Solar Probe Plus EPI-Hi Instrument Flight Software Requirements Document

Version 0.3~~1~~

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CHANGE LOG

DATE	SECTIONS CHANGED	REASON FOR CHANGE (ECR)	REVISION
7/19/2013	All	--	Initial preliminary release
8/05/2013	All	- Incorporate comments/additions from team	0.1
10/01/2013	All	Incorporate comments from reviewer David Artis, plus a few other updates	0.2
10/03/2013	3.3	Deleted L5-INSTSW-94, which wasa a repeat of L5-INSTSW-90, inserted by mistake in version 0.2	0.3

Table of Contents

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1 Introduction

1.1 Purpose and Scope

This document contains the requirements on the Solar Probe Plus (SPP) EPI-Hi instrument flight software. The requirements are derived from the ISIS Level 3 and Level 4 requirements, EPI-Hi science requirements, and general best practices.

1.2 Requirement Parent Modules and External Documents

Ref. 1 EPI-Hi Science Requirements Document

Ref. 2 ISIS Level 3 Requirements Document

Ref. 3 ISIS Level 4 Requirements Document

Ref. 4 EPI-Hi Flight Software Development Plan

Ref. 5 SPP General Instrument Specification (GIS)

Ref. 6 P24 MISC Processor Manual

Ref. 7 EPI-Hi Flight Software Design Document

Ref. 8 EPI-Hi Data Format Document

Ref. 9 EPI-Hi Flight Software Test Plan

Ref. 10 EPI-Hi Commanding and User Manual

1.3 Conventions, Typography and Tolerances

Requirement parameters encompassed by brackets such as [25]: The parameter is To Be Confirmed (TBC) and may be changed as the mission is refined. To Be Determined items are highlighted in red, and labeled TBD. To Be Resolved items are highlighted in red, and labeled TBR.

2 Architecture of the Instrument Flight Software

The instrument flight software operates the instrument electronics system, consisting of the Data Processing Unit (DPU) board, the LET1, LET2 and HET boards, the Bias Supply board, and the following subsystems:

- Heaters
- Test Pulsers
- Spacecraft interface

The flight software will reside in the 4 P24 MISC microprocessors installed in the instrument electronics. These MISCs are FPGA-based. One “central MISC” is installed in the DPU, and one “peripheral MISC” is installed in each of the LET1, LET2 and HET boards. The central

MISC has some control over the operation of the peripheral MISCs. The architecture is described in more detail in the Flight Software Development Plan (Ref. 4) and Flight Software Design Doc (Ref. 7).

