 1 = FSYS_EEPROM1 Enable writing to EEPROM1 filesystem. 2 = FSYS_EEPROM2 Enable writing to EEPROM2 filesystem. ENABLE (UB) 1=enable writing, 0=disable writing to EEPROM Range: 0 to 1 0 = OFF 0 = NO 0 = FALSE 1 = YES 1 = TRUE 1 = ON
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMEEP1FSWR (U12) TRUE indicates that the EEPROM1 Filesystem is enabled for writing. TSMEEP2FSWR (U12) TRUE indicates that the EEPROM2 Filesystem is enabled for writing.

4.1.2 EEPROM Device Level Software Data Protection Mode

The RAD6000 EEPROM is a Hitachi HN58C1001 Series device. It is a 131072-word x 8-bit Electrically Erasable and Programmable CMOS ROM. It has a Software Data Protection (SDP) mode that helps prevent inadvertent writes to EEPROM by forcing a specific data pattern to be written for each byte stored in the EEPROM. The RAD6000 combines 8 chips into one 'package' to create a 1 MB EEPROM device that is 262144-word x 32-bits. This means that there are two sets of 4 chips, each forming 32-bits. When enabling or disabling SDP mode, the special data pattern must be written to every EEPROM device in the package for the first 2 Mbytes of EEPROM.

What this means is that there are six ‘banks’ of EEPROM, each 512 Kbytes, for which SDP mode can separately enabled or disabled. Only the first four banks (2 Mbytes) have the SDP mode enabled. The software functions to enable and disable the EEPROM device level Software Data Protection (SDP) mode does not exist in the flight software. To enable or disable the EEPROM SDP, additional code must be uploaded and dynamically linked into the O/S. The object file “hessi/fsw/patches/eeprom_sdp.o’ contains three functions for use in enable, disabling and testing the SDP mode, named eepromEnableSdpMode(), eepromDisableSdpMode(), eepromTestSdpMode(size_t bankId).

eepromEnableSdpMode(int bankId)

Enables the Hitachi EEPROM Software Data Protection (SDP) mode for the commanded EEPROM bank. Each bank of EEPROM is 512 Kbytes in length. The SDP mode is enabled using the following steps:

1) Read a single 32-bit value for beginning of the bank of EEPROM.
2) Write enable SDP mode pattern.
3) Write the original 32-bit value to EEPROM.

Inputs:
bankId - the EEPROM bank for which to enable SDP mode protection. Range is 1 to 6.
Returns:
0 if successful; -1 on error.

eepromDisableSdpMode()

Disables the Hitachi EEPROM Software Data Protection mode for the commanded EEPROM bank. Each bank of EEPROM is 512 Kbytes in length.

Inputs:
bankId – the EEPROM bank for which to disable SDP mode protection. Range is 1 to 6.
Returns:
0 if successful; -1 on error

```
eepromTestSdpMode(int bankId)

Tests to see if Software Data Protection mode is in effect by writing to a location in the commanded EEPROM
bank. Each bank of EEPROM is 512 Kbytes in length. The location and original value are printed before any
modifications are made. This SDP test is accomplished using the following steps:

1) Read value at specific EEPROM address.
2) Write a different value.
3) Wait 10 ms.
4) Read value. If it is the original value, then test is successful. If it is the different value, test failed.
5) If test failed, write the original value; wait 10 ms.

Input:
   bankId – the EEPROM bank for which to test.
Returns:
   0 if SDP mode is in effect, and write to EEPROM failed as expected
   -1 if SDP mode is NOT in effect, and EEPROM was modified by write
```

To enable, disable or test the EEPROM SDP mode, the eeprom_sdp.o object file must first be uploaded to the HESSI spacecraft, loaded into the O/S, and then calling the various functions. Use the following steps to accomplish this:

a. Use the binToTableLoad utility program (Section 17.1 binToTableLoad on page 101) to generate an ITOS table load file for one of the general purpose files (FILE00 – FILE03) from the eeprom_sdp.o file.
b. Use a text editor to generate one or more script files containing the functions that need to be called.
c. Use the binToTableLoad utility program to generate an ITOS table load file(s) from the script file(s).
d. Uplink the load files containing the eeprom_sdp.o and script file (s) files using the ITOS LOAD command.
e. Load the eeprom_sdp.o file into the O/S using the SMLOADMODULE telecommand.
f. Execute the script(s) using the SMRUNSCRIPT telecommand.

4.1.3 Example of modifying the EEPROM1 filesystem

The following is an example of saving a new initial stored sequence, RTS00, to the EEPROM1 filesystem. This is a realistic example in that the RTS00 sequence is likely to be changed before launch.

a. Build a new RTS00 load file using MPS or the ITOS leditor application.
b. Uplink RTS00 using the ITOS LOADPKT or LOAD command to the RAM filesystem.
c. Use the binToTableLoad utility program to generate an ITOS table load file from the eeprom_sdp.o object module:
   binToTableLoad –c –t file00 –i ~/hessi/fsw/patches/eeprom_sdp.o –o ~/hessi/build/itos/loads/eeprom_sdp.atf
d. Use a text editor to generate two script files containing the functions to be called:

File enablesdp.txt:
```
eepromEnableSdpMode(1)
eepromEnableSdpMode(2)
eepromEnableSdpMode(3)
eepromEnableSdpMode(4)
eepromTestSdpMode(1)
eepromTestSdpMode(2)
eepromTestSdpMode(3)
eepromTestSdpMode(4)
```

File disablesdp.txt:
```
eepromDisableSdpMode(1)
eepromDisableSdpMode(2)
eepromDisableSdpMode(3)
eepromDisableSdpMode(4)
```

e. Use the binToTableLoad utility program to generate an ITOS table load files from the two script files:
binToTableLoad –t file01 –i enablesdp.txt –o ~/hessi/build/itos/loads/enablesdp.atf
binToTableLoad –t file02 –i disablesdp.txt –o ~/hessi/build/itos/loads/disablesdp.atf

f. Uplink the load files containing the eeprom_sdp.o and script files files using the ITOS LOAD command:
LOAD eepromsdp.atf
LOAD enablesdp.atf
LOAD disablesdp.atf

g. Load the eeprom_sdp.o file into the O/S using the SMLOADMODULE telecommand:
/SMLOADMODULE FSW_RAM, FILE00

h. Enable writes to the EEPROM1 filesystem with the SMEPROMWRITE telecommand:
/SMEPROMWRITE FSYS_EEPROM1, ON

i. Enable writes to the EEPROM by setting CRC21:
START CRCSET(21)

j. Disable the EEPROM SDP mode by running the disablesdp.txt script:
/SMRUNSCRIPT FSW_RAM, FILE02

k. Copy the RTS00 table from RAM to the EEPROM1 filesystem:
/SMTBLSELECT RTS00, SRCSRAM, DESTEEPROM1
/SMTBLCOMMIT CKDISABLE, CHECKSUM=0

l. Enable the EEPROM SDP mode by running the enablespd.txt script:
/SMRUNSCRIPT FSW_RAM, FILE01

m. Disable writes to EEPROM by clearing CRC21:
START CRCCLEAR(21)

n. Disable writes to the EEPROM1 filesystem:
/SMEPROMWRITE FSYS_EEPROM1, OFF

4.2 Filesystem Content Telecommand

The SMTBLDESCDUMP telecommand will downlink a directory listing of all files in a specific filesystem. The ITOS pages SMFSWFILES and SMSEQFILES display telemetry points downlinked by this telecommand.

SMTBLDESCDMP Dumps info about each table: timestamp, size, checksum, etc TABLE_DEVICE (UB) Specifies one of three table devices. Range: 1 to 3 1 = DEV_EEPROM1 Read-only EEPROM device 2 = DEV_EEPROM2 Read-write EEPROM device 3 = DEV_RAM RAM device	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.	

5. STORAGE MANAGEMENT SUBSYSTEM

The Storage Management subsystem provides telecommand access to the in-flight filesystem, system memory, the VME bus, pseudo non-volatile error logs, and various housekeeping configuration functionality.

5.1 Loading Tables

ITOS tables are stored in files in the in-flight filesystems. The HESSI FSW provides several telecommands to select, load and dump files in the in-flight filesystem. The format and usage of these telecommands were driven by those already in use on other NASA Small Explorer (SMEX) satellites and for which there is direct ITOS support. If the ground operator is familiar with telecommand structure of ITOS and other SMEX satellites, the HESSI table manipulation telecommand will be vary similar to those previously used.

A table is loaded, or uplinked, by “selecting” the table name to operate on, and then sending one or more “load” telecommands, followed by a “commit” telecommand indicating that the loaded table should be saved. The SMTBLSELECT telecommand is used to “select” the table. The effect is to copy the existing file into a temporary working buffer. The SMTBLLOAD telecommand is used to “load” data into the temporary working buffer. The SMTBLCOMMIT telecommand is used to indicate that all loaded data, and unmodified previous data, in the temporary working buffer should be saved to selected file.

The following is a description of each of these telecommands.

SMTBLSELECT Select Table Operation. Copies requested file into temporary working buffer.

TABLEID (U12) Identification number of table to select.

Range: 0 to 103

0 = DIRECTORY Filesystem Directory
1 = FSW00 FSW Object File 0 (Boot Image)
2 = FSW01 FSW Object File 1
3 = FSW02 FSW Object File 2
. . .
(see Telecommand Database document for complete listing of filenames)

SOURCE_TABLE (U12) Type of source memory for the table.

Range: 1 to 4

1 = SRCEEPROM1 Source is table from version in read-only EEPROM
2 = SRCSRAM Source is operational version in SRAM
3 = SRCZERO Source is zero-filled version of table
4 = SRCEEPROM2 Source is table from version in read/write EEPROM

DEST_TABLE (U12) Type of destination memory for the table.

Range: 1 to 4

1 = DUMPONLY Table data can not be changed
2 = DESTEEPROM2 On commit, change version in R/W EEPROM
3 = DESTSRAM On commit, change operational version in SRAM
4 = DESTEEPROM1 On commit, change version in R/O EEPROM (ground only)

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one.

TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification

TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.

TSMOPSTATUS (UB) Table/memory operations status will be set to discrete value SMSTNONE (0).

TSMLSTOPSTAT (UB) Last table/memory operations status will be set to discrete value SMSTTBLSELCT (7).

TMTBLID (UB) Table ID currently selected will be set to TABLEID in telecommand.

TSMSELTBLSIZ (U1234) Size of the currently selected table.

TSMSRCTYPE (UB) Table/memory operations source type, SOURCE_TABLE from telecommand.

TSMDESTTYPE (UB) Table/memory operations destination type, DEST_TABLE from telecommand.

SMTBLLOAD Load data into temporary working buffer. OFFSET (U1234) Byte offset into working table to begin load. Range: 0x00000000 to 0xFFFFFFFF DUMMYARG UB Destination, which is ignored, aways 2. Range: This parameter is ignored and may contain anything. It exists only to maintain compatability with other SMEX missions. 2 **=** DEFAULT Default value of dummy argument NUMBYTES (UB) Number of bytes to load. Range: 1 to 200 DATA (UB) An array of <NUMBYTES> bytes of data Range: 0 to 0xFF	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMOPSTATUS (UB) Table/memory operations status will be set to discrete value SMSTNONE (0). TSMLSTOPSTAT (UB) Last table/memory operations status will be set to discrete value SMSTTBLLOAD (5). TSMSELTBLSIZ (U1234) Size of the table after the load TSMNUMBYTES (U12) Number of bytes that were loaded as specified by NUMBYTES in telecommand TSMSTARTLOC (U1234) Starting offset of load specified by OFFSET in telecommand TSMTLDRECVD (UB) # of SMTBLLOAD commands received TSMTLDREJCT (UB) # of SMTBLLOAD commands rejected	
Notes: OFFSET must be less than maximum file size, and OFFSET + NUMBYTES must be no larger than maximum file size or an error will result.	

SMTBLCOMMIT Commit software table data. SELECT (U12) Commit table if checksum mismatch control flag. Range: 0 to 1 0 = CKDISABLE Disables use of the CHECKSUM parameter 1 = DEFAULT Same as CKDISABLE 1 = CKENABLE Enables use of the CHECKSUM parameter 2 = UNCOMPRESS Uncompress file, then apply CHECKSUM parameter CHECKSUM (U12) The checksum to be used with the table. Range: 0x0 to 0xFFFF
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMOPSTATUS (UB) Table/memory operations status will be set to discrete value SMSTNONE (0). TSMLSTOPSTAT (UB) Last table/memory operations status will be set to discrete value SMSTTBLCOMIT (6). TMTBLID (UB) Table ID currently selected will be set to TABLEID in telecommand will be set to 0xFF (no table). TSMTCMTRECVD (UB) # of SMTBLCOMMIT commands received TSMTCMTREJCT (UB) # of SMTBLCOMMIT commands rejected TSMATSSTMPAI (TIME40) Creation Timestamp of ATS Table A set equal to first 4 bytes of file if ATSA TSMATSSTMPBI (TIME40) Creation Timestamp of ATS Table B set equal to first 4 bytes of file if ATSB TSMTBLNUM??? (U23) (where ??? is file number) Will be set to TRUE if committed table has a file size greater than zero, FALSE otherwise.

5.2 Dumping Tables

ITOS tables are stored in files in the in-flight filesystems. The HESSI FSW provides a telecommand dump file in the in-flight filesystem, and a telecommand to abort a dump that is in process. The format and usage of these telecommands were driven by those already in use on other NASA SMEX satellites and for which there is direct ITOS support. If the ground operator is familiar with telecommand structure of ITOS and other SMEX satellites, the HESSI table manipulation telecommand will be very similar to those previously used.

Before a table can be dumped, it must be selected with the SMTBLSELECT telecommand. Depending on the size of the table dumped, one or more telemetry packets will be downlinked on Virtual Channel 1, APID 7.

The following is a description of the dump and abort telecommand.

SMTBLDUMP Dump software table data. OFFSET (U1234) Byte Offset Into Table to Begin Dump. Range: 0x0 to 0xFFFFFFFF NUMBYTES (U12) Number of Bytes to Dump. Range: 1 to 65535 NUMCOPYS (U12) Number of Copies of Dump to Transmit . Range: 1 to 8
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMOPSTATUS (UB) Table/memory operations status will be set initially to discrete value SMSTTBLDUMP (4), then set to SMSTNONE (0) on table dump completion. TSMLSTOPSTAT (UB) Last table/memory operations status will be set to discrete value SMSTTBLDUMP (4) on completion. TSMSTARTLOC (U1234) Starting location of dump offset set to OFFSET from telecommand TSMNUMBYTES (U12) Number of bytes to dump set to NUMBYTES from telecommand TSMBYTESREMN (U12) Number of bytes remaining to dump decrements from NUMBYTES to 0 as dump telemetry is downlinked. TSMCOPIES (UB) - # of copies of dump to transmit set to NUMCOPYS from telecommand TSMCPYREMAIN (UB) # of remaining copies to dump decrements from NUMCOPYS to 0 as dump telemetry is downlinked.
Notes: Table dump telemetry is downlink on Virtual Channel 1, APID 7.

5.3 Aborting Table Operations

The SMDUMPABORT is used to abort a table or memory dump operation. If aborting a table dump, then the current table is left selected. The SMTBLRESET telecommand is used to reset table operations. SMTBLRESET will also abort a table load, but not a memory load. Unlike the SMDUMPABORT telecommand, the SMTBLRESET telecommand will leave no table selected.

SMDUMPABORT Abort memory or table dump. (no parameters)	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMOPSTATUS (UB) Table/memory operations status will be set to discrete value SMSTNONE (0). TSMLSTOPSTAT (UB) Last table/memory operations status will be set to previous value of TSMOPSTATUS. TSMBYTESREMN (U12) Number of bytes remaining to dump set to 0. TSMCPYREMAIN (UB) # of remaining copies to dump set to 0.	
Notes: This telecommand will return error if the current TSMOPSTATUS is not SMSTMEMDUMP, SMSTTBLDUMP or SMSTPNVRAM.	

SMTBLRESET (no parameters)	Reset Software Table Operations.
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMOPSTATUS (UB) Table/memory operations status will be set to discrete value SMSTNONE (0). TSMLSTOPSTAT (UB) Last table/memory operations status will be set to previous value of TSMOPSTATUS. TMTBLID (UB) Table ID currently selected will be set to 0xFF (no table). TSMSELTBLSIZ (U1234) Size of the currently selected table set to 0. TSMSRCTYPE (UB) Table/memory operations source type set to 0. TSMDESTTYPE (UB) Table/memory operations destination type set to 0. TSMSTARTLOC (U1234) Starting location of load address set to 0. TSMNUMBYTES (U12) Number of bytes to dump set to 0. TSMBYTESREMN (U12) Number of bytes remaining to dump set to 0. TSMCOPIES (UB) - # of copies of dump to transmit set to 0. TSMCPYREMAIN (UB) # of remaining copies to dump set to 0.	
Notes: This telecommand will return error if the current TSMOPSTATUS is not SMSTNONE, SMSTTBLDUMP or SMSTPNVRAM.	

5.4 Loading, Copying and Dumping Memory

The HESSI FSW provides a telecommand to load and copy CPU and VME memory, and to dump memory to telemetry. The parameter format and usage of these telecommands were driven by those already in use on other NASA SMEX satellites. If the ground operator is familiar with telecommand structure of ITOS and other SMEX satellites, the HESSI memory dump telecommand will be very similar to that previously used.

Memory dump telemetry packets will be downlinked on Virtual Channel 1, APID 7. The SMDUMPABORT telecommand can be used to abort a memory dump in progress. The following is a description of the memory load dump, copy and dump telecommand.

SMMEMLOAD Load C&DH Processor Memory ADDRESS (U1234) Starting address of load. Range: 0x0 to 0xFFFFFFFF DESTINATION (U12) Destination memory type and data write size. Range: 1 to 2 2 = RAM RAM memory type. 2 = DEFAULT Default value NUMBYTES (UB) Number of bytes to load. Range: 1 to 200 DATA (UB) An array of <NUMBYTES> bytes of data, Range: 0 to 0xFF
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMOPSTATUS (UB) Table/memory operations status will be set initially to discrete value SMSTNONE (0). TSMLSTOPSTAT (UB) Last table/memory operations status will be set to discrete value SMSTMEMDUMP (2). TSMSTARTLOC (U1234) Starting location of load address set to ADDRESS from telecommand TSMNUMBYTES (U12) Number of bytes to load set to NUMBYTES from telecommand TSMBYTESREMN (U12) Number of bytes remaining set to 0. TSMMLDRECVD (UB) # of SMMEMLOAD commands received will increment by one. TSMMLDREJCT (UB) # of SMMEMLOAD commands rejected will increment if a parameter is out of range.
Notes: The RAD6000 contains 128 MB of memory: CPU Addresses 0x00000000 to 0x07FFFFFE The VME A24:D16 bus starts at the CPU offset of 0xB0000000. Not all VME bus addresses are can written to. All other addresses are invalid. Reading from invalid addresses have an unpredictable behavior.

