DOCUMENT TYPE: Requirements Specification

TITLE:

DEBIE DPU SW
Software Requirements Document

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DOCUMENT STATUS SHEET

	Date	Modified pages or sections	Reason for change / Comments
1.0	11.5.1998	All	First Issue.
1.1	15.9.1998	1.3	Corrected the document reference number of the [AD1] and added [AD4].
		1.1	Added explanation about requirements that will be implemented in Prototype SW and that will not.
		1.5	Deleted FIFO and added EGSE, LSB, MSB, TC and TM
		Chapters 3 - 7	Requirements updated, see change bars
1.2	4.2.1999	1.1	This issue presents both Proto SW and Flight SW requirements
		1.2	Chapter 3 is splitted to two chapters.
		1.4	Added Sofware User Manual, RTX user manual and 8051 reference manual to reference documents.
		1.5	Added ADC, PROM, RTX, us, ms
		2.5	Added new section
		2.6	Added desciption of the requirement format
		Chapters 3 - 8	Requirements updated, see change bars Main changes: - Each requirement given a brief name - Updates for new applicable document versions - TC response requirements centralised - Terms and definitions from section 2.5 are used
1.3	21.2.2000		Updates for new issues of applicable documents: Requirements Spec., DEB-FIN-RS-001, Issue 2B; TM/TC ICD, DEB-FIN-IC-001, Issue 1D; HW/SW ICD, DEB-FIN-IC-002, Issue 2C. Some updates due to implementation choices. Change bars have been generated with the Frame-Maker Document Comparison utility. Note that changes in tables are not always shown in detail. Changes in the Input/Output tables are consequences of changes in the requirements and are not listed below. Some change bars correspond to editorial corrections (typo and grammar corrections) which are not listed below.

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	Date	Modified pages or sections	Reason for change / Comments
		2.5.4	Deleted bullet for “TC_ResponseFlag”; this variable no longer exists.
		4.3.1: SWR-GEN-00010 SWR-GEN-00020 SWR-GEN-00030 SWR-GEN-00040	Deleted unimplemented requirements on RTX Error Handling and updated the implemented requirements. Errors reported by RTX are recorded in telemetry, but no other action is taken.
		4.3.3: SWR-GEN-01100 SWR-GEN-01110	There are no longer separate Digital and Analog Supply Error bits, but a joint Supply Error bit.
		4.3.3: SWR-GEN-01200	Added note on the timing of the Memory (SRAM) Test.
		4.3.3: SWR-GEN-01400	Corrected typo in requirement identifier and ordering.
		4.3.4: SWR-GEN-13000	Requirement changed: Science TM requests shall be ignored (not even an error response given) in DPU Self Test. This is because the TC/TM function is inactive for most of the DPU Self Test (SRAM test).
		4.3.4: SWR-GEN-14000	Removed TBC; no telemetry is possible during SRAM test because the TC/TM function is inactive.
		4.3.7: SWR-GEN-40210 SWR-GEN-40220 SWR-GEN-41000 SWR-GEN-41010 SWR-GEN-41120	SU Self Test requirements updated to comply with the new HW/SW ICD.
		4.4: SWR-GEN-52000	ADC settling times updated to comply with the new HW/SW ICD.
		5.3.9: SWR-TCTM-06110	This requirement applies only to a TC with valid parity.
		5.3.9: SWR-TCTM-06150	Added note that the effect of the Error Status Clear TC is delayed.
		5.3.13: SWR-TCTM-17000	Updated note. The error bits are cleared when the TC is executed, not when it is checked.
		5.3.15: SWR-TCTM-19030	Added requirement to check the “execution command” of a Write Memory TC.

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	Date	Modified pages or sections	Reason for change / Comments
		7.3: SWR-ACQ-03000	Updated requirement and removed TBD.
		7.4: SWR-ACQ-90000 SWR-ACQ-90100	Delays updated for new HW/SW ICD.
		8.7: SWR-NONF-30000 SWR-NONF-31000 SWR-NONF-32000	Removed TBD/TBC on memory margins, replaced by note that margins were not specified.

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1 Introduction

1.1 Scope

This document contains the software requirements for the DEBIE DPU Software.

The DEBIE DPU software runs on an 80C32 processor in the DEBIE Data Processor Unit (the DPU). The software configures the DEBIE Sensor Units, records impact events and transmits the records to the spacecraft main computer. The software is controlled by telecommands issued from the spacecraft main computer.

The software also monitors the health of the DEBIE instrument and shuts down failed Sensor Units.

There are two kinds of requirements: those that will be implemented in the Prototype SW and those that will not. Requirements that will be implemented in the Prototype SW concern configuring the DEBIE HW, housekeeping measurements and telemetry, performing particle hit measurements for one hit, storing one event record and sending it into telemetry. For example memory patching, memory reading, memory checksum calculations, event classification and buffering several event records will not be implemented in the Prototype SW.

The requirements that will be implemented in the Prototype SW are marked with the following text:

Following requirement is implemented in Prototype SW

This issue presents both the Prototype SW and Flight SW requirements.

Many requirements are deleted, because they were obsolete or redundant with some other requirement. Some are replaced with some more general definition or requirement or with reference to some interface control document.

1.2 Overview

Chapter 2 shows the general description of the software.

Chapter 3 defines the general requirements.

Chapter 4 defines the general functional requirements.

Chapter 5 defines the Telecommand and Telemetry requirements.

Chapter 6 defines the Health Monitoring requirements

Chapter 7 defines the Acquisition Function requirements.

Chapter 8 defines the non-functional requirements.

1.3 Applicable Documents

[AD1] DEBIE Requirements Specification, DEB-FIN-RS-001

[AD2] DEBIE TM/TC Interface Control Document, DEB-FIN-IC-001

[AD3] DEBIE HW/SW Interface Control Document, DEB-FIN-IC-002

[AD4] DEBIE DPU SW Design and Coding Standard, DEB-SSF-ST-001

From these the [AD1] is the principal source for the software requirements and [AD2] and [AD3] are used to define aspects that are not described in the [AD1] concerning Telecommands, Telemetry and HW/SW interface. If same requirement is defined in several places the [AD1] is used as a reference.

1.4 Reference Documents

[RD1] DEBIE Software Development Plan, DEB-SSF-PL-001

[RD2] DEBIE DPU SW User Manual, DEB-SSF-MA-001

[RD3] RTX-51/RTX-251 User's Guide 05.96
Keil Elektronik GmbH

[RD4] 8-bit Embedded Controllers 1990
Intel Corporation

1.5 Definitions, Acronyms and Abbreviations

ADC	Analog to Digital Converter
DEBIE	Debris in Orbit Evaluator
Byte	Octet, datum of 8 bits
DPU	Data Processing Unit
EGSE	Electrical Ground Support Environment
HK_Buff	See Table 1 on page 4
HW	Hardware
LSB	Least Significant Byte
ms	millisecond
MSB	Most Significant Byte
OP_Buff	See Table 1 on page 4
PROM	Programmable Read Only Memory
PZT	Piezoelectric Transducer
RTU	Remote Terminal Unit
RTX	Real-Time multitasking eXecutive

SC_Buff	See Table 1 on page 4
SWR	Software Requirement
SRD	Software Requirements Document
SSF	Space Systems Finland Ltd.
SU	Sensor Unit
TBA	To Be Added
TBC	To Be Confirmed
TBD	To Be Defined
TC	TeleCommand
TM	TeleMetry
us	microsecond

2 General Description

2.1 Function and Purpose

The main purpose of the software is to detect, measure and classify the incoming particle hits from the space debris. These particle hit measurements will be sent to the spacecraft on request. The software will also monitor the temperatures and the secondary voltages of the Sensor Units and switch off any faulty units.

2.2 Relations to Other Systems

The relations of the DEBIE DPU Software to the hardware and the EGSE are described in the DEBIE Software Development Plan [RD1].

2.3 General Constraints

The main part of the software will be written with portable C code, which can be compiled both with a native workstation compiler and a 8051 cross-compiler. The 8051 specific code will be isolated in the hardware specific part of the software. Assembler will be used only in this hardware specific part of the software. This partition of the software is described in the DEBIE Software Development Plan [RD1].

2.4 Sources and Destinations

The source and destination codes used in the following input and output tables are the following:

Table 1: Source and Destination Codes

Code	Desciription
HK_Buff	Housekeeping telemetry buffer
HW	DEBIE hardware
OP_Buff	Operational telemetry buffer
Processor	80C32 microprocessor of the DEBIE
RAM	DEBIE RAM memory
RAM / ROM	DEBIE RAM and/or ROM
ROM	DEBIE ROM memory
SC_Buff	Science telemetry buffer
SW_Internal	SW internal status or data

2.5 Terms and Definitions

In this section we will define concepts and terms necessary to define software requirements.

2.5.1 Bit Numbering

Bits in bytes, words etc. are numbered starting from zero which corresponds to the least significant bit.

2.5.2 DPU Reset Classification

The DEBIE DPU can be reset in the following ways:

- HW Resets: software execution restarts from code address zero. This can have two causes which can be separated by reading Watchdog Status (see [AD3]).
    - Power-up reset happens when DPU power is switched On.
    - Watchdog reset happens when the Watchdog Counter is not reset frequently enough.
- SW Resets: software execution restarts itself in response to telecommand or software detected failure. The following types of software resets exist.
    - SoftReset is executed in response to SoftReset telecommand, Write Program Memory telecommands (if execution command requires it).
    - WarmReset is executed in response to Write Program Memory telecommands (if execution command requires it).
    - ChecksumReset is executed when the software detects a checksum error in the program memory.

Unless otherwise specified requirement to initialize a variable applies to all types of DPU resets.

2.5.3 Boot Sequence

Every reset causes execution of the Boot Sequence. Actions performed during it depends on the type of the reset.

2.5.4 Telecommand Processing Phases

The processing of the telecommands depends on the following factors:

- Elapsed time from the previous telecommand
- State of the Telecommand Execution Task (TC_State)
- Format of the Telecommand (TC_Address, TC_Code and TC_P)
- DEBIE mode
- Sensor Unit States

The steps in the telecommand processing are:

1. TC interrupt reception
2. TC interval check
3. TC state check
4. TC format check
5. TC execution

There are some special telecommands which are handled differently.

States of the telecommands are:

- received: telecommand has passed TC interval check
- discarded: telecommand has failed TC interval check.
- accepted: telecommand has passed the TC format check
- rejected: telelecommand has failed TC format check
- refused: telecommand format has been accepted but execution has been refused due to context (for example wrong DEBIE mode or SU state)

2.5.5 Telemetry Block Transmission

Telemetry block is a sequence of 16 bit words. Transmitting the telemetry block means writing the the words belonging to the sequence to the telemetry transmit HW registers one by one, and waiting for the TM interrupt after each word before writing the next one.

The transmission of the block is complete, when the TM interrupt for the last word of the sequence is received.

2.5.6 Status Register Telemetry Block

The Status Register Telemetry block is an infinite sequence of 16-bit words containing consecutive DEBIE TM Status registers starting from some even numbered register defined by Send Status Register telecommand. Each word contains a pair of registers with the even numbered register in the MSB and the odd numbered in the LSB. The word containing the last two registers is followed by a word containing the first two registers.

The Status Register Telemetry block is transmitted as any other telemetry block except that it is never completely transmitted.

2.5.7 Event Processing States

The states of the Event Processing are the following:

- signalled: Hit Trigger interrupt is received
- accepted: DEBIE mode and/or state of the responsible Sensor Unit is acceptable.
- rejected: signalled, but not accepted Event.
- measured: event measurements are performed
- stored: event measurement results are stored in the Science Data memory

2.6 Format of Requirements

The software requirements are presented in the following format:

Name of the requirement **Requirement Id**

Description of the requirement.