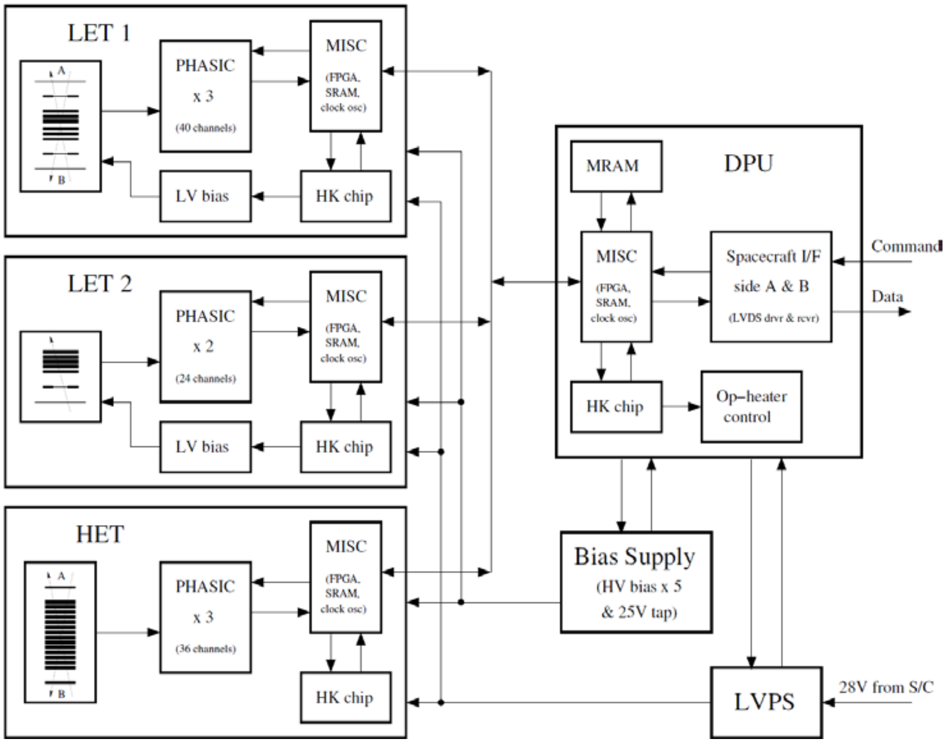

Figure 1 – Instrument Electronics block diagram.

3 Requirements on the Instrument Flight Software

3.1 Requirements Common to the Flight Software in all Four MISCs

The following requirements apply to the Flight Software (FSW) residing in all of the MISCs.

Each MISC FSW shall maintain a command table containing all variable settings (thresholds, gains, modes, etc.)

Context: This table will be used to refresh the settings periodically, and will be incorporated into the instrument Housekeeping (HK) telemetry.

Rationale/Flowdown: This requirement is self-imposed, to enable monitoring of software status on the ground.

ID: L5-INSTSW-1

Each MISC FSW shall calculate a checksum on the command table and other static lookup tables periodically.

Context: Checksums will be included in the instrument HK telemetry and monitored on the ground.

Rationale/Flowdown: This requirement is self-imposed, to enable monitoring of software status on the ground. Also, ISIS-380.

ID: L5-INSTSW-2

In the event of a command table checksum change that is not the result of an uploaded command, each MISC FSW shall report the event in telemetry.

Context: A table checksum change that is not the result of an uploaded command is an error.

Rationale/Flowdown: ISIS-380.

ID: L5-INSTSW-3

Each MISC FSW shall be capable of changing the contents of the command table in response to a command received on the serial command interface.

Context: Capability is needed to change command table parameters on orbit during commissioning period, for investigation and resolution of anomalies, and for routine calibration updates.

Note: the command tables exist in SRAM. For such changes to persist across resets or power-cycles, changes to the command table must also be stored in MRAM by the DPU. See Section 3.3.

Rationale/Flowdown: ISIS-226

ID: L5-INSTSW-4

Each MISC FSW shall be capable of modifying operational flight software in response to SOC instrument commands.

Context: Capability is needed to change flight software on-orbit during commissioning period, for investigation and resolution of anomalies, and to improve software performance.

Note: the operation flight software exists in SRAM. For such changes to persist across resets or power-cycles, changes to the software must also be stored in MRAM by the DPU. See Section 3.3.

Rationale/Flowdown: ISIS-226

ID: L5-INSTSW-5

Each MISC FSW shall provide a capability to execute command sequences, i.e. macros, and to save/restore them to/from MRAM.

Context: Capability is needed to support autonomous instrument operations during encounters.

Note: this capability is inherent in the Forth operating system implemented in each of the MISC processors. All of the operators, control structures and subroutine-calling capabilities etc. of the Forth programming language are available for use within macros.

Rationale/Flowdown: ISIS-284, and GIS (Ref. 5)

ID: L5-INSTSW-6

3.2 Peripheral MISC Flight Software Requirements

Context: The LET1, LET2, and HET MISCs are the peripheral MISCs that control the LET1, LET2, and HET sensors. These sensors are similar in operation, and will use very similar software code, with somewhat different command tables and other input parameters. Specifically, each peripheral MISC controls the following hardware modules:

- Several PHASICs (Pulse Height Analysis Application Specific Integrated Circuit), from which the science data are acquired.
- Several housekeeping data acquisition modules
- Data and command interfaces with the DPU

Context: Bias voltage supply and operational heaters will be controlled by the DPU.