SMMEMCOPY Copy EPROM, EEPROM, SRAM or VME memory.

SOURCEAD (U1234) Starting address of source memory.
Range: 0x0 to 0xFFFFFFFF

DESTINATION (U12) Destination memory type.
Range: Only 2
2 = DESTRAM Selects RAM as destination memory type.
2 = DEFAULT Default value

DESTADD (U1234) Starting address of destination memory.
Range: 0x0 to 0xFFFFFFFF

NUMBYTES (U12) Number of bytes to copy.
Range: 1 to 65535

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one.

TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification

TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.

TSMOPSTATUS (UB) Table/memory operations status will be set initially to discrete value SMSTNONE (0).

TSMLSTOPSTAT (UB) Last table/memory operations status will be set to discrete value SMSTMEMCOPY (3).

TSMSTARTLOC (U1234) Starting location of load address set to SOURCEAD from telecommand

TSMCOPYLOC (U1234) Destination address of memory copy set to DESTADD from telecommand

TSMNUMBYTES (U12) Number of bytes to load set to NUMBYTES from telecommand

TSMBYTESREMN (U12) Number of bytes remaining set to 0.

TSMMCPRECVD (UB) # of SMMEMCOPY commands received will increment by one.

TSMMCPREJCT (UB) # of SMMEMCOPY commands rejected will increment if a parameter is out of range.

Notes:

The RAD6000 contains 128 MB of memory: CPU Addresses 0x00000000 to 0x07FFFFFE

Memory copies are limited to CPU memory only; copies can NOT make use of the VME Bus.

All other addresses are invalid. Reading from invalid addresses have an unpredictable behavior.

Overlapping memory regions will be copied correctly.

SMMEMDUMP Dump SRAM or VME memory. ADDRESS (U1234) Starting address of dump. Range: 0x0 to 0xFFFFFFFF DUMPSIZE (U12) Number of bytes to dump. Range: 1 to 65535 NUMCOPYS (U12) Number of copies of dump to transmit. Range: 1 to 8
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMOPSTATUS (UB) Table/memory operations status will be set initially to discrete value SMSTNONE (0). TSMLSTOPSTAT (UB) Last table/memory operations status will be set to discrete value SMSTMEMDUMP (1). TSMSTARTLOC (U1234) Starting location of load address set to ADDRESS from telecommand TSMNUMBYTES (U12) Number of bytes to dump set to DUMPSIZE from telecommand TSMBYTESREMN (U12) Number of bytes remaining to dump decrements from DUMPSIZE to 0 as dump telemetry is downlinked. TSMCOPIES (UB) - # of copies of dump to transmit set to NUMCOPYS from telecommand TSMCPYREMAIN (UB) # of remaining copies to dump decrements from NUMCOPYS to 0 as dump telemetry is downlinked. TSMMLDRECVD (UB) # of SMMEMLOAD commands received will increment by one. TSMMLDREJCT (UB) # of SMMEMLOAD commands rejected will increment if a parameter is out of range.
Notes: The RAD6000 contains 128 MB of memory: CPU Addresses 0x00000000 to 0x07FFFFFE The VME A24:D16 bus starts at the CPU offset of 0xB0000000. Not all VME bus addresses are written to. All other addresses are invalid. Reading from invalid addresses have an unpredictable behavior. Table dump telemetry is downlink on Virtual Channel 1, APID 8.

5.5 PACI Pseudo Non-Volatile Logs

To help in the post-analysis of the reason for a CPU reset, FSW continually logs information to the PACI Pseudo Non-Volatile RAM (PNVRAM). The RAM is termed pseudo non-volatile because it is not a true non-volatile RAM device, it is just that the PACI hardware board is on the essential bus and is never powered off, and thus the contents of RAM are never lost. The PNVRAM memory is also made up of RAM with single bit upset immunity (EDAC) RAM to protect against single bit errors.

The PNVRAM is divided into three log areas, allowing the ground to retrieve data about the last three CPU resets that occurred. The current log area number is downlinked in the TFMCURPNVIDX telemetry point, is determined by reading the CIB Watchdog Timer reset count, and has a range of 0, 1 and 2.

Each log area has the capacity to store:

a. 60 seconds of SOH telemetry (1 frame per second)
b. 48 most recently received telecommands
c. 100 most recently received event error or warning messages

There are three telecommands available that act upon the PNVRAM logs. The SMDLPNVTLM telecommand is used to downlink the contents of one of the log areas. The SMCLRPNVTLM telecommand is used to clear the contents of one of the log areas. The SMREINITPNV telecommand is used to reinitialize the entire PNVRAM EDAC RAM area.

The last FSW boot time, TFMBOOTIME, and the TFMCURPNVIDX telemetry point are displayed on the ITOS FAULTMANAGEMENT page. If either of these values change unexpectedly, then the previous PNVRAM log should be downlinked for analysis.

All PNVRAM telemetry is downlinked on Virtual Channel 1. SOH telemetry has is downlinked with APID 1, The stored telecommand log is downlinked with APID 10 for complete telecommands, and APID 12 for codeblocks. Event messages are downlinked with APID 40.

SMDLPNVTLM Downlink one of the three PACI Pseudo Non-Volatile RAM (PNVRAM) logs LOGNUMBER (UB) The PNVRAM telemetry log index Range: 0 to 2
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.

SMCLRPNVTLM Clear one of the three PACI Pseudo Non-Volatile RAM (PNVRAM) logs LOGNUMBER (UB) The PNVRAM telemetry log index Range: 0 to 2	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.	

SMREINITPNV Reinitialize all PACI Pseudo Non-Volatile RAM (PNVRAM) Region (non parameters)	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification	

5.6 Managing Event Messages

Event message allow FSW to efficient communicate readable English messages to the ground. Event messages are used for a variety of situations:

a. To report error information that can not be easy communicated in normal SOH telemetry.
b. To report why a telecommand has returned an error
c. To provide information for diagnostic purposes

When enabled for downlink, event messages are displayed in the hessiLogTool window of the ITOS desktop. The Downlink Subsystem will store 100 telemetry frames of event messages, which is approximately 2000 individual event messages (depending on data lengths).

Event messages report the subsystem from which the message originated, the message severity, a message number, and optional data associated with the message. Event message severity is categorized by six levels of severity:

a. Fatal – will cause the CPU to reboot
b. Error – an error occurred during processing
c. Warning – want operator of a potential problem
d. Info_Low – a low volume informational message
e. Info_Medium – a moderate volume informational message
f. Info_High – a high volume informational message

The ground operator can filter out messages by severity from being downlinked or stored in the Stored Telemetry Database. Only warning and informational messages can be filtered out. The SMEVTFILTALL telecommand will change the event filter for all subsystems. The SMEVTFILTER telecommand will change the event filter for a specific subsystem.

SMEVTFILTER Sets the Event Message Filter for a specific task TASKNAME (UB) A task name Range: 0 to 12 0 = SCHEDULER Scheduler Task 1 = ACS ACS Task 2 = PCBINTERFACE PCB Interface Task 3 = UPLINK Uplink Task 4 = TCPUPLINK TCP Uplink Task (test only) 5 = CMDPROCESSOR Command Processor Task 6 = SOH SOH Task 7 = PLINTERFACE Payload Interface Task 8 = SSRINTERFACE SSR Interface Task 9 = FAULTMGMT Fault Management Task 10 = TCPDOWNLINK TCP Downlink Task (test only) 11 = DOWNLINK Downlink Task 12 = REPROGRAM Reprogramming Task VOLUME (UB) Volume of Event Messages desired Range: 0 to 4 0 = NONE Only Error Event Messages will be output 1 = WARNING Error, warning Event Messages will be output 2 = INFO_LOW Error, warning, low volume informational messages 3 = INFO_MEDIUM Error, warning, medium volume informational messages 4 = INFO_HIGH Error, warning, high volume informational messages
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.

SMEVTFILTALL Set Event Message Filter for all tasks VOLUME (UB) Event Message Filter Volume Range: 0 to 4 0 = NONE Only Error Event Messages will be output 1 = WARNING Error, warning Event Messages will be output 2 = INFO_LOW Error, warning, low volume informational messages 3 = INFO_MEDIUM Error, warning, medium volume informational messages 4 = INFO_HIGH Error, warning, high volume informational messages	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.	

5.7 In-flight FSW Reprogramming

As discussed previously in Section 3. FSW Boot Sequence, FSW is partitioned into 24 separate files stored in an in-flight filesystem. This section will discuss the details of how to reprogram the FSW while in flight.

At power up, a boot program (one file) is loaded and run. This boot program is the first file in the filesystem. There is only one version of this file that is ever used, and it is located in the first EEPROM filesystem at "/hessiFs/eeprom1/bootrom.bin".

The boot program loads and runs the Wind River VxWorks real-time operating system, which is one file having the name 'vxWorks'. There are two versions of this file available for boot. This first is the default boot O/S located in the first EEPROM filesystem at "/hessiFs/eeprom1/vxWorks". The second version of this file is in the RAM filesystem located at "/hessiFs/ram/vxWorks". The second version can only be used as a result of the SMREBOOT telecommand discussed in Section 3.6 Manually Rebooting on page 3.

After the operating system boots, it loads 22 flight software files from one of the three in-flight filesystems. By default, the O/S looks at the CRC22 bit to determine whether the FSW files should be loaded from the EEPROM1 or EEPROM2 filesystem. This can be overridden by the SMREBOOT telecommand.

Because there are 22 flight software files, it would be very hard to have one number that reflects the state of every file, and so this is not attempted. Instead, the telemetry point TFSWVERSION reflects the state of all files at the specific point in time when all 22 files where released together. The value of the flight software version number reported in TFSWVERSION is stored in the file 'fsw_infrastructure.o". A better indication of the version of each of the 22 FSW files would probably be the checksum of each file as these will almost certainly change between versions. The checksum for each of the FSW files can be retrieved using the SMTBLDESCDUMP telecommand.

In addition to modifying one of the 22 flight software files, another method of modifying flight software would be to load an addition software module. This can be accomplished using the SMLOADMODULE telecommand. The general purpose files FILE00 to FILE03 provide a convenient location to stored addition software modules. When the SMLOADMODULE telecommand is used, the commanded object file is loaded and linked into the currently running operating system. Afterwards, specific functions (as determined by the programmer) will automatically be executed after the file is loaded, or any loaded functions can be executed directly from a script run with the SMRUNSCRIPT telecommand.

The binToTableLoad ground utility, described in Section 17.1 on page 101, is provided to generated an ITOS load file from any file. This is used to create load files for object and script files.

To decrease the uplink time necessary, any file can be compressed on the ground, uplinked, and then uncompressed in flight. Two ground utilities provide the compress capabilities: deflate and binToTableLoad. The deflate utility, described in Section 17.6 on page 103, simply compresses an file, much like other compression utilities. The binToTableLoad has a compression option that will first compress the input file using deflate and then generate the ITOS load file; inside the load file, the SMTBLCOMMIT telecommand specifies the UNCOMPRESS parameter to indicate the file should be uncompressed when it is committed. A file can also be compressed before the binToTableLoad utility is used, and then uncompressed in flight with the SMUNCOMPRESS telecommand.

The last method of modifying flight software is to modify the current O/S and FSW image running in RAM. This can is done with the SMMEMLOAD, SMMEMDUMP and SMMEMCOPY telecommands. This method might be used to change the values of a few locations in memory.

The SMRUNSCRIPT is a very versatile telecommand in that it runs a script that can call any VxWorks O/S or FSW function currently loaded into RAM. The output of the script is redirected into telemetry on Virtual Channel 1, APID 41. The output is decoded and displayed in the 'hessiLogTool' window on the ITOS display.

Since the 22 FSW files are dynamically linked into the O/S at run-time, there is no static map of what FSW will look like in RAM. This means a single global variable will not be in located in the same RAM address after every reboot. To determine the location of a global variable, a VxWorks script would be written, uplinked and executed. In addition, the same script could also modify the value of the global so that a subsequence SMMEMLOAD would not be required.

The various telecommands used to reprogram FSW are discussed below.

SMLOADMODULE Load an object module from a HESSI filesystem FILESYSTEM (UB) The HESSI filesystem from which to load file Range: 0 to 2 0 = FSW_EEPROM1 EEPROM1 FSW /hessiFs/eeprom1/ 1 = FSW_EEPROM2 EEPROM2 FSW /hessiFs/eeprom2/ 2 = FSW_RAM RAM FSW /hessiFs/ram/ FILENUMBER (UB) The file number to load Range: 0 to 103 0 = DIRECTORY Filesystem Directory 1 = FSW00 FSW Object File 0 (Boot Image) 2 = FSW01 FSW Object File 1 3 = FSW02 FSW Object File 2 . . . (see Telecommand Database document for complete listing of filenames)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification. TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.

SMRUNSCRIPT Run a VxWorks script from HESSI filesystem FILESYSTEM (UB) The HESSI filesystem from which to load script Range: 0 to 2 0 = FSW_EEPROM1 EEPROM1 FSW /hessiFs/eeprom1/ 1 = FSW_EEPROM2 EEPROM2 FSW /hessiFs/eeprom2/ 2 = FSW_RAM RAM FSW /hessiFs/ram/ FILENUMBER UB The file number of script to run Range: 0 to 103 0 = DIRECTORY Filesystem Directory 1 = FSW00 FSW Object File 0 (Boot Image) 2 = FSW01 FSW Object File 1 3 = FSW02 FSW Object File 2 . . . (see Telecommand Database document for complete listing of filenames)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.

SMUNCOMPRESS Uncompress the selected file, which was previously compressed. (no parameters)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TSMOPSTATUS (UB) Table/memory operations status will be set to discrete value SMSTNONE (0). TSMLSTOPSTAT (UB) Last table/memory operations status set to discrete value SMSTUNCOMPRESS (9). TSMSELTBLSIZ (U1234) Size of the table after the uncompress operation.
Notes: Because the size of the uncompressed file is not known, the size is calculated inferred by the uncompressed data. The algorithm used requires that the last byte in the uncompressed file can not be 0xA5. This algorithm works for all object and script files, but may not work for all stored telecommand sequence files.

5.8 Spacecraft Clock

The spacecraft clock (SCLK) can be set to a specific time using the SMSCLKSET telecommand. The spacecraft clock can be change but a specific number of seconds using the SMSCLKDELTA telecommand. The ITOS procedure SET_SCLK_TO_WALLCLOCK is useful during integration and test, and after a reboot, to set the spacecraft SCLK to the current wall clock time.

SMSCLKSET Set the seconds of the PACI Spacecraft Clock SCLKSECONDS (U1234) Number of seconds for Spacecraft Clock Range: 0 to 0xFFFFFFFF
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: All subsequent Transfer Frame and Source Packet time stamps. TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification

SMSCLKDELTA Change the PACI Spacecraft Clock by <DELTA> seconds SCLKDELTA (I12) Delta seconds to change Spacecraft Clock. Range: -32768 to 32767
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: All subsequent Transfer Frame and Source Packet time stamps. TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification

5.9 VME Interrupt Control

The SMINTERRUPT telecommand enables the ground to enable and disable VME interrupts from various sources. Generally, this telecommand should not need to be used, but is provided for completeness.

SMINTERRUPT Enable or disable various VME interrupts. INTERRUPT (UB)The interrupt source Range: 1 to 7 1 = CIBCODEBLOCK CIB Codeblock received interrupt 2 = CIBBUFAVAIL CIB Telemetry Buffer Available interrupt 3 = PACIBUSTICK PACI 1 Hz Bus Tick Interrupt 4 = PACIANALOG PACI 8 Hz Analog Scan Interrupt 5 = PACIIDPUDATA PACI IDPU Data Ready Interrupt 6 = PACISSRDATA PACI SSR Data Ready Interrupt 7 = PACIEDACERR PACI EDAC Double Bit Error Interrupt ENABLE (UB) 0=disable interrupt, 1=enable interrupt. Range: 0 to 1 0 = OFF Off 0 = NO No 0 = FALSE False 1 = YES Yes 1 = TRUE True 1 = ON On	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.	

5.10 Miscellaneous Housekeeping

In addition to the telecommands discussed in the previous subsections, there are a few other housekeeping telecommands. The Storage Management Subsystem is also a kind of catch-all for miscellaneous telecommand that do not have a good home elsewhere.

The SMNOOP telecommand is available to simply determine that the Storage Management Subsystem is receiving and acknowledging telecommands. The SMNOOP does nothing but increment a telecommand received counter. The SMTCRESET telecommand is used to reset the Storage Management Subsystem telecommands received, rejected and error counters. The SMRESET telecommands sets the table load and commit, memory load, and copy received and reject counters to zero.

The SMCLREVTFLAG telecommand resets a few warning indicators that the operator should not miss.

The SMPACIDIGOUT telecommand allows the ground direct control over the PACI Transistor-Transistor Logic (TTL) Digital Output bits. This telecommand is generally meant for ground testing.

The SMTCMSGDIAG telecommand allows the ground to enable or disable an Event Message diagnostic that reports timing information about the routing of telecommands. This telecommand is generally meant for ground testing.

SMNOOP (no parameters)	Storage management no operation telecommand.
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one.	

SMTCRESET (no parameters)	Resets Storage Mgr. APIDs TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will be set to one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification will be set to 0. TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will be set to 0.	

SMRESET (no parameters)	Reset Memory Manager software statuses.
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTLDRECVD (UB) # of SMTBLLOAD commands received set to 0. TSMTLDREJCT (UB) # of SMTBLLOAD commands rejected set to 0. TSMTCMTRECVD (UB) # of SMTBLCOMMIT commands received set to 0. TSMTCMTREJCT (UB) # of SMTBLCOMMIT commands rejected set to 0. TSMMLDRECVD (UB) # of SMMEMLOAD commands received set to 0. TSMMLDREJCT (UB) # of SMMEMLOAD commands rejected set to 0. TSMMCPRECVD (UB) # of SMMEMCOPY commands received set to 0. TSMMCPREJCT (UB) # of SMMEMCOPY commands rejected set to 0.	

SMCLREVTFLAG Clears a specific latched event flag EVENTFLAG (UB) Identifies the event flag to clear Range: 0 to 15 0 = EVTSSRWOVRD Indicates SSR record pointer overtook read pointer 1 = EVTNORTFRAM Indicates all real-time telemetry frames allocated
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TEVTNORTFRAM (U12) Indicates that FSW allocated all real-time telemetry frames TEVTSSRWOVRD (U12) Event Flag indicates SSR record pointer overtook read pointer

SMPACIDIGOUT Write to bits in PACI Digital Output Register BITMASK (U12) Selects the bits to which to write Range: 0 to 65535 BITVALUES (U12) Sets values of the bits selected in BITMASK Range: 0 to 65535
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results. TPACMDDIGOUT (U12) Last commanded PACI Digital Output Word

SMTCMSGDIAG	Enable/disable TC message routing event message diagnostics
ENABLE	UB1=enable diagnostics; 0=disable diagnostics
	Range: 0 to 1 0 = OFF Off 0 = NO No 0 = FALSE False 1 = YES Yes 1 = TRUE True 1 = ON On
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSMTCRECVD (UB) # of Storage Manager TCs received will increment by one. TSMTCREJECT (UB) # of Storage Manager TCs that failed telecommand verification TSMTCERRORS (UB) # of Storage Manager TCs that failed to execute will increment if error results.	