Comment related to the requirement - not part of the actual requirement.

3 General Requirements

3.1 User Interface

User interface exists only via the Telecommand and Telemetry interface and that is defined in the Chapter 5.

4 General Functional Requirements

4.1 Inputs

Inputs for this function are the following:

Table 2: General Requirements Inputs

Mnemonic	Description	Source	Unit	Range
HV_Status	SU high voltage status	HW	[AD3]	[AD3]
HW_DPU_V	Supply voltage (+5V) of the DPU	HW	[AD3]	[AD3]
HW_SU_Ti	Temperature of Sensor Unit i	HW	[AD3]	[AD3]
HW_SU_Vi	Supply voltage of Sensor Unit i	HW	[AD3]	[AD3]
Mode	DEBIE mode	SW_Internal	Mode enum	DPU Self Test, Standby, Acquisition
SU_State	Sensor Unit State	SW_Internal	SU_State enum	Off, StartSwitching, Switching, On, SelfTest, Acquisition
V_Down	+-5V voltage status	HW	bit	0, 1
WD_ST	Watchdog failure status	HW	bit	0, 1

4.2 Outputs

Outputs from this function are the following:

Table 3: General Requirements Outputs

Mnemonic	Description	Destination	Unit	Range
ChecksumFailures	Checksum failure counter	OP_Buff	One failure	0 .. 255
ComStatusReg	Command Status Register	OP_Buff	[AD2]	[AD2]
DPU_V	Supply voltage (+5V) of the DPU	HK_Buff	[AD2]	[AD2]
ErrorReg	Error Status Register	OP_Buff	[AD2]	[AD2]
HitIT	Particle Hit interrupt request	HW	NA	NA

Table 3: General Requirements Outputs

Mnemonic	Description	Destination	Unit	Range
HW_SU_ON_OFFi	On/Off power status of Sensor Unit i	HW	[AD3]	[AD3]
Mode	DEBIE mode	SW_Internal	Mode enum	DPU Self Test, Standby, Acquisition
ModeReg	Mode Status Register	OP_Buff	[AD2]	[AD2]
ScienceData	Science data (Event Class Counters and Event Records)	SC_Buff	[AD2]	[AD2]
SelfTestSU	Sensor Unit to which Self Test is being performed (0 means none).	SW_Internal	SU number	0 / 1 .. 4
SU_State	Sensor Unit State	SW_Internal	SU_State enum	Off, StartSwitching, Switching, On, SelfTest, Acquisition
SU_Status	SU Status Register	HK_Buff	[AD2]	[AD2]
SU_Ti	Temperature of Sensor Unit i	HK_Buff	[AD2]	[AD2]
SU_Vi	Supply voltage of Sensor Unit i	HK_Buff	[AD2]	[AD2]
WatchdogFailures	Watchdog failure counter	OP_Buff	One Failure	0 .. 255

4.3 Functional Requirements

4.3.1 RTX Error Handling

Fatal RTX errors **SWR-GEN-00010**

DELETED

Non fatal RTX errors **SWR-GEN-00020**

When an RTX system call returns an error, the corresponding error indicator shall be set without performing soft reset.

See error bit locations from the TM/TC ICD [AD2].

Consecutive non fatal RTX errors **SWR-GEN-00030**

DELETED

Consecutive fatal RTX errors **SWR-GEN-00040**

DELETED

4.3.2 Boot Sequence

Program copy after reset **SWR-GEN-00100**

Upon a HW reset, SoftReset or ChecksumReset the program code shall be copied from PROM to RAM and the program execution shall be continued from the RAM.

See [AD3] for details about how the program code can be copied from PROM to RAM (memory mappings etc).

Incrementing Watchdog Failure conter after watchdog reset **SWR-GEN-00200**

Upon WatchdogReset the **WatchdogFailures** shall be incremented, if less than its maximum value.

Following requirement is implemented in Prototype SW

Clearing error registers after reset **SWR-GEN-00300**

Upon Power-up reset, SoftReset or WarmReset the **ErrorReg, ComStatusReg, ChecksumFailures** and **WatchdogFailures** shall be cleared.

ChecksumFailures and WatchdogFailures will not be implemented in the Prototype SW.

Reset triggered by checksum failure **SWR-GEN-00400**

Upon ChecksumReset the **ChecksumFailures** shall be incremented, if it is less than its maximum value.

Entering DPU Self Test after boot **SWR-GEN-00500**

After the boot sequence is completed, the DPU Self Test mode is entered.

4.3.3 DPU Self Test Sequence

DPU Self Test voltage measurement **SWR-GEN-01000**

In the DPU SelfTest the 5V supply voltage to DPU and +/- 5V voltage to SU 1/2 shall be measured.

Action for out-of limits DPU voltage **SWR-GEN-01100**

If the 5V DPU voltage is out-of limits, the Supply Error status bit shall be set in **ModeReg** .

Error in SU 1/2 +/-5V voltage **SWR-GEN-01110**

If the SU 1/2 +/-5V voltage is out of limits, the Supply Error bit in **ModeReg** shall be set.

Memory tests **SWR-GEN-01200**

In the DPU Self Test, the program (SRAM) and data memory shall be tested in the following way:
1. Simple walking 1/0 across the data bus in single location
2. Writing lsb of the address to each location
3. Writing the area with patterns 0x55 and 0xAA

This memory test is done immediately after the DPU is reset, before any other SW function (e.g. TC/TM) is activated, before PROM is copied to RAM, and before the supply voltage tests.

Error in program memory **SWR-GEN-01300**

If an error is found from program (SRAM) memory, the Program Memory Error bit in **ModeReg** shall be set and the program execution shall continue from PROM.

Error in data memory **SWR-GEN-01400**

If an error is found from data memory, the Data Memory Error bit in **ModeReg** shall be set.

Switch voltages one by one **SWR-GEN-02000**

DELETED

Minimum delay between switching On supply voltages. **SWR-GEN-02010**

DELETED

Maximum delay between switching On supply voltages **SWR-GEN-02020**

DELETED

Minimum delay between switch On and Calibration pulse **SWR-GEN-02100**

DELETED

Maximum delay between switch on and Calibration pulse **SWR-GEN-02110**

DELETED

Calibration pulse generation **SWR-GEN-03000**

DELETED

Calibration measurement usage **SWR-GEN-03100**

DELETED

4.3.4 DPU Self Test Mode

Transition to DPU Self Test mode after Reset **SWR-GEN-10000**

DELETED

Self Test Sequence in DPU Self Test mode **SWR-GEN-11000**

In the DPU Self Test mode DEBIE shall perform one DPU Self Test sequence.

Acquisition Function passive in DPU Self Test mode **SWR-GEN-12000**

The Acquisition Function shall be inhibited when the DPU Self Test mode is entered.

No science telemetry in DPU Self Test mode **SWR-GEN-13000**

Science data telemetry requests shall be ignored in DPU Self Test mode.

During Memory Test, the TC/TM function is not active (see SWR-GEN-01200). It is active during supply-voltage self-test, but this phase is very brief.

Telemetry in DPU Self Test mode **SWR-GEN-14000**

In the DPU Self Test mode DEBIE shall transmit the housekeeping and operational data to the spacecraft on request, except during SRAM test.

The TM/TC function is inactive during SRAM test (see SWR-GEN-01200).

Storing of DPU Self Test results **SWR-GEN-14100**

DPU Self Test results shall be stored into location defined in [AD2] for later telemetry.

Automatic transition from DPU Self Test to Standby **SWR-GEN-15000**

After completion of the software initialization and DPU Self Test sequence DEBIE shall automatically enter the Standby mode.

4.3.5 Standby Mode

Following requirement is implemented in Prototype SW

Telemetry in Standby **SWR-GEN-20000**

In the Standby mode DEBIE shall transmit the housekeeping, operational and science data to the spacecraft on request.

In the Prototype software the Health Monitoring task measures only Sensor Unit temperatures.

Following requirement is implemented in Prototype SW

Acquisition Function passive in Standby **SWR-GEN-21000**

The Acquisition Function shall be inhibited in the Standby mode.

Sensor Units off in Standby **SWR-GEN-22000**

DELETED

Following requirement is implemented in Prototype SW

Health Monitoring in Standby **SWR-GEN-23000**

The Health Monitoring Function shall be executed continuously in the Standby mode.

From the Standby mode DEBIE enters to Acquisition mode by specific telecommand (see corresponding telecommand). In the Prototype SW only SU temperatures are measured.

4.3.6 Acquisition Mode

Following requirement is implemented in Prototype SW

Acquisition Function in Acquistion mode **SWR-GEN-30000**

In the Acquisition mode DEBIE shall execute the Acquisition Function continuously.

SU voltage switching in Acquisition mode entry **SWR-GEN-31000**

DELETED

Monitor voltages in Acquisition mode entry **SWR-GEN-31100**

DELETED

Health Monitoring in Acquisition mode **SWR-GEN-32000**

The Health Monitoring Function shall be executed continuously in the Acquisition mode.

Following requirement is implemented in Prototype SW

Telemetry in Acquisition mode **SWR-GEN-33000**

In the Acquisition mode DEBIE shall transmit the housekeeping, operational and science data to the spacecraft on request.

From Acquisition mode DEBIE enters to Standby mode by specific telecommand (see the corresponding telecommand). In the Prototype SW housekeeping data contains only SU temperatures.

4.3.7 Sensor Unit States

Following requirement is implemented in Prototype SW

SU Off state **SWR-GEN-40000**

When the Sensor Unit is in the Off state the supply voltages shall be switched off.

In this state the Sensor Unit is not operational. From this state the Sensor Unit can be switched to the On state with a specific telecommand (see corresponding telecommands).

Following requirement is implemented in Prototype SW

SU On state **SWR-GEN-40100**

When the Sensor Unit is in the On state, the supply voltages to it shall be switched On.

In this state the Sensor Unit can detect particle hits. From this state the Sensor Unit can be switched to Off and Self Test states with specific telecommands (see corresponding telecommands).

SU Self Test state **SWR-GEN-40200**

When the Sensor Unit is in the Self Test state, the Sensor Unit self test sequence shall be performed to it.

Low voltage status checks in SU Self Test **SWR-GEN-40210**

To start the SU Self Test Sequence, **V_Down** shall be checked. If it indicates (see [AD3]) that one (or several) of the +-5V DC/DC converters is limiting the output current, all Sensor Unit supply voltages shall be switched Off and the LV Supply Error bit in all **SU_Status** shall be set, as well as the corresponding bits in **ErrorReg** . The Self Test shall be aborted.

High voltage status checks in SU Self Test **SWR-GEN-40220**

Next in the SU Self Test Sequence, the two flags in **HV_Status** for this SU shall be checked. If they indicate overcurrent (see [AD3]) in either +50 V or -50V, the HV Supply Error bit in **SU_Status** shall be set, as well as the bit for this SU in **ErrorReg** .

An overcurrent indication does not abort the Self Test.

Voltage measurement in SU Self Test **SWR-GEN-41000**

Next in the SU Self Test sequence, the +/-5 V and +/- 50 Vsupply voltages to the Sensor Unit shall be measured. If they are not within the limits specified in [AD2], the HV and/or LV Supply Error bits (depending on test result) in the **SU_Status** register shall be set, as well as the bit for this SU in **ErrorReg** .

Errors do not abort the Self Test.

Temperature measurement in SU Self Test **SWR-GEN-41010**

Next in the SU Self Test sequence, the temperatures of the Sensor Unit shall be measured and checked against the upper limit specified in [AD2]. If any temperature exceeds the limit, the SU shall be switched Off, the corresponding Temp Error bits in the **SU_Status** register shall be set, as well as the bit for this SU in **ErrorReg** , and the Self Test shall be aborted.

