Alenia SPAZIO LABEN

SHARAD DES

DOCUMENT TYPE: INTERFACE CONTROL DOCUMENT

TITLE: **TLC/TCM PACKET STRUCTURE DEFINITION (SP-15)**

DOCUMENT No.: TL 19769 **PAGE:** I of V, 48

PROJECT Ref.: ID-SHR-0002-LAB

ISSUE No.: 7

PREPARED BY: SHARAD TEAM

CHECKED BY: D. RAVASI

PROJECT LEADER: P. MARCHESI **DATE:** 15/9/2004

PAPM: P. RUSCONI **DATE:** 15/09/04

PROGRAM MANAGER: E. ALIPPI **DATE:** 15/9/2004

CONFIGURATION: L. E. RONDELLI

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
1	JULY '03	ALL	FIRST ISSUE OF THE DOCUMENT	PDR/SRR
2	OCT '03	ALL	Upgrade of requirements according to issue 2 of [RD.1]	CDR
3	DEC '03	ALL	Upgrade of TM/TC layout after HW / SW integration phase	EM CDR
4	MAR '04	ALL	Upgrade of TM/TC layout after MOM MIN/SHR/0116/ALS	SW CDR Close-out
5	MAY '04	ALL	Upgrade of TM/TC layout after Tacking layout definition	
6	JUL '04	ALL	Modification according to revision 2.3 of the software package	
7	SEP '04	ALL	Modification according to revision 2.4 of the software package	

TABLE OF CONTENTS

Alenia SPAZIO LABEN

1. INTRODUCTION

This document presents the interfacing of DES towards its user.
Scientists operate on DES passing through the MRO C&DH on which Telecommands shall be stored before their issuing to DES.
Also TLM coming from DES, before arriving to Scientists, has an intermediate storage buffering into the MRO on-board Solid State Recorder.

1.1. PURPOSE

This document presents the structure of MRO CMD and DES TLM packets as seen and used from the MRO C&DH.

The structure of the document is the following:
chapter 3 presents the DES SW Interfacing
chapter 4 presents the MRO Commands and their data structure
chapter 5 presents the DES Telemetry packets
chapter 6 is devoted to a OBT command which requires special explanation

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1. APPLICABLE DOCUMENTS

[AD.1] Digital Electronic Section (DES) Requirement Specification, SPE/SHR/0027/ALS

[AD.2] On-Board Digital Signal Processing, RQS/SHR/0014/ALS

[AD.3] Sharad Des Design Report, TL 19749 Issue 3

2.2. REFERENCE DOCUMENTS

[RD.1] Software Requirements, TL19763

3. SPACECRAFT SW INTERFACES

SHARAD software interfaces with the S/C are implemented through the DES. These interfaces provide details for protocol/formats used for Commands and Science Data/Telemetry exchanges between, respectively, the S/C's C&DH and DES and the DES and the S/C's SSR.

Protocol layering is detailed in Figure 3-1, while the information encapsulation process is detailed in Figure 3-2a and Figure 3-2b. Additional details are provided in the next two paragraphs.

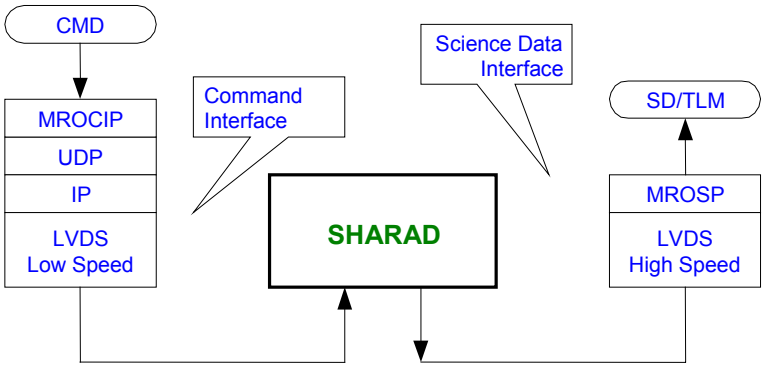

Figure 3-1. - SHARAD protocols layering

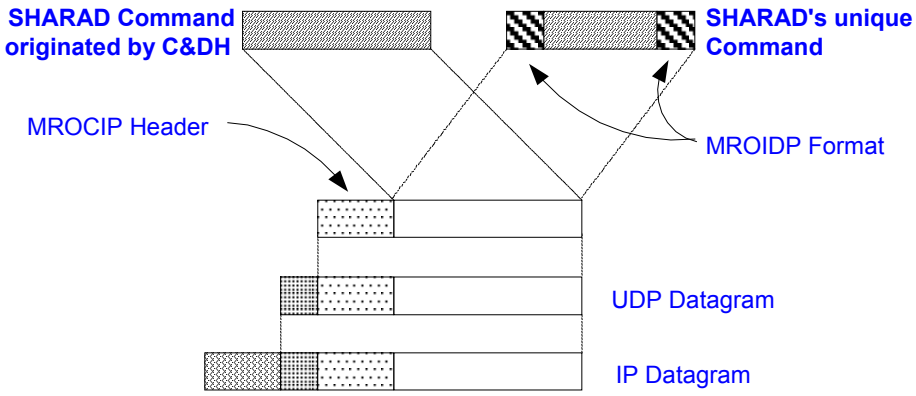

Figure 3-2a. - SHARAD protocols encapsulation (commands)

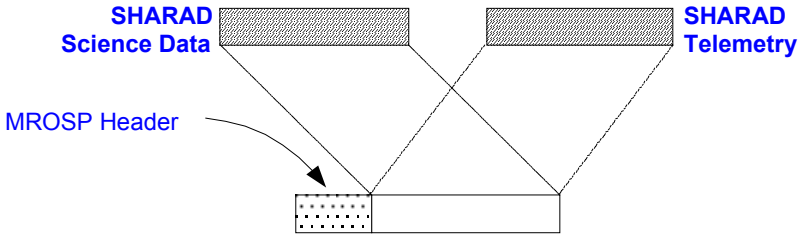

Figure 3-2b. - SHARAD protocols encapsulation (science data/telemetry)

SRQI.-3/010 Bit Numbering Rules

[AD.1] SHR-DES-3.2.3-0005

All bytes sent across a LVDS interface to or from the instrument shall be sent most significant bit first.
All words consisting of more than one byte sent across a LVDS interface to or from the instrument shall be sent most significant byte first.