6. STORED TELECOMMAND SEQUENCES

The Stored Command Subsystem manages the starting, processing, and stopping of stored sequences of telecommands. The are two types of stored telecommand sequences: absolute time-sequenced telecommands and relative time-sequences telecommands. An Absolute Time-Sequenced (ATS) telecommand has a timestamp that indicates the precise second when the telecommand should be executed. A Relative Time-Sequenced (RTS) telecommand indicates a precise number of seconds that should be waited before executing a telecommand. The format of the ATS and RTS files is documented in 1110- EW-T17380 HESSI Telecommand Format Specification.

In general, only one telecommand affecting an ATS can be received in any one second; only one telecommand per RTS can be received in any one second.

6.1 Absolute-Time Sequences

There are two ATS tables, named ATSA and ATSB, of which only one can be active at any time. Each ATS table contains up to 35004 bytes of data.

The SCATSSTART is used to start processing ATS table. When started, the stored telecommand processor will skip all telecommands that have a timestamp less than the current time. Up to eight ATS telecommands having the same timestamp will be executed in the same second; any other telecommands with the same timestamp will be skipped.

The SCATSSTOP is used to stop a currently processing ATS file. The SCATSSWITCH telecommand is used to switch to executing the other ATS that is currently not processing.

The SCATSVERIFY telecommand is used to verify that there are no errors in the format of an ATS file. An ATS file can be verified while it is active. To avoid confusion, invalid telecommands detected by SCATSVERIFY and those encountered during ATS execution are flagged differently in telemetry.

These telecommands have been designed to have the same general format and behavior as those used on other SMEX spacecraft.

There are a number of telemetry points that don't get set as a result of a telecommand, but get set as an ATS is processed. The following discusses these telecommand points:

a. TSCATSRECVD (U12) Total of all ATS stored telecommands processed
b. TSCATSREJECT (U12) Total of all ATS stored telecommands that failed verification
c. TSCATSERRORS (U12) Total of all ATS stored telecommands that failed to route
d. TSCATSLICDRI (UB) ID of the ATS containing the last invalid ATS stored TC
e. TSCATSLICDIX (U12) Index of the last invalid ATS stored telecommand
f. TSCATSLICDST (UB) Status of the last invalid ATS stored telecommand
g. TSCATSLICDTS (TIME40) Timestamp of the last invalid ATS stored telecommand

SCATSSTART Start Stored Command Absolute Time Sequence. BUFFER (U12) ATS buffer select. Range: 1 to 2 1 = BUFA ATS Buffer A 2 = BUFB ATS Buffer B
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCATSAVSTTS (BOOL) Activation state of the ATS will equal 1 (Active) TSCATSNTCDIX (U12) Index of the next stored telecommand to execute in the ATS TSCATSNTCDTS (TIME40) Timestamp of the next stored telecommand to execute in the ATS TSCATSPAVSSI (UB) ID of the currently active ATS set equal to BUFFER parameter of telecommand.
Notes: SCATSSTART will fail if an ATS is currently processing. SCATSSTART will fail is another ATS telecommand was received previously in the same second.

SCATSSTOP (no parameters)	Stop Stored Command Absolute Time Sequence.
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCATSAVSTTS (BOOL) Activation state of the ATS will equal 0 (Idle)	
Notes: SCATSSTOP will fail if an ATS is not currently processing. SCATSSTOP will fail is another ATS telecommand was received previously in the same second.	

SCATSSWITCH (no parameters)	Switch Absolute Time Sequence Buffers.
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCATSAVSTTS (BOOL) Activation state of the ATS will equal 1 (Active) TSCATSNTCDIX (U12) Index of the next stored telecommand to execute in the ATS TSCATSNTCDTS (TIME40) Timestamp of the next stored telecommand to execute in the ATS TSCATSPAVSSI (UB) ID of the currently active ATS set equal to BUFFER parameter of telecommand. TSCATSSWCHPG (BOOL) ATS Switch is pending state	
Notes: SCATSSWITCH will fail if an ATS is not currently processing. SCATSSWITCH will fail is another ATS telecommand was received previously in the same second.	

SCATSVERIFY Verifies that an ATS table has the correct format. BUFFER (UB) ATS buffer select. Range: 1 to 2 1 = BUFA ATS Buffer A 2 = BUFB ATS Buffer B
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCATSVRFYID (UB) ID of the ATS table verified, BUFFER from the telecommand TSCATSVRFYST (BOOL) State of last ATS table verification (1=pass, 0=failed)
Notes: SCATSVERIFY will fail is another ATS telecommand was received previously in the same second.

6.2 Relative-Time Sequences

There are 64 RTS tables, named RTS00 to RTS63, of which 16 can be active or suspended at any one time. Each RTS contains up to 304 bytes of data.

The SCRTSSTART is used to start processing RTS table. Telecommands with a timestamp of zero following a telecommand with a non-zero timestamp will be executed in the same second. A maximum of eight telecommands per RTS can be executed in any one second; subsequent zero timestamped telecommands will be skipped.

The SCRTSSTOP is used to stop a currently processing RTS file. The SCRTSSUSPEND telecommand is used suspend an active RTS, remembering the telecommand index and time count where it left off. The SCRTSRESUME telecommand is used to reactivate a previously suspended RTS; the RTS starts executing at the index and time count where it left off.

The SCRTSVERIFY telecommand is used to verify that there are no errors in the format of an RTS file.

The SCRTSDISABLE and SCRTSENABLE telecommands are used to prevent and allow the ability to start a specific RTS table. These telecommands provide a mechanism for loading an RTS table, but making sure that it can't be executed. On boot-up, RTS00 through RTS31 are enabled and RTS32 through RTS63 are disabled. Sending the SCRTSDISABLE telecommand for an RTS that is currently executing does not stop the RTS, but prevents it from being started again after it stops.

These telecommands have been designed to have the same general format and behavior has those used on other SMEX spacecraft.

There are a number of telemetry points that don't get set as a result of a telecommand, but get set as the active RTS's are processed. The following discusses these telecommand points:

a. TSCRTSRECVD (U12) Total of all RTS stored telecommands processed.
b. TSCRTSREJECT (U12) Total of all RTS stored telecommands that failed verification.
c. TSCRTSERRORS (U12) Total of all RTS stored telecommands that failed to route.
d. TSCRTSLICDRI (UB) ID of the RTS containing the last invalid RTS stored TC.
e. TSCRTSLICDIX (UB) Index of the last invalid RTS stored telecommand.
f. TSCRTSLICDST (UB) Status of the last invalid RTS stored telecommand.
g. TSCRTSLICDTS (U1234) Timestamp of the last invalid RTS stored telecommand.

SCRTSSTART Start Stored Command Relative Time Sequence.

RTSNUM (U12) RTS number to start.

Range: 0 to 63

0 = RTS00	RTS00
1 = RTS01	RTS01
. . .	
63 = RTS63	RTS63

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TSCTCRECVD (UB) # of Command Processor TCs received will increment by one

TSCTCREJECT (UB) # of Command Processor TCs that failed verification

TSCTCERRORS (UB) # of Command Processor TCs that failed to execute

TSCRTSNRACTV (UB) Number of active-suspended RTSs

TSCRTSNRACTH (UB) High-Water mark for number of active-suspended RTSs

TSCRTSID?? (UB) ID of the Active or Suspended RTS set to RTSNUM, where ?? is 00 to 15.

TSCRTSSTTS?? (BOOL) State of the RTS set to 1 (1=Active, 0=Suspended), where ?? is 00 to 15.

TSCRTSNXTI?? (UB) Index of the next stored telecommand to execute in the RTS set to 0, where ?? is 00 to 15.

TSCRTSELAP?? (U1234) Elapsed time in seconds since the RTS was started set to 0, where ?? is 00 to 15.

Notes:

There are 16 'slots' that track the status of the 0 to 15 active or suspended RTS's at any one time. When the SCRTSSTART telecommand is received, the first idle slot is used to track the status of the RTS. If all 16 slots are being used, then telecommand returns in error.

SCRTSSUSPEND Suspends a stored command relative time sequence. RTSNUM (UB) The active RTS number to suspend Range: 0 to 63 0 = RTS00 RTS00 1 = RTS01 RTS01 . . . 63 = RTS63 RTS63
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCRTSSTTS?? (BOOL) State of the RTS set to 0 (1=Active, 0=Suspended), where ?? is 00 to 15

SCRTSRESUME Resumes a previously suspended RTS. RTSNUM (UB) The suspended RTS to resume. Range: 0 to 63 0 = RTS00 RTS00 1 = RTS01 RTS01 . . . 63 = RTS63 RTS63
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCRTSSTTS?? (BOOL) State of the RTS set to 1 (1=Active, 0=Suspended), where ?? is 00 to 15

SCRTSSTOP Stop Stored Command Relative Time Sequence. RTSNUM (U12) RTS number to stop. Range: 0 to 63 0 = RTS00 RTS00 1 = RTS01 RTS01 . . . 63 = RTS63 RTS63	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCRTSNRACTV (UB) Number of active-suspended RTSs TSCRTSNRACTH (UB) High-Water mark for number of active-suspended RTSs TSCRTSID?? (UB) ID of the Active or Suspended RTS set to 0xFF, where ?? is 00 to 15. TSCRTSSTTS?? (BOOL) State of the RTS set to 0 (1=Active, 0=Suspended), where ?? is 00 to 15. TSCRTSNXTI?? (UB) Index of the next stored telecommand to execute in the RTS set to 0, where ?? is 00 to 15. TSCRTSELAP?? (U1234) Elapsed time in seconds since the RTS was started set to 0, where ?? is 00 to 15.	
Notes: There are 16 ‘slots’ that track the status of the 0 to 15 active or suspended RTS’s at any one time. When the SCRTSSTOP telecommand is received, the slot used to track the status of that RTS made available for the SCRTSSTART telecommand. If no slot is being used by that RTS, then telecommand returns in error.	

SCRTSDISABLE Disable Stored Command Relative Time Sequence. RTSNUM (U12) RTS number to disable. Range: 0 to 63 0 = RTS00 RTS00 1 = RTS01 RTS01 . . . 63 = RTS63 RTS63	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCRTS??ENAB (BOOL) Enabled-Disabled State of RTS set to 0 (disabled), where ?? is 00 to 63 from RTSNUM	
Notes: On boot-up, RTS00 through RTS31 are enabled, RTS32 through RTS63 are disabled.	

SCRTSENABLE Enable Stored Command Relative Time Sequence. RTSNUM (U12) RTS number to enable. Range: 0 to 63 0 = RTS00 RTS00 1 = RTS01 RTS01 . . . 63 = RTS63 RTS63	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCRTS??ENAB (BOOL) Enabled-Disabled State of RTS set to 1 (enabled), where ?? is 00 to 63 from RTSNUM	
Notes: On boot-up, RTS00 through RTS31 are enabled, RTS32 through RTS63 are disabled.	

SCRTSVERIFY Verifies that an RTS table has the correct format. RTSNUM (UB) RTS number of verify. Range: 0 to 63 0 = RTS00 RTS00 1 = RTS01 RTS01 . . . 63 = RTS63 RTS63
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSCTCRECVD (UB) # of Command Processor TCs received will increment by one TSCTCREJECT (UB) # of Command Processor TCs that failed verification TSCTCERRORS (UB) # of Command Processor TCs that failed to execute TSCRTSVRFYID (UB) ID of the RTS table verified, RTSNUM from telecommand TSCRTSVRFYST (BOOL) State of RTS table verification (1=pass, 0=failed)

6.3 Stored Sequences and the Filesystem

A SMTBLCOMMIT telecommand will return in error if the file being committed is the currently executing ATS or one of the executing RTS files.

The filesystem enforces the maximum length of a stored sequence.

6.4 Specific Relative-Time Sequences

There are several RTS files that have a specific purpose. By convention, RTS00 through RTS19 are reserved for special purpose relative-time sequences, and RTS20 to RTS31 are available to be started from the first 20 RTS's. Table 6-1 lists each of the special purpose relative-time sequences.

Table 6-1. Special Purpose Relative-Time Sequences

RTS File	Purpose
RTS00	Initial RTS started after boot when the Mission Mode is 'Launch'.
RTS01	Initial RTS started after boot when the Mission Mode is 'Nominal'.
RTS10	Fault Management RTS started when an ACS Pointing Error is detected.
RTS11	Fault Management RTS started when no telecommands have been received by the CIB after a specific period of time.
RTS12	Fault Management RTS started when a Battery 1 Pressure Low Error is detected.
RTS13	Fault Management RTS started when a Battery 2 Pressure Low Error is detected.
RTS14	Fault Management RTS started when an NEB1 Over current Condition is detected.
RTS15	Fault Management RTS started when an NEB2 Over current Condition is detected.
RTS16	Fault Management RTS started when an IDPU Heater Over current Condition is detected.
RTS17	Fault Management RTS started when an IDPU Over current Condition is detected.
RTS18	Fault Management RTS started when a CRYO Over current Condition is detected.
RTS19	Fault Management RTS started when an IDPU Switched Over current Condition is detected.

7. PAYLOAD INTERFACE SUBSYSTEM

FSW communicates with the IDPU via the PACI board, which transmits data bi-directionally over a serial link. Every second, the Payload Interface Subsystem sends a command record to the IDPU, and receives a telemetry record from the IDPU. FSW will only communicate with the IDPU when the IDPU power is on as reported by telemetry point TPCBS1_IDPU.

7.1 Payload Commanding

The Payload Interface Subsystem will be scheduled to receive wakeup messages that coincides with the 1 Hz Bus Tick. When this message is received, a 1040 byte command record is constructed that consists of a 16 byte "Spacecraft Status Segment" and a 1024 byte "Command Segment", as specified by HIS_SYS_001 HESSI Spacecraft to IDPU Interface Control Document. The command record is sent to the IDPU via the PACI, with the start of transmission within 100 milliseconds of the 1 Hz Bus Tick.

The 1024 byte Command Segment consists of a concatenation of telecommands with APIDs between 0x100 and 0x1FF, with the unused portion zero filled. Any IDPU telecommand received within a one-second period that can not fit into the remaining bytes available in the Command Segment buffer will be discarded. The TPLCMDRECVD telemetry point records the total number of telecommands received for the IDPU device. The TPLCMDREJECT telemetry point records the total number of IDPU device telecommands rejected because the size of the Command Segment was exceeded. The TPLCMDSENT telemetry point records the total number of IDPU device telecommands last communicated in the Command Segment.

Table 7-1 documents how each field of the Spacecraft Status Segment is populated. The Spacecraft Status Segment is also downlinked in SOH telemetry, and the names of these telemetry points are in parenthesis beneath the field name.

Table 7-1. Spacecraft Status Segment Sources

Field	**Sub-Field**	**Data Length**	**Source of data**
Time Field (TPLCMDTIME)	N/A	4 bytes	Current seconds from SCLK in a little-endian data format.
SSR Field (TPLCMDSSR)	N/A	1 byte	TPLCMDSSR telemetry point set by the SSR Interface Subsystem.0 means empty, 255 means full.
Power Field (TPLCMDPOWER)	Heater Bit	1 bit	TPCBS1_IDPUH telemetry point set by PCB Interface Subsystem
	IDPU	1 bit	TPCBS1_IDPU telemetry point set by PCB Interface Subsystem
	Cryo	1 bit	TPCBS1_CRYO telemetry point set by PCB Interface Subsystem
	Switched	1 bit	TPCBS1_IDPU28 telemetry point set by PCB Interface Subsystem
	SSR Power	1 bit	TPCBS1_SSR telemetry point set by SSR Interface Subsystem
	SSR Recording	1 bit	TSSWRTPTRVLD telemetry point set by the SSR Interface Subsystem
TC Status Field (TPLCMDTC)	Xmit	1 bit	TPADINBIT20 telemetry point set by PACI Digital Input
	SendSSR	1 bit	TSSRCRDINPRG telemetry point set by the SSR Interface Subsystem
	Lock	1 bit	Bit 8 (0x0100) of the TCBHCDSTAT telemetry point set by the Uplink Subsystem
	Send	1 bit	Set if any FSW stored telemetry is enabled for downlink, or if the SSR is currently in playback mode
ACS Field (TPLCMDACS)	InSun	1 bit	TPADINBIT17 telemetry point set by PACI Digital Input

7.2 Payload Telemetry

After the IDPU receives the 1 Hz Bus Tick, it sends a 1468 telemetry record to the PACI board, which stores the data in a memory buffer. After all data has been received by the PACI board, a VME interrupt is generated and received by the CPU. Upon receiving the interrupt, FSW reads the IDPU telemetry record from the PACI board. The TPLTLMRCTIME telemetry point records the S/C time when the IDPU telemetry record was received.

The IDPU telemetry record consists of three parts: a SAS segment for use by the ACS Subsystem, a SOH segment, and a diagnostic telemetry packet segment. Both the SAS segment and the SOH segment are incorporated into the FSW real-time SOH telemetry packet transmitted on VC0, APID 1. The diagnostic telemetry packet segment contains a fully populated CCSDS Source Packet sized to exactly fill one transfer frame. When the Consultative Committee for Space Data System (CCSDS) Source Packet contains a fill packet (APID 2047), it is discarded. If the CCSDS Source Packet contains other than a fill packet, it is sent to the Downlink Subsystem for downlink or storage.

The IDPU SAS segment is available in real-time SOH at telemetry points TPLSASSEGX1 to TPLSASSEGX8, and TPLSASSEGY1 to TPLSASSEGY8. The IDPU SOH segment is available in real-time SOH at telemetry point TPLSOHSEGMNT.

7.3 Science Telemetry

The IDPU stores science data directly to the SSR device as a complete CCSDS Source Packet sized exactly to fill one transfer frame. For synchronization purposes, each packet is preceded by a synchronization marker. To downlink the data, the SSR device transmits the IDPU science data directly to the CIB device. Commanding of the SSR device to record or playback IDPU data is controlled via the SSR Interface Subsystem.

7.4 Payload Telecommands

The PLRESET telecommand sends a reset signal to the IDPU device that is pulsed high for 100 milliseconds.

The PLNOOP telecommand acknowledges that the Payload Interface Subsystem is receiving telecommands.

The PLTCRESET telecommand resets the Payload Interface Subsystem telecommand received, rejected and error counters.