SU Self Test sequence **SWR-GEN-41100**

The SU Self Test sequence shall include a test sequence, where a test pulse is generated in the way defined in [AD3] to each detector channel one by one and the **SelfTestSU** is set to indicate the Sensor Unit under test.

SU Self Test levels **SWR-GEN-41110**

Two test levels (high and low) shall be used to test each sensor channel.

HW triggers **SWR-GEN-41120**

DELETED

SW triggers **SWR-GEN-41130**

For channels that cannot generate HW hit trigger, the software shall trigger the **HitIT** via processor's interrupt registers.

See [AD3] for channels that can and cannot generate HW triggers. Those channels can generate hit triggers to which a trigger threshold can be set.

SU Self Test measurements **SWR-GEN-41200**

All peak detector outputs, rise time of the Plasma 1e and timing delays shall be measured and reset for each test signal pulse.

See Acquisition function requirements for more details about these measurements.

SU Self Test results **SWR-GEN-41300**

The results of SU Self Test measurements shall be stored into the Science Data area as Event Records with the highest quality number in a fixed order (see Software User Manual [RD2]).

See Acquisition Function requrements for details about Science Data area and Event Records.

SU state transition from Self Test to On **SWR-GEN-42000**

After the SU Self Test sequence is completed, the SU State shall be changed to On.

4.4 Performance Requirements

Minimum delay between the SU Self Test pulses **SWR-GEN-03010**

The minimum delay between SU Self Test triggers shall follow definitions in [AD3].

Limiting factors are the minimum delays between reset signals for Peak Detecors and Delay Counters (see Acquisition Function performance requirements).

Maximum delay between Calibration pulses **SWR-GEN-03020**

DELETED

Switching off short circuited voltages **SWR-GEN-50000**

If a supply voltage status is not valid, that voltage output shall be switched off immediately when the fault is detected.

See Health Monitoring requirements for details about detecting faulty supply voltages.

Following requirement is implemented in Prototype SW

Delay after boot **SWR-GEN-51000**

There shall be at least 550 ms delay between reset and entering the DPU Self Test mode.

Signal stabilization delay after reset **SWR-GEN-51100**

There shall be at least 100 ms delay after power-up reset before any HW registers are accessed.

ADC channel settling time **SWR-GEN-52000**

The delay after ADC channel selection before the corresponding AD conversion is started shall be at least 150 us for the Peak Detector channels, and at least 2 ms for the SU temperature and secondary supply voltage channels.

5 Telecommand and Telemetry Function

5.1 Inputs

Inputs for this function are the following

Table 4: Telecommand and Telemetry Inputs

Mnemonic	Description	Source	Unit	Range
MemReadData	Data read from memory	RAM	NA	N x 0 .. 255
NewMemData	New data to be written to memory (given in TC parameters)	HW	NA	N x 0 .. 255
TC_Address	Telecommand address	HW	[AD2]	[AD2]
TC_Code	Telecommand code	HW	[AD2]	[AD2]
TC_IT	Telecommand interrupt request	HW	NA	NA
TC_P	Telecommand parity	HW	[AD2]	[AD2]
TC_State	Telecommand and Telemetry Function state	SW_Internal	TC_State enum	TC_Handling, Read-Memory, Memory-Dump, Write-Memory, Memory-Patch, HK_TM,

5.2 Outputs

Outputs from this function are the following:

Table 5: Telecommand and Telemetry Outputs

Mnemonic	Description	Destination	Unit	Range
ChecksumFail-ures	Checksum failure counter	OP_Buff	One fail-ure	0 .. 255
ClassLevel_i	Classification set level of Sensor Unit i	OP_Buff	[AD2]	[AD2]
ComStatusReg	Command Status Register	OP_Buff	[AD2]	[AD2]
DelayReset	Delay Counter Reset	HW	bit	0, 1
ErrorReg	Error Status Register	OP_Buff	[AD2]	[AD2]

Table 5: Telecommand and Telemetry Outputs

Mnemonic	Description	Destination	Unit	Range
EventCountChecksum	Checksum of the Event Class Counters	SC_Buff	NA	0 .. 255
HitIT	Particle Hit interrupt request	HW	NA	NA
HK_Data	Housekeeping data	HK_Buff	[AD2]	[AD2]
MaxDelays	Maximum Time Delays	SW_Internal	TBD	0 .. 255
MemoryTM	Memory data to be sent to telemetry	HW	NA	N x 0 .. 255
MemWriteData	Data written to memory	RAM	NA	N x 0 .. 255
MinDelays	Minimum Time Delays	SW_Internal	TBD	0 .. 255
Mode	DEBIE mode	SW_Internal	Mode enum	DPU Self Test, Standby, Acquisition
ModeReg	Mode Status Register	OP_Buff	[AD2]	[AD2]
PeakReset	Peak Detector Reset	HW	bit	0, 1
QualCoefficient_i	Coefficient i in the Quality Number formula	SW_Internal	None	0 .. 255
RegisterTelemetry	Status Register Terlemetry	HW	[AD2]	[AD2]
SC_Telemetry	Science telemetry	HW	[AD2]	[AD2]
ScienceData	Science data (Event Class Counters and Event Records)	SC_Buff	[AD2]	[AD2]
SU_State	Sensor Unit State	SW_Internal	SU_State enum	Off, StartSwitching, Switching, On, SelfTest, Acquisition
SU_Status	SU Status Register	HK_Buff	[AD2]	[AD2]
TC_Code	Telecommand code	HW	[AD2]	[AD2]
TC_Response	Response to TC Format Check: Error Status Register and Mode Status	HW	[AD2]	[AD2]

Table 5: Telecommand and Telemetry Outputs

Mnemonic	Description	Destination	Unit	Range
TC_State	Telecommand and Telemetry Function state	SW_Internal	TC_State enum	TC_Handling, Read-Memory, Memory-Dump, Write-Memory, Memory-Patch, HK_TM,
Thresholds_i	Trigger thresholds for Sensor Unit i	HW	[AD3]	[AD3]
Time	Internal time	OP_Buff	Second	0 .. 2^32-1
TimetagReg	Command Timetag Register	OP_Buff	Second	0 .. 2^32-1
WatchdogFailures	Watchdog failure counter	OP_Buff	One Failure	0 .. 255

5.3 Functional Requirements

Start of the TC Processing **SWR-TCTM-00010**

When the **TC_IT** is received, the Telecommand processing shall be started.

TC Processing phases **SWR-TCTM-00020**

Telecommand Processing phases shall be performed in the order defined in section 2.5.4.

Aborting TC Processing **SWR-TCTM-00030**

If any Telecommand Processing phase fails, processing of the Telecommand shall be aborted and remaining phases shall be omitted, unless otherwise specified by another requirement.

5.3.1 Telecommand and Telemetry States

TC / TM modes **SWR-TCTM-00100**

DELETED

Following requirement is implemented in Prototype SW

Initial TC / TM mode **SWR-TCTM-00150**

The **TC_State** shall be initialized to TC_Handling.

5.3.2 Telecommand Handling State

Following requirement is implemented in Prototype SW

TC Handling mode **SWR-TCTM-00200**

In the TC_Handling state all accepted telecommands shall be executed or refused.

NOTE: some telecommands trigger other Telecommand and Telemetry states, so their "execution" is not completed in the TC_Handling state. Some telecommands are processed completely in some other state.

5.3.3 Read Memory State

Read Memory mode **SWR-TCTM-00300**

When the Read Memory LSB Telecommand is accepted in ReadMemory **TC_State** , it shall be executed.

See Read Memory LSB and Read Memory MSB telecommand requirements.

Aborting ReadMemory mode **SWR-TCTM-00310**

If an accepted Telecommand in Read Memory state is not Read Memory LSB, the TC_Handling **TC_State** shall be entered and the telecommand shall be refused.

Start of the Read Memory TM block **SWR-TCTM-00320**

The **ErrorReg** and the **ModeReg** shall be transferred first at the start of the TM data block.

5.3.4 Memory Dump State

Sending memory block **SWR-TCTM-00340**

In the MemoryDump **TC state** the software shall transmit the memory dump TM block as defined in [AD2] (Data Memory Read TM Sequence) excluding word number zero.

The word zero of Data Memory Read sequence has been already sent in ReadMemory state as a result of TC format check.

Two bytes transferred in one TM word **SWR-TCTM-00350**

DELETED

Checksum of the whole TM data block **SWR-TCTM-00360**

DELETED

Ignoring of telecommands during MemoryDump **SWR-TCTM-00370**

Received telecommands shall be ignored and not further processed in MemoryDump **TC_State** .

End of the MemoryDump mode **SWR-TCTM-00380**

After the memory block is transmitted, the Telecommand and Telemetry Function shall return to the TC_Handling state.

5.3.5 Write Memory State

Write Memory mode **SWR-TCTM-00400**

When the Write Data/Program Memory LSB Telecommand is executed in WriteMemory **TC_State** the write memory sequence (see [AD2]) shall be started.

See Write Data/Program Memory LSB and Write Data/Program Memory MSB telecommand requirements.

Aborting WriteMemory mode **SWR-TCTM-00410**

If an accepted Telecommand in WriteMemory state is not Write Memory LSB, the TC_Handling **TC_State** shall be entered and TC Error bit in **ErrorReg** set (TBC) and the telecommand shall be refused.

5.3.6 Memory Patch State

Receiving Memory Patch sequence **SWR-TCTM-00420**

In the MemoryPatch **TC_State** the software shall accept the Memory Patch sequence following the format defined in [AD2] excluding the first two words.

The first two words contain the Write Memory MSB and LSB telecommands.

Two bytes in one TM word **SWR-TCTM-00430**

DELETED

Last TM word **SWR-TCTM-00440**

DELETED

Valid Memory Write addresses **SWR-TCTM-00445**

If the address of every byte in the write memory block lies within the valid range (0x1000 - 0x7FFF for code and 0x0000 - 0xFEFF for data memory), the start address shall be considered valid, otherwise invalid.

Valid checksum in Write Memory block **SWR-TCTM-00450**

If the start address is valid and the received checksum equals the checksum of the whole transferred TC block (memory block + 2 telecommand words), the telecommand shall be considered successful.

Invalid checksum in Write Memory block **SWR-TCTM-00455**

If the start address is invalid or the received checksum does not equal the checksum of the whole transferred TC block (memory block + 2 telecommand words), the telecommand shall be refused, TC_handling **TC_State** shall be entered and the corresponding error bit in the **ModeReg** shall be set.

Writing to data memory **SWR-TCTM-00460**

If the Write Data Memory TC is successful the received memory block shall be written to the data memory at the address defined by the TC.

See section Update Memory.

Writing to code memory **SWR-TCTM-00465**

If the Write Program Memory TC is successful, the received memory block shall be written to the program memory at the address defined by the TC and the expected code checksum shall be updated.

See section Update Memory

Transition from MemoryPatch state to TC_Handling **SWR-TCTM-00480**

If the execution command of successful TC is 00H, the Telecommand and Telemetry Function shall return to the TC_Handling state.

Note that if the WriteMemory TC State was entered after the Write Data Memory TC was received, the execution command should always be zero.

Execute a soft reset after Write Memory TC **SWR-TCTM-00481**

If the execution command of successful TC is 09H, the soft reset shall be executed.

See Soft Reset TC requirements and Boot Sequence in general functional requirements.

Execute warm reset after Write Memory TC **SWR-TCTM-00482**

If the execution command of successful TC is 37H, a warm reset shall be executed.

Jump to the start of patched memory **SWR-TCTM-00483**

If the execution command of successful TC is 5AH, program execution shall call the code located at the start address of the patched memory segment as a parameterless subroutine. If this subroutine call returns, the TC_handling **TC_State** shall be entered.