EOR

3.1. COMMAND INTERFACE

SRQI.-3.1/010 Command Protocol

[AD.1] SHR-DES-3.2.3-0010

The DES shall receive commands formatted as follows:

- each command is contained in a single LVDS frame;
- each command is preceded by a MROCIP header, an UDP header and an IP header;
- commands are of two types:
  - commands generated by S/C
  - command defined by SHARAD.

The succession of headers within the command frame (delimited by the activation of the Data Valid signal) is shown in Figure 3.1-1.

EOR

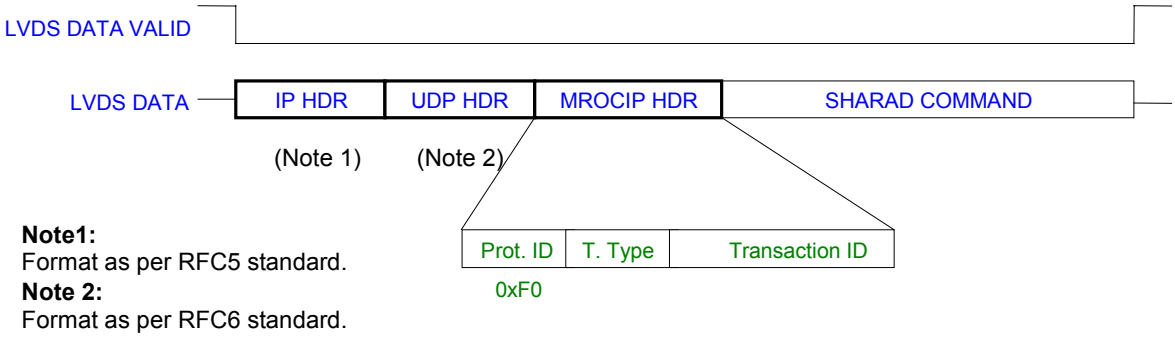

Figure 3.1-1.- Command protocol format

SRQI.-3.1/020 IP Header

[AD.1] SHR-DES-3.2.3-0020

The IP Header is based upon the Internet RFC5 standard as in Fig.3.1-2..

EOR

31				*0*
4 bit	*4 bit*	*8 bit*	*3 bit*	*13 bit*
VERS	IHL	Type of Service	Total Length	
Identification			Flags	Fragment offset
Time to leave		Protocol	Header Checksum	
Source IP address				
Destination IP address				

Figure 3.1-2.- IP Header format

Relevant fields in this format are:

Name	Bits No	Description
VERS	4	[constant] indicates the version of the IP protocol so that any incompatibility can be discovered. Value = 4 dec.
IHL	4	[constant] indicates the length of the header in 32 bit words. Value = 5 dec.
Type of Service	8	holds the flags used for TOS and precedence. Value = 0 dec.
Total Length	16	total length of the IP datagram measured in octets, including the header and data Value = variable, min 20 dec.
Identification	16	an integer value used to help identify all fragments of a datagram
Flags	3	flags to control fragmentation. Value = 2 dec.
Fragment Offset	13	used with fragmented datagram to indicate the position that the data in this fragment occupies in the original message
Time to leave	8	set by the datagram sender and is decrement by routers as the datagram passes through them
Protocol	8	transport layer protocol carried by this datagram. Value = 17 dec.
Header Checksum	16	IP header checksum protect header and does not protect the data it carries. Value = variable dec.
Source IP Address	32	[constant] source IP address. Value = 192.168.1.1.
Dest. IP Address	32	[constant] destination IP address. Value = 192.169.1.7

Note. *The maximum length of the IP datagram establishes the absolute maximum length of the previous layers.*

Note. **VERS, IHL, Source IP Address, Dest. IP Address** *and* **Options** *fields shall be considered as Constant, a warning shall be sent through the TLM_ACK packet, but the command shall be executed*

Note. **Type of Service, Identification, Flags, Fragment Offset** *and* **Time to leave** *fields shall be ignored in cmd verification process*

SRQI.-3.1/030 UDP Header

[AD.1] SHR-DES-3.2.3-0030

The UDP Header is based upon the Internet RFC6 standard as in Fig. 3.1-3.

EOR

31	*0*
16 bit	*16 bit*
Source Port address	Destination Port address
UDP Length	UDP Checksum

Figure 3.1-3.- UDP Header format

Relevant fields in this format are:

Source Port application source of the data. Value = 5007
Destination Port application destination of the data. Value = 5007.
UDP Length Number of bytes in the UDP datagram. Value = variable, min 8
UDP Checksum Check value computed over all UDP datagram bytes, plus a few selected fields of the IP Header. Value = variable.

SRQI.-3.1/040 MROCIP Header

[AD.1] SHR-DES-3.2.3-0040

The MROCIP Header contains information relevant to the sequencing of commands (or their relationship with science data/telemetry) and the type of command being carried. The MROCIP Header contains the following fields as in Fig 3.1-4.

EOR

31		*0*
8 bit	*8 bit*	*16 bit*
Protocol ID	Transaction Type	Transaction ID

Figure 3.1-4.- MROCIP Header format

Relevant fields in this format are:

Protocol ID MROCIP identification protocol. Value = 0F0 hex
Transaction Type Message type. Value = 01 hex C&DH cmd, 02 hex SHARAD cmd.
Transaction ID Sequence to identify uniquely the command. To be used in replies, acks and science telemetries. Value = variable

3.2. SCIENCE AND HK DATA INTERFACE

SRQI.-3.2/010 HK and Science Data Telemetry protocol

[AD.1] SHR-DES-3.2.3-0100

The DES shall provide Science Data blocks and Telemetry blocks formatted as follows:
each block is contained in a single LVDS frame;
each block is preceded by a MROSP header.
The succession of headers within the Science Data/Telemetry frame (delimited by the activation of the Data Valid signal) is shown in Fig. 3.2-1.