PLNOOP (no parameters)	Verifies that the Payload Interface Subsystem is responding
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPLTCRECVD (UB) # of Payload Subsystem TCs received will increment by one	

PLTCRESET (no parameters)	Resets Payload Interface Subsystems TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPLTCRECVD (UB) # of Payload Subsystem TCs received will increment by one TPLTCREJECT (UB) # of Payload Subsystem TCs that failed verification set to zero TPLTCERRORS (UB) # of Payload Subsystem TCs that failed to execute set to zero	

PLRESET (no parameters)	Resets the IDPU Device to known state
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPLTCRECVD (UB) # of Payload Subsystem TCs received will increment by one	
Notes: Sends a reset signal to the IDPU device that is pulsed high for 100 milliseconds.	

8. SSR INTERFACE SUBSYSTEM

The SSR Interface Subsystem is responsible for commanding and receiving responses from the Solid State Recorder (SSR) device. The SSR device is solid state 'tape recorder' that supports sequential recording of data, and sequential playback of data. The SSR device has a capacity of 4 Gigabytes of EDAC RAM storage. The SSR supports partitioning into the multiple logical drives, is partitioned into just one loopback drive. Although the SSR record and playback functionality is like that of a tape recorder, it differs in that all data is lost when the SSR is powered off.

FSW communicates with the SSR via the PACI board using a serial interface. To communicate with the SSR, FSW sends a data record in accordance with a specific command format, and receives a response data record in a specific format. The User's Manual for the HESSI SSR documents all commands, and associated responses, that can be sent to the SSR device. FSW only communicates with the SSR when it is powered, as indicated by the TPCBS1_SSR telemetry point, and the SSR Command Ready signal is low, as indicated by telemetry point TPADINBIT16. Under these conditions, the SSR SOH telemetry (termed "Normal Telemetry" in the SSR Users Manual) is queried at a 1 Hz rate when the TSSR1HZPRCEN telemetry point is TRUE, which is nominally TRUE but can be set with the SSRWORK1HZ telecommand.

8.1 SSR Subsystem Initialization

When the SSR is powered and the SSR Command Ready signal is low, the SSR Interface Subsystem stores current stored science playback and record pointer information to the PACI PNVRAM. This is done to ease recovery if FSW unexpectedly reboots while the SSR is record and/or playback mode. When the SSR Subsystem is initialized, it sets the stored science playback and record pointer telemetry points to those values recorded in Table 8-1, SSR Subsystem Initial Values. After initialization, the SSR Subsystem reads the last stored values from PNVRAM for these telemetry points. Subsequent to initialization, these telemetry points are set based on data received from the SSR device.

Table 8-1. SSR Subsystem Initial Values

Telemetry Point	Initial Value
TSSLSTWRTPTR (U1234) Last stored science record position Status	0
TSSLSTRDPTR (U1234) Last stored science playback position	0
TSSCURRDPTR (U1234) Row Offset of read pointer from when Real-Time Science Playback is in progress.	0

TSSRTMSCIPRG (BOOL) Real-time IDPU science data playback in progress	FALSE
TSSSTDSCIPRG (BOOL) Stored IDPU science data playback in progress	FALSE
TSSRCRDINPRG (BOOL) Indicates that a SSR Record is in progress	FALSE

8.2 SSR Subsystem 1 Hz Processing

At 1 Hz rate, the SSR Interface Subsystem retrieves the current state of the SSR device, and executes various pending telecommands. To retrieve the state of the SSR device, the SSR device commands “Send Normal Telemetry” and “Pointer Status” device commands are sent (see SSR Users Manual for details). The telemetry points in Table 8-1 are updated and stored in PACI PNVRAM. After retrieving the current state, pending telecommands are processed. The SSRPLAY, SSRPLAYRTSCI, SSRRECORD, SSRMAKEPART, and SSRPORTRESET telecommands are not executed immediately after they are received, but are scheduled for execution during 1 Hz processing.

8.3 Record and Playback Telecommands

There are two methods of SSR data playback. The first, via the SSRPLAY telecommand, is the nominal playback of previously stored science data that has yet to be downlinked on Virtual Channel 3. The second method, using the SSRPLAYRTSCI telecommand, is what is termed ‘real-time’ science telemetry. This method downlinks a commanded number of the most recently recorded packets of stored science data on Virtual Channel 2. An SSRPLAYRTSCI telecommand can be received while a nominal playback of stored science data is in progress. In this scenario, the first playback will be suspended, the real-time science will be played, and then the original playback will be resumed from where it left off.

The SSRSTOPPLAY telecommand is used to stop a science data playback. Because the IDPU science data packets don’t fit into an increment of bytes which makes up an addressable block used by the SSR, a single duplicate science data packet may be downlinked when a playback is stopped and then resumed. The ground will be able to detect this by interrogating data contained within the science data packet. If an SSRSTOPPLAY telecommand is received while a real-time science playback is in operation, then that playback is stopped and a previously suspended nominal playback will be resumed.

The SSRRECORD telecommand is used to start recording data. This is generally done once after a reboot allowing the IDPU to store science data as needed. The SSRSTOPREC telecommand is used to stop the recording of data.

SSRPLAY Starts the playback of SSR stored science data

BYPASSEDAC (UB) Indicates whether EDAC should be bypassed

Range: 0 to 1

0 = OFF	Off
0 = NO	No
0 = FALSE	False
1 = YES	Yes
1 = TRUE	True
1 = ON	On

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one

TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification

TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute

TSSSTDSCIPRG (BOOL) Stored IDPU science data playback in progress set to one.

TSSCRSPCMDID (UB) SSR command response telemetry command Id set to 0x26 (Random Playback)

TSSCRSPRTNCD (UB) SSR command response telemetry return code set to 0 (OK)

TSSCURRDPTR (U1234) Row Offset of read pointer from SSR Pointer Status will start incrementing

TSSLSTRDPTR (U1234) Last stored science playback position will start incrementing

TSSRDPTRVLD (BOOL) Indicates whether TSSLSTRDPTR is valid set to 1 (Valid)

TSSREDACBYPS (BOOL) Indicates EDAC bypass during playback was commanded set to BYPASSEDDAC.

TPLCMDSSR (UB) Indicates how full much data the SSR contains that has not been downlinked: 0 means empty, 255 means full.

Notes:

SSRPLAY will fail under the following conditions:

- the SSR is not powered, or the SSR Command Ready signal is high
- 1 Hz Normal Telemetry processing has been disabled
- a stored science playback is currently in progress
- a SSRPLAY, SSRPLAYRTSCI, SSRMAKEPART or SSRPORTRESET telecommand was previously received within the last second

SSRPLAYRTSCI Playback of real-time science data NUMPACKETS (U12) Number of real-time tlm packets to playback Range: 1 to 65535 BYPASSEDAC (UB) Indicates whether EDAC should be bypassed Range: 0 to 1 0 = OFF Off 0 = NO No 0 = FALSE False 1 = YES Yes 1 = TRUE True 1 = ON On	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSRTMSCIPRG (BOOL) Real-time IDPU science data playback in progress set to one. TSSCRSPCMDID (UB) SSR command response telemetry command Id set to 0x26 (Random Playback) TSSCRSPRTNCD (UB) SSR command response telemetry return code set to 0 (OK) TSSCURRDPTR (U1234) Row Offset of read pointer from SSR Pointer Status will start incrementing TSSLSTRDPTR (U1234) Last stored science playback position will not increment TSSREDACBYPS (BOOL) Indicates EDAC bypass during playback was commanded set to BYPASSEDDAC.	
Notes: SSRPLAYRTSCI will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high •1 Hz Normal Telemetry processing has been disabled •a stored science playback is currently in progress •a SSRPLAY, SSRPLAYRTSCI, SSRMAKEPART or SSRPORTRESET telecommand was previously received within the last second	

SSRSTOPPLAY Stops the playback of IDPU science data (no parameters)	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSRTMSCIPRG (BOOL) Real-time IDPU science data playback in progress set to zero. TSSSTDSCIPRG (BOOL) Stored IDPU science data playback in progress set to zero if real-time playback was not in progress. TSSCRSPCMDID (UB) SSR command response telemetry command Id set to 0x37 (Stop Playback) if real-time playback was not in progress. TSSCRSPRTNCD (UB) SSR command response telemetry return code set to 0 (OK) TSSCURRDPTR (U1234) Row Offset of read pointer from SSR Pointer Status will start incrementing if real-time playback was not in progress. TSSLSTRDPTR (U1234) Last stored science playback position will not increment if real-time playback was not in progress.	
Notes: SSRSTOPPLAY will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high	

SSRRECORD Starts the recording of IDPU science data STARTOFFSET (U1234) The start offset at which to begin recording Range: to 0 to 0xffffffff	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSCRSPCMDID (UB) SSR command response telemetry command Id set to 0x27 (Random Record) TSSCRSPRTNCD (UB) SSR command response telemetry return code set to 0 (OK) TSSRCRDINPRG (BOOL) Indicates that a SSR Record is in progress set to 1 TSSWRTPTRVLD (BOOL) Indicates whether TSSLSTWRTPTR is valid set to 1 (Valid) TSSCURWRTPTR (U1234) Row Offset of write pointer from SSR Pointer Status increments when IDPU stores data TSSLSTWRTPTR (U1234) Last stored science record position Status will increment when IDPU stores data TPLCMDSSR (UB) Indicates how full much data the SSR contains that has not been downlinked: 0 means empty, 255 means full.	
Notes: SSRRECORD will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high •1 Hz Normal Telemetry processing has been disabled •a previous SSRSTOPREC telecommand is in the process of being executed •a SSRRECORD, SSRMAKEPART or SSRPORTRESET telecommand was previously received within the last second •the STARTOFFSET parameters is out-of-range for the capacity of the SSR device.	

SSRSTOPREC (no parameters)	Stops the recording of IDPU science data
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSCRSPCMDID (UB) SSR command response telemetry command Id set to 0x36 (Stop Record) TSSCRSPRTNCD (UB) SSR command response telemetry return code set to 0 (OK) TSSRCRDINPRG (BOOL) Indicates that a SSR Record is in progress set to 0 TSSWRTPTRVLD (BOOL) Indicates whether TSSLSTWRTPTR is valid set to 0 (Invalid) TSSCURWRTPTR (U1234) Row Offset of write pointer from SSR Pointer Status set to 0 TSSLSTWRTPTR (U1234) Last stored science record position Status set to last position written.	
Notes: SSRSTOPREC will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high	

8.4 SSR Passthrough Telecommand

The SSR Interface Subsystem does not implement a separate telecommand for every command that the SSR device supports. Instead, the SSRPASSTHRU telecommand allows the ground to send any desired command directly to the SSR device, giving the ground full control of the SSR device. The SSR Command Response is downlinked in its entirety in VC 1, with an APID of 0x200 plus the decimal value of the command code. For example, the SSR Command Response telemetry for a Random Playback command would be downlinked on APID 0x226.

There are two classes of SSR device commands, "Privileged Commands", and "User Commands". The Privileged Commands must be sent twice, back to back, to the SSR device before they are acted upon. The SSR Subsystem automatically does this for the ground. The main reason that the SSR Subsystem automates this is because the 1 Hz processing, which sends status commands to the SSR device, can often occur during the gap in time between two received SSRPASSTHRU telecommands, thus invalidating the ground command. User Commands only need to be received by the SSR device once before they are acted upon.

During certain types of operations, it may be desirable to disable the SSR Subsystem 1 Hz processing. This will ensure that no commands, other than those that the ground sends, will ever be received by the SSR device. The SSRWORK1HZ telecommand allows the ground to enable or disable the SSR Subsystem 1 Hz processing.

SSRPASSTHRU Transmits the specified 16-byte command to the SSR. COMMANDCODE (UB) SSR Device Command Code Range: 0 to 0xFF COMMANDID (UB) SSR Device Command ID Range: 0 to 0xFF WORD1 (U12) Word 1 of SSR Device Command Parameters Range: 0 to 0xFFFF WORD2 (U12) Word 2 of SSR Device Command Parameters Range: 0 to 0xFFFF WORD3 (U12) Word 3 of SSR Device Command Parameters Range: 0 to 0xFFFF WORD4 (U12) Word 4 of SSR Device Command Parameters Range: 0 to 0xFFFF WORD5 (U12) Word 5 of SSR Device Command Parameters Range: 0 to 0xFFFF WORD6 (U12) Word 6 of SSR Device Command Parameters Range: 0 to 0xFFFF	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSCRSPCMDID (UB) SSR command response telemetry command ID set to COMMANDCODE from telecommand TSSCRSPRTNCD (UB) SSR command response telemetry return code set to response	
Notes: SSR Command Response is downlinked in its entirety in VC 1, with an APID of 0x200 plus the decimal value of the command code. SSRPASSTHRU will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high	

SSRWORK1HZ Enable/Disable SSR 1Hz Processing ENABLE (UB) 1=Enable, 0=Disable Range: 0 = OFF Off 0 = NO No 0 = FALSE False 1 = YES Yes 1 = TRUE True 1 = ON On	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSR1HZPRCEN (BOOL) SSR 1Hz processing is enabled set to ENABLE parameter from telecommand	

8.5 SSR SOH Telemetry

When the SSR device is powered on, SSR Command Ready signal is low, and the TSSR1HZPRCEN telemetry point is TRUE, the SSR Subsystem will read, and downlink, the SSR SOH (called Normal Telemetry in SSR documentation) telemetry at 1 Hz. The SSR SOH telemetry is downlink in the real-time telemetry frame on VC0, APID 1. The SSR SOH telemetry contains a wealth of status, error and diagnostic information about the current state of the SSR. Because FSW will not autonomously act on any error information, the ground must monitor this data to detect when errors are occurring. Table 8-2 lists a few specific fields in the ground must monitor.

Table 8-2. SSR Telemetry to Monitor

Field Name NOTE: Need to define telemetry points for SSR Normal Telemetry	**Description**
DRAM Mapping Status	0=Nothing needs to be remapped 1,2,3=Reconfigure Memory required
Various Test Results	Words 11, 13, 14, and 16 contains various test results
EDAC Errors	Words 10, 20, 21, 22, and 25 contains various EDAC error report information.
Scrubbing Errors	Words 26
Board failures and exceptions	Words 4, 6, 17

8.6 SSR Maintenance Telecommands

When the SSR device is powered on, it needs to be initialized before any record or playback command will be accepted. The SSR device initialization is not done autonomously by FSW.

The SSRMAKEPART telecommand will reset the SSR device (Reset Memory command), removing any previous formatting, and then create one "loop-back" partition (Create Partition command) using all available memory. A loop-back partition allows record and playback operations to automatically wrap from the end of memory to the beginning of memory during processing.

The SSRPORTRESET telecommand will reset the SSR record and playback ports. Although this command should never need to be sent, it is useful if the ground suspects transmission errors because of the data ports. Upon receiving the SSRPORTRESET telecommand, the SSR Subsystem will stop any record or playback that is in progress, send the "Reset Data Ports" command to the SSR device, and the restart an record or playback that was previously in progress.

The SSRDLERRHIS telecommand should be periodically sent by the ground to downlink an extensive error history of the SSR device. This command returns the locations of the last 16 unfixable errors, the last 16 hard single-symbol errors, and the last 16 corrected single-symbol errors that have been found by the scrub task. The SSR device error history structure is cleared when the command completes.

SSRMAKEPART Creates a new partition in the SSR DRAM. (no parameters)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSCRSPCMDID (UB) SSR command response telemetry command ID set to 0x00 (Create Partition) TSSCRSPRTNCD (UB) SSR command response telemetry return code set to 0x0 (OK)
Notes: SSRMAKEPART will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high •a stored science or real-time science playback, record or stop record is in progress •a SSRRECORD, SSRMAKEPART or SSRPORTRESET, SSRPLAY, SSRPLAYRTSCI telecommand was previously received within the last second

SSRPORTRESET Resets SSR Data Ports; restarts previous record/playback (no parameters)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSCRSPCMDID (UB) SSR command response telemetry command ID set to 0x14 (Reset Data Ports) TSSCRSPRTNCD (UB) SSR command response telemetry return code set 0x0 (OK)
Notes: SSRPORTRESET will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high •1 Hz Normal Telemetry processing has been disabled •a SSRRECORD, SSRMAKEPART or SSRPORTRESET, SSRPLAY, SSRPLAYRTSCI telecommand was previously received within the last second

SSRDLERRHIS Requests SSR Error History (no parameters)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSCRSPCMDID (UB) SSR command response telemetry command ID set to 0x2F (Error History) TSSCRSPRTNCD (UB) SSR command response telemetry return code set to 0x0 (OK)
Notes: SSRDLERRHIS will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high

8.7 SSR Housekeeping Telecommands

If the ground would like to replay some previously played stored science data, the SSRSETPLYPTR telecommand will set the playback pointer, telemetry point TSSLSTRDPTR, to any desired value. This will affect the calculation for the amount of data stored in the SSR which has not yet been downlinked, which is telemetry point TPLCMDSSR.

Normally, the SSR command response telemetry is only downlinked in a telemetry source packet as a result of an SSRPASSTHRU or SSRDLERRHIS telecommand. The SSRCMDRSPTLM telecommand allows the ground to enable or disable SSR command response telemetry for all telecommands, which can be useful for diagnostic purposes.

The SSRSTATEINIT telecommand is like an SSR Subsystem reset command; it resets the state of the SSR Subsystem to that when the FSW was first booted.

The SSRNOOP telecommand acknowledges that the SSR Interface Subsystem is receiving telecommands.

The SSRTCRESET telecommand resets the SSR Interface Subsystem telecommand received, rejected and error counters.

SSRSETPLYPTR Set the SSR Playback Pointer PLAYPOINTER (U1234) The new value of the SSR play pointer Range: 0 to 0xFFFFFFFF
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSLSTRDPTR (U1234) Last stored science playback position set to PLAYPOINTER TPLCMDSSR (UB) Indicates how full much data the SSR contains that has not been downlinked: 0 means empty, 255 means full.
Notes: SSRSETPLYPTR will fail under the following conditions: •the SSR is not powered, or the SSR Command Ready signal is high •a stored or real-time science playback is currently in progress •a SSRPLAY, SSRPLAYRTSCI, SSRPORTRESET telecommand was previously received within the last second •the PLAYPOINTER parameters is out-of-range for the SSR device memory capacity.

SSRCMDRSPTLM Enables SSR command response telemetry for non-SSRPASSTHRU TCs ENABLE UB1=Enables SSR command response telemetry; 0=Disable Range: 0 to 1 0 = OFF Off 0 = NO No 0 = FALSE False 1 = YES Yes 1 = TRUE True 1 = ON On	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute TSSRCMDRSPEN (BOOL) SSR Command Response telemetry enabled set to 1.	
Notes: SSR Command Response is downlinked in its entirety in VC 1, with an APID of 0x200 plus the decimal value of the command code.	

SSRSTATEINIT Reinitialize the state of the SSR task. (no parameters)	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one TSSTCREJECT (UB) # of SSR Subsystem TCs that failed verification TSSTCERRORS (UB) # of SSR Subsystem TCs that failed to execute	
Notes: Resets the state of the SSR Subsystem to that when the FSW was first booted.	