This is a hazardous option. It is totally user's responsibilty what are the consequences. There are no guarantees what can happen as a result of this.

5.3.7 Science Telemetry State

Following requirement is implemented in Prototype SW

SC_TM mode **SWR-TCTM-00700**

In the SC_TM state the Telecommand and Telemetry Function shall transmit **ScienceData** to the **SC_Telemetry** , including all and only the events counted and/or stored between the preceding science TM and this entry to SC_TM state.

*Note that in the Prototype SW there will be only FIVE Event Records in the **ScienceData** .*

Ignoring telecommands during Science Telemetry **SWR-TCTM-00705**

Received telecommands shall be ignored and not further processed during SC_TM **TC_State** .

SC_TM mode with no unsent Science Data Files **SWR-TCTM-00710**

DELETED

Following requirement is implemented in Prototype SW

Content of the Science telemetry **SWR-TCTM-00720**

DELETED

Science Telemetry format is defined in [AD2].

Clearing counters and Quality numbers **SWR-TCTM-00750**

After all **ScienceData** is transmitted to **SC_Telemetry** the transmitted Events shall be subtracted from the corresponding Event counters in Science Data memory and Housekeeping Data memory.

End of the SC_TM mode **SWR-TCTM-00780**

After all Event counters are updated, the Telecommand and Telemetry Function shall return to the TC_Handling state.

5.3.8 Register Telemetry State

Following requirement is implemented in Prototype SW

RegisterTM state **SWR-TCTM-00800**

In the RegisterTM state the Telecommand and Telemetry Function shall transmit the Status Register telemetry block to the **RegisterTelemetry** .

See Send Status Register TC

Following requirement is implemented in Prototype SW

Sending successive registers in RegisterTM mode **SWR-TCTM-00810**

DELETED

See section 2.5.

Following requirement is implemented in Prototype SW

Wrap-around in register TM **SWR-TCTM-00820**

DELETED

See section 2.5

Following requirement is implemented in Prototype SW

End of the RegisterTM state **SWR-TCTM-00880**

When a new telecommand is accepted, the Telecommand and Telemetry Function shall return to the TC_Handling state and process the telecommand.

If the accepted telecommand is Send Status Register telecommand the Telecommand and Telemetry Function immediately re-enters to RegisterTM state.

5.3.9 Telecommand Format Check

Following requirement is implemented in Prototype SW

Telecommand address check **SWR-TCTM-01000**

The address of the received telecommand, **TC_Address** , shall be checked against the set of defined addresses.

See [AD2] for acceptable TC_Address values.

Following requirement is implemented in Prototype SW

Telecommand parity check **SWR-TCTM-02000**

The parity of the received telecommand, **TC_P** , shall be checked; it is valid if the total number of 1 bits in **TC_Address** , **TC_code** and **TC_P** is even.

Following requirement is implemented in Prototype SW

Telecommand code check **SWR-TCTM-03000**

The code of the received telecommand, **TC_Code** , shall be checked against the set of valid codes for given **TC_Address** .

See [AD2] for valid TC_Codes for each valid TC_Address.

Following requirement is implemented in Prototype SW

Telecommand acceptance **SWR-TCTM-04000**

If a telecommand has valid address, parity and code, it shall be accepted, otherwise it shall be rejected.

Accepted telecommands can be later refused. See section 2.5

TC response enabled initially **SWR-TCTM-05000**

DELETED

TC_Response disabled during telemetry **SWR-TCTM-05100**

DELETED

Following requirement is implemented in Prototype SW

Response to accepted TC **SWR-TCTM-06000**

When a telecommand is accepted, and neither TC Error nor Parity Error bit in **ErrorReg** are set and the telecommand is not Send Status Register, the accepted telecommand shall be written to the **ComStatusReg** and the **Time** shall be written to the **TimetagReg** .

Following requirement is implemented in Prototype SW

Response to invalid Parity **SWR-TCTM-06100**

When a telecommand is rejected because of invalid Parity, and neither TC Error nor Parity Error bit in **ErrorReg** are set, the rejected telecommand shall be latched to the **ComStatusReg** , the Parity Error bit in the **Error-Reg** shall be set ('1'), the **Time** shall be latched to the **TimetagReg** .

Following requirement is implemented in Prototype SW

Response to invalid TC Code **SWR-TCTM-06110**

When a telecommand with valid parity is rejected because of invalid TC Code, and neither TC Error nor Parity Error bit in **ErrorReg** are set, the rejected telecommand shall be latched to the **ComStatusReg** , the TC Error Error bit in the **ErrorReg** shall be set ('1'), the **Time** shall be latched to the **TimetagReg** .

Accepted Error Status Clear TC **SWR-TCTM-06150**

When the accepted telecommand is Error Status Clear TC, **ErrorReg** and the error bits in **ModeReg** shall be cleared.

The effect is not visible in the 1 ms TC response, but only after the TC is exected (10 ms).

Following requirement is implemented in Prototype SW

Enabling TC response after TM read **SWR-TCTM-06200**

DELETED

See Error Status Clear TC.

Writing TC Response to telemetry **SWR-TCTM-06300**

At the end of the TC format check, the **TC_Response** shall be sent to telemetry unless the telecommand was accepted and was Send Science Data or Send Status Register.

*Note that because the TC response is written before the TC is actually executed, the **ModeReg** value written to the TM register will correspond to the old mode even if the mode is changed, and the **ErrorReg** will not show errors occurred during TC execution unless otherwise specified.*

5.3.10 Start Acquisition

Following requirement is implemented in Prototype SW

Start Acquisition in Standby mode **SWR-TCTM-10000**

When the Start Acquisition command is accepted in the Standby mode, the Acquisition mode shall be entered, **PeakReset** of all Sensor Units and **DelayReset** pulses shall be generated, **HitIT** cleared and the mode bits of the **ModeReg** updated to value 02H.

The means to generate PeakReset and DelayReset are defined in [AD3].

Start Acquisition in DPU Self Test mode **SWR-TCTM-11000**

When the Start Acquisition command is accepted in the DPU Self Test mode, the TC error bit in the **ErrorReg** shall be set and the telecommand shall be refused.

Because the TC response is sent before the command execution is attempted, this setting of TC Error bit is not visible in the TC response of this command.

Following requirement is implemented in Prototype SW

Start Acquisition in Acquisition mode **SWR-TCTM-11100**

When the Start Acquisition command is accepted in the Acquisition mode, the TC error bit in the **ErrorReg** shall be set and the telecommand shall be refused.

Because the TC response is sent before the command execution is attempted, this setting of TC Error bit is not visible in the TC response of this command.

Following requirement is implemented in Prototype SW

Response to StartAcquisition TC **SWR-TCTM-11900**

DELETED

5.3.11 Stop Acquisition

Following requirement is implemented in Prototype SW

Stop Acquisition in Acquisition mode **SWR-TCTM-15000**

When the Stop Acquisition command is accepted in the Acquisition mode, the Standby mode shall be entered and the mode bits of the **ModeReg** updated to the value 01H.

Stop Acquisition in DPU Self Test mode **SWR-TCTM-16100**

When Stop Acquisition command format is accepted in the DPU Self Test mode, the TC error bit in the **ErrorReg** shall be set and the telecommand shall be refused..

Because the TC response is sent before the command execution is attempted, this setting of TC Error bit is not visible in the TC response of this command.

Following requirement is implemented in Prototype SW

Stop Acquisition in Standby mode **SWR-TCTM-16200**

When the Stop Acquisition command format is accepted in the Standby mode, the TC error bit in the **ErrorReg** shall be set and the telecommand shall be refused.

Because the TC response is sent before the command execution is attempted, this setting of TC Error bit is not visible in the TC response of this command.

Following requirement is implemented in Prototype SW

Response to StopAcquisition TC **SWR-TCTM-16900**

DELETED

5.3.12 DELETED: Initialise

Init TC in the Standby mode **SWR-TCTM-18000**

DELETED

Init TC in the Init mode **SWR-TCTM-18500**

DELETED

Init TC in the Acquisition mode **SWR-TCTM-18600**

DELETED

Response to Init TC **SWR-TCTM-18900**

DELETED

5.3.13 Clear Error Status

Clear Error Status TC **SWR-TCTM-17000**

DELETED

See SWR-TCTM-06150.

Error Status Clear TC response **SWR-TCTM-17900**

DELETED

5.3.14 Read Data Memory

Read Memory MSB TC **SWR-TCTM-20000**

The Telecommand and Telemetry function shall enter the ReadMemory **TC_State** , when the Read Data Memory MSB Telecommand is executed.

MSB of the Read Memory block **SWR-TCTM-20100**

The **TC_Code** of the Read Data Memory MSB Telecommand shall be used as the MSB of the start address of the memory block to be read from memory.

Refusing Read Memory LSB TC **SWR-TCTM-20500**

If the **TC_State** is not ReadMemory, the Read Data Memory LSB Telecommand shall be refused and the TC error bit in **ErrorReg** shall be set (TBC).

LSB of the Read Memory block **SWR-TCTM-20510**

If the telecommand is not refused the **TC_Code** of the Read Data Memory LSB Telecommand shall be used as the LSB of the start address of the memory block to be read from memory and MemoryDump **TC_State** shall be entered.

Read Data Memory address check **SWR-TCTM-20600**

If the start address of the memory block does not locate the whole memory block within the 64 kbyte range, the telecommand shall be refused and TC Error bit in **ErrorReg** shall be set.

Response to the Read Memory TCs **SWR-TCTM-20900**

DELETED

5.3.15 Update Memory

Entering WriteMemory State after Write Memory TC **SWR-TCTM-19000**

When the Write Data/Program Memory MSB telecommand is executed in the Standby mode, the WriteMemory **TC_State** shall be entered and the software shall memorize whether the program or data memory is indicated.

Entering WriteMemory State after Write Code Memory TC **SWR-TCTM-19010**

DELETED

Refusing WriteMemory telecommands **SWR-TCTM-19020**

If Write Data/Program Memory MSB telecommand is accepted and the DEBIE mode is not Standby, the telecommand shall be refused.

Refusing Execution Command **SWR-TCTM-19030**

If Write Program Memory telecommand includes an incorrect execution command, the received data block shall be discarded and error indication shall be set in the SU_Status.

MSB of the Write Memory block **SWR-TCTM-19100**

The **TC_Code** of the Write Memory Telecommands shall be used as the MSB of the start of the memory block to be written.

Refusing of Write Memory LSB TC **SWR-TCTM-19500**

If the **TC_State** is not WriteMemory, the Write Memory LSB Telecommands shall be refused.

LSB of the Write Memory block **SWR-TCTM-19510**

When the Write Memory LSB telecommand is executed, its **TC_Code** shall be used as the LSB of the start of the memory block to be written and the Memory Patch **TC_State** shall be entered.

Illegal Write Memory start address **SWR-TCTM-19600**

DELETED

Response to the Write Memory TCs **SWR-TCTM-19900**

DELETED

5.3.16 Set Time

Set Time Byte 0 TC **SWR-TCTM-21000**

If the Set Time Byte 0 command is accepted at most 1.0 seconds after the Set Time Byte 1 command with no other intervening telecommand, the Telecommand and Telemetry Function shall set the least significant byte (bits 0 - 7) of **Time** to the value given in the **TC_Code** .

Refusing Set Time Byte 0 TC **SWR-TCTM-21010**

If the Set Time Byte 0 command is accepted more than 1.0 seconds after the Set Time Byte 1 command or if the previous telecommand was not Set Time Byte 1 telecommand, it shall be refused and TC_Error bit in **ErrorReg** shall be set.