Context: In addition, each peripheral MISC will perform the data processing required to analyze the science data and prepare the science data for telemetry.

3.2.1 Initialization Behavior Requirements

Each of the peripheral MISCs shall boot via the serial link from the DPU upon power on or reset, using the protocols defined in the Instrument Flight Software Design Document (Ref. 7).

Context: The peripheral MISCs are not equipped with MRAM, and must boot via the serial link from the DPU. A small boot program burned into the MISC FPGA manages the reception of boot-code from the DPU.

Rationale/Flowdown: This requirement is self-imposed.

ID: L5-INSTSW-10

During the boot process, each peripheral MISC FSW shall calculate a checksum on the boot code, and include the value in its telemetered data.

Context: Allows the DPU and ground personnel to verify the integrity of the boot code.

Rationale/Flowdown: This is a self-imposed code-integrity requirement – best practices. Also, ISIS-380.

ID: L5-INSTSW-11

After the boot process, each peripheral MISC FSW shall configure the electronics under its control into a safe default state, and wait for further commands.

Context: The default state will be defined in tables loaded into SRAM during the boot process. Commands to enter an operational science mode may come either from the ground, or from an autonomous sequence running in the DPU. In normal operation, the DPU will monitor information contained in the S/C time and status message to determine the appropriate operating mode, and will command the peripheral MISCs accordingly.

Rationale/Flowdown: This is a self-imposed safety requirement – best practices.

ID: L5-INSTSW-12

3.2.2 Inter-MISC Communication Requirements

Each peripheral MISC FSW shall communicate with the DPU using the inter-MISC serial interfaces, using protocols specified in the Instrument Flight Software Design Document (Ref. 7).

Context: Each of the peripheral MISCs will have two serial interfaces to communicate with the DPU MISC. The first interface will be bi-directional, for transferring boot-code, commands, and command responses. The second interface will be uni-directional, for transferring data from the peripheral MISCs to the DPU MISC.

Rationale/Flowdown: This requirement is self-imposed.

ID: L5-INSTSW-20

Each peripheral MISC FSW shall format all telemetry data into the formats specified by the ~~Science~~ Data Format Document (Ref 8)

Context: The Data Format Document describes both science and HK CCSDS packet data formats, and also the format of data transferred between the peripheral MISCs and the DPU. All CCSDS packet formatting will actually be performed by the DPU, not the peripheral MISCs.

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Rationale/Flowdown: Self-imposed.

ID: L5-INSTSW-21

Each peripheral MISC FSW shall sample the analog rates, particle event data, and other housekeeping data items defined in the Science Data Format Doc, and forward these data to the DPU at the rates specified by the Science Data Format Document.

Rationale/Flowdown: Self-imposed.

ID: L5-INSTSW-22

3.2.3 Time Synchronization Requirements

The peripheral MISC clocks shall be synchronized to within ±2 msec (3σ), relative to the DPU clock.

Context: The DPU clock is required to limit its internal instrument timing uncertainty to ±2 msec (3σ) relative to the most recently received spacecraft time reference. We are flowing this requirement down to the peripheral MISCs for timing consistency. The DPU will provide a once-per-second timing reference to the peripheral MISCs to facilitate this requirement.

Rationale/Flowdown: See L4-ISIS-230

ID: L5-INSTSW-30

If the once-per-second timing reference from the DPU is not being received, each peripheral MISC shall generate a once-per-second pulse internally, and indicate in HK telemetry data that the once-per-second pulse is not being received.

Context: Allows the peripheral MISCs to function independently of the DPU. This is useful for test purposes.

Rationale/Flowdown: This is a self-imposed requirement. Also ISIS-380.

ID: L5-INSTSW-31

Each peripheral MISC shall assign a time-tag to each telemetered event with accuracy such that it shall be possible in ground processing to determine the rate-period during which the event occurred, without ambiguity.

Context: Assuming (for this discussion) that the highest-cadence rate data is 1 second, then the time-tag for each telemetered event shall be accurate enough to determine the second during which the event occurred, with no ambiguity.