SSRNOOP Verifies that the SSR Subsystem is responding (no parameters)	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSSTCRECVD (UB) # of SSR Subsystem TCs received will increment by one	

SSRTCRESET (no parameters)	Resets SSR Subsystems TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPLTCRECVD (UB) # of Payload Subsystem TCs received will increment by one TPLTCREJECT (UB) # of Payload Subsystem TCs that failed verification set to zero TPLTCERRORS (UB) # of Payload Subsystem TCs that failed to execute set to zero	

9. ATTITUDE CONTROL SUBSYSTEM

The Attitude Control Subsystem (ACS) has two telecommands, and many Flight Parameters, used to control operations of the ACS algorithms. See Section 16 on page 95 for a discussion of how to set the Flight Parameters. The ACS Subsystem is scheduled at 8 Hz via the receipt of a "Analog Scan Down" interrupt received from the PACI device.

9.1 ACS Control Telecommands

The ACSSETMODE telecommand is used to for the ACS Subsystem to transition into, and stay in, a specific operating mode. Under nominal operations, the ACS operating mode is "AUTO", which allows the ACS Subsystem to autonomously transition between modes as required by the algorithms.

The ACSSUNSENSOR telecommand directs the ACS Subsystem to use a specific sensor, either the Fine Sun Sensor (FSS) or the SAS Instrument, for pointing. Nominally, the sensor used is the FSS.

ACSSETMODE Sets the desired ACS operating mode MODE (UB) The desired ACS mode. Range: 0 to 5 0 = AUTO Allows ACS to change modes autonomously (default) 1 = ACQUISITION Establishes spin rate, damps transverse rates 2 = PRECESSION Establishes Sun-pointing orientation 3 = NORMAL Maintains Sun-pointing, nominal spin rate 4 = SPIN Establishes desired spin rate 5 = IDLE Disables control until ground intervention
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TACTCRECVD (UB) # of ACS Subsystem TCs received will increment by one TACTCREJECT (UB) # of ACS Subsystem TCs that failed verification TACTCERRORS (UB) # of ACS Subsystem TCs that failed to execute TACSCMDMODE (BOOL) Set to 0 (Autonomous Mode) if MODE parameter is AUTO, otherwise set to 1 (Commanded Mode) TACSMODE (UB) ACS current mode

ACSSUNSENSOR Selects the desired ACS Sun Sensor mode SUNSENSOR (UB) Sun Sensor Mode Range: 0 to 1 0 = FSS Fine Sun Sensor 1 = SAS SAS Instrument Telemetry Data
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TACTCRECVD (UB) # of ACS Subsystem TCs received will increment by one TACTCREJECT (UB) # of ACS Subsystem TCs that failed verification TACTCERRORS (UB) # of ACS Subsystem TCs that failed to execute TACINSUNSENS (BOOL) Sun Sensor used by ACS set to SUNSENSOR parameter.

9.2 ACS Flight Parameters

The 1110-EW-S16620 HESSI Attitude Control Subsystem Flight Software Specification document describes the usage of each ACS Flight Parameter. Table 9-1 describes the mapping between the ACS document's parameters name and the FSW Flight Parameter name.

Table 9-1. ACS Flight Parameters

ACS Document Parameter	FSW Flight Parameter	Parameter Description
N/A	VTRQZSELECT	Selects the primary Z-axis torque rod; 1 selects redundant
MAG_BIAS_X	VMAGBIASX	Magnetometer bias for the X-axis
MAG_BIAS_Y	VMAGBIASY	Magnetometer bias for the Y-axis
SAS_DELAY	VSASDELAY	SAS Delay in seconds between collection time and receipt time
CCS_THRESH	VCSSTHRESH	ACS CCS threshold (amps).
FSS_BIASX	VFSS_BIASX	ACS FSS bias along x-axis
FSS_BIASY	VFSS_BIASY	ACS FSS bias along y-axis
TQR_COMP11	VTQRCOMP11	ACS Torque rod compensation matrix component
TQR_COMP12	VTQRCOMP12	ACS Torque rod compensation matrix component
TQR_COMP13	VTQRCOMP13	ACS Torque rod compensation matrix component
TQR_COMP21	VTQRCOMP21	ACS Torque rod compensation matrix component
TQR_COMP22	VTQRCOMP22	ACS Torque rod compensation matrix component
TQR_COMP23	VTQRCOMP23	ACS Torque rod compensation matrix component
TQR_COMP31	VTQRCOMP31	ACS Torque rod compensation matrix component
TQR_COMP32	VTQRCOMP32	ACS Torque rod compensation matrix component
TQR_COMP33	VTQRCOMP33	ACS Torque rod compensation matrix component
TQR_SAT_HIGH	VTQRSATHIGH	ACS Torque rod high saturation level (amp-m^2)
TQR_SAT_POINT_LOW	VTQRSATPNTLO	ACS Torque rod low saturation level in pointing (amp-m^2)
TQR_SAT_SPIN_LOW	VTQRSATSPNLO	ACS Torque rod low saturation level in spin (amp-m^2)
ACQ_SPIN_COM	VACQSPINCOM	ACS Commanded spin rate during acquisition (rad/sec)
NORM_SPIN_COM	VNORMSPINCOM	ACS Commanded spin rate during normal operations (rad/sec)
ACQ_GAIN	VACQGAIN	ACS Acquisition control gain (amp-m^2-sec/tesla)
COARSE_PREC_GAIN	VCRSPRECGAIN	ACS Coarse precession control gain (amp-m^2)
FINE_PREC_GAIN	VFINEPRCGAIN	ACS Fine precession control gain (N-m-sec)
FINE_NUT_GAIN	VFINENUTGAIN	ACS Fine nutation control gain (N-m-sec)
SPIN_GAIN	VSPINGAIN	ACS Spin control gain (amp-m^2-sec-tesla)
POINT_HIGH	VPOINTHIGH	ACS High setting for pointing hysteresis logic (rad)
POINT_LOW	VPOINTLOW	ACS Low setting for pointing hysteresis logic (rad)
POINT_CHECK	VPOINTCHECK	ACS Initial status of pointing hysteresis logic
DELTA_SPIN_HIGH	VDELTASPINHI	ACS High setting for pointing hysteresis logic (rad/sec)

Table 9-1. ACS Flight Parameters (Continued)

DELTA_SPIN_LOW	VDELTASPINLO	ACS Low setting for pointing hysteresis logic (rad/sec)
SPIN_CHECK	VSPINCHECK	ACS Initial state of spin hysteresis log
POINT_ACQ2NORM	VPTACQ2NORM	ACS Transition pointing error from Acquisition to Idle (rad)
POINT_PREC2NORM	VPTPREC2NORM	ACS Transition pointing error from Precession to Normal (rad)
POINT_NORM2IDLE	VPTNORM2IDLE	ACS Transition pointing error from Normal to Idle (rad)
POINT_SPIN2NORM	VPTSPIN2NORM	ACS Transition pointing error from Spin to Normal (rad)
RATE_ACQ2NORM	VRTACQ2NORM	ACS Transition rate from Precession to Normal (rad/sec)
DRATE_PREC2NORM	VDRTPREC2NRM	ACS Transition rate error from Precession to Normal (rad/sec)
DRATE_NORM2IDLE	VDRTNRM2IDLE	ACS Transition rate error from Normal to Idle (rad/sec)
DRATE_SPIN2NORM	VDRTSPIN2NRM	ACS Transition rate error from Spin to Normal
TIME_ACQ2NORM	VTIMACQ2NORM	ACS Transition time from Acquisition to Idle (sec)
TIME_ACQ2PREC	VTIMACQ2PREC	ACS Transition time from Acquisition to Precession (sec)

9.3 ACS Telemetry

Table 9-2 lists the SOH telemetry that is generated by the ACS Control Algorithms.

Table 9-2. ACS Telemetry

Mnemonic	Parameter Type	ITOS Description
TACCSSPNTERR	DFP	ACS Coarse Sun Sensor Pointing Error (derived)
TACESTSPINRT	SFP	ACS estimated spin rate
TACFSSPNTERR	DFP	ACS Fine Sun Sensor Pointing Error (derived)
TACINSUNSENS	BOOL	Sun Sensor used by ACS (0 = FSS, 1 = SAS)
TACSASPNTERR	DFP	ACS SAS Pointing Error (derived)
TACSCMDMODE	BOOL	0=autonomous mode, 1=commanded mode
TACSCSSSPI	BOOL	ACS CSS Sun Presence indicator
TACSCSSX	SFP	ACS CCS Sun vector along X-axis
TACSCSSY	SFP	ACS CCS Sun vector along Y-axis
TACSCSSZ	SFP	ACS CCS Sun vector along Z-axis
TACSFSSX	SFP	ACS FSS Sun vector along X-axis

Table 9-2. ACS Telemetry (Continued)

TACSFSSY	SFP	ACS FSS Sun vector along Y-axis
TACSFSSZ	SFP	ACS FSS Sun vector along Z-axis
TACSMAGX	SFP	ACS Magnetic field along X-axis
TACSMAGY	SFP	ACS Magnetic field along Y-axis
TACSMAGZ	SFP	ACS Magnetic field along Z-axis
TACSMODE	UB	ACS current mode
TACSSASSPI	BOOL	ACS SAS Sun Presence Indicator
TACSSASX	SFP	ACS SAS Sun vector along X-axis
TACSSASY	SFP	ACS SAS Sun vector along Y-axis
TACSSASZ	SFP	ACS SAS Sun vector along Z-axis
TACTOIDLEFLG	UB	ACS Flag describing transition to Idle Mode
TACTQRXCUR	SFP	ACS Commanded current to X torque rod
TACTQRYCUR	SFP	ACS Commanded current to Y torque rod
TACTQRZCUR	SFP	ACS Commanded current to Z torque rod
TACTRANSVRTX	SFP	ACS Transverse rate along X-axis
TACTRANSVRTY	SFP	ACS Transverse rate along Y-axis

9.4 ACS Housekeeping Telecommands

The ACSNOOP telecommand acknowledges that the Attitude Control Subsystem is receiving telecommands.

The ACSTCRESET telecommand resets the Attitude Control Subsystem telecommand received, rejected and error counters.

ACSNOOP (no parameters)	Verifies that the Attitude Control Subsystem is responding
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TACTCRECVD (UB) # of ACS Subsystem TCs received will increment by one	

ACSTCRESET (no parameters)	Resets Attitude Control Subsystems TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TACTCRECVD (UB) # of ACS Subsystem TCs received will increment by one TACTCREJECT (UB) # of ACS Subsystem TCs that failed verification set to zero TACTCERRORS (UB) # of ACS Subsystem TCs that failed to execute set to zero	

10. STATE OF HEALTH SUBSYSTEM

The SOH Subsystem is responsible for building the FSW SOH telemetry frames, for storing telemetry frames in the stored telemetry database, and storing telemetry frames in PACI PNVRAM.

The SOH Subsystem will read the rate for which the PACI is downlinking telemetry, as commanded by CRC17, and build the FSW SOH telemetry frame at the same rate. The FSW portion of the VC0 SOH telemetry frame is written to PACI device memory, and the PACI transmits the entire telemetry frame contents to the CIB device for downlink. VC0 APID 0 is hardware only SOH telemetry. VC1 APID 1 is hardware and FSW SOH telemetry.

After a power-up or reset, FSW will read and store in the telemetry database, the VC1 APID 1 telemetry for 10 minutes at a 1 Hz rate. A fter ten minutes, the VC1 APID 1 telemetry is read and stored at a rate specified by the VSSOHRATE flight parameter, which is specified as a period of seconds, and is by default 10 seconds.

Every second, the VC0 APID 1 telemetry will be stored in the PACI PNVRAM for retrieval in event of a CPU reset.

There are three SOH Subsystem telecommands. The SOHNOOP telecommand acknowledges that the SOH Subsystem is receiving telecommands. The SOHTCRESET telecommand resets the SOH Subsystem telecommand received, rejected and error counters. The SOHFORCEBLD telecommand is useful when all O/S clock sources have been loss. The SOHFORCEBLD telecommand forces the SOH Subsystem to build a FSW SOH frame and write it out to the PACI.

SOHNOOP (no parameters)	Verifies that the SOH Subsystem is responding
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSOTCRECVD (UB) # of SOH Subsystem TCs received will increment by one	

SOHTCRESET Resets SOH Subsystems TC received/rejected/error counters (no parameters)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSOTCRECVD (UB) # of SOH Subsystem TCs received will increment by one TSOTCREJECT (UB) # of SOH Subsystem TCs that failed verification set to zero TSOTCERRORS (UB) # of SOH Subsystem TCs that failed to execute set to zero

SOHFORCEBLD Forces FSW to build FSW portion of real-time SOH telemetry (no parameters)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TSOTCRECVD (UB) # of SOH Subsystem TCs received will increment by one TSOTCREJECT (UB) # of SOH Subsystem TCs that failed verification TSOTCERRORS (UB) # of SOH Subsystem TCs that failed to execute

11. UPLINK SUBSYSTEM

The Uplink Subsystem is responsible for reconstructing telecommands from CCSDS Codeblocks received from the CIB board, and then routing them to the appropriate subsystem. To ensure that an unlinked command will be received, FSW uses two methods to detect that a new codeblock has been received. At 16 Hz, the Uplink Subsystem queries the CIB registers to detect whether a codeblock has been received. In addition, the CIB will send a VME interrupt for each codeblock received.

11.1 CCSDS COP-1 Protocol Control

The Uplink Subsystem supports the Command Operation Procedure-1 (COP-1) and Frame Acceptance and Reporting Mechanism-1 (FARM-1) protocol for telecommand acceptance and reporting as defined in the CCSDS 202.1-B-1 document. COP-1 is a closed-loop telecommanding protocol that utilizes sequential retransmission techniques to correct telecommand frames that were rejected by the spacecraft because of error. If one or more frames are missed, retransmission is initiated either in response to a "Retransmit" Flag in the Command Link Control Word (CLCW) or a timeout on the ground.

Two COP-1 protocol control telecommands help the ground synchronize communications with the S/C. When the S/C FARM-1 has received too many out of sequence telecommands, it enters a CCSDS “Lockout” state. The CCSDS Unlock telecommand, sent using the ITOS procedure CCSDS_UNLOCK, will move the S/C FARM-1 to an “Open” state. To reset the telecommand sequence number that the S/C FARM-1 is expecting to zero, the ground can send the CCSDS Set V(R) telecommand using the ITOS procedure CCSDS_RESET.

11.2 Uplink Subsystem CRC Commands

The ground will generally send CRC telecommands using Virtual Channel 0 (VC0). Only Virtual Channel 1 (VC1) telecommands can be sent from an RTS or ATS. FSW supports four telecommands for setting and clearing CRC bits. The ground must enable EFC Mask bits to allow FSW telecommands to change CRC bits. Therefore, a VC1 telecommand to change a CRC bit will only be successful if the ground has explicitly allowed that specific bit to be changed.

The UPCRCBITSET telecommand will set any one of the 24 CRC bits. The UPCRCBITCLR telecommand will clear any one of the 24 CRC bits. The UPCRCSET telecommand can set any of the 8 bits in one CRC byte. The UPCRCCLR telecommand can clear any of the 8 bits in one CRC byte.

UPCRCBITSET Sets a specific bit on the JPL HCD/CRC ASIC BITNUM (UB) The specific CRC bit to set. Range: 0 to 23 0 = CRCRESET The HCD/CRC ASIC Reset Bit 1 = CRCCPUPOWER CPU Power 2 = CRCXMITCTRL Transmitter Control 3 = CRCANTENNA Transmit Antenna Select 4 = CRCWINGUPRI Solar Wing Release Upper Pri Release 5 = CRCWINGLPRI Solar Wing Release Lower Pri Release 6 = CRCWINGLURED Solar Wing Release Upper Red Release 7 = CRCWINGLRED Solar Wing Release Lower Red Release 8 = CRCWINGXEN Solar Wing +/- X Release Enable 9 = CRCWINGYEN Solar Wing +/- Y Release Enable 10 = CRCUVTRIPCTL Under voltage Trip Control 11 = CRCOVTRIPCTL Over voltage Trip Control 12 = CRCVTCRVSEL1 V/T Curve Select 1 of 4 13 = CRCVTCRVSEL2 V/T Curve Select 2 of 4 14 = CRCVTCRVSEL3 V/T Curve Select 3 of 4 15 = CRCVTCRVSEL4 V/T Curve Select 4 of 4 16 = CRCBATTMPSEL Battery Temp Sensor Select 17 = CRCSOHRATE SOH Packet Rate (0 = 1Hz, 1 = 8Hz) 18 = CRCDLRATE Downlink Data Rate (0 = Nominal, 1 = Low Rate) 19 = CRCWDTENABLE CIB Watchdog Timer Enable 20 = CRCEEPROM EEPROM Write Enable 21 = CRCBOOTSEL Boot Image Select (0=Primary, 1=Secondary)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TUPTCRECVD (UB) # of Uplink Subsystem TCs received will increment by one TUPTCREJECT (UB) # of Uplink Subsystem TCs that failed verification TUPTCERRORS (UB) # of Uplink Subsystem TCs that failed to execute TCBCRCBIT0 to TCBCRCBIT232 (BOOL) State of a specific CRC bit

UPCRCBITCLR Clear a specific HCD/CRC bit BITNUM (UB) The specific bit to clear Range: 0 to 23 0 = CRCRESET The HCD/CRC ASIC Reset Bit 1 = CRCCPUPOWER CPU Power 2 = CRCXMITCTRL Transmitter Control 3 = CRCANTENNA Transmit Antenna Select 4 = CRCWINGUPRI Solar Wing Release Upper Pri Release 5 = CRCWINGLPRI Solar Wing Release Lower Pri Release 6 = CRCWINGLURED Solar Wing Release Upper Red Release 7 = CRCWINGLRED Solar Wing Release Lower Red Release 8 = CRCWINGXEN Solar Wing +/- X Release Enable 9 = CRCWINGYEN Solar Wing +/- Y Release Enable 10 = CRCUVTRIPCTL Under voltage Trip Control 11 = CRCOVTRIPCTL Over voltage Trip Control 12 = CRCVTCRVSEL1 V/T Curve Select 1 of 4 13 = CRCVTCRVSEL2 V/T Curve Select 2 of 4 14 = CRCVTCRVSEL3 V/T Curve Select 3 of 4 15 = CRCVTCRVSEL4 V/T Curve Select 4 of 4 16 = CRCBATTMPSEL Battery Temp Sensor Select 17 = CRCSOHRATE SOH Packet Rate (0 = 1Hz, 1 = 8Hz) 18 = CRCDLRATE Downlink Data Rate (0 = Nominal, 1 = Low Rate) 19 = CRCWDTENABLE CIB Watchdog Timer Enable 20 = CRCEEPROM EEPROM Write Enable 21 = CRCBOOTSEL Boot Image Select (0=Primary, 1=Secondary)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TUPTCRECVD (UB) # of Uplink Subsystem TCs received will increment by one TUPTCREJECT (UB) # of Uplink Subsystem TCs that failed verification TUPTCERRORS (UB) # of Uplink Subsystem TCs that failed to execute TCBCRCBIT0 to TCBCRCBIT232 (BOOL) State of a specific CRC bit

UPCRCSET Set bits in a specific HCD/CRC byte CRCBYTE (UB) The specific CRC byte to set. Range: 0 to 2 BYTEVALUE (UB) A '1' in each bit position sets the CRC bit Range: 0 to 255
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TUPTCRECVD (UB) # of Uplink Subsystem TCs received will increment by one TUPTCREJECT (UB) # of Uplink Subsystem TCs that failed verification TUPTCERRORS (UB) # of Uplink Subsystem TCs that failed to execute TCBCRCBIT0 to TCBCRCBIT232 (BOOL) State of a specific CRC bit

UPCRCCLEAR Clear bits in a specific HCD/CRC byte. CRCBYTE (UB) The specific CRC byte to clear. Range: 0 to 2 BYTEVALUE (UB) A '1' in each bit position clears the CRC bit Range: 0 to 255
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TUPTCRECVD (UB) # of Uplink Subsystem TCs received will increment by one TUPTCREJECT (UB) # of Uplink Subsystem TCs that failed verification TUPTCERRORS (UB) # of Uplink Subsystem TCs that failed to execute TCBCRCBIT0 to TCBCRCBIT232 (BOOL) State of a specific CRC bit

11.3 Resetting the CIB Device FPGAs

The CIB device is on the essential power bus and is never powered off. In the event of upset, UPCIBRESET telecommand allows various CIB FPGAs can be reset. This UPCIBRESET telecommand will most likely be sent from an RTS in response to a loss of telecommanding fault response.