EOR

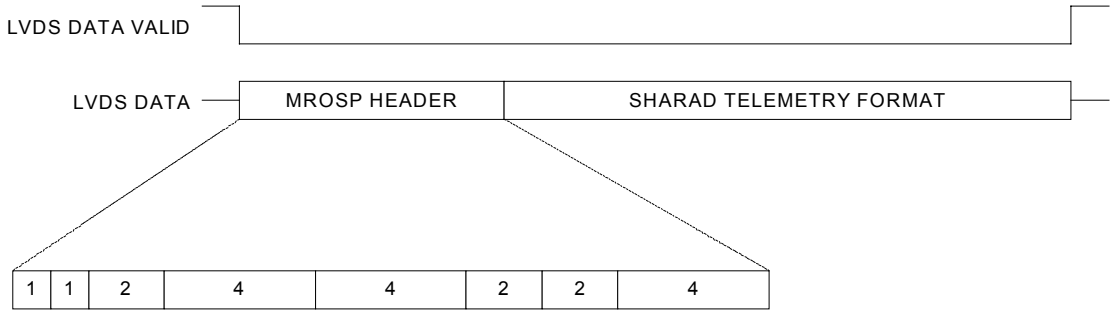

Figure 3.2-1. - Science Data/Telemetry protocol format

SRQI.-3.2/020 MROSP Header

[AD.1] SHR-DES-3.2.3-0110

The MROSP Header contains information pertaining the segmentation of the data sent to the SSR and a reference value provided by the S/C's C&DH as in Fig.3.2-2.

EOR

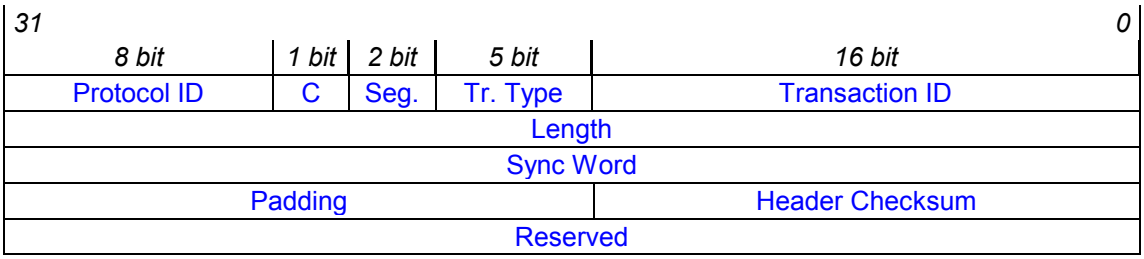

Figure 3.2-2. – MROSP Header format

Relevant fields in this format are:

Protocol ID	8 bits	Packet as being MROSP Value = FF hex.
Compression	1 bit	Compression applied after leaving the instrument but before arrival at the SFC. Always 0 for SHARAD. Value = 0
Segmentation	2 bits	flags to control fragmentation. Value = 00 – No segmentation 01 – First segment 10 – Middle segment 11 – Last segment
Transaction type	5 bits	Data type in the pkt. Value = 1 dec science, 2 dec HK
Transaction ID	16 bits	Sequencing info to relate cmds to tlm. Value = tr id of the cmd that generated the tm pkt
Length	32 bits	Number of octets (header included). Value = variable, min 20.
Sync word	32 bits	Constant to sync Value = 0XFED4AFEE hex.
Padding	16 bits	To align Value = 0 hex
Header Checksum	16 bits	Checksum value computed over all MROSP Header bytes (assuming the checksum field set at 0000 hex)
Reserved	4 bytes	reserved. Value = 0.

***Note**: The Transaction Type of the MROSP Header reflects the different kind of data (Housekeeping Telemetry or Science Data) and permits an higher form of segmentation for Science Data. This distinction is used by the S/C's C&DH to perform the correct packetisation, and to assign the proper APID to the telemetry data (during the packetisation the MROSP Header is stripped out). The overall telemetry format for Science Data is in § 5.2.*

4. TELECOMMANDS

In this section SHARAD Commands are introduced as DES HW provides them to the SW.[i]

SRQI.-4/010 SHARAD Commands

[AD.1] SHR-DES-3.4.3-0010 The DES shall interpret and execute commands in Tab 4.-1.

EOR

Tab. 4-1. – SHARAD Commands

CMD NAME	CMD_ID	CMD DESCRIPTION
TIME_UPDATE	0x01	Provides a new time value to update SHARAD's OBT.
HK_EN_DIS	0x10	Enables/Disables the generation of housekeeping Telemetries.
ENABLE_OST	0x11	Enables the execution of an Operational Sequence Table.
PATCH_MEMORY	0x12	Loads data in any processor memory.
DUMP_MEMORY	0x13	Copies data from any processor memory to the telemetry stream.
LOAD_OST	0x14	Loads OST entries.
LOAD_PT	0x15	Loads parameters in the PT.
LOAD_ODT	0x20	Loads orbit interpolation values in the ODT.
RESTART	0x30	Restarts SHARAD's software.
LOAD_REQUEST	0x12	SHARAD's software upload request (at Boot time only).
LOAD_DATA	0x12	SHARAD's software upload data (at Boot time only).

Note. *The ID assigned to TIME_UPDATE Command does not apply to the command format and exists only for reference.*

[i] DES HW provides an interrupt for each 32 bit word received from CMD I/F

SRQI.-4/020 SHARAD Commands Format

[AD.1] SHR-DES-3.4.3-0020
[AD.1] SHR-DES-3.4.3-0030

The SHRAD Commands are grouped in:
C&DH Commands (see Tab. 4.-2)
Instruments Commands (see Tab. 4.-3)

EOR

Tab. 4.-2. – C&DH Commands Format

MSB 32 … 25	24 … 17	16 … *LSB* 1	
Protocol Id	Transaction Type **0x01**	Transaction Id	*Mrocip header*
Command data (part 1)		Command data (part 2)	*1*
……		……	……

Note: Command Data are in multiple of 4 bytes.

The Command Data total length is from 0 to 19968 bytes.

Tab. 4.-3. – Instrument Commands Format

MSB 32 … 25	24 … 17	16 … *LSB* 1	
Protocol Id	Transaction Type **0x02**	Transaction Id	*Mrocip header*
Start of Command	Command Id	Command data (part 1)	*1*
Command data (part 2)		……	*2*
……		……	……
Command data (part n)		End of Command	

Note: Command Data are in multiple of 4 bytes.
The Command Data total length is from 0 to 19964 bytes.
This field shall be padded with 0's to always be multiple of 32 bits in length.