The time-tagging of events is in fact extremely precise (milliseconds). This requirement has been included to remind us to properly book-keep events that are acquired close in time to rate-period accumulation time-boundaries. We have solved this issue for previous missions, and just need to carry over the proper procedures to this current mission.

Rationale/Flowdown: This is a self-imposed requirement.

ID: L5-INSTSW-32

3.2.4 Housekeeping Telemetry Requirements

Each peripheral MISC FSW shall collect housekeeping and status data assigned to that MISC, and forward the data to the DPU.

Context: The housekeeping and status data include:

- MISC analog data (voltages, currents, temperatures, rates)
- MISC Status data (contents of command, status, and configuration tables)

Rationale/Flowdown: This requirement is self-imposed, to enable monitoring of instrument status on the ground.

ID: L5-INSTSW-40

3.2.5 Fault Protection Behavior and Autonomy Requirements

General note: The software shall be robust in handling errors or failures. It is not expected that automatic onboard correction of error conditions will be implemented, but whenever possible (consistent with instrument safety) the system shall remain in an operational state following an error, to facilitate error diagnosis. Error conditions will be flagged in the science telemetry.

Upon power-up/reset, the peripheral MISCS shall initialize into a safe state, and wait for boot code from the DPU.

Context: Rationale/Flowdown: This requirement is self-imposed. – best practices.

ID: L5-INSTSW-50

All errors detected by the FSW in each peripheral MISC shall be communicated via telemetry to the DPU.

Context: This is generally achieved via housekeeping telemetry.

Rationale/Flowdown: ISIS-380

ID: L5-INSTSW-51

Each peripheral MISC FSW shall transfer a copy of its command table to the DPU at a regular cadence. The cadence shall be commandable.

Context: This is generally achieved via housekeeping telemetry. The DPU shall store these command table copies in MRAM for use in autonomously reconfiguring the MISCs after a reset (see L5-INSTSW-93 and L5-INSTSW-165).

Rationale/Flowdown: This capability is required to support autonomous reconfiguration into a known operational state after power-on/reset. See L4-ISIS-284

ID: L5-INSTSW-52

Each peripheral MISC FSW shall telemeter a once-per-second "heartbeat" message to the DPU, when in a nominal operating mode.

Context: The DPU will monitor heart beat from each peripheral MISC. The actions to be taken by the DPU if a heartbeat stops will be described in the Instrument Flight Software Design Document (Ref. 7). The likely action is a SRAM dump and a reboot.

Rationale/Flowdown: This capability is required to support autonomous reboot into a known operational state after a fault. See L4-ISIS-284

ID: L5-INSTSW-53

Each peripheral MISC shall support a watchdog timer system that will reset the MISC if the main program fails to service the watchdog interrupt. The reset shall stop the normal once-per-second "heartbeat" message to the DPU.

Context: The actions to be taken by the DPU after a peripheral MISC resets due to a watchdog timer exception will be described in the Instrument Flight Software Design Document (Ref. 7).

Rationale/Flowdown: This requirement is self-imposed.

ID: L5-INSTSW-54

Each peripheral MISC FSW shall monitor the detector electronics temperatures at a commandable cadence.

Context: Allows for autonomous compensation for small temperature-dependent gain and offset effects in on-board particle analysis algorithms.

Rationale/Flowdown: This capability is required to support autonomous accurate science data acquisition over a wide range of operating temperatures. This is a self-imposed requirement.

ID: L5-INSTSW-55

Each peripheral MISC FSW shall monitor several key counting rates at a commandable cadence.

Context: Allows for autonomous adjustment of flight software operating mode to optimize data quality over a wide range of particle intensity environments. The specific rates to monitor will be defined in the Instrument Flight Software Design Document (Ref. 7).