Set Time Byte 1 TC **SWR-TCTM-21030**

If the Set Time Byte 1 command is accepted at most 1.0 seconds after the Set Time Byte 2 command with no other intervening telecommand, the Telecommand and Telemetry Function shall set the byte 1 (bits 8 - 15) of **Time** to the value given in the **TC_Code** and clear the least significant byte.

Refusing Set Time Byte 1 TC **SWR-TCTM-21040**

If the Set Time Byte 1 command is accepted more than 1.0 seconds after the Set Time Byte 2 command or if the previous telecommand was not Set Time Byte 2 telecommand, it shall be refused and TC_Error bit in **ErrorReg** shall be set.

Set Time Byte 2 TC **SWR-TCTM-21060**

If the Set Time Byte 2 command is accepted at most 1.0 seconds after the Set Time Byte 3 command with no other intervening telecommand, the Telecommand and Telemetry Function shall set the byte 2 (bits 16 - 23) of **Time** to the value given in the **TC_Code** and clear the two least significant bytes.

Refusing Set Time Byte 2 TC **SWR-TCTM-21070**

If the Set Time Byte 2 command is accepted more than 1.0 seconds after the Set Time Byte 3 command or if the previous telecommand was not Set Time Byte 3 telecommand, it shall be refused and TC_Error bit in **ErrorReg** shall be set.

Response to the Set Time LSB TC **SWR-TCTM-21090**

DELETED

Set Time Byte 3 TC **SWR-TCTM-21100**

When the Set Time Byte 3 command is accepted, the Telecommand and Telemetry Function shall set the most significant byte (bits 24 - 31) of **Time** to the value given in **TC_Code** and clear the three least significant bytes.

Response to the Set Time MSB TC **SWR-TCTM-21190**

DELETED

5.3.17 Soft Reset

Following requirement is implemented in Prototype SW

Soft Reset TC **SWR-TCTM-22000**

Execution of the Soft Reset telecommand shall trigger SoftReset.

See section 2.5

No response in TM from Soft Reset TC **SWR-TCTM-22900**

DELETED

5.3.18 Clear Failure Counters

Clear Watchdog Failure Counter **SWR-TCTM-23000**

When the Clear Watchdog Failure Counter TC is executed, the Telecommand and Telemetry Function shall clear the **WatchdogFailures** .

Response to the Clear Watchdog Failure Counter TC **SWR-TCTM-23090**

DELETED

Clear Checksum Failure Counter **SWR-TCTM-23100**

When the Clear Checksum Failure Counter command is executed, the Telecommand and Telemetry Function shall clear the **ChecksumFailures** .

Response to the Clear Checksum Failure Counter TC **SWR-TCTM-23190**

DELETED

5.3.19 Send Status Register

Following requirement is implemented in Prototype SW

Send Status Register TC with even TC_Code **SWR-TCTM-25000**

When the Send Status Register command with a **TC_Code** which is even and at most equal to number of TM registers - 1 is executed, the Telecommand and Telemetry Function shall enter the RegisterTM state.

See section Register Telemetry State. The validity of the TC Code is actually checked during the TC Format Check - as usual, but because this is quite special case, the correct format of the TC Code is specified here.

Following requirement is implemented in Prototype SW

Send Status Register TC with odd TC_Code **SWR-TCTM-25010**

Any Send Status Register TC with odd **TC_Code** shall be rejected.

Following requirement is implemented in Prototype SW

Send Status with too big TC_Code **SWR-TCTM-25020**

If the **TC_Code** is bigger than number of TM registers - 1, the Send Status Register TC shall be rejected.

Following requirement is implemented in Prototype SW

First TM register to be sent **SWR-TCTM-25100**

The first TM register from the first pair to be sent shall be the one identified by the **TC_Code** .

Following requirement is implemented in Prototype SW

Second TM Register to be sent **SWR-TCTM-25110**

The second TM register from the first pair shall be the one following the register specified by the **TC_Code** .

Exceptional TM register handling **SWR-TCTM-26000**

DELETED

Clearing Error Status and Command Status **SWR-TCTM-27000**

DELETED

Clearing Memory Write Error after sending Mode Status **SWR-TCTM-27100**

DELETED

5.3.20 Switch Sensor Unit State

Switch SU TC in Acquisition mode **SWR-TCTM-29000**

If any Switch SU telecommand is accepted in the Acquisition mode, it shall be refused and TC Error bit in **ErrorReg** shall be entered.

Refusing Switch SU Self Test telecommands **SWR-TCTM-29100**

Any Switch SU Self Test telecommand shall be refused and TC Error bit in **ErrorReg** shall be set, if the corresponding Sensor Unit is not in On state.

Refusing Switch SU On telecommands **SWR-TCTM-29110**

Any Switch SU On telecommand shall be refused and TC Error bit in **ErrorReg** shall be set, if the corresponding Sensor Unit is not in Off state.

Executing Switch SU telecommands **SWR-TCTM-29200**

DELETED

Following requirement is implemented in Prototype SW

Switch SU1 On **SWR-TCTM-30000**

The Sensor Unit 1 shall be switched to the On state, when the Switch SU1 On/Off telecommand is executed with **TC_Code** 55H.

Following requirement is implemented in Prototype SW

Switch SU1 Off **SWR-TCTM-30010**

The Sensor Unit 1 shall be switched to Off state, when the Switch SU1 On/Off telecommand is executed with **TC_Code** 73H.

Switch SU1 to Self Test **SWR-TCTM-30030**

The Sensor Unit 1 shall be switched to Self Test state, when the Switch SU1 On/Off telecommand is executed with **TC_Code** 99H.

Switch SU2 On **SWR-TCTM-30100**

The Sensor Unit 2 shall be switched to the On state, when the Switch SU2 On/Off telecommand is executed with **TC_Code** 55H.

Switch SU2 Off **SWR-TCTM-30110**

The Sensor Unit 2 shall be switched to Off state, when the Switch SU2 On/Off telecommand is executed with **TC_Code** 73H.

Switch SU2 to Self Test **SWR-TCTM-30130**

The Sensor Unit 2 shall be switched to Self Test state, when the Switch SU2 On/Off telecommand is executed with **TC_Code** 99H.

Switch SU3 On **SWR-TCTM-30200**

The Sensor Unit 3 shall be switched to the On state, when the Switch SU3 On/Off telecommand is executed with **TC_Code** 55H.

Switch SU3 Off **SWR-TCTM-30210**

The Sensor Unit 3 shall be switched to Off state, when the Switch SU3 On/Off telecommand is executed with **TC_Code** 73H.

Switch SU3 to Self Test **SWR-TCTM-30230**

The Sensor Unit 3 shall be switched to Self Test state, when the Switch SU3 On/Off telecommand is executed with **TC_Code** 99H.

Switch SU4 On **SWR-TCTM-30300**

The Sensor Unit 4 shall be switched to the On state, when the Switch SU4 On/Off telecommand is executed with **TC_Code** 55H.

Switch SU4 Off **SWR-TCTM-30310**

The Sensor Unit 4 shall be switched to Off state, when the Switch SU4 On/Off telecommand is executed with **TC_Code** 73H.

Switch SU4 to Self Test **SWR-TCTM-30330**

The Sensor Unit 4 shall be switched to Self Test state, when the Switch SU4 On/Off telecommand is executed with **TC_Code** 99H.

Response to the Set SUi On/Off TC **SWR-TCTM-30900**

DELETED

5.3.21 Set Sensor Unit Threshold Level

Following requirement is implemented in Prototype SW

Set SU1 Plasma1e Threshold Level **SWR-TCTM-31000**

The Sensor Unit 1 Plasma 1e Threshold Level shall be set to value given in the **TC_Code** of the Set SU1 Plasma1e telecommand.

Set SU2 Plasma1e Threshold Level **SWR-TCTM-31010**

The Sensor Unit 2 Plasma 1e Threshold Level shall be set to value given in the **TC_Code** of the Set SU2 Plasma1e telecommand.

Set SU3 Plasma1e Threshold Level **SWR-TCTM-31020**

The Sensor Unit 3 Plasma 1e Threshold Level shall be set to value given in the **TC_Code** of the Set SU3 Plasma1e telecommand.

Set SU4 Plasma1e Threshold Level **SWR-TCTM-31030**

The Sensor Unit 4 Plasma 1e Threshold Level shall be set to value given in the **TC_Code** of the Set SU4 Plasma1e telecommand.

Set SU1 Plasma1i Threshold Level **SWR-TCTM-31100**

The Sensor Unit 1 Plasma 1i Threshold Level shall be set to value given in the **TC_Code** of the Set SU1 Plasma1i telecommand.

Set SU2 Plasma1i Threshold Level **SWR-TCTM-31110**

The Sensor Unit 2 Plasma 1i Threshold Level shall be set to value given in the **TC_Code** of the Set SU2 Plasma1i telecommand.

Set SU3 Plasma1i Threshold Level **SWR-TCTM-31120**

The Sensor Unit 3 Plasma 1i Threshold Level shall be set to value given in the **TC_Code** of the Set SU3 Plasma1i telecommand.

Set SU4 Plasma1i Threshold Level **SWR-TCTM-31130**

The Sensor Unit 4 Plasma 1i Threshold Level shall be set to value given in the **TC_Code** of the Set SU4 Plasma1i telecommand.

Response to Set SUi Plasma1e Threshold Level TC **SWR-TCTM-31900**

DELETED

Following requirement is implemented in Prototype SW

Set SU1 PZT Threshold Level **SWR-TCTM-32000**

The Sensor Unit 1 Piezo-Electric Sensor Threshold Level shall be set to value given in the **TC_Code** of the Set SU1 PZT Threshold Level command.

Set SU2 PZT Threshold Level **SWR-TCTM-32010**

The Sensor Unit 2 Piezo-Electric Sensor Threshold Level shall be set to value given in the **TC_Code** of the Set SU2 PZT Threshold Level command.

Set SU3 PZT Threshold Level **SWR-TCTM-32020**

The Sensor Unit 3 Piezo-Electric Sensor Threshold Level shall be set to value given in the **TC_Code** of the Set SU3 PZT Threshold Level command.

Set SU4 PZT Threshold Level **SWR-TCTM-32030**

The Sensor Unit 4 Piezo-Electric Sensor Threshold Level shall be set to value given in the **TC_Code** of the Set SU4 PZT Threshold Level command.

Response to the set SUi PZT Threshold Level TC **SWR-TCTM-32900**

DELETED

Set SU1 PZT2 Threshold Level TC **SWR-TCTM-33000**

DELETED

Response to the Set SUi PZT2 Threshold Level TC **SWR-TCTM-33900**

DELETED

5.3.22 Set Sensor Unit Classification Level

Set SU1 Plasma1e Classification Level 1 TC **SWR-TCTM-34000**

The Sensor Unit 1 Plasma1e Classification Level shall be set to value given in the **TC_Code** of the Set SU1 Plasma1e Classification Level command.

Set SU2 Plasma1e Classification Level TC **SWR-TCTM-34100**

The Sensor Unit 2 Plasma1e Classification Level shall be set to value given in the **TC_Code** of the Set SU2 Plasma1e Classification Level command.

Set SU3 Plasma1e Classification Level TC **SWR-TCTM-34200**

The Sensor Unit 3 Plasma1e Classification Level shall be set to value given in the **TC_Code** of the Set SU3 Plasma1e Classification Level command.

Set SU4 Plasma1e Classification Level TC **SWR-TCTM-34300**

The Sensor Unit 4 Plasma1e Classification Level shall be set to value given in the **TC_Code** of the Set SU4 Plasma1e Classification Level command.

Response to Set SUi Plasma1e Classification Level 1 **SWR-TCTM-34900**

DELETED

Set SU1 Plasma1i Classification Level 1 TC **SWR-TCTM-35000**

The Sensor Unit 1 Plasma1i Classification Level shall be set to value given in the **TC_Code** of the Set SU1 Plasma1i Classification Level command.