Fixed patterns are:
Start Of Command: constant, value 7E
End of Command: constant, value FF7E

SRQI.-4/030 SHARAD Command Frame

[AD.1] SHR-DES-3.2.2-0260

Commands received from the Command Interface are NRZ-L formatted, bit contiguous frames. The length of each frame is a multiple of 32 bits. Frames shall be received MSB first.

EOR

4.1. C&DH COMMANDS

SRQI.-4.1/010 TIME UPDATE

[AD.1] SHR-DES-3.4.3-0100

The DES SW shall accept the TIME_UPDATE Command. The command format is in Tab.:4.1-1.

EOR

Tab. 4.1-1. – TIME_UPDATE Command Format

MSB 32 … 25	24 … 17	16 … *LSB* 1	
Protocol Id	Transaction Type **0x01h**	Transaction Id	*Mrocip header*
SECONDS (part 1)		SECONDS (part 2)	*1*
FRACT_SEC		Filler = 0000h	*2*

Relevant fields in this format are:

SECONDS Integer number of seconds from a fixed time origin.

FRACT_SEC Fractional number of seconds (1 LSB = $1/2^{16}$ seconds).

4.2. INSTRUMENT COMMANDS

SRQI.-4.2/010 HK_EN_DIS

[AD.1] SHR-DES-3.4.3-0110 The DES SW shall accept the HK_EN_DIS Command. The Command format is in Tab.4.2-1.

EOR

Tab. 4.2-1. – HK_EN_DIS Command Format

MSB 32 … 25	24 … 17	16 … 9	8 … *LSB* 1	
Protocol Id	Transaction Type **0x02**	Transaction Id		*Mrocip header*
Start of Command	Command Id **0x10**	TLM_SEL	ENG_INT	*1*
Filler = 0000h		End of Command		*2*

Relevant fields in this format are:

TLM_SEL Enable/Disable for each telemetry type:
- Bit 0: TLM_ENG (1=Enabled, 0=Disabled)
- Bit 1: TLM_CMD (1=Enabled, 0=Disabled)
- Bit 2: TLM_LOG (1=Enabled, 0=Disabled)
- Bit 3: TLM_DMP (1=Enabled, 0=Disabled)
- Bit 4: CMD_LOG (1=Enabled, 0=Disabled)
- Bit 4 to 6: Unused, set to 0.
- Bit 7: TLM_BUFFER (1=Enabled, 0=Disabled)

ENG_INT Integer seconds (0 to 255) to specify a new value for the interval between two subsequent engineering telemetry blocks. The value 0 means to leave the current setting as it is.

Note. *Every time the command is issued, the bits status shall reflect the desired condition for all telemetry types.*

Note. *The Eng_Interval value is related to the rate with which TLM_ENG packets are sent to the SSR and not to the sampling rate of engineering/status parameters within DES.*

Note*. The TLM_BUFFER flag is related to the internal buffer function. If enabled all the HK Telemetry packets are stored in an internal circular buffer and the HK Telemetry transmission is suspended. The internal buffer characteristics are the following: up to 77 packets, each packet is up to 276 16-bits words.*

SRQI.-4.2/020 ENABLE_OST

[AD.1] SHR-DES-3.4.3-0120 The DES SW shall accept the ENABLE_OST Command. The Command format is in Tab.4.2-2.

EOR

Tab. 4.2-2. – ENABLR_OST Command Format

MSB 32 … 25	24 … 17	16 … *LSB* 1	*Mrocip header*
Protocol Id	Transaction Type **0x02**	Transaction Id	*1*
Start of Command	Command Id **0x11**	Filler = 0000h	
SECONDS (part 1)		SECONDS (part 2)	*2*
FRACT_SEC		End of Command	*3*

Relevant fields in this format are:

SECONDS Integer number of seconds from a fixed time origin.
FRACT_SEC Fractional number of seconds (1 LSB = 1 / 2^{16}).

Notes:

1. Successful execution of ENABLE_OST activate the transition to Warm Up 1 and the activation of SHR_Operating discrete.
2. The absolute-time Time Tag expressed with fields SECONDS and FRACT_SEC defines the starting time of an observation (i.e. of an OST). If the Time tag is 0, then the corresponding value in the PT is used, if not 0, as starting time."

SRQI.-4.2/030 PATCH_MEMORY

[AD.1] SHR-DES-3.4.3-0130

The DES SW shall accept the PATCH_MEMORY Command. The Command format is in Tab.4.2-3.

EOR

Tab. 4.2-3. – PATCH_MEMORY Command Format

MSB 32 … 25	24 … 17	16 … 9	8 … *LSB* 1	
Protocol Id	Transaction Type **0x02**	Transaction Id		*Mrocip header*
Start of Command	Command Id **0x12**	TARGET_MEM	N_BLOCKS	*1*
START_ADDR				*2*
N_LOCATIONS		DATA		*3*
DATA ….		DATA (padding)		….
Other Patch Blocks				
DATA (padding)		End of Command		

Relevant fields in this format are:

TARGET_MEM — Bit selection logic to define the single target for the patch (at least and only one shall be set):
- Bit 0: SPV_EEPROM (1=Selected, 0=Unselected)
- Bit 1: SPV_Prog (1=Selected, 0=Unselected)
- Bit 2: SPV_Data (1=Selected, 0=Unselected)
- Bit 3 to 7: unused, set to 0

N_BLOCKS — Number of patch blocks contained in the single PATCH_MEMORY Command (from 1 to 255, 0 is N/A).

START_ADDR — Start address (first location absolute) of the first patch block.

N_LOCATIONS — Number of consecutive locations to be patched starting from START_ADDRESS (included). Shall be more than zero. The size of memory token depends upon the hardware architecture: one location is 4 bytes for SPV_Data and 6 bytes for the SPV_EEPROM and SPV_Prog.

DATA — N_LOCATIONS of data to be patched as the first patch block (more than zero). The number of bytes required for each memory location depends on the target memory (4 bytes or 6 bytes).

Padding — Sequence of 0, 1, 2 or 3 bytes set to 00h to pad the overall length of the command to a multiple of 32 bits.