UPCIBRESET Reset one of three FPGAs on the CIB device CIBFPGA (UB) FPGA to reset Range: 1 to 3 1 = VMEFPGA Reset the CIB DLCTLR, SSRPACI and STSOH VME FPGAs 2 = ULCTLRFPGA Reset the CIB ULCTLR FPGA 3 = HCDASIC Reset the HCD ASIC	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TUPTCRECVD (UB) # of Uplink Subsystem TCs received will increment by one TUPTCREJECT (UB) # of Uplink Subsystem TCs that failed verification TUPTCERRORS (UB) # of Uplink Subsystem TCs that failed to execute	

11.4 Switching CIB Uplink Channel

When there is a device failure, and the CIB device no longer gets lock on one of the two uplink input channels, the UPSWITCHAB telcommand instructs the CIB device to toggle the decoded input channel. This UPCIBRESET telecommand will most likely be sent from an RTS in response to a loss of telecommanding fault response.

UPSWITCHAB Switch between CIB Uplink Channel A and B inputs (no parameters)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TUPTCRECVD (UB) # of Uplink Subsystem TCs received will increment by one TUPTCREJECT (UB) # of Uplink Subsystem TCs that failed verification TUPTCERRORS (UB) # of Uplink Subsystem TCs that failed to execute TCBUPCTLUPSG (BOOL) 0 = UPL A signals for commanding; 1 = UPL B signals

11.5 Uplink Subsystem Housekeeping

The UPNOOP telecommand acknowledges that the Uplink Subsystem is receiving telecommands.

The UPTCRESET telecommand resets the Uplink Subsystem telecommand received, rejected and error counters.

The UPCBTCRESET telecommand resets the counters for the number of codeblocks and telecommands received from the CIB device.

UPNOOP (no parameters)	Verifies that the Uplink Subsystem is responding
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TUPTCRECVD (UB) # of Uplink Subsystem TCs received will increment by one	

UPTCRESET (no parameters)	Resets Uplink Subsystems TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TUPTCRECVD (UB) # of Uplink Subsystem TCs received will increment by one TUPTCREJECT (UB) # of Uplink Subsystem TCs that failed verification set to zero TUPTCERRORS (UB) # of Uplink Subsystem TCs that failed to execute set to zero	

UPCBTCRESET (no parameters)	Resets counters for CIB codeblocks and telecommands
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TCBCBERRORS (UB) Total number of codeblocks received with errors set to zero. TCBCBRECVD (UB) Total number of codeblocks received from CIB set to zero. TCBCBREJECT (UB) Total number of codeblocks rejected from CIB set to zero. TCBTCERRORS (UB) Total number of telecommand errors received from CIB set to zero. TCBTCRECVD (UB) Total number of telecommands received from CIB set to zero. TCBTCREJECT (UB) Total number of telecommands rejected from CIB set to zero.	

12. DOWNLINK SUBSYSTEM

The Downlink Subsystem is responsible for communicating CCSDS Source Packet telemetry generated by FSW to the CIB board. All FSW generated telemetry (except VC0 APID 1) is downlinked on Virtual Channel 1.

When not in contact with the ground, the Downlink Subsystem will store most types of source packets in a Stored Telemetry Database. There are five different telemetry types that are stored in the database, as described in Table 12-1. Each of these five telemetry types can be separately enabled or disables for downlink during a pass. The DLENABLETLM telecommand enables a telemetry type for downlink to the ground. The DLDISABLETLM telecommand disables a telemetry type from being downlinked. When enabled for downlink and all previously stored telemetry has been downlinked, new telemetry added to the database is immediately downlinked.

Table 12-1. Stored Telemetry APIDs

Source Packet Telemetry Type	APIDs	No. of Transfer Frames
Stored State Of Health	1	10340
Telecommand Log	10, 11, 12	100
IDPU Diagnostic Packets	151 through 199	1000
Event Message Log	40, 41	100
SSR Response Telemetry	0x200 – 0x2FF	100

12.1 Transmitter and Bypass

Normally, the transmitter must be powered on for stored telemetry to be enabled for downlink. For range safety reasons, the FSW might need to be tested without powering the transmitter. The DLBYPASSTX telecommand will allow stored telemetry to be downlinked when the transmitter is powered off. Either the transmitter must be powered, or the transmitter bypass flag must be on (telemetry point TDLTXBYPASS), to enable the downlink of stored telemetry. When both the transmitter is power off and the transmitter bypass flag are turned off, all stored telemetry will automatically be disabled for downlink.

It should be noted that the CIB buffers up to 238 VC1 transfer frames. Therefore, even when FSW disables all stored telemetry for downlinking, the CIB will continue to transmit the previously buffered VC1 transfer frames.

DLBYPASSTX	Allows downlinking stored tlm despite status of transmitter	
ENABLE (UB) 1=bypass transmitter status; 0=use tx status		
Range: 0 to 1		
0 = OFF	Off	
0 = NO	No	
0 = FALSE	False	
1 = YES	Yes	
1 = TRUE	True	
1 = ON	On	

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one

TDLTCREJECT (UB) # of Downlink Subsystem TCs that failed verification

TDLTCERRORS (UB) # of Downlink Subsystem TCs that failed to execute

TDLTXBYPASS (BOOL) 1=stored telemetry can be downlinked; 0=downlinked based on transmitter status

12.2 Managing Stored Telemetry

The DLENABLETLM telecommand enables downlinking one or more sources of stored telemetry. The transmitter must be powered on, or the transmitter bypass flag must be on, to enable stored telemetry to be downlinked.

When more than one source of telemetry is enabled for downlink, one telemetry frame is retrieved in an round-robin fashion from each enabled source and downlinked until each enabled source has no more telemetry frames in the database. The DLSETWEIGHT telecommand allows the ground to slow the retrieval of telemetry frames from specific sources, thereby increasing the rate at which the other telemetry types are downlinked. The higher the weight, the slower a telemetry source is downlinked. A weight of zero is the nominal value. A weight of N means that N requests for a telemetry frame will be skipped before a frame is downlinked. For example, if the SOH downlink weight is 0, and the TC Log downlink weight is 10, then 11 SOH frames will be downlinked for every 1 TC Log frame.

It is important to note that the DLSETWEIGHT telecommand does not change the CIB device downlink frame, just the percentage of one stored telemetry source versus another source.

The DLDISABLETLM telecommand disables the downlinking of one or more sources of stored telemetry.

The DLDELETETLM deletes all stored telemetry for one more telemetry type.

DLENABLETLM	Enables downlinking of one or more stored telemetry types
TLMTYPE1 UB	1st stored telemetry type
Range: 0 to 1	
0 = DEFAULT	
1 = SSOH	Stored State of Health
TLMTYPE2 UB	2nd stored telemetry type
Range: 0 or 2	
0 = DEFAULT	
2 = TCLOG	Telecommand Log
TLMTYPE3 UB	3rd stored telemetry type
Range: 0 or 3	
0 = DEFAULT	
3 = IDPUDIAG	IDPU Diagnostics
TLMTYPE4 UB	4th stored telemetry type
Range: 0 or 4	
0 = DEFAULT	
4 = EVENTLOG	Event Message Log
TLMTYPE5 UB	5th stored telemetry type
Range: 0 or 5	
0 = DEFAULT	
5 = SSR	SSR Telemetry

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one

TDLTCREJECT (UB) # of Downlink Subsystem TCs that failed verification

TDLTCERRORS (UB) # of Downlink Subsystem TCs that failed to execute

TDLENBLEVENT (BOOL) Indicates that stored event messages are enabled for downlink

TDLENBLIDIAG (BOOL) Indicates that stored IDPU Diagnostics are enable for downlink

TDLENBLSOH (BOOL) Indicates that Stored SOH is enabled to be downlinked

TDLENBLSSR (BOOL) Indicates that stored SSR telemetry is enabled for downlink

TDLENBLTCLOG (BOOL) Indicates that stored telecommand log is enabled for downlink

DLDISABLETLM	Disables downlinking of one or more stored telemetry types
TLMTYPE1 UB	1st stored telemetry type
Range: 0 to 1	
0 = DEFAULT	
1 = SSOH	Stored State of Health
TLMTYPE2 UB	2nd stored telemetry type
Range: 0 or 2	
0 = DEFAULT	
2 = TCLOG	Telecommand Log
TLMTYPE3 UB	3rd stored telemetry type
Range: 0 or 3	
0 = DEFAULT	
3 = IDPUDIAG	IDPU Diagnostics
TLMTYPE4 UB	4th stored telemetry type
Range: 0 or 4	
0 = DEFAULT	
4 = EVENTLOG	Event Message Log
TLMTYPE5 UB	5th stored telemetry type
Range: 0 or 5	
0 = DEFAULT	
5 = SSR	SSR Telemetry

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one

TDLTCREJECT (UB) # of Downlink Subsystem TCs that failed verification

TDLTCERRORS (UB) # of Downlink Subsystem TCs that failed to execute

TDLENBLEVENT (BOOL) Indicates that stored event messages are enabled for downlink

TDLENBLIDIAG (BOOL) Indicates that stored IDPU Diagnostics are enable for downlink

TDLENBLSOH (BOOL) Indicates that Stored SOH is enabled to be downlinked

TDLENBLSSR (BOOL) Indicates that stored SSR telemetry is enabled for downlink

TDLENBLTCLOG (BOOL) Indicates that stored telecommand log is enabled for downlink

DLSETWEIGHT Sets the transmission weight of a stored telemetry type. TLMTYPE (U12) The stored telemetry type Range: 1 to 5 1 = SSOH Stored State of Health 2 = TCLOG Telecommand Log 3 = IDPUDIAG Stored IDPU Diagnostics 4 = EVENTLOG Event Message Log 5 = SSR Stored SSR Telemetry WEIGHT (UB) The new transmission weight Range: 0 to 255	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one TDLTCREJECT (UB) # of Downlink Subsystem TCs that failed verification TDLTCERRORS (UB) # of Downlink Subsystem TCs that failed to execute TDLTXWTEVENT (UB) Transmission weight for Message Event TDLTXWTIDIAG (UB) Transmission weight for IDPU Diagnostic TDLTXWTSOH (UB) Transmission weight for SOH TDLTXWTSSR (UB) Transmission weight for SSR TDLTXWTTCLOG (UB) Transmission weight for Telecommand Log	

DLDELETETLM Deletes all stored telemetry of one or more types TLMTYPE1 UB 1st stored telemetry type Range: 0 to 1 0 = DEFAULT 1 = SSOH Stored State of Health TLMTYPE2 UB 2nd stored telemetry type Range: 0 or 2 0 = DEFAULT 2 = TCLOG Telecommand Log TLMTYPE3 UB 3rd stored telemetry type Range: 0 or 3 0 = DEFAULT 3 = IDPUDIAG IDPU Diagnostics TLMTYPE4 UB 4th stored telemetry type Range: 0 or 4 0 = DEFAULT 4 = EVENTLOG Event Message Log TLMTYPE5 UB 5th stored telemetry type Range: 0 or 5 0 = DEFAULT 5 = SSR SSR Telemetry
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one TDLTCREJECT (UB) # of Downlink Subsystem TCs that failed verification TDLTCERRORS (UB) # of Downlink Subsystem TCs that failed to execute TDLNUMEVENT (UB) # of Message Event stored tlm frames TDLNUMIDIAG (U12) # of IDPU Diagnostic stored tlm frames TDLNUMRT (UB) Number of real-time telemetry frames queued for downlink TDLNUMRTHIGH (UB) High watermark for queued real-time telemetry frames TDLNUMSOH (U12) # of SOH stored tlm frames TDLNUMSSR (UB) # of SSR stored tlm frames

12.3 CIB Device Downlink Bit Rate

The CRC18 bit selects between the CIB low and high rate. The low rate is always 125 kbps. The high rate is nominally 4 Mbps, but can be changed with the DLSETRATE telecommand.

DLSETRATE Sets the CIB Board's nominal downlink bit rate BITRATE (UB) The nominal downlink bit rate. Range: 0 to 5 0 = RATE4MBPS 4 Mbps 1 = RATE2MBPS 2 Mbps 2 = RATE1MBPS 1 Mbps 3 = RATE500KBPS 500 kbps 4 = RATE250KBPS 250 kbps 5 = RATE125KBPS 125 kbps	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one TDLTCREJECT (UB) # of Downlink Subsystem TCs that failed verification set to zero TDLTCERRORS (UB) # of Downlink Subsystem TCs that failed to execute set to zero TCBDLCTLHIRT (U12) High Rate Downlink Rate	

12.4 Downlinked Housekeeping

The DLNOOP telecommand acknowledges that the Downlink Subsystem is receiving telecommands.

The DLTCRESET telecommand resets the Downlink Subsystem telecommand received, rejected and error counters.

Multiple CCSDS Source Packets that are smaller than one transfer frame (TC log, Event Messages, SSR telemetry) can be concatenated to fit into one transfer frame. The DLRTMULTIPKT telecommand, normally only used in testing, controls this concatenation. Enabling multiple source packets per transfer frame is the nominal state.

DLNOOP Verifies that the Downlink Subsystem is responding (no parameters)	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one	

DLTCRESET (no parameters)	Resets Downlink Subsystems TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one TDLTCREJECT (UB) # of Downlink Subsystem TCs that failed verification set to zero TDLTCERRORS (UB) # of Downlink Subsystem TCs that failed to execute set to zero	

DLRTMULTIPKT	Selects downlink multiple source packets per frame mode
APPENDSEL (UB) 1 = selects multi-packet, 0 = single packet Range: 0 to 1 0 = OFF Off 0 = NO No 0 = FALSE False 1 = YES Yes 1 = TRUE True 1 = ON On	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TDLTCRECVD (UB) # of Downlink Subsystem TCs received will increment by one TDLTCREJECT (UB) # of Downlink Subsystem TCs that failed verification TDLTCERRORS (UB) # of Downlink Subsystem TCs that failed to execute	

13. PCB INTERFACE SYSTEM

The Power Controller Board (PCB) Interface Subsystem is responsible for communications between the FSW and the hardware power subsystem. There are four major interfaces in the power subsystem: power switches, torque rods, inertial adjustment device, and the solar array releases.

13.1 Power Switches

The PCBSETSWITCH telecommand is used to turn a power switch on or off.

PCBSETSWITCH Set a specific power switch on the Power Converter Board

PCBSWITCH (UB) The ID of the switch to set.

Range: 0 to 24

0 = PCBNEB1	Primary Bus - Non-essential bus #1
1 = PCBIDPUH	Primary Bus - IDPU heater bus
2 = PCBNEB2	Primary Bus - Non-essential bus #2
3 = PCBCRYO	Primary Bus - Cryocooler bus
4 = PCBIDPU	Primary Bus - IDPU bus
5 = PCBIDPU28	Primary Bus - +28V bus
6 = PCBSSR	Primary Bus - Solid State Recorder bus
7 = PCBRF	Primary Bus - RF Antenna (on=forward, off=aft)
8 = PCBFSSHTR	Secondary Bus - Fine Sun Sensor heater
9 = PCBSADHTR	Secondary Bus - Solar Array Damper Heater
10 = PCBTQHTR	Secondary Bus - Torque Rod heater
11 = PCBXPHTR	Secondary Bus - Transponder heater
12 = PCBSSRHTR	Secondary Bus - Solid State Recorder heater
13 = PCBSPARE1	Secondary Bus - Spare secondary switch #1
14 = PCBSEMHTR	Secondary Bus - SEM heater
15 = PCBBATHTR	Secondary Bus - Battery heater
16 = PCBXZTQ	Secondary Bus - Torque Rod XZ
17 = PCBYZTQ	Secondary Bus - Torque Rod YZ
18 = PCBSPARE2	Secondary Bus - Spare secondary switch #2
19 = PCBIAD1	Secondary Bus - Inertia Adjustment Device #1
20 = PCBIAD2	Secondary Bus - Inertia Adjustment Device #2
21 = PCBBATHTR2	Secondary Bus - Battery heater #2
22 = PCBFSS	Secondary Bus - Fine Sun Sensor
23 = PCBXMIT	Secondary Bus – Transmitter
24 = PCBMAG	Secondary Bus – Magnetometer

SWITCH_VALUE (UB) The desired switch value.

Range: 0 to 1

0 = OFF	Off
0 = NO	No
0 = FALSE	False
1 = YES	Yes
1 = TRUE	True
1 = ON	On

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one

TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification

TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute

13.1.1 Transmitter Switch

For Range Safety purposes, the transmitter power switch has a FSW protection to help prevent inadvertent powering of the transmitter. The PCBENABLTXSW telecommand enables the transmitter to be powered on if the PCBSWITCH telecommand to power the transmitter (PCBSETSWTICH PCBXMIT, ON) is received within 10 seconds. After 10 seconds, the enable expires, and the PCBSWITCH telecommand to power the transmitter will have no effect. In addition, a transmitter switch off telecommand will cause the enable to expire.