Set SU2 Plasma1i Classification Level TC **SWR-TCTM-35100**

The Sensor Unit 2 Plasma1i Classification Level shall be set to value given in the **TC_Code** of the Set SU2 Plasma1i Classification Level command.

Set SU3 Plasma1i Classification Level TC **SWR-TCTM-35200**

The Sensor Unit 3 Plasma1i Classification Level shall be set to value given in the **TC_Code** of the Set SU3 Plasma1i Classification Level command.

Set SU4 Plasma1i Classification Level TC **SWR-TCTM-35300**

The Sensor Unit 4 Plasma1i Classification Level shall be set to value given in the **TC_Code** of the Set SU4 Plasma1i Classification Level command.

Response to Set SUi Plasma1i Classification Level 1 **SWR-TCTM-35900**

DELETED

Set SU1 PZT1 Classification Level 1 TC **SWR-TCTM-36000**

The Sensor Unit 1 PZT1 Classification Level shall be set to value given in the **TC_Code** of the Set SU1 PZT1 Classification Level command.

Set SU2 PZT1 Classification Level TC **SWR-TCTM-36100**

The Sensor Unit 2 PZT1 Classification Level shall be set to value given in the **TC_Code** of the Set SU2 PZT1 Classification Level command.

Set SU3 PZT1 Classification Level TC **SWR-TCTM-36200**

The Sensor Unit 3 PZT1 Classification Level shall be set to value given in the **TC_Code** of the Set SU3 PZT1 Classification Level command.

Set SU4 PZT1 Classification Level TC **SWR-TCTM-36300**

The Sensor Unit 4 PZT1 Classification Level shall be set to value given in the **TC_Code** of the Set SU4 PZT1 Classification Level command.

Response to Set SUi PZT1 Classification Level 1 **SWR-TCTM-36900**

DELETED

Set SU1 PZT2 Classification Level TC **SWR-TCTM-37000**

The Sensor Unit 1 PZT2 Classification Level shall be set to value given in the **TC_Code** of the Set SU1 PZT2 Classification Level command.

Set SU2 PZT2 Classification Level TC **SWR-TCTM-37100**

The Sensor Unit 2 PZT2 Classification Level shall be set to value given in the **TC_Code** of the Set SU2 PZT2 Classification Level command.

Set SU3 PZT2 Classification Level TC **SWR-TCTM-37200**

The Sensor Unit 3 PZT2 Classification Level shall be set to value given in the **TC_Code** of the Set SU3 PZT2 Classification Level command.

Set SU4 PZT2 Classification Level TC **SWR-TCTM-37300**

The Sensor Unit 4 PZT2 Classification Level shall be set to value given in the **TC_Code** of the Set SU4 PZT2 Classification Level command.

Response to Set SUi PZT2 Classification Level 1 **SWR-TCTM-37400**

DELETED

Set SU1 Plasma 2e Classification Level TC **SWR-TCTM-37500**

The Sensor Unit 1 Plasma 2e Classification Level shall be set to value given in the **TC_Code** of the Set SU1 Plasma 2e Classification Level command.

Set SU2 Plasma 2e Classification Level TC **SWR-TCTM-37600**

The Sensor Unit 2 Plasma 2e Classification Level shall be set to value given in the **TC_Code** of the Set SU2 Plasma 2e Classification Level command.

Set SU3 Plasma 2e Classification Level TC **SWR-TCTM-37700**

The Sensor Unit 3 Plasma 2e Classification Level shall be set to value given in the **TC_Code** of the Set SU3 Plasma 2e Classification Level command.

Set SU4 Plasma 2e Classification Level TC **SWR-TCTM-37800**

The Sensor Unit 4 Plasma 2e Classification Level shall be set to value given in the **TC_Code** of the Set SU4 Plasma 2e Classification Level command.

Response to Set SUi Plasma 2e Classification Level 1 **SWR-TCTM-37900**

DELETED

Set SU1 Plasma1e Classification Level 2 TC **SWR-TCTM-39000**

DELETED

Response to Set SUi Plasma1e Classification Level 2 **SWR-TCTM-39900**

DELETED

Set SU1 Plasma1i Classification Level 2 TC **SWR-TCTM-40000**

DELETED

Response to Set SUi Plasma1i Classification Level 2 **SWR-TCTM-40900**

DELETED

Set SU1 PZT1 Classification Level 2 TC **SWR-TCTM-41000**

DELETED

Response to Set SUi PZT1 Classification Level 2 **SWR-TCTM-41900**

DELETED

Set SU1 PZT2 Classification Level 2 TC **SWR-TCTM-42000**

DELETED

Response to Set SUi PZT2 Classification Level 2 **SWR-TCTM-42900**

DELETED

5.3.23 DELETED: Select Sensor Unit Classification Channel

Select SU1 Classification Channel TC **SWR-TCTM-38000**

DELETED

Selected Classification Channels **SWR-TCTM-38100**

DELETED

Unselected Classification Channels **SWR-TCTM-38110**

DELETED

Response to Select SUi Claffication Channels TC **SWR-TCTM-38900**

DELETED

5.3.24 Send Science Data File

Following requirement is implemented in Prototype SW

Send Science Data File TC **SWR-TCTM-45000**

DEBIE shall enter the SC_TM **TC_State** when the Send Science Data File TC is executed.

For the Prototype SW the Science Data File contains only five Event Records.

5.3.25 DELETED: Clear Science Data Memory

Clear Science Data Overflow TC **SWR-TCTM-46000**

DELETED

Response to Clear Science Data Overflow TC **SWR-TCTM-46900**

DELETED

5.3.26 Set Quality Number Formula Coefficients

Set Quality coefficient 0 TC **SWR-TCTM-47000**

The coefficient 0 of the Quality number shall be set to the value of **TC_Code** of the Set Coefficient 0 TC.

Set Quality coefficient 1 TC **SWR-TCTM-47010**

The coefficient 1 of the Quality number shall be set to the value of **TC_Code** of the Set Coefficient 1 TC.

Set Quality coefficient 2 TC **SWR-TCTM-47020**

The coefficient 2 of the Quality number shall be set to the value of **TC_Code** of the Set Coefficient 2 TC.

Set Quality coefficient 3 TC **SWR-TCTM-47030**

The coefficient 3 of the Quality number shall be set to the value of **TC_Code** of the Set Coefficient 3 TC.

Set Quality coefficient 4 TC **SWR-TCTM-47040**

The coefficient 4 of the Quality number shall be set to the value of **TC_Code** of the Set Coefficient 4 TC.

Set Quality coefficient 5 TC **SWR-TCTM-47050**

DELETED

Set Quality coefficient 6 TC **SWR-TCTM-47060**

DELETED

Set Quality coefficient 7 TC **SWR-TCTM-47070**

DELETED

Set Quality coefficient 8 TC **SWR-TCTM-47080**

DELETED

Set Quality coefficient 9 TC **SWR-TCTM-47090**

DELETED

5.3.27 Set Delay Time Windows

Set SU 1 Plasma 1e to 1i Max time **SWR-TCTM-48000**

The maximum time delay from Sensor Unit 1 Plasma 1e to 1i shall be set to value of **TC_Code** of the Set SU 1 Plasma 1e to 1i Max time TC.

Set SU 2 Plasma 1e to 1i Max time **SWR-TCTM-48010**

The maximum time delay from Sensor Unit 2 Plasma 1e to 1i shall be set to value of **TC_Code** of the Set SU 2 Plasma 1e to 1i Max time TC.

Set SU 3 Plasma 1e to 1i Max time **SWR-TCTM-48020**

The maximum time delay from Sensor Unit 3 Plasma 1e to 1i shall be set to value of **TC_Code** of the Set SU 3 Plasma 1e to 1i Max time TC.

Set SU 4 Plasma 1e to 1i Max time **SWR-TCTM-48030**

The maximum time delay from Sensor Unit 4 Plasma 1e to 1i shall be set to value of **TC_Code** of the Set SU 4 Plasma 1e to 1i Max time TC.

Set SU 1 Plasma 1e to PZT Min time **SWR-TCTM-48100**

The minimum time delay from Sensor Unit 1 Plasma 1e to PZT 1/2 shall be set to the value of **TC_Code** of the Set SU 1 Plasma 1e to PZT Min time TC.

Set SU 2 Plasma 1e to PZT Min time **SWR-TCTM-48110**

The minimum time delay from Sensor Unit 2 Plasma 1e to PZT 1/2 shall be set to the value of **TC_Code** of the Set SU 2 Plasma 1e to PZT Min time TC.

Set SU 3 Plasma 1e to PZT Min time **SWR-TCTM-48120**

The minimum time delay from Sensor Unit 3 Plasma 1e to PZT 1/2 shall be set to the value of **TC_Code** of the Set SU 3 Plasma 1e to PZT Min time TC.

Set SU 4 Plasma 1e to PZT Min time **SWR-TCTM-48130**

The minimum time delay from Sensor Unit 4 Plasma 1e to PZT 1/2 shall be set to the value of **TC_Code** of the Set SU 4 Plasma 1e to PZT Min time TC.

Set SU 1 Plasma 1e to PZT Max time **SWR-TCTM-48200**

The maximum time delay from Sensor Unit 1 Plasma 1e to PZT shall be set to value of **TC_Code** of the Set SU 1 Plasma 1e to PZT Max time TC.

Set SU 2 Plasma 1e to PZT Max time **SWR-TCTM-48210**

The maximum time delay from Sensor Unit 2 Plasma 1e to PZT shall be set to value of **TC_Code** of the Set SU 2 Plasma 1e to PZT Max time TC.

Set SU 3 Plasma 1e to PZT Max time **SWR-TCTM-48220**

The maximum time delay from Sensor Unit 3 Plasma 1e to PZT shall be set to value of **TC_Code** of the Set SU 3 Plasma 1e to PZT Max time TC.

Set SU 4 Plasma 1e to PZT Max time **SWR-TCTM-48230**

The maximum time delay from Sensor Unit 4 Plasma 1e to PZT shall be set to value of **TC_Code** of the Set SU 4 Plasma 1e to PZT Max time TC.

Set SU 1 Plasma 1i to PZT Min time **SWR-TCTM-48300**

The minimum time delay from Sensor Unit 1 Plasma 1i to PZT 1/2 shall be set to the value of **TC_Code** of the Set SU 1 Plasma 1i to PZT Min time TC.

Set SU 2 Plasma 1i to PZT Min time **SWR-TCTM-48310**

The minimum time delay from Sensor Unit 2 Plasma 1i to PZT 1/2 shall be set to the value of **TC_Code** of the Set SU 2 Plasma 1i to PZT Min time TC.

Set SU 3 Plasma 1i to PZT Min time **SWR-TCTM-48320**

The minimum time delay from Sensor Unit 3 Plasma 1i to PZT 1/2 shall be set to the value of **TC_Code** of the Set SU 3 Plasma 1i to PZT Min time TC.

Set SU 4 Plasma 1i to PZT Min time **SWR-TCTM-48330**

The minimum time delay from Sensor Unit 4 Plasma 1i to PZT 1/2 shall be set to the value of **TC_Code** of the Set SU 4 Plasma 1i to PZT Min time TC.

Set SU 1 Plasma 1i to PZT Max time **SWR-TCTM-48400**

The maximum time delay from Sensor Unit 1 Plasma 1i to PZT shall be set to value of **TC_Code** of the Set SU 1 Plasma 1i to PZT Max time TC.

Set SU 2 Plasma 1i to PZT Max time **SWR-TCTM-48410**

The maximum time delay from Sensor Unit 2 Plasma 1i to PZT shall be set to value of **TC_Code** of the Set SU 2 Plasma 1i to PZT Max time TC.