Other Patch Blocks — The sequence of fields START_ADDRESS, N_LOCATIONS and DATA is repeated for all the N_BLOCKS to be contained in the command.

***Note**. The overall number of patch blocks expressed in a single command shall be so to respect the maximum size limits specified for SHARAD's Commands.*

***Note**. For the SPV_EEPROM the address is referred to the current partition (A or B). The available EEPROM memory is the current 64 KWords EEPROM (each word is 48 bits long). The required locations must be all in the same partition.*

***Note**. xxx*

SRQI.-4.2/040 DUMP_MEMORY

[AD.1] SHR-DES-3.4.3-0140

The DES SW shall accept the DUMP_MEMORY Command. The Command format is in Tab.4.2-4.

EOR

Tab. 4.2-4. – DUMP_MEMORY Command Format

MSB 32 … 25	24 … 17	16 … 9	8 … LSB 1	
Protocol Id	Transaction Type **0x02**	Transaction Id		*Mrocip header*
Start of Command	Command Id **0x13**	TARGET_MEM	Filler = 00h	*1*
START_ADDR				*2*
N_LOCATIONS				*3*
Filler = 0000h		End of Command		*4*

Relevant fields in this format are:

TARGET_MEM Bit selection logic to define the single target for the patch:
Bit 0: SPV_EEPROM (1=Selected, 0=Unselected)
Bit 1: SPV_Prog (1=Selected, 0=Unselected)
Bit 2: SPV_Data (1=Selected, 0=Unselected)
Bit 3 to 7: unused, set to 0

START_ADDR Start address (first location) of the first dump word.

N_LOCATIONS Number of consecutive locations to be dumped starting from START_ADDRESS (included). Shall be more than zero. The number of bytes required for each memory (4 bytes for SPV_Data or 6 bytes for SPV_EEPROM and SVP_PROG).

For the SPV_EEPROM the address is referred to the current partition (A or B). The available EEPROM memory is the current 64 KWords EEPROM (each word is 48 bits long).

SRQI.-4.2/050 LOAD_OST

[AD.1] SHR-DES-3.4.3-0150 The DES SW shall accept the LOAD_OST Command. The Command format is in Tab.4.2-5.

EOR

Tab. 4.2-5. – LOAD_OST Command Format

MSB 32 … 25	24 … 17	16	15 … *LSB* 1	*Mrocip header*
Protocol Id	Transaction Type **0x02**	Transaction Id		
Start of Command	Command Id **0x14**	S	N_ENTRIES	*1*
ENTRY 1st (part 1)		ENTRY 1st (part 2)		*2*
…….		…….		….
ENTRY 1st (part 7)		ENTRY 1st (part 8)		*5*
…….		…….		….
ENTRY nth (part 1)		ENTRY nth (part 2)		*(N-1) x 4 +2*
…….		…….		
ENTRY nth (part 7)		ENTRY nth (part 8)		*(N-1) x 4 +5*
Filler = 0000h		End of Command		*(N-1) x 4 +6*

Relevant fields in this format are:

S (Reserved) Spare - reserved for future uses Value = 0
N_ENTRIES (8 bits) Number of entries contained in the command (from 1 to 255, 0 is N/A).
ENTRY Data related to one entry of the OST. The bit pattern for each entry is 128 bits long;
Filler Two bytes set at 0000h to pad the overall length of the command to a multiple of 32 bits.

SRQI.-4.2/060 LOAD_PT

[AD.1] SHR-DES-3.4.3-0160 The DES SW shall accept the LOAD_PT Command. The Command format is in Tab.4.2-6.

EOR

Tab. 4.2-6. – LOAD_PT Command Format

MSB 32 … 25	24 … 17	16 … *LSB* 1	*Mrocip header*
Protocol Id	Transaction Type **0x02**	Transaction Id	
Start of Command	Command Id **0x15**	N_BLOCKS	*1*
START_ADDR1st block		N_LOCATION1st block	*2*
DATA 1st block (part 1)		DATA 1st block (part 2)	*3*
START_ADDR 2nd block		N_LOCATION2nd block	*4*
DATA 2nd block (part 1)		DATA 2nd block (part 2)	*5*
…….		…….	
START_ADDR nth block		N_LOCATION nth block	
DATA nnd block (part 1)		DATA nnd block (part 2)	
Filler = 0000h		End of Command	

Relevant fields in this format are:.

N_BLOCKS	Number of data blocks contained in the command (from 1 to 2495, 0 is N/A).
START_ADDR	Relative addresses.
N_LOCATION	Size of the data block (from 1 to 4990, 0 is N/A).
DATA	32 bits each value
Filler	Two bytes set at 0000h to pad the overall length of the command to a multiple of 32 bits.

***Note**: The overall number of PT parameter/value entries expressed in a single command shall be so to respect the maximum size limits specified for SHARAD's Commands.*

SRQI.-4.2/070 LOAD_ODT

[AD.1] SHR-DES-3.4.3-0170

The DES SW shall accept the LOAD_ODT Command.
The Command format is in Tab.4.2-7.

EOR

Tab. 4.2-7. – LOAD_ODT Command Format

MSB 32 … 25	24 … 17	16 15 14 … 9 8	*LSB* 1	
Protocol Id	Transaction Type **0x02**	Transaction Id		*Mrocip header*
Start of Command	Command Id **0x20**	S	DELTA_T	*1*
SECONDS (part 1)		SECONDS (part 2)		*2*
FRACT_SEC		N_LINES		*3*
DATA_LINE 1st (part 1)				*4*
DATA_LINE 1st (part 2)				*5*
DATA_LINE 1st (part 3)				*6*
DATA_LINE 1sd (part 4)				*7*
…….				
DATA_LINE nth (part 1)				*N x 4*
…….				
…….				
DATA_LINE nth (part 4)				*N x 4 + 4*
Filler = 0000h		End of Command		*N x 4 + 5*

Relevant fields in this format are:.