PCBENABLTXSW Enable the transmitter power switch to be turned on ENABLE (UB) 1=enableTx switch to be turned on; 0 = disable Range: 0 to 1 0 = OFF Off 0 = NO No 0 = FALSE False 1 = YES Yes 1 = TRUE True 1 = ON On
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute TPCTXSWENBL (BOOL) The Transmitter Power Switch Enable is set to ENABLE from telecommand.
Notes: When ENABLE is ON, the TPCTXSWENBL telemetry point will have a value of one until: •the following telecommand is received: PCBSETSWITCH PCBXMIT, ON •the following telecommand is received: PCBSETSWITCH PCBXMIT, OFF •the following telecommand is received: PCBENABLETX OFF •ten seconds after PCBENABLETXSW telecommand was received

13.2 Torque Rods

The PCBCMDTORQUE telecommand is used to manually drive each of the torque rods with a specific current for 2.5 seconds, which is when the PCB device automatically shuts off the current.

PCBCMDTORQUE Command the torque rods XTORQUEROD (SFP) Desired X torque rod current in amps Range: -0.25 to 0.25 YTORQUEROD (SFP) Desired Y torque rod current in amps Range: -0.25 to 0.25 Z1TORQUEROD (SFP) Desired Z torque rod #1 current in amps Range: -0.25 to 0.25 Z2TORQUEROD (SFP) Desired Z torque rod #2 current in amps Range: -0.25 to 0.25
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute TPCBTRQCMDX (U12) Last commanded Torque Rod X count TPCBTRQCMDY (U12) Last commanded Torque Rod Y count TPCBTRQCMDZ1 (U12) Last commanded primary Torque Rod Z count TPCBTRQCMDZ2 (U12) Last commanded redundant Torque Rod Z count

13.3 Inertial Adjustment Device

The PCBDRIVEIAD telecommand allows the ground to drive the Inertial Adjustment Device. This will generally be one at the beginning of the mission.

PCBDRIVEIAD Drive the Inertial Adjustment Device DRIVE_NUMBER (UB) Range: 1 to 2 1 = IAD1 Inertial Adjustment Device 1 2 = IAD2 Inertial Adjustment Device 2 STEPS (U12) Number of IAD motor steps. Range: 0 to 1023 IADDIRECTION (UB) Direction of motor movement. Range: 0 to 1 0 = CLOCKWISE Drive IAD motor clockwise (+Z Wingtip Travel) 1 = COUNTERCLOCK Drive IAD motor counter-clockwise (-Z Wingtip)	
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute TADBIADSEL (BOOL) Which IAD device is selected; 0 = IAD#1, 1 = IAD#2 TADBIADXPHA (BOOL) Current command for the IADX Phase A TADBIADXPHB (BOOL) Current command for the IADX Phase B TADBIADYPHA (BOOL) Current command for the IADY Phase A TADBIADYPHB (BOOL) Current command for the IADY Phase B TADBPULSECNT (BOOL) The IAD Pulse Count TADBSTEPCNT (BOOL) The IAD step count TADBUPCNT (BOOL) IAD rotation direction; 0 = counter clockwise, 1 = clockwise	

13.4 Solar Array Releases

The PCBSAENABLE telecommand enables a solar array release mechanism. The PCBSADISABLE telecommand disables a solar array release mechanism. These two telecommands are useful in test and for anomaly conditions.

PCBSAENABLE   Enable a Solar Array Release

RELEASE_P (UB) Primary Solar Array Release Mechanism

Range: 0 or 255

0 = PRIMARY   Primary Solar Array Release
255 = DEFAULT

RELEASE_S (UB) Secondary Solar Array Release Mechanism

Range: 1 or 255

1 = SECONDARY Secondary Solar Array Release
255 = DEFAULT

RELEASE_XU (UB) X-Axis Upper Solar Array Release Mechanism

Range: 2 or 255

2 = XUPPER   ADB X-Axis Upper Solar Array Release Mechanism
255 = DEFAULT

RELEASE_YU (UB) Y-Axis Upper Solar Array Release Mechanism

Range: 3 or 255

3 = YUPPER   ADB Y-Axis Upper Solar Array Release Mechanism
255 = DEFAULT

RELEASE_XL (UB) X-Axis Lower Solar Array Release Mechanism

Range: 4 or 255

4 = XLOWER   ADB X-Axis Lower Solar Array Release Mechanism
255 = DEFAULT

RELEASE_YL (UB) Y-Axis Lower Solar Array Release Mechanism

Range: 5 or 255

5 = YLOWER   ADB Y-Axis Lower Solar Array Release Mechanism
255 = DEFAULT

Telemetry:

After execution of the telecommand, the following telemetry points will be set appropriately:

TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one

TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification

TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute

TADBSAPRI (BOOL) Solar array release primary bus command monitor

TADBSASEC (BOOL) Solar array release secondary bus command monitor

TADBSAXLOW (BOOL) Solar array release X-axis lower command monitor

TADBSAXUP (BOOL) Solar array release X-axis upper command monitor

TADBSAYLOW (BOOL) Solar array release Y-axis lower command monitor TADBSAYUP (BOOL) Solar array release Y-axis upper command monitor TADBSEPCOUNT (BOOL) The current automated array release count TADBXLPRI (BOOL) Status of X-axis lower primary array release TADBXLSEC (BOOL) Status of X-axis lower secondary array release TADBXUPRI (BOOL) Status of X-axis upper primary array release TADBXUSEC (BOOL) Status of X-axis upper secondary array release TADBYLPRI (BOOL) Status of Y-axis lower primary array release TADBYLSEC (BOOL) Status of Y-axis lower secondary array release TADBYUPRI (BOOL) Status of Y-axis upper primary array release TADBYUSEC (BOOL) Status of Y-axis upper secondary array release

13.5 Mission Mode

The FSW Mission Mode determines which initial stored sequence is started after the Mission Mode indicator is selectable via two bits in the PCB. If either of the bits is zero, then the Mission Mode is the ‘Launch’, and the RTS00 stored sequence will be started. If both bits are one, then the Mission Mode is ‘Nominal’, and the RTS01 stored sequence will be started. The PCBMISSNMODE telecommand will set these two bits.

PCBMISSNMODE Sets mission mode which determines the boot-up sequence. MODEPARAM (UB) Mission mode is either launch or nominal. Range: 0 to 1 0 = LAUNCH Use launch boot-up sequence 1 = NOMINAL Use post-launch, or nominal boot-up sequence
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute TPADINBIT05 (BOOL) CCB MISSION MODE STATUS 1 set to MODEPARAM in telecommand TPADINBIT06 (BOOL) CCB MISSION MODE STATUS 2 set to MODEPARAM in telecommand

13.6 PCB Miscellaneous Telecommand

The PCBCLRLATCH telecommand clears the PCB device latched outputs OC, LUV1, LUV2 and LUV3.

The PCBFPGARESET telecommand resets the PCB FPGA logic devices. This telecommand does not affect the state of the switches.

The PCBSETUVLEVL sets or clears the degrade bit for each of the under voltage trip levels.

PCBCLRLATCH (no parameters)	Clears the PCB latched outputs OC, LUV1, LUV2, and LUV3
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute	

PCBFPGARESET (no parameters)	Resets the PCB FPGA Logic. Does not affect switch states.
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute	

PCBSETUVLEVL Sets/clears the degrade bit for under voltage trip levels UVTRIPSELECT (UB) Selects the UV trip level to operate upon Range: 1 to 3 1 = UV1 Under Voltage trip level 1 2 = UV2 Under Voltage trip level 2 3 = UV3 Under Voltage trip level 3 BITSTATE (UB) When set, degrades UV trip level. Clear=nominal Range: 0 to 1 0 = OFF Off 0 = NO No 0 = FALSE False 1 = YES Yes 1 = TRUE True 1 = ON On
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute

13.7 PCB Interface Housekeeping Telecommands

The PCBNOOP telecommand acknowledges that the PCB Interface Subsystem is receiving telecommands.

The PCBTCRESET telecommand resets the PCB Interface Subsystem telecommand received, rejected and error counters.

PCBNOOP Verifies that the PCB Interface Subsystem is responding (no parameters)
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one

PCBTCRESET (no parameters)	Resets PCB Interface Subsystems TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TPCTCRECVD (UB) # of PCB Interface Subsystem TCs received will increment by one TPCTCREJECT (UB) # of PCB Interface Subsystem TCs that failed verification set to zero TPCTCERRORS (UB) # of PCB Interface Subsystem TCs that failed to execute set to zero	

14. SCHEDULER SUBSYSTEM

The Scheduler Subsystem is responsible for synchronizing the 64 Hz CPU clock with the 1 Hz Bus Tick received from the PACI, and for sending "wakeup" messages to each of the Subsystems at a specific rate. Table 14-1 lists the rates at which each of the Subsystems are scheduled.

Table 14-1. Subsystem Wakeup Schedule

Subsystem	Ticks Received
ACS	none
Downlink Subsystem	8th
Fault Management Subsystem	16th, 48th
Payload Interface Subsystem	0th
PCB Interface Subsystem	8th
SOH Subsystem	8th tick, and 8 Hz starting from 3rd tick
SSR Interface Subsystem	0th
Storage Management Subsystem	none
Stored Command Processor	0th
Uplink Subsystem	16 Hz starting from 0th tick

The Scheduler Subsystem receives a 64 Hz interrupt from the CPU clock, a 1 Hz Bus Tick interrupt from the PACI device, and an 8 Hz Analog Scan Done interrupt from the PACI device. The Scheduler task uses these three interrupts to ensure that it will always be able to schedule the various tasks. By default, all scheduling uses the CPU 64 Hz clock. If the 64 Hz clock is lost, the 8 Hz PACI interrupt is used for scheduling. If the 8 Hz PACI interrupt is lost, then the 1 Hz PACI interrupt is used for scheduling. It should be noted that at 1 Hz, the Fault Management Subsystem can't feed the CIB Watchdog Timer quick enough, so the Timer must be disabled by the ground. In addition, if scheduling is based on the 1 Hz PACI interrupt, then all tasks in Table 4-1 only be run at a 1 Hz rate.

15. FAULT MANAGEMENT

The Fault Management Subsystem monitors the system looking for anomalous conditions, and if found, makes a predefined response. In addition, the Fault Management Subsystem is responsible for feeding the CIB Watchdog Timer, and for scrubbing the CPU EDAC RAM.

15.1 Interrupts

The Fault Management Subsystem monitors interrupts received, and alerts the ground when an interrupt source is lost. In addition, spurious interruptS that may occur from the PACI and CIB devices are tracked. There are seven interrupt sources that are monitored, for which the monitoring can individually be enabled or disabled. Table 15-1 contains a list of all interrupt monitors, the flight parameter for enabling/disabling the monitor, and the telemetry point used for reporting. Table 15-2 contains a list of telemetry points that report the current interrupt state.

Table 15-1. Interrupt Monitors

Interrupt Description	FM Monitor Enable Flight Parameter	Interrupt Active Telemetry Point	No. Times Loss Telemetry Point
64 Hz CPU clock interrupt	VFMEN64HTICK	TFMRCVCPUINT	TFMLS64HZTCK
1 Hz PACI Bus Tick interrupt	VFMEN1HZINTR	TFMRCV1HZINT	TFMLSBUSTCK
8 Hz PACI Analog Scan Done interrupt	VFMEN8HZINTR	TFMRCV8HZINT	TFMLSACSINT
PACI IDPU data received interrupt	VFMENPLINTR	TFMRCVPLINT	TFMLSIDPUINT
PACI SSR data received interrupt	VFMENSSRINTR	TFMRCVSSRINT	TFMLSSSRINT
CIB codeblock received interrupt	VFMENCBINTR	TFMRCVCBINT	TFMLSCBINT
CIB downlink buffer empty interrupt	VFMENDLINTR	TFMRCVTLMINT	TFMLSDLINT

Table 15-2. FSW Interrupt Telemetry Points

TFMLS64HZTCK (UB) Number of times the 64 Hz Bus Tick was lost.
TFMLSACSINT (UB) Counts PACI Analog Scan interrupt losses
TFMLSBUSTCK (UB) Number of times the 1 Hz Bus Tick was lost.
TFMLSCBINT (UB) Counts CIB codeblock interrupt losses
TFMLSDLINT (UB) Counts CIB downlink buffer empty interrupt losses
TFMLSIDPUINT (UB) Counts PACI IDPU data receive interrupt losses
TFMLSSSRINT (UB) Counts PACI SSR data receive interrupt losses
TFMRCV1HZINT (BOOL) Currently receiving PACI 1 Hz Bus Tick interrupt
TFMRCV8HZINT (BOOL) Currently receiving PACI 8 Hz Analog Scan interrupt
TFMRCVCBINT (BOOL) Currently receiving CIB Codeblock Received interrupt
TFMRCVCPUINT (BOOL) Currently receiving CPU 64Hz Interrupt.
TFMRCVPLINT (BOOL) Currently receiving PACI IDPU Data Ready interrupt
TFMRCVSSRINT (BOOL) Currently receiving PACI SSR Data Ready interrupt
TFMRCVTLMINT (BOOL) Currently receiving CIB Telemetry Buffer Available interrupt
TFMSPCIBINT (BOOL) Spurious CIB interrupts occurred; CIB interrupts disabled
TFMSPPACIINT (BOOL) Spurious PACI interrupts occurred; PACI interrupts disabled
TFMUNKNINTR (UB) Counts number of unknown interrupts that occur

15.2 Fault Monitors

The Fault Management Subsystem monitor eight different analog channels, ACS Sun Pointing and loss of the ability of the S/C to received telecommands. When a fault is detected, a specific RTS is started. The name of each RTS associated with a fault response is listed in Table 6-1, Special Purpose Relative-Time Sequences. Except for the Loss of Telecommanding fault response, a fault response will only be triggered once until the fault response indicator telemetry point has been cleared using the FMCLEAR telecommand (see Section 15.2.4 Clearing Fault Response Indications on page 91).

15.2.1 Analog Sensors

The Fault Management Subsystem monitors eight different analog channels for sensor reading that are out of the “safe” range as determined by Systems Engineering. Table 15-3 lists the following in each column:

a. Name of a analog channel fault monitor test
b. RTS that is started when a fault condition is met
c. Flight parameter name for the variable that enables the fault monitor test. By default, this test is disable when booting the primary FSW image.
d. The flight parameter names for the range of values that will trigger a fault response

e. The analog telemetry point that is checked and the telemetry point that is set when a fault response is triggered.

A specific analog fault monitor test can be enabled or disabled by setting the ‘enabling’ flight parameter to TRUE or FALSE accordingly. Flight parameters can be changed during flight using the procedures outlined in Section 16. FLIGHT PARAMETERS starting on page 95.

Table 15-3. Analog Sensor Fault Monitors

Fault Description	**RTS Started**	**Enabling Flight Parameter**	**Fault Range Flight Parameters**	**Telemetry Points**
Battery 1 Pressure Low Fault	RTS12	VFMENLOWBAT	VFMLMTLOBATL VFMLMTLOBATH	TPAGPACH03 TFMHITLOBAT1
Battery 2 Pressure Low Fault	RTS13	VFMENLOWBAT	VFMLMTLOBATL VFMLMTLOBATH	TPAGPACH04 TFMHITLOBAT2
NEB1 Over Current Fault	RTS14	VFMENNEB1	VFMLMTNEB1L VFMLMTNEB1H	TPAGPACH31 TFMHITNEB1
NEB2 Over Current Fault	RTS15	VFMENNEB2	VFMLMTNEB2L VFMLMTNEB2H	TPAGPACH33 TFMHITNEB2
IDPU Heater Over Current Fault	RTS16	VFMENIDPUH	VFMLMTIDPUHL VFMLMTIDPUHH	TPAGPACH32 TFMHITIDPUH
IDPU Over Current Fault	RTS17	VFMENIDPU	VFMLMTIDPUL VFMLMTIDPUH	TPAGPACH34 TFMHITIDPU
Cryocooler Over Current Fault	RTS18	VFMENCRYO	VFMLMTCRYOL VFMLMTCRYOH	TPAGPACH35 TFMHITCRYO
IDPU Switched Over Current Fault	RTS19	VFMENIDPUSW	VFMLMTIDPUSL VFMLMTIDPUSH	TPAGPACH36 TFMHITIDPUS W

15.2.2 ACS Sun Pointing Fault

The ACS Subsystem transitions to the ‘Idle’ mode when its pointing error is outside of an acceptable range. FSW duplicates this check to protect against the event that the ACS Subsystem fails and continues to command the spacecraft to point outside the acceptable range. Table 15-4 lists the following in each column:

a. Name of fault monitor test

b. RTS that is started when a fault condition is met

c. Flight parameter name for the variable that enables the fault monitor test. By default, this test is disable when booting the primary FSW image.

d. The flight parameter names for the range of values that pointing error must fall between to avert a fault response. FSW converts the Gray Code received in the telemetry point to a decimal value, then compares then to flight parameter values.

e. The analog telemetry points that are checked and the telemetry point that is set when a fault response is triggered.

The ACS Sun Pointing fault monitor test can be enabled or disabled by setting the 'enabling' flight parameter to TRUE or FALSE accordingly. Flight parameters can be changed during flight using the procedures outlined in Section 16. FLIGHT PARAMETERS starting on page 95.

Table 15-4. ACS Fault Monitor

Fault Description	RTS Started	Enabling Flight Parameter	Valid Range Flight Parameters	Telemetry Points
ACS Sun Pointing Fault	RTS10	VFMENSUNPT	VFMLMTSUNPTL VFMLMTSUNPTH	TPAFSSSIN1 TPAFSSSIN2 TFMHITSUNPT

15.2.3 Loss of Telecommanding

The CIB device is on the Essential Bus, and never gets powered off, and nominally never gets reset. In the event that the CIB device has a failure that results in no telecommands being received by FSW after a certain amount of time, an RTS will be started that will attempt to reset the CIB device. After the fault response is triggered, the seconds since the last telecommand was received will be reset to zero. The fault response can then be triggered again after no telecommands have been received by FSW after the set period of time. This is the only fault monitor response that will continue to be triggered after the faults have been previously triggered.

Table 15-5 lists the following in each column:

a. Name of fault monitor test.

b. RTS that is started when a fault condition is met.

c. Flight parameter name for the variable that enables the fault monitor test.

d. The flight parameter names for the value to be exceeded before the fault response is triggered.

e. The telemetry point reporting the number of seconds since the last FSW telecommand was received, and the telemetry point that is set when a fault response is triggered.

The Loss of Telecommanding fault monitor test can be enable or disabled by setting the 'enabling' flight parameter to TRUE or FALSE accordingly. Flight parameters can be changed during flight using the procedures outlined in Section 16. FLIGHT PARAMETERS starting on page 95.