Set SU 3 Plasma 1i to PZT Max time **SWR-TCTM-48420**

The maximum time delay from Sensor Unit 3 Plasma 1i to PZT shall be set to value of **TC_Code** of the Set SU 3 Plasma 1i to PZT Max time TC.

Set SU 4 Plasma 1i to PZT Max time **SWR-TCTM-48430**

The maximum time delay from Sensor Unit 4 Plasma 1i to PZT shall be set to value of **TC_Code** of the Set SU 4 Plasma 1i to PZT Max time TC.

5.3.28 Telemetry Data

16 Telemetry data word **SWR-TCTM-50000**

DELETED

All telemetry follows the formats in [AD2] as required by other software requirements.

Following requirement is implemented in Prototype SW

Byte order in TM words **SWR-TCTM-50100**

The order of the bytes sent to telemetry follows the definitions in [AD2].

5.3.29 Science Telemetry

Content of the Science Data File **SWR-TCTM-55000**

The size and content of the Science Data File shall be according to the [AD2].

Resetting the Science Data Memory during initialization **SWR-TCTM-55100**

DELETED

Resetting the Science Data memory after telemetry **SWR-TCTM-55110**

DELETED

Writing next hits **SWR-TCTM-55120**

DELETED

Event counter checksum **SWR-TCTM-55200**

Every time the event counters are updated the **EventCountChecksum** shall be updated.

Checksum of event record **SWR-TCTM-55210**

When a new event record is stored in **ScienceData** , a checksum shall be calculated from it and included in it.

Wrap-around of write pointer **SWR-TCTM-55220**

DELETED

Wrap-around of read pointer **SWR-TCTM-55230**

DELETED

Setting Science Data Overflow **SWR-TCTM-55300**

DELETED

Hits not stored after Science Data overflow **SWR-TCTM-55310**

DELETED

Updating file count **SWR-TCTM-55900**

DELETED

5.4 Performance Requirements

Following requirement is implemented in Prototype SW

TC response dead line **SWR-TCTM-90000**

The **TC_Response** shall be written to the TM transmit registers within 1 ms from the reception of TC interrupt.

The software will not usually wait for the following TM interrupt.

Following requirement is implemented in Prototype SW

TC execution dead line **SWR-TCTM-90100**

All other Telecommands except TM requests and the Soft Reset telecommand shall be executed within 10 ms from the TC interrupt.

Note that all Telecommands are not implemented in the Prototype SW.

Execution time of Soft Reset TC **SWR-TCTM-90101**

The Soft Reset telecommand shall be executed in at most one second.

Discarding telecommand received too soon **SWR-TCTM-90110**

If a TC interrupt is received before 10 ms has elapsed after reception of previous one, the telecommand shall be discarded and the TC Error bit in **ErrorReg** shall be set.

Write Program/Data memory time-out **SWR-TCTM-90200**

If there is more than 1 second delay between the Telecommand words during the Write Data or Program memory sequences, the software shall abort the WriteMemory state, set the TC Error bit in the **ErrorReg** , enter the TC_Handling state and discard the received data.

Following requirement is implemented in Prototype SW

TM response to TM IT dead-line **SWR-TCTM-91000**

During telemetry transmissions a new TM word shall be written to Telemetry transmit registers within 1 ms from the TM interrupt, if there are more words to be transmitted.

Dead line for the first Science telemetry word **SWR-TCTM-91100**

The first **SC_Telemetry** word shall be written to Telemetry transmit registers within 1 ms from the TC interrupt.

Dead line for the first Register telemetry word **SWR-TCTM-91200**

The first **RegisterTelemetry** word shall be written within 1 ms from TC interrupt.

6 Health Monitoring Function

6.1 Inputs

Inputs for this function are the following

Table 6: Health Monitoring Inputs

Mnemonic	Description	Source	Unit	Range
HV_Status	SU high voltage status	HW	[AD3]	[AD3]
HW_DPU_V	Supply voltage (+5V) of the DPU	HW	[AD3]	[AD3]
HW_SU_Ti	Temperature of Sensor Unit i	HW	[AD3]	[AD3]
HW_SU_Vi	Supply voltage of Sensor Unit i	HW	[AD3]	[AD3]
V_Down	+-5V voltage status	HW	bit	0, 1

6.2 Outputs

Outputs from this function are the following:

Table 7: Health Monitoring Outputs

Mnemonic	Description	Destination	Unit	Range
DelayReset	Delay Counter Reset	HW	bit	0, 1
DPU_V	Supply voltage (+5V) of the DPU	HK_Buff	[AD2]	[AD2]
ErrorReg	Error Status Register	OP_Buff	[AD2]	[AD2]
HitIT	Particle Hit interrupt request	HW	NA	NA
HK_Data	Housekeeping data	HK_Buff	[AD2]	[AD2]
OP_Data	Operational data	OP_Buff	[AD2]	[AD2]
PeakReset	Peak Detector Reset	HW	bit	0, 1
SignalledEvents	Number of signalled Hit Events	SW_Internal	One Event	0 .. 255
SU_State	Sensor Unit State	SW_Internal	SU_State enum	Off, StartS-witching, Switch-ing, On, SelfTest, Acquisi-tion
SU_Status	SU Status Register	HK_Buff	[AD2]	[AD2]
SU_Ti	Temperature of Sensor Unit i	HK_Buff	[AD2]	[AD2]

Table 7: Health Monitoring Outputs

Mnemonic	Description	Destination	Unit	Range
SU_Vi	Supply voltage of Sensor Unit i	HK_Buff	[AD2]	[AD2]
Time	Internal time	OP_Buff	Second	0 .. 2^32-1

6.3 Functional Requirements

Following requirement is implemented in Prototype SW

Temperatures in the Health Monitoring **SWR-MON-01000**

All Sensor Unit temperatures shall be measured in the way described in [AD3].

Voltage measurements in Health Monitoring **SWR-MON-01100**

All secondary supply voltages shall be measured in the way described in [AD3].

Enabling disabled hit triggers **SWR-MON-02000**

If the **HitIT** triggers were disabled during the previous Health Monitoring period (see Health Monitoring performance requirements), the software shall give **DelayReset** , **PeakReset** signals, clear and enable **HitIT** requests.

See Acquisition requirements and [AD3].

Self Test after power-up **SWR-MON-05000**

DELETED

Following requirement is implemented in Prototype SW

Housekeeping telemetry data **SWR-MON-10000**

Sensor Unit temperatures and all secondary supply voltages shall be included in the **HK_Buff** .

Only Sensor Unit temperatures are measured in the Prototype SW

Operational telemetry data **SWR-MON-10100**

DELETED

Voltage measurement bits stored in telemetry **SWR-MON-10110**

From the voltage measurement results bits 8 .. 15 shall be stored in the **HK_Data** .

Too low temperature measurement results **SWR-MON-10120**

If the most significant bit 15 in a temperature measurement is zero, a zero temperature value shall be stored in **HK_Data** .

Normal temperature measurement results **SWR-MON-10130**

If the most significant bit 15 of a temperature measurement result is one, bits 7 .. 14 shall be stored in **HK_Data** .

Failed SU temperature measurements **SWR-MON-11000**

If a SU temperature measurement fails, the corresponding Sensor Unit shall be switched Off and an indication of this shall be stored in **OP_Data** (TBC).

This is not required by User Requirements, but additional information for the user. See Software User Manual for details.

Short circuited supply high voltages **SWR-MON-15000**

If any of the **HV_Status** bits indicate (see [AD3]) a short circuit or overload, the corresponding voltage output shall be switched off and the corresponding Error Status Bit in the **ErrorReg** and corresponding **SU_Status** shall be set.

Short circuited +- 5V supply **SWR-MON-15050**

If **V_Down** indicates (see [AD3]) that one (or several) of the +-5V DC/DC converters is limiting the output current, all Sensor Unit supply voltages shall be switched Off and corresponding bits in the **ErrorReg** and all **SU_Status** shall be set.

Overheated Sensor Units **SWR-MON-15100**

If the temperature of any of the Sensor Units exceeds 90 degrees Celsius, all secondary supply voltages to that Sensor Unit shall be switched off and the corresponding Error Status Bit in the **ErrorReg** and corresponding **SU_Status** shall be set.

Resetting the Watchdog **SWR-MON-20000**

The Watchdog counter shall be reset periodically.

Watchdog reset **SWR-MON-20100**

DELETED

Checksum calculation **SWR-MON-30000**

A checksum shall be calculated periodically from the whole 32 kByte code memory.

The checksum covers also the unused part of the code memory.

Checksum failure **SWR-MON-31000**

When the calculated checksum does not match the expected checksum and no Write Program Memory telecommand has been successfully executed during the checksum calculation, the checksum failure counter shall be incremented, if the counter has value less than its maximum, and the DEBIE

shall execute the Soft Reset function preserving the **ErrorReg** and failure counters.

The expected checksum will change if the code memory is patched.

Following requirement is implemented in Prototype SW

Health Monitoring trigger **SWR-MON-50000**

The Health Monitoring function shall be executed periodically after initialization sequence including SW initialization and DPU Self Test is executed.

In the Prototype software the Health Monitoring task measures only Sensor Unit temperatures.

6.4 Performance Requirements

Health Monitoring frequency **SWR-MON-99000**

The supply voltages status shall be monitored at least once in 10 seconds.

Voltage switch off dead line. **SWR-MON-99100**

DELETED

Checksum dead line **SWR-MON-99200**

The checksum from the program code shall be calculated and checked at least once in 60 seconds.

Frequency of temperature measurements **SWR-MON-99300**

The Sensor Unit temperatures shall be measured at least once in 60 seconds.

Voltage measurement frequency **SWR-MON-99400**

The supply voltages shall be measured at least once in 180 seconds.

Watchdog counter reset inerval **SWR-MON-99500**

The Watchdog counter shall be reset at least once in 10 seconds.

Updating internal time **SWR-MON-99600**

The **Time** shall be incremented once per second on average.

The accuracy of Time updating will be described in the User Manual.

7 Acquisition Function

7.1 Inputs

Inputs for this function are the following

Table 8: Acquisition Inputs

Mnemonic	Description	Source	Unit	Range
ClassLevel_i	Classification set level of Sensor Unit i	OP_Buff	[AD2]	[AD2]
ClassLUT	Classification look-up table	SW_Internal	Class number	1..10
EventEnable	Event handling and storage enable/disable flag	HW	bit	0, 1
HitIT	Particle Hit interrupt request	HW	NA	NA
HitSource	HW Hit Trigger source	HW	[AD3]	[AD3]
MaxDelays	Maximum Time Delays	SW_Internal	TBD	0 .. 255
MinDelays	Minimum Time Delays	SW_Internal	TBD	0 .. 255
PeakData	Peak detector outputs	HW	[AD3]	[AD3]
QualCoefficient_i	Coefficient i in the Quality Number formula	SW_Internal	None	0 .. 255
RelTiming-Counters	Relative timing counters from Plasma 1e and Plasma 1i triggers to PZT	HW	[AD3]	0 .. 4095 (TBC)
RiseTimeCounter	Counter for the Rise Time of the Plasma 1e sensor	HW	[AD3]	0 .. 255 (TBC)
ScienceData	Science data (Event Class Counters and Event Records)	SC_Buff	[AD2]	[AD2]
SelfTestSU	Sensor Unit to which Self Test is being performed (0 means none).	SW_Internal	SU number	0 / 1 .. 4
SU_State	Sensor Unit State	SW_Internal	SU_State enum	Off, StartSwitching, Switching, On, SelfTest, Acquisition
SU_Ti	Temperature of Sensor Unit i	HK_Buff	[AD2]	[AD2]
Time	Internal time	OP_Buff	Second	0 .. 2^32-1

7.2 Outputs

Outputs from this function are the following:

Table 9: Acquisition Outputs

Mnemonic	Description	Destination	Unit	Range
DelayReset	Delay Counter Reset	HW	bit	0, 1
HitIT	Particle Hit interrupt request	HW	NA	NA
PeakReset	Peak Detector Reset	HW	bit	0, 1
ScienceData	Science data (Event Class Counters and Event Records)	SC_Buff	[AD2]	[AD2]
SignalledEvents	Number of signalled Hit Events	SW_Internal	One Event	0 .. 255

7.3 Functional Requirements

Acquision data handling modes **SWR-ACQ-01000**

DELETED

Default acquisition data mode **SWR-ACQ-01100**

DELETED

Detecting Self Test SU **SWR-ACQ-02000**

When an Event is signalled and the **SelfTestSU** indicates Sensor Unit being Self Tested, that Sensor Unit shall be held responsible for the Event.