S (Reserved)	Spare. Value = 0
DELTA_T	(8 bits) Number of seconds between two successive lines of the ODT (from 1 to 255, 0 is N/A).
SECONDS	Integer number of seconds from a fixed time origin.
FRACT_SEC	Fractional number of seconds (1 LSB = 1 / 2^16). The SECONDS and FRACTIONAL SECONDS fields provide the initial time value of the first row of the ODT.
N_LINES	Number of rows contained in the command (from 1 to 1247, 0 is N/A).
DATA_LINE	Data related to one line of the OST (4 times 32 bit float)
Filler	Two bytes set at 0000h to pad the overall length of the command to a multiple of 32 bits.

SRQI.-4.2/080 RESTART

[AD.1] SHR-DES-3.4.3-0180 The DES SW shall accept the RESTART Command. The Command format is in Tab.4.2-8.

EOR

Tab. 4.2-8. – RESTART Command Format

MSB 32 … 25	24 … 17	16 … *LSB* 1		*Mrocip header*
Protocol Id	Transaction Type **0x02**	Transaction Id		*Mrocip header*
Start of Command	Command Id **0x30**	COMMAND	PARAM	*1*
Filler = 0000h		End of Command		*2*

Relevant fields in this format are:

COMMAND
- 0 = Full-Restart from EEPROM
  - PARAM: 0 = from EEPROM partition A; 1 = from EEPROM partition B
- 1 = Re-write EEPROM
  - PARAM: 0 = EEPROM partition A; 1 = EEPROM partition B
- 2 = Warm-Restart (from the Program RAM copy)
  - PARAM: 0
- 3 = PT reload (from EEPROM) and re-compute PT params
  - PARAM: 0

SRQI.-4.2/090 LOAD_REQUEST

[AD.1] SHR-DES-3.4.3-0180 (TBW) The DES SW shall accept the LOAD_REQUEST Command. The Command format is in Tab.4.2-9.

EOR

Tab. 4.2-9. – LOAD_REQUEST Command Format

MSB 32 … 25	24 … 17	16 … *LSB* 1		*Mrocip header*
Protocol Id	Transaction Type **0x02**	Transaction Id		*Mrocip header*
Start of Command	Command Id **0x12**	0x10	Filler = 00h	*1*
Filler = 0000h		End of Command		*2*

Relevant fields in this format are:

Filler Bytes set at 00h to pad the overall length of the command to a multiple of 32 bits.

***Note**: This command must be sent during the 15 seconds dedicated for the SW Reload (see table 5.3.4).*

SRQI.-4.2/100 LOAD_DATA

[AD.1] SHR-DES-3.4.3-0180 (TBW) The DES SW shall accept the LOAD_DATA Command. The Command format is in Tab.4.2-10.

EOR

Tab. 4.2-10. – LOAD_DATA Command Format

MSB 32 … 25	24 … 17	16 15 14 … 9 8	*LSB* 1	
Protocol Id	Transaction Type **0x02**	Transaction Id		*Mrocip header*
Start of Command	Command Id **0x12**	LOAD_TYPE	COUNTER	*1*
DATA		DATA		*2*
DATA		DATA		*3*
DATA		DATA or Filler		
DATA or Filler		End of Command		

Relevant fields in this format are:

LOAD_TYPE Bit selection logic, it's value shall be:
0x20 LOAD DATA
Data to be loaded in EEPROM
The following values shall contain the SHARAD Code
0x60 DATA CHECKSUM
the following values shall contain the SHARAD Code checksum (this is the last command received for the SW Reload)

COUNTER Load Data TC sequence counter. This number must start from 0 and the COUNTER increment between two consecutive LOAD_DATA must be 1.

DATA Reload data

Filler Bytes set at 0000h to pad the overall length of the command to a multiple of 32 bits.

Note 1: the EEPROM partition (A or B) involved in the SW Reload depend on the TC Discrete value.
Note 2: an TLM_ACK is sent for each LOAD_DATA reporting the result of the command execution.
Note 2: there is not timeout after the Load_Request command. The DES SW waits all LOAD_DATA TCs. The last one must be the Checksum. The DES SW shall calculate the Checksum and check it with the received Checksum. If the test is OK the system reboot automatically
Note 4: if some test fails (checksum test, error on counter increment, the system go in Safe/Idle (see table 5.3.4).

4.3. DISCRETE TELECOMMAND

SRQI.-5.3/010 SHARAD Discrete TCs

The DES shall provide one discrete input line, toward Sharad, according to the configuration shown in Figure 4.3-1.

The discrete line shall be used in two situation:

- during boot operations to start from the first or the second EEPROM partition (A or B; DES_TC_1 = not active then partition = A)
- during the normal operation to allows the TFE switch on (DES_TC_1 = not active then TFE is always switched off).

EOR

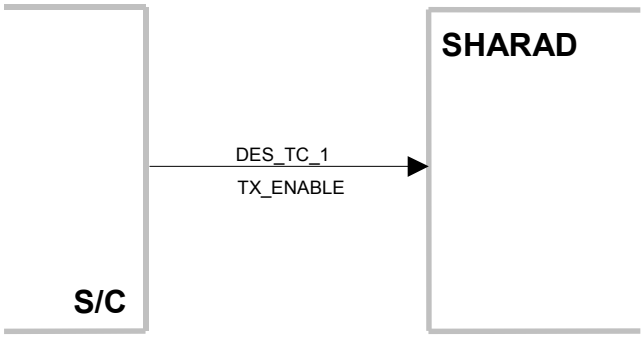

Figure 5.3-1. – Discrete TCs

5. TELEMETRIES

SRQI.-5/010 SHARAD Telemetries

[AD.1] SHR-DES-3.4.3-0300

The DES shall provide:

- HK Packets (see Tab. 5-1) identified as TLM_ENG, TLM_ACK, TLM_LOG, TLM_DMP, TLM_CMD
- Science Data Packets (see Tab 5-2)
- Discrete TMs (see § 5.3)

EOR

Tab. 5-1. – HK Telemetry Formats

Format ID	Format	Description
TLM_ENG = 0xE, 1110b	Engineering Tm	It includes all DES engineering parameters values and other values (e.g., software values) to be generated periodically toward the SSR.
TLM_ACK= 0xA, 1010b	Command ACK Tm	It provides a positive/negative acknowledge to received commands. The format is generated for each command before the command is executed.
TLM_LOG= 0xF, 1111b	Event/Error Log Tm	It provides indication of SHARAD/DES events and to notify errors of any sort (command, software or engineering).
TLM_DMP= 0xD, 1101b	Memory Dump Tm	It contains memory locations value following a Memory Dump request.
TLM_CMD= 0xC, 1100b	Command Log Tm	It provides a dump of the commands received by SHARAD.
TLM_BTR= 0xB, 1011b	Boot Report Tm	It provides a SHARAD report at Boot time.