Rationale/Flowdown: This capability is required to support autonomous operation over a wide range of particle intensity environments. See L4-ISIS-213, L4-ISIS-215

ID: L5-INSTSW-56

3.2.6 Science Data Collection and Analysis Requirements

Context: Each energetic ion or electron that impinges on one of the EPI-Hi sensors (LET1, LET2 or HET) and satisfies the detector coincidence requirements generates an "event". The telemetry bandwidth allocated to EPI-Hi is inadequate to telemeter all of the data for all of the events recorded by the sensors. The objective of the onboard event processing performed by each of the peripheral MISCs will be to analyze each event to determine the species and energy of the particle that generated the event, and to maintain tables of species/energy counters that will record the rates of different categories of events. The rate data will be the main telemetered data product, along with a prioritized subset of the event data (for diagnostic purposes).

Each peripheral MISC FSW shall acquire science event data from the front-end electronics (the PHASICs) in each EPI-Hi Sensor.

Context: Event control logic on the FPGA will interrupt the MISC processor (also embedded in the FPGA) and the flight software when event data are ready to be read into memory.

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-60

Each peripheral MISC FSW shall, at regular intervals, acquire singles and other rate-counter data from registers in the front-end electronics in each EPI-Hi Sensor.

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-74

Each Peripheral MISC FSW shall configure, and periodically refresh, the settings of the front end electronics in each EPI-Hi sensor per the contents of the command table.

Context: Modes, thresholds, and other settings, are under MISC FSW control. These modes and settings are changeable by command, and the current modes/settings are contained in the command table maintained by each peripheral MISC FSW.

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-61

Each peripheral MISC FSW shall be capable of identifying and determining the energy of protons and electrons at a rate of at least [1000] events/second.

Context: Required to meet science statistical accuracy requirements.

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-62

Each peripheral MISC FSW shall be capable of identifying and measuring the energy of Z>1 events at a rate of at least [800] events/second.

Context: Required to meet science statistical accuracy requirements.

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-63

Each peripheral MISC FSW shall perform isotopic mass determination of events identified as helium or neon at a rate of at least [300] events/second.

Context: Required to meet science statistical accuracy requirements.

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-64

The LET and HET FSW together shall measure the energy of electron events from [0.5] to [6] MeV and bin the measured energies into at least 6 bins per decade.

Context: Required to meet L4 electron energy-range requirements.

Rationale/Flowdown: ISIS-200, ISIS-201

ID: L5-INSTSW-65

The HET FSW together shall measure the angular distribution of electrons, using sectors of width ≤ 45°.

Context: Required to meet L4 electron angular distribution requirements. HET is the primary sensor providing electron angular distributions. Electron measurements with the LET1 sensor will have only front-back sector information because electron signals in the thin front detectors will be below threshold, and LET2 is a single-ended telescope.

Rationale/Flowdown: ISIS-205

ID: L5-INSTSW-66

The LET and HET FSW together shall perform ion charge determination with accuracy high enough to separate at least the elements H, He, C, O, Ne, Mg, Si, and Fe, over the energy range [1] – 100 MeV/nucleon.

Context: Required to meet L4 ion composition and energy-range requirements. For purposes of meeting this requirement, the full-width-at-half-maximum (FWHM) charge (Z) resolution for each element in this list shall be ≤ 0.5 times the charge separation from the nearest neighbor element in the list.

Rationale/Flowdown: ISIS-211, ISIS-206

ID: L5-INSTSW-67

The LET and HET FSW together shall measure the 3He/4He ratio in at least one decade in energy above [1] MeV/nucleon and resolve 4He with a FWHM mass resolution ≤ 0.5 AMU.

Context: Required to meet L4 3He/4He ratio measurement requirements. Analysis of helium isotopes will be restricted to the central region of the view cone of each telescope where the variation of particle path-length through the detectors will be small enough to not compromise mass resolution.

Rationale/Flowdown: ISIS-212

ID: L5-INSTSW-68

The LET and HET FSW together shall, for each ion species identified, bin the measured energies into at least 6 bins per decade.

Context: Required to meet L4 ion energy resolution requirements.