Detecting triggering SU **SWR-ACQ-02100**

When the Event is signalled and **SelfTestSU** indicates no Self Test in progress, the **HitSource** shall be taken as the responsible Sensor Unit for the Event.

Disabling Hit triggers **SWR-ACQ-03000**

In each 10-second period, at most 20 **SignalledEvents** shall be accepted. If more events occur, they shall be ignored by disabling the **HitIT** interrupt response for the remainder of the 10-second period, and then the interrupt shall be enabled again.

The purpose of this requirement is prevent the burst of Hit Triggers to block the execution of Health Monitoring task.

Accepting Events **SWR-ACQ-05000**

When the **HitIT** is detected when the **EventEnable** is set and either the responsible Sensor Unit is in Self Test state or the DEBIE mode is Acqusition and the Sensor Unit is in On state, the signalled Event shall be accepted and an Event record created as defined in [AD2].

Following requirement is implemented in Prototype SW

Reading Rise Time counter **SWR-ACQ-10000**

When an Event is accepted, the Acquisition function shall read the **RiseTimeCounter** and store the value to the Event record.

Following requirement is implemented in Prototype SW

Reading Relative Rise Timing Counter **SWR-ACQ-10500**

When an Event is accepted, two **RelTimingCounters** shall be read and values stored in the Event record.

Following requirement is implemented in Prototype SW

Difference of Relative Timing counters **SWR-ACQ-10550**

The difference of the **RelTimingCounters** shall be calculated and if the result is in the valid range (see below) the result stored in the Event record.

Too small delay difference value **SWR-ACQ-10560**

If the difference of **RelTimingCounters** is less than -128, the value -128 shall be stored.

Too big delay difference value **SWR-ACQ-10570**

If the difference of the **RelTimingCounters** is bigger than 127 the value 127 shall be stored.

Following requirement is implemented in Prototype SW

Resetting counters **SWR-ACQ-10900**

After reading **RiseTimeCounter** and **RelTimingCounters** or after the Event is rejected, they shall be reset with **DelayReset** pulse.

The generation of DelayReset pulse is described in [AD3].

Following requirement is implemented in Prototype SW

Sampling the peak detector outputs **SWR-ACQ-11000**

When an Event is accepted, the peak detector outputs of each plasma and piezoelectric sensor, **PeakData** shall be sampled in the way described in [AD3].

Following requirement is implemented in Prototype SW

Resetting Peak Detectors **SWR-ACQ-11900**

After the Peak Detectors are sampled or after the Event is rejected, the **PeakReset** signal shall be given to the triggering Sensor Unit twice.

See [AD3] for details about Peak Detector Reset signal.

Following requirement is implemented in Prototype SW

Measurement timetag **SWR-ACQ-19000**

When an Event is accepted, the **Time** shall be stored in the Event Record.

Following requirement is implemented in Prototype SW

Sensor Unit temperatures from Housekeeping TM **SWR-ACQ-20000**

When an Event is accepted, the Sensor Unit temperatures, **SU_Ti** , last sampled by the Health Monitoring function shall be stored in the Event record.

Classification thresholds **SWR-ACQ-30000**

The amplitude of each measured sensor of a measured Event shall be compared to adjustable classification threshold levels and the relative timing of the sensor signals shall be compared to adjustable time windows as described in [AD2].

See TCTM Function requirements for details about adjusting the classification thresholds and time windows.

Result of the classification comparisons **SWR-ACQ-30100**

The result of classification threshold and time window comparisons shall be a number called classification index consisting of 8 bits as defined in [AD1].

Classification comparison result coding **SWR-ACQ-30200**

The associated bit in the classification index shall be set to ’1’ if the corresponding signal amplitude is above the threshold or the relative timing is within the time window.

See SWR-ACQ-30100 and SWR-ACQ-30300.

Meaning of bits in the comparison bits **SWR-ACQ-30210**

DELETED

Classification number **SWR-ACQ-30300**

The classification index shall be used as index to a **ClassLUT** giving the classification number. Contents of the **ClassLUT** shall be as defined in [AD1].

Storing the classification number **SWR-ACQ-30400**

The classification number shall be stored in the Event Record.

Event counters **SWR-ACQ-30500**

The accepted events shall be counted separately for each sensor (4) and event class (10) giving 40 counters.

The accepted event shall be counted even if the Event Record is not stored in the Science Data.

Quality number for SU On Events **SWR-ACQ-31000**

If the Sensor Unit responsible for the measured Event is not in Self Test state, a Quality number shall be calculated with formula defined in the [AD1].

The coefficients of the formula are programmable with specific telecommands (see corresponding TC requirements).

Quality number for SU Self Test Events **SWR-ACQ-31005**

If the Sensor Unit responsible for the measured Event is in Self Test state, the quality number shall be set to the maximum value.

Storing the Quality numbers **SWR-ACQ-31010**

The Quality number shall be stored in the Event Record.

Meaning of the Quality number **SWR-ACQ-31020**

DELETED

Storing Event Record when ScienceData is not full **SWR-ACQ-31100**

If the **ScienceData** is not full, the completed Event Record shall be stored in the next free place in the **ScienceData** .

Finding lowest Quality Event **SWR-ACQ-31200**

If the **ScienceData** is full, the event or events with the lowest Quality number shall be searched from the **ScienceData** .

Discarding Event Record **SWR-ACQ-31300**

If the Quality number of the new event is less than the Quality number of all stored Event Records in the full **ScienceData** , the completed new Event Record shall not be stored.

Replacing the lowest quality event **SWR-ACQ-31500**

The lowest quality event record from the full **ScienceData** shall be replaced with the completed new Event Record, if the Quality number of the new event is higher or equal.

Replacing oldest of the lowest quality events **SWR-ACQ-31510**

If the full **ScienceData** contains several Event Records of the same, lowest quality, lower or equal than the Quality number of the new event, the oldest such Event Record shall be replaced by the completed new Event Record.

Event counting **SWR-ACQ-35000**

DELETED

Processed data in telemetry **SWR-ACQ-80000**

DELETED

Raw measurement data in telemetry **SWR-ACQ-81000**

DELETED

7.4 Performance Requirements

Following requirement is implemented in Prototype SW

Piezo peak detector reading timing **SWR-ACQ-90000**

For the accepted events the peak detector outputs of Piezo sensors shall be read at least 400 us and at most 2 ms after the Particle Hit interrupt, **HitIT** .

Following requirement is implemented in Prototype SW

Plasma peak detector read time **SWR-ACQ-90100**

For accepted events the peak detector outputs of Plasma sensors shall be read at least 400 us and at most 2 ms after the Particle Hit interrupt, **HitIT** .

Following requirement is implemented in Prototype SW

Delay for first Peak Detector Reset **SWR-ACQ-91000**

There shall be at least 10 ms delay after reading Peak Detector outputs, Rise Time Counter and Delay Counters for accepted Events or after the **HitIT** for rejected events before the Peak Detector ouputs are reset for the first time (for this event).

Following requirement is implemented in Prototype SW

Delay for second Peak Detector Reset **SWR-ACQ-91100**

There shall be at least 10 ms delay after the first Peak Detector Reset before the second one.

Following requirement is implemented in Prototype SW

Delay for Delay counter reset **SWR-ACQ-91200**

There shall be at least 1 ms delay after the second Peak Detector Reset before the Delay Counters are reset (for this event).

Following requirement is implemented in Prototype SW

Acquisition functions timing **SWR-ACQ-92000**

All applicable acquisition functions for signalled Events shall be executed in less than one second.

Following requirement is implemented in Prototype SW

Peak Detector Reset pulse length **SWR-ACQ-95000**

The Peak Detector reset pulse length shall be between 10 and 12 microseconds.

Following requirement is implemented in Prototype SW

Delay Counter reset pulse length **SWR-ACQ-95100**

The Delay Counter reset pulse length shall be between 1 and 2 microseconds.

8 Non-Functional Requirements

8.1 Performance Requirements

Performance requirements related to the required DEBIE functions are defined in the previous chapters.

8.2 Operational Requirements

None (TBC).

8.3 Documentation Requirements

The documentation requirements are stated in the DEBIE Software Development Plan [RD1].

8.4 Security Requirements

None (TBC).

8.5 Safety Requirements

None (TBC).

8.6 Interface Requirements

Following requirement is implemented in Prototype SW

Usage of external functions and variables **SWR-NONF-10000**

Software functions (subprograms) shall use only those external functions and variables which are defined in the architectural design and included in the header files of other software modules.

Following requirement is implemented in Prototype SW

Usage of the DEBIE hardware **SWR-NONF-11000**

The DEBIE hardware shall be handled only through specific subprograms which implement the interface according to the DEBIE HW/SW Interface Control Document.

Following requirement is implemented in Prototype SW

Usage of the real time kernel **SWR-NONF-12000**

The RTX real time kernel shall be used via specific subprograms which implement the interface according to Keil RTX documentation [RD3].

8.7 Resource Requirements

Following requirement is implemented in Prototype SW

Size of the program code **SWR-NONF-30000**

The size of the program code shall not exceed 32 kilobytes.

A margin shall, of course, be present, but is not specified by the customer.

Following requirement is implemented in Prototype SW

Size of the data memory **SWR-NONF-31000**

The size of the data memory shall not exceed 64 kilobytes.

A margin shall, of course, be present, but is not specified by the customer.

Science Data Memory size **SWR-NONF-32000**

The size of the Science Data Memory shall be at least 32 kBytes.

8.8 Verification Requirements

Verification of the requirements **SWR-NONF-40000**

All requirements shall be verified with functional tests, inspection or analysis.

Generation of VCD **SWR-NONF-41000**

A Verification Control Document shall be generated to trace the software requirements to the verification methods (test or inspection) guaranteeing that all requirements are verified.

8.9 Portability Requirements

Following requirement is implemented in Prototype SW

Portability of the software **SWR-NONF-50000**

The DEBIE Application Software shall be portable to a native workstation environment.

See [RD1] for description of different parts fo DEBIE DPU Software.

8.10 Quality Requirements

Following requirement is implemented in Prototype SW

DEBIE coding standards quality rules **SWR-NONF-60000**

The quality rules in the DEBIE coding standards [AD4] shall be followed.

8.11 Reliability Requirements

Watchdog interrupt never disabled **SWR-NONF-70000**

DELETED

Following requirement is implemented in Prototype SW

Dynamic memory allocation never used **SWR-NONF-71000**

Dynamic memory allocation shall not be used.

This prevents any risk for memory allocation and deallocation errors.

8.12 Maintainability Requirements

Following requirement is implemented in Prototype SW

Configuration management used **SWR-NONF-80000**

Configuration management shall be applied to the source code files.

DISTRIBUTION LIST

Quantity	Person and Organisation
1	Juha Kuitunen, Patria Finavitec Systems