Tab. 5-2. – SD Telemetry Formats

Format ID	Format	Description
SCI_DATA = 0x0, 0000b	Science Tm	

SRQI.-5/020 SHARAD Telemetry Frame

[AD.1] SHR-DES-3.2.2-0350

Science/HK data sent from the Science Data Interface are NRZ-L formatted, bit contiguous frames. The length of each frame is a multiple of 32 bits. Frames shall be sent MSB first.

EOR

SRQI.-5/030 SHARAD Telemetry MROSP Header

[AD.1] SHR-DES-3.4.3-0310
[AD.1] SHR-DES-3.4.3-0315
[AD.1] SHR-DES-3.4.5-0515

The DES SW shall produce the MROSP Header both for HK and Science Data.
The format is in Tab.5-3.
The C, Seg, TR Type shall be filled according to TM Type.

EOR

Tab. 5-3. – MROSP Telemetry Format

MSB 32 – 25	24	23 – 22	21 – 17	16 – 9	8 – LSB 1	
Protocol Id	C	Seg	TR Type	Transaction Id		1
LENGTH (part 1)				LENGTH (part 2)		2
SYNCH_WORD (part 1)				SYNCH_WORD (part 2)		3
Filler = 0x00				HEADER_CHK		4
Reserved = 0x0000				Reserved = 0x0000		5
Data						.....

Relevant fields in this format are:

Transaction id	HK case: set to 0x0, for all types of HK Telemetry SC case: value provided in the Transaction ID field of the ENABLE_OST command that started current generation of SC data
Seg	Segmentation (applicable to SD to manage segmentation of SC data)
LENGTH	Overall length of the entire MROSP packet, header included

5.1. HK TELEMETRY

SRQI.-5.1/010 SHARAD HK Telemetry Pkts Format

[AD.1] SHR-DES-3.4.3-0312
[AD.1] SHR-DES-3.4.3-0320
[AD.1] SHR-DES-3.4.3-0330
[AD.1] SHR-DES-3.4.3-0400
[AD.1] SHR-DES-3.4.3-0410
[AD.1] SHR-DES-3.4.3-0420
[AD.1] SHR-DES-3.4.3-0430
[AD.1] SHR-DES-3.4.3-0440

The specialised layout of SHARAD HK Telemetry shall therefore adhere to the format in Tab.5.1-1 and Tab. 5.1-2.

EOR

Tab. 5.1-1. – MROSP HK Telemetry Format

MSB 32 … 25	24 … 3	2 … 1	20 … 17	16 … 9	8 … *LSB* 1	
C= 0, Seg = 0, TR Type = 00010						*MROSP Header*
Start of Telemetry	FMT_ID	S_M_ID	SECONDS (part 1)			*6*
SECONDS (part 2)			FRACT_SEC			*7*
TLM_COUNTER						*8*
FMT_LENGTH			Spare = 0x0			*9*
HK_DATA_FORMAT						….
CHECKSUM			End of Telemetry			

Relevant fields in this format are:

Start of Telemetry	Fixed bit pattern **0x7E**
FMT_ID	HK Telemetry format identifier (TLM_ENG, TLM_ACK, ….).
S_M_ID	DES' State, or Mode, at the moment of TLM generation (see Tab 5.1-2).
SECONDS	Integer seconds part of the Time Tag associated to the format.
FRAC_SEC	Fractional seconds part of the Time Tag associated to the format.
FMT_LENGTH	Length of format (Header and Trailer not included).
TLM_COUNTER	Sequential counter value of the HK Telemetry formats generated. This counter is incremented every time any HK Telemetry Format is sent to the S/C's SSR.
CHECKSUM	16 bit checksum of the whole HK Telemetry format. Header included, Trailer and MROSP Header not included. The CRC formula is CRC-16 polynomial: $x^{16} + x^{15} + x^2 + 1$.
End of Telemetry	Fixed bit pattern (value = **0x FF7E**).

Tab. 5.1-2. – State/mode field values

State	Mode	Value
CHECK/INIT		**0x0**
STAND BY		**0x1**
WARM UP 1 Activation		**0x2**
WARM UP 2 Activation		**0x3**
SAFE/IDLE		**0x4**
Measurement Modes	SUB-SURFACE SOUNDING	**0x5**
	RECEIVE ONLY	**0x6**
	WAIT	**0x7**
	CALIBRATION	**0x8**
	TEST	**0xB**
WARM UP 1 De-activation		**0x9**
WARM UP 2 De-activation		**0xA**

***Note**: Requirements for interleaving a sequence of TLM_DMP frames with other Telemetry formats are under review*

SRQI.-5.1/020 Engineering Telemetry Format

[AD.1] SHR-DES-3.4.3-0400
[AD.1] SHR-DES-3.4.3-0405

The specialised layout of Engineering Telemetry shall therefore adhere to the format in Tab.5.1-3.

EOR

Tab. 5.1-3. – TLM_ENG Telemetry Format

MSB 32 … 25	24 … 21	20 … 17	16 … 9	8 … LSB 1	
C= 0, Seg = 0, TR Type = 00010					1..5 MROSP Header
Start of Telemetry	FMT_ID 0xE	S_M_ID	SECONDS (part 1)		6
SECONDS (part 2)			FRACT_SEC		7
TLM_COUNTER					8
FMT_LENGTH			Spare = 0x0		9
DES_TEMP	DES_5V		DES_12V	DES_2V5	10
RX_TEMP	TX_TEMP		TX_LEV	TX_CURR	11
EXT_STATUS	HW_STATUS		CURR_PRESUM	CURR_COMPR	12
PRI_TOTAL_COUNTER					13
High Resolution Time H					14
High Resolution Time L					15
Memory Segment	BOOT_INFO		HK Enabled	HK Interval	16
OST START TIME					17
			OST START TIME (fractional part)		18
TLM_ENG_COUNTER					19
RECEIVED_TC_CNT					20
REJECTED_TC_CNT					21
EXECUTED_TC_CNT					22
CHECKSUM			End of Telemetry		23