Rationale/Flowdown: ISIS-207

ID: L5-INSTSW-69

The LET and HET FSW together shall measure the angular distribution of protons and heavy ions, using sectors of width ≤ 30°.

Context: Required to meet L4 ion angular distribution requirements.

Rationale/Flowdown: ISIS-210

ID: L5-INSTSW-70

Each peripheral MISC FSW shall provide the capability to accumulate the count of events identified in each of the species, energy, and angular look-direction bins defined for that sensor.

Context: Required to meet L4 electron/ion measurement cadence and cadence selection requirements.

Rationale/Flowdown: ISIS-203,204,208,209

ID: L5-INSTSW-71

Each peripheral MISC FSW shall provide the capability to report in telemetry the count rate of events identified in each of the species, energy, and angular look-direction bins defined for that sensor, at several cadences ranging from 1second to 1 day.

Context: Required to meet L4 electron/ion measurement cadence and cadence selection requirements.

Rationale/Flowdown: ISIS-203,204,208,209

ID: L5-INSTSW-72

Each peripheral MISC FSW shall provide the capability to dynamically and autonomously adjust selected detector thresholds, in order to reduce saturation and background during times of high particle intensity.

Context: Required to meet L4 electron/ion count rate requirements

Rationale/Flowdown: ISIS-213, 215

ID: L5-INSTSW-73

3.2.7 Instrument Live Time Telemetry Requirements

Each peripheral MISC FSW shall sample the instrument live time as determined by the electronics and record it in the data stream on [1] second intervals.

Context: The instrument livetime is the fraction of time that the instrument is ready to record an incoming event.

Rationale/Flowdown: Self-imposed – required to convert count rates to particle intensities.

ID: L5-INSTSW-80

3.3 DPU MISC Flight Software Requirements

Context: The DPU MISC serves as the instrument controller. It provides the interface to the spacecraft bus and controls the peripheral MISCs.

3.3.1 Initialization Requirements

Context: Included in the FPGA implementation of each MISC is a small PROM program that boots the system either directly via MRAM, or over the serial link. The peripheral MISCs in the system always boot over the serial link with the DPU. For EPI-Hi, the DPU MISC is equipped with 2M×8 of MRAM. The other MISCs in the system always boot over the serial link with the DPU. The MRAM in the DPU can be updated via the command interface, initiated by a command that specifies page number, followed by fixed length binary data block. The protocols and formats for MRAM uploads are the same as for Caltech's NuSTAR instrument, and will be documented in the EPI-Hi Commanding and User Manual (Ref. 10). MRAM uploads will utilize the instrument commanding interface described in the SPP GIS (Ref. 5).

Upon power-on/reset, t~~T~~he DPU shall be capable of autonomously booting either from one of several code images contained in the MRAM, or via a code image~~program~~ loaded over the serial command link from the spacecraft.

Context: Allows for a backup means of booting the DPU in case of MRAM failure of corruption of one of the MRAM code images. The details of the DPU boot sequence will be described in the Flight Software Design Doc (Ref. 7).

Rationale/Flowdown: Self-imposed.

ID: L5-INSTSW-90

The DPU shall support a "reboot" command from the ground that contains parameters that control the operation of the PROM boot loader.

Context: Allows for control of the DPU boot sequence, including MRAM/serial-link booting, specifying which pages of MRAM to boot from, etc. The details of the DPU boot sequence will be described in the Flight Software Design Doc (Ref. 7).

Rationale/Flowdown: Self-imposed.

ID: L5-INSTSW-91

After booting, the DPU shall autonomously reconfigure its operational state, based on information received in the spacecraft ITF, in accordance with the SPP General Instrument Specification (GIS) (Ref. 5).

Context: Required to support autonomous recovery to an operational mode from power-on or reset.

Rationale/Flowdown: ISIS-284, and the GIS.

ID: L5-INSTSW-92

Following a successful boot and reconfiguration to an operational state, the DPU shall reset and reload the peripheral MISCs to an appropriate operational state, based on information received in the spacecraft ITF, in accordance with the SPP General Instrument Specification (GIS) (Ref. 5).