Table 15-5. Loss of Telecommand Fault Response

Fault Description	RTS Started	Enabling Flight Parameter	Loss Threshold Parameters	Telemetry Points
Loss of Telecommanding	RTS11	VFMENTCLOSS	VFMLMTTCLOSS	TFMSECLASTTC TFMHITTCLOSS

15.2.4 Clearing Fault Response Indications

Each of the telemetry points that indicate that a fault response had previously been trigger can be reset using the FMCLEAR telecommand. Except for the TFMHITTCLOSS telemetry point, all other telemetry points being set will prevent the fault response from being triggered in the future. So, not only does using this command let the

Operations acknowledge to FSW that it has recognized that the fault had occurred, but it allows FSW to trigger the fault again in the future.

FMCLEAR	Clear the Fault Management telemetry counters and flags FAULTID (UB) ID of fault response to clear. Range: 1 to 11 1 = HITNEB1 Clear NEB1 fault response indicator 2 = HITNEB2 Clear NEB2 fault response indicator 3 = HITLOBAT1 Clear Low Battery 1 fault response indicator 4 = HITLOBAT2 Clear Low Battery 2 fault response indicator 5 = HITCRYO Clear CRYO fault response indicator 6 = HITIDPU Clear IDPU fault response indicator 7 = HITIDPUH Clear IDPU Heater fault response indicator 8 = HITSUNPT Clear ACS Sun Pointing fault response indicator 9 = HITTCLOSS Clear telecommand loss fault response indicator 10 = INTERRUPTCNT Clear all interrupt loss counters 11 = HITIDPUSW Clear IDPU Switched fault response indicator
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TFMTCRECVD (UB) # of Fault Management Subsystem TCs received will increment by one TFMTCREJECT (UB) # of Fault Management Subsystem TCs that failed verification TFMTCERRORS (UB) # of Fault Management Subsystem TCs that failed to execute TFMHITLOBAT1 (BOOL) Low BAT1 State of Charge fault response occurred TFMHITLOBAT2 (BOOL) Low BAT2 State of Charge fault response occurred TFMHITNEB1 (BOOL) Hit NEB1 over current condition TFMHITNEB2 (BOOL) Hit NEB2 over current condition TFMHITIDPUH (BOOL) Hit IDPU Heater over current condition TFMHITIDPU (BOOL) Hit IDPU over current condition TFMHITCRYO (BOOL) Hit CRYO over current condition TFMHITIDPUSW (BOOL) Hit IDPU Switched over current condition TFMHITSUNPT (BOOL) Sun Pointer Error fault response occurred TFMHITTCLOSS (BOOL) Telecommand loss fault response occurred	

15.3 CPU EDAC RAM Scrubbing

The Fault Management Subsystem completely scrubs all 128 MB of CPU EDAC RAM every 18.2 hours. During the scrub process, the CPU records any single-bit errors that were fixed, allow with the CPU RAM address where the error occurred. CPU EDAC RAM scrubbing can be disabled be setting the flight parameter VFMENEDACSCB to FALSE.

TFMSBEDACADR(U1234) CPU Address of last RAD6000 CPU EDAC Single Bit Error TFMSBEDACNUM (UB) Number of RAD6000 CPU EDAC Single Bit Errors

15.4 PACI EDAC RAM Scrubbing

The PACI device continually scrubs it own 256 Kbytes of EDAC RAM. PACI EDAC RAM scrubbing can not be disabled. When a double-bit error is encountered, a VME interrupt is issued. FSW acknowledges the interrupt and increments a counter, and telemeters this information to the ground. The TFMEDACERRCT telemetry point indicates the number of PACI EDAC double-bit error interrupts received (counts at most 255 interrupts). The TFMHITEDAC telemetry point simply alerts the ground that at least one PACI EDAC double-bit error interrupt was received.

TFMEDACERRCT (UB) Count of the number of EDAC error interrupts from PACI TFMHITEDAC (BOOL) At least one PACI EDAC memory error occurred.

15.5 CIB Watchdog Timer

On power up, or reset, the CIB Watchdog Timer does not expire until 60 seconds, and is not feed until all FSW has been loaded and the Fault Management Subsystem has been started. After the Fault Management Subsystem had been started, it feeds the watchdog timer at a rate of 2 Hz.

The CIB device counts the number of times that the watchdog timer has expired, which is reported in the telemetry point TCBSYSRSTCNT and has a range of 0 to 2. After the 1st and 2nd watchdog timer time-out, the CIB sends a VME SYSRESET signal, resetting the CPU, PACI, PCB, and ADB boards. When the watchdog timer time-out count is 2, and another time-out occurs, the CIB sends a signal to the CCB board to power cycle the CPU. After the CPU has been power cycled, the TCBSYSRSTCNT telemetry point will read 0.

The ground can reset the CIB watchdog timer time-out count with the FMCLRWDTCNT telecommand.

The CIB Watchdog Timer can only be disabled with a VC0 HCD/CRC telecommand.

FMTCRESET (no parameters)	Resets Fault Management Subsystems TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TFMTCRECVD (UB) # of Fault Management Subsystem TCs received will increment by one TFMTCREJECT (UB) # of Fault Management Subsystem TCs that failed verification TFMTCERRORS (UB) # of Fault Management Subsystem TCs that failed to execute TCBSYSRSTCNT (U12) CIB VME SYSRESET count (range is 0 to 2)	

15.6 FSW O/S Task Monitor

The Fault Management Subsystem monitors all FSW tasks running under the VxWorks O/S to ensure that none have died or have suspended. If any task has died or is suspended, then the Fault Management Subsystem will withhold feeding the CIB Watchdog Timer, and let the CPU be reset. This task monitor can be enabled or disable with the VFMENTASKCHK flight parameter. By default, it is enabled when booting the primary FSW image.

15.7 FSW Program Text Segment Corruption Monitor

At 1 Hz, the Fault Management Subsystem calculates a checksum on all of the FSW that has been loaded into RAM. If any loaded FSW has become corrupted, the Fault Management Subsystem will withhold feeding the CIB Watchdog Timer, and let the CPU be reset. This task monitor can be enabled or disable with the VFMENMODCHSM flight parameter. Before any RAM patch is made to FSW, this flight parameter must be set to FALSE or FSW will reboot. By default, the flight parameter is enabled when booting the primary FSW image.

15.8 Fault Management Housekeeping

The FMNOOP telecommand acknowledges that the Fault Management Subsystem is receiving telecommands.

The FMTCRESET telecommand resets the Fault Management Subsystem telecommand received, rejected and error counters.

FMNOOP (no parameters)	Verifies that the Fault Management Subsystem is responding
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TFMTCRECVD (UB) # of Fault Management Subsystem TCs received will increment by one	

FMTCRESET (no parameters)	Resets Fault Management Subsystems TC received/rejected/error counters
Telemetry: After execution of the telecommand, the following telemetry points will be set appropriately: TFMTCRECVD (UB) # of Fault Management Subsystem TCs received will increment by one TFMTCREJECT (UB) # of Fault Management Subsystem TCs that failed verification set to zero TFMTCERRORS (UB) # of Fault Management Subsystem TCs that failed to execute set to zero	

16. FLIGHT PARAMETERS

Flight parameters allow the ground to modify and customize the behavior of FSW. Flight parameters change the value of data variables used by FSW. Some flight parameters enable or disable certain FSW tests. Other variables are used to modify data used in the Attitude Control Subsystem algorithms. Table 16-1 contains a complete list of all of the FSW flight parameters.

Flight parameters are stored in binary form in the file named 'params' in the in-flight filesystem. When FSW is booted, the flight parameters table is copied from the boot filesystem to the RAM filesystem, and then read. The RAM filesystem is considered to contain the working copy of the flight parameters file. To update the flight parameters used during flight, the ground uplinks a flight parameters file to the RAM filesystem. When the flight parameters table is committed, FSW will start using the new parameter values. See Section 5.1 Loading Tables on page 12 for the telecommands that support unlinking a file in flight.

During boot, if the flight parameters file is empty or has been corrupted (file checksum is incorrect), then the default values given in Table 16-1 are used for each variable. When a new flight parameter file is uplinked, it must be of the correct size or the SMTBLCOMMIT telecommands will return in error.

Table 16-1. Flight Parameters

Mnemonic	Data Type	Default Value	Range Low	Range High	ITOS Description
SPAREBYTE01	unsigned char	0	0	0	Spare Byte 01
SPAREBYTE02	unsigned char	0	0	0	Spare Byte 02
SPAREBYTE03	unsigned char	0	0	0	Spare Byte 03
SPAREBYTE04	unsigned char	0	0	0	Spare Byte 04
VFMENLOWBAT	unsigned char	0	0	1	Value of true enables Low Battery State Of Charge FM response

SPAREBYTE05	unsigned char	0	0	0	Spare Byte 05
SPAREBYTE06	unsigned char	0	0	0	Spare Byte 06
VFMENSUNPT	unsigned char	0	0	1	Value of true enables Sun Pointing Error FM response
VFMENTCLOSS	unsigned char	1	0	1	Value of true enables the Uplink Telecommand Low FM response
VSSOHRATE	unsigned char	10	1	255	Period of seconds between each Stored SOH collection.
VTRQZSELECT	unsigned char	0	0	1	0 selects the primary Z-axis torque rod; 1 selects redundant
VFMEN1HZINTR	unsigned char	1	0	1	True enables the PACI 1 Hz interrupt check
VFMEN8HZINTR	unsigned char	1	0	1	True enables the PACI 8 Hz interrupt check
VFMEN64HTICK	unsigned char	1	0	1	True enables the CPU 64 Hz clock check
SPAREBYTE07	unsigned char	1	0	1	Spare Byte 07
VFMENCBINTR	unsigned char	1	0	1	True enables CIB codeblock received interrupt check

Table 16-1. Flight Parameters (Continued)

VFMENDLINTR	unsigned char	1	0	1	True enables CIB downlink buffer empty interrupt check
VFMENPLINTR	unsigned char	1	0	1	True enables PACI IDPU Data Ready interrupt check
VFMENSSRINTR	unsigned char	1	0	1	True enables PACI SSR Data Ready interrupt check
VFMENEDACSCB	unsigned char	1	0	1	True enables EDAC RAM scrubbing
VFMLMTLOBATL	unsigned short	2595	0	4095	Low Battery State of Charge low bad range
VFMLMTLOBATH	unsigned short	3100	0	4095	Low Battery State of Charge high bad range
VFMLMTNEB1L	unsigned short	2459	0	4095	NEB1 overcurrent condition low bad range
VFMLMTNEB1H	unsigned short	4095	0	4095	NEB1 overcurrent condition high bad range
VFMLMTNEB2L	unsigned short	2569	0	4095	NEB2 overcurrent condition low bad range
VFMLMTNEB2H	unsigned short	4095	0	4095	NEB2 overcurrent condition high bad range
VFMLMTIDPUHL	unsigned short	2451	0	4095	IDPU Heater overcurrent condition low bad range
VFMLMTIDPUHH	unsigned short	4095	0	4095	IDPU Heater overcurrent condition high bad range
VFMLMTIDPUL	unsigned short	2384	0	4095	IDPU overcurrent condition low bad range
VFMLMTIDPUH	unsigned short	4095	0	4095	IDPU overcurrent condition high bad range
VFMLMTCRYOL	unsigned short	2712	0	4095	CRYO overcurrent condition low bad range
VFMLMTCRYOH	unsigned short	4095	0	4095	CRYO overcurrent condition high bad range
VFMLMTIDPUSL	unsigned short	2382	0	4095	IDPU Switched overcurrent condition low bad range
VFMLMTIDPUSH	unsigned short	4095	0	4095	IDPU Switched overcurrent condition high bad range
SPAREWORD11	unsigned short	0	0	0	

SPAREWORD12	unsigned short	0	0	0	

Table 16-1. Flight Parameters (Continued)

VFMLMTTCLOSS	unsigned long	345600	86400	2592000	Uplink Telecommand Loss limit in seconds to be exceeded
VMAGBIASX	float	0	-0.00002	0.00002	Magnetometer bias for the X-axis
VMAGBIASY	float	0	-0.00002	0.00002	Magnetometer bias for the Y-axis
VSASDELAY	float	2.5	0	3.5	SAS Delay in seconds between collection time and receipt time
VCSSTHRESH	float	0.0005	0	0.001	ACS CCS threshold (amps).
VFSS_BIASX	float	0	-1	1	ACS FSS bias along x-axis
VFSS_BIASY	float	0	-1	1	ACS FSS bias along y-axis
VTQRCOMP11	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRCOMP12	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRCOMP13	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRCOMP21	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRCOMP22	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRCOMP23	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRCOMP31	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRCOMP32	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRCOMP33	float	0	-20	20	ACS Torque rod compensation maxtrix component
VTQRSATHIGH	float	60	0	100	ACS Torque rod high saturation level (amp-m^2)
VTQRSATPNTLO	float	30	0	100	ACS Torque rod low saturation level in pointing (amp-m^2)
VTQRSATSPNLO	float	10	0	100	ACS Torque rod low saturation level in spin (amp-m^2)
VACQSPINCOM	float	0.035	0	0.1	ACS Commanded spin rate durning acquisition (rad/sec)

VNORMSPINCOM	float	1.57	0	2	ACS Commanded spin rate during normal operations (rad/sec)
VACQGAIN	double	1E+11	0	1E+11	ACS Acquisition control gain (amp-m^2-sec/tesla)

Table 16-1. Flight Parameters (Continued)

VCRSPRECGAIN	float	10000	0	1000000	ACS Coarse precession control gain (amp-m^2)
VFINEPRCGAIN	float	1.5	0	5	ACS Fine precssion control gain (N-m-sec)
VFINENUTGAIN	float	4.5	0	20	ACS Fine nutation control gain (N-m-sec)
VSPINGAIN	float	1	0	10	ACS Spin control gain (amp-m^2-sec-tesla)
VPOINTHIGH	float	0.001745	0	0.004	ACS High setting for pointing hysteresis logic (rad)
VPOINTLOW	float	0.0008725	0	0.002	ACS Low setting for pointing hysteresis logic (rad)
VPOINTCHECK	unsigned long	1	0	1	ACS Initial status of pointing hysteresis logic
VDELTASPINHI	float	0.1	0	0.4	ACS High setting for pointing hysteresis logic (rad/sec)
VDELTASPINLO	float	0.05	0	0.2	ACS Low setting for pointing hysteresis logic (rad/sec)
VSPINCHECK	unsigned long	1	0	1	ACS Initial state of spin hysteresis log
VPTACQ2NORM	float	0.0873	0	0.2	ACS Transition pointing error from Acquisition to Idle (rad)
VPTPREC2NORM	float	0.0035	0	0.01	ACS Transistion pointing error from Precession to Normal (rad)
VPTNORM2IDLE	float	0.0088	0	0.01	ACS Transition pointing error from Normal to Idle (rad)
VPTSPIN2NORM	float	0.0035	0	0.01	ACS Transition pointing error from Spin to Normal (rad)
VRTACQ2NORM	float	0.0126	0	0.1	ACS Transition rate from Precession to Normal (rad/sec)
VDRTPREC2NRM	float	0.05	0	0.5	ACS Transition rate error from Precession to Nomal (rad/sec)
VDRTNRM2IDLE	float	0.15	0	0.5	ACS Transition rate error from Normal to Idle (rad/sec)

VDRTSPIN2NRM	float	0.05	0	0.5	ACS Transition rate error from Spin to Normal

Table 16-1. Flight Parameters (Continued)

VTIMACQ2NORM	float	600	0	1800	ACS Transition time from Acquisition to Idle (sec)
VTIMACQ2PREC	float	9000	0	11000	ACS Transition time from Acquition to Precession (sec)
VFMENTASKCHK	unsigned char	1	0	1	Enable the Fault Management Tasks Alive check
VFMENMODCHSM	unsigned char	1	0	1	Enable the Fault Management O/S Module not corrupt check
VFMLMTSUNPTL	unsigned char	30	0	63	Sun Pointing Error low good range
VFMLMTSUNPTH	unsigned char	34	0	63	Sun Pointing Error high good range
VFMENNEB1	unsigned char	0	0	1	Value of true enables the NEB1 Overcurrent check
VFMENNEB2	unsigned char	0	0	1	Value of true enables the NEB2 Overcurrent check
VFMENIDPUH	unsigned char	0	0	1	Value of true enables the IDPU Heater Overcurrent check
VFMENIDPU	unsigned char	0	0	1	Value of true enables the IDPU Overcurrent check
VFMENCRYO	unsigned char	0	0	1	Value of true enables the CYRO Overcurrent check
VFMENIDPUSW	unsigned char	0	0	1	Value of true enables the IDPU Switched Overcurrent check

16.1 Changing Flight Parameters

The FSW distribution contains the ITOS file ‘hessi/build/itos/loads/tablefields.data’ that defines the flight parameter table with the mnemonics, types, default values and ranges as defined in Table 16-1. The ITOS ‘leditor’ application is used for changing parameter values and generating table loads. After a table load file is created, the flight parameter table can be uplinked using the ITOS ‘LOAD’ command.

17. UTILITY APPLICATIONS

The FSW distribution contains the directory ‘hessi/bin’ that contains a number of utility applications that may be of use to the Operations and for FSW maintenance.

17.1 binToTableLoad

The binToTableLoad application is used to generate an ITOS formatted image load file. The ITOS LOAD command can be used to uplinked the file to the spacecraft.

```
binToTableLoad [-c] -t tableName -i inputFile -o outputFile

Parameters:
-c    compress file for uplink
-t    tableName is the table identifier from the SMTBLSELECT TABLEID parameter
-i    inputFile is the name of the file from which to generate a formatted image load file.
-o    outputFile is the name of the generated formatted image load file. Should probably be a file name with a
          complete path to the ITOS loads directory
```

17.2 gen_itos_report

The gen_itos_report application is used during FSW testing to generate a report using an ITOS log file as input.

```
gen_itos_report < filename

where filename is an ITOS log file.
```

17.3 hessiChecksum

The hessiChecksum application is used to calculate the checksum of a file on the ground. The checksum is calculated using the same method as used in FSW.

```
hessiChecksum filename

where filename is the file for which to calculate a checksum.
```

17.4 hessiLogTool

The hessiLogTool application is used to decode Event Message (APID 40, 41) and Telecommand Log (APID 10, 11, 12) telemetry into human readable ASCII output. The hessiLogTool is automatically started when ITOS is started via the 'forward_fswevents.proc' STOL script.

```
hessiLogTool -e eventFile -t tcFile [-p portnum]

Parameters:
-e    eventFile is the hessi/include/auto_events.h header file
-t    tcFile is the hessi/build/itos/dbx/itos-tc-query.txt telecommand database extract file
-p    portnum is an optional port number for the socket (default=20342) used for input communications
```

17.5 sendbin

The sendbin application is used for initial programming of the RAD6000. It will never be used by Operations, but might be used by the Spectrum Astro staff if FSW need to be loaded onto the RAD6000 CPU from scratch.

17.6 default

The default application is used to compress a file on the ground that can later be uncompressed in flight. This utility is used by the binToTableLoad application when the '-c' option is selected.

```
deflate < inputFile > outputFile
```

where *inputFile* is the file to be compressed, and *outputFile* is the resulting compress file.