Context: Required to support autonomous recovery to an operational mode from power-on or reset.

Rationale/Flowdown: ISIS-284, and the GIS (Ref. 5).

ID: L5-INSTSW-93

3.3.2 Spacecraft Interface Requirements

The DPU MISC FSW shall comply with the Command and Data Handling Interface Requirements specified in the ~~communicate with the Spacecraft using the serial interfaces and protocols specified in the~~ GIS (Ref. 5).

Context:

Rationale/Flowdown: We must comply with the GIS…

ID: L5-INSTSW-100

3.3.3 Software Upload Requirements

The DPU MISC FSW shall be capable of receiving a new FSW upload and writing that upload to the DPU MRAM.

Context: Capability is needed to change flight software on-orbit during commissioning period or to correct software bugs. The protocols for preparing and uploading new FSW will be documented in the Commanding and User Manual (Ref. 10).

Rationale/Flowdown: ISIS-225

ID: L5-INSTSW-110

The DPU MISC FSW shall be capable of receiving a FSW patch and appending that patch to a section of the DPU MRAM dedicated to storage of software patches.

Context: Required to support autonomous reconfiguration to a known operational state across power-cycles and resets.

Rationale/Flowdown: ISIS-284, and the GIS (Ref. 5).

ID: L5-INSTSW-111

3.3.4 DPU Thermal Control Requirements

The DPU MISC FSW shall provide active temperature control of the operational heaters connected to the DPU.

Context:

Rationale/Flowdown: Self-imposed.

ID: L5-INSTSW-120

All Instrument FSW closed loop heater logic shall have at a minimum the ability to change the Temperature set point parameter(s) in flight, in response to a ground command

Rationale/Flowdown: Self imposed

ID: L5-INSTSW-121

All Instrument FSW closed loop heater logic shall be capable of being disabled in flight.

Rationale/Flowdown: Self imposed

ID: L5-INSTSW-122

3.3.5 Science and Housekeeping Data Collection & Control Requirements

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The DPU MISC FSW shall accept science and housekeeping data blocks from the peripheral MISCs, in accordance with the protocols described in the Data Format Document (Ref. 8)

Context:

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-130

The DPU MISC FSW shall format all data to be telemetered (science and housekeeping data, command responses, SMRAM dumps, etc.) into CCSDS packets, in accordance with the Data Format Document (Ref. 8)

Context: The Data Format Document describes both science and HK CCSDS packet data formats, and also the format of data transferred between the peripheral MISCs and the DPU. All CCSDS packet formatting will actually be performed by the DPU, not the peripheral MISCs.

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Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-131

The DPU MISC FSW shall encapsulate all CCSDS packets into ITFs and forward them to the Spacecraft in accordance with the GIS (Ref. 5)

Context:

Rationale/Flowdown: We must comply with the GIS.

ID: L5-INSTSW-132

The DPU MISC FSW shall time-tag all data and command-response packets transferred to the spacecraft to an accuracy of ±1 second (3σ), relative to the S/C clock.

Context: We need to be sure that the instrument and S/C clocks do not have a “one second off” error.

Rationale/Flowdown: GIS (Ref. 5)

ID: L5-INSTSW-133

During encounters, the DPU MISC FSW shall manage the volume of EPI-Hi instrument data telemetered to the Spacecraft as a function of time, based on the Solid-State-Recorder “fill-level” information in the Spacecraft status message, and the time-length of the current encounter. The algorithm to be used by the DPU to perform this management function shall be described in the Data Format Document (Ref. 8)

Context: The volume of data written by EPI-Hi to the spacecraft as a function of time must be managed so that we do not run out of SSR space before the end of the encounter.

Rationale/Flowdown: Self-imposed.

ID: L5-INSTSW-134

3.3.6 Bias ~~and~~Supply Control Requirements

The DPU MISC FSW shall provide active control of the programmable Bias Supply.

Context:

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-140

Settings for the Bias Supply shall be maintained in tables that can be modified by ground command.

Context:

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-141

3.3.7 Time synchronization Requirements

The DPU MISC FSW shall limit its internal timing uncertainty to ±2 msec (3σ) relative to the most recently received spacecraft time reference.

Context: Will be done using a 1 pulse per second signal from the spacecraft, see the GIS (Ref. 5)

Rationale/Flowdown: L4-ISIS-230

ID: L5-INSTSW-150

If the once-per-second S/C status message is not being received, the DPU MISC FSW shall generate a once-per-second pulse internally, fan this internally-generated pulse out to the peripheral MISCs, and indicate in HK telemetry that the S/C status message is not being received.

Context: Allows the instrument to function independently of the spacecraft. This is useful for test purposes.

Rationale/Flowdown: This is a self-imposed requirement

ID: L5-INSTSW-151

The DPU MISC FSW shall be capable of accepting, at any time, a time update command from the ground to update the DPU clock.

Context: Allows the instrument clock to be set when the once-per-second S/C status message is not being received. This is useful for test purposes.

Rationale/Flowdown: This is a self-imposed requirement

ID: L5-INSTSW-152

3.3.8 Instrument Command Processing Requirements

The DPU MISC FSW shall be capable of processing and responding to all commands and time-keeping messages received through the spacecraft interface.

Context:

Note: the DPU MISC FSW is a bent-pipe for Commands addressed to the peripheral MISCs.

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-160

The DPU FSW shall be capable of entering a safe state for powering down, within the period of time specified in the GIS (Ref. 5), upon receipt of a spacecraft-provided bit in the spacecraft status message to request that the instrument put itself in a safe state for power down.

Rationale/Flowdown: GIS (Ref. 5)

ID: L5-INSTSW-161

3.3.9 Peripheral MISC Control and Communications Requirements

Each DPU MISC FSW shall communicate with the peripheral MISCs using the inter-MISC serial interfaces, using protocols specified in the Instrument Flight Software Design Document (Ref. 7).

Context: Each of the peripheral MISCs will have two serial interfaces to communicate with the DPU MISC. The first interface will be bi-directional, for transferring boot-code, commands, and command responses. The second interface will be uni-directional, for transferring data from the peripheral MISCs to the DPU MISC.

Rationale/Flowdown: Self-imposed.

ID: L5-INSTSW-162

The DPU MISC FSW shall route commands to each peripheral MISC via the inter-MISC serial interface.

Context:

Rationale/Flowdown: Self-imposed.

ID: L5-INSTSW-163

The DPU MISC FSW shall accept command responses from each individual MISC via the inter-MISC serial interface.

Context:

Rationale/Flowdown: Self-imposed

ID: L5-INSTSW-164

The DPU shall store in MRAM the command table copies received from each peripheral MISC for use in autonomously reconfiguring the MISCs after a reset.

Context: Required to support autonomous recovery to an operational mode from power-on or reset. See L5-INSTSW-52.

Rationale/Flowdown: ISIS-284, and the GIS (Ref. 5).

ID: L5-INSTSW-165

4 Acronym List

CCSDS	Consultative Committee for Space Data Systems
DPU	Data Processing Unit
EPI-Hi	ISIS High Energy Particle Detector
FPGA	Field Programmable Gate Array
FSW	Flight Software
FWHM	Full Width at Half Maximum
GIS	General Instrument Specification
HET	High Energy Telescope
HK	HouseKeeping
I&T	Integration and Test
ICD	Interface Control Document
ISIS	Integrated Science Investigation of the Sun
ITF	Instrument Transfer Frame
LET	Low Energy Telescope

MET	Mission Elapsed Time
MISC	Minimal Instruction Set Computer
MRAM	Magnetoresistive Random Access Memory
OS	Operating System
PHA	Pulse Height Analyzer
PHASIC	Pulse Height Analysis System Integrated Circuit
RAM	Random Access Memory
SRAM	Static Random Access Memory
SPP	Solar Probe Plus
SSR	Solid State Recorder