Relevant fields in this format are:

FMT_ID	HK Telemetry format identifier: TLM_ENG = 0xE
DES_TEMP	Internal DES Temperature
DES_5V	DES Digital 5V Supply
DES_12V	DES Analog 12V Supply
DES_2V5	DES Digital 2V5 Supply
RX_TEMP	Internal RX Temperature
TX_TEMP	Internal TFE Temperature
TX_LEV	TFE output power level
TX_CURR	TFE primary power current (measured internally to TFE)
EXT_STATUS	The current status as follow: Bit 0: Status of discrete 1 TC line (1=Active, 0=Not Active) Bit 1…4: Status of discrete 4 TM lines (1=Active, 0=Not Active):

	ALIVE, OPERATING, RUNNING, SAFE/IDLE Bit 5; TX -TFE Status (0 disabled, 1 enabled) Bit 6: RX Status (0 disabled, 1 enabled)
HW_STATUS	C&C Status Bit 0: 0= OK, 1= Time Tic too Late Bit 1: 0= OK, 1= Watchdog Slave Status Bit 4: 1= OK, 0= FIFO full Bit 5: 0= OK, 1= TC Over Run Bit 6: 0= OK, 1= Error DMA
CURR_PRESUM	Processing current Pre-Summing value (0 not in measure mode)
CURR_COMPR	Processing current Bit Compression value (0 not in measure mode)
PRI_TOTAL_COUNTER	PRI total counter (is an HW counter, start at DES switch-on and increment for every PRI frequency)
High Resolution Time	Current value of High Resolution Counter Timer (40 bits). The 32 MSB are in the High word the 8 LSB in the Low word (bits 1..8).
Memory Segment	EEPROM Segment Bit 0: 0 = EEPROM A, 1 = EEPROM B
BOOT_INFO	Restart Info, Bit 0..1: 0= Nominal, Full Restart 1= Warm Restart, 2= After Watchdog
HK Enable	Status of HK Telemetry. This field reports the status of the enabled HK TM (see HK_EN_DIS telecommand)
HK Interval	Interval Value of Eng HK TM. This field reports the value of the HK TM interval (see HK_EN_DIS telecommand)
OST START TIME, OST START TIME FRACTIONAL PART	OST Time Tag programmed value. The default value is 0, but changes after the ENABLE_OST command. At the end of the OST execution the value is reset to 0.
TLM_ENG_COUNTER	Counter of Eng HK TM
RECEIVED_TC_COUNTER	Counter of Received TC
REJECTED_TC_COUNTER	Counter of Rejected TC (not acknowledged)
EXECUTED_TC_COUNTER	Counter of Executed TC

SRQI.-5.1/030 Acknowledge Telemetry Format

[AD.1] SHR-DES-3.4.3-0410
[AD.1] SHR-DES-3.4.3-0415

The specialised layout of Acknowledge Telemetry shall therefore adhere to the format in Tab.5.1-4.

EOR

Tab. 5.1-4. – TLM_ACK Telemetry Format

MSB 32 … 25	24 … 21	20 … 17	16 … 9	8 … LSB 1	
C= 0, Seg = 0, TR Type = 00010					*1..5 MROSP Header*
Start of Telemetry	FMT_ID 0xA	S_M_ID	SECONDS (part 1)		*6*
SECONDS (part 2)			FRACT_SEC		*7*
TLM_COUNTER					*8*
FMT_LENGTH			Filler = 0000		*9*
Command ID					*10*
Command Transaction Type			Command Transaction ID		*11*
Warning Code					*12*
Error Code					*13*
CHECKSUM			End of Telemetry		*14*

Relevant fields in this format are:

FMT_ID	Fixed bit pattern 0xA
Command ID	Copy of Command ID
Command Transaction Type	Copy of Transaction_type of the S/C C&DH command
Command Transaction ID	Copy of Transaction_ID of the S/C C&DH command
Warning Code	Warning Code of the parsed command A bit with value = 1 means a failed check: Bit 0 = Not Used Bit 1 = Invalid IP checksum field Bit 2 = Invalid IP Version Bit 3 = Invalid IP Length. Bit 4 = Invalid IP Protocol Bit 5 = Invalid IP Source. Bit 6 = Invalid IP Destination. Bit 7 = Invalid UDP Source. Bit 8 = Invalid UDP Destination Bit 9 = One or more MROCIP fields are invalid. Bit 10 = IP length fields mismatch or length not multiple of 4 Bit 11 = Command data header invalid. Bit 12 = Command data trailer invalid. Bit 13 = Command id invalid. Bit 14 = Command received while SHARAD is operating. Bit 15 = Invalid UDP Checksum. Bit 28 = Command reception timeout
Error Code	0x0 = OK

0xFFFFFFFF = Error

SRQI.-5.1/040 Log Telemetry Format

[AD.1] SHR-DES-3.4.3-0420
[AD.1] SHR-DES-3.4.3-0425

The specialised layout of Log Telemetry shall therefore adhere to the format in Tab.5.1-6.

EOR

Tab. 5.1-6. – TLM_LOG Telemetry Format

MSB 32 … 25	24 … 21	20 … 17	16 … 9	8 … *LSB* 1	
C= 0, Seg = 0, TR Type = 00010					*1..5 MROSP Header*
Start of Telemetry	FMT_ID 0xF	S_M_ID	SECONDS (part 1)		*6*
SECONDS (part 2)			FRACT_SEC		*7*
TLM_COUNTER					*8*
FMT_LENGTH			Filler = 0000		*9*
LOG_CODE					*10*
LOG_FORMAT					….
LOG ERROR CODE					*17*
CHECKSUM			End of Telemetry		*18*

Relevant fields in this format are:
LOG_CODE (see Tab 5.1-7)
LOG_FORMAT See following tables
LOG ERROR CODE 0 = No error, 0xFFFFFFFF = Error

Tab. 5.1-7. – Log_Code field values

Description	Value
Transition	**0x1**
Operating	**0x2**
Time	**0x3**
Command Execution	**0x4**
SW Event	**0x5**

Tab. 5.1-8. – Transition fields

LOG_CODE = TRANSITION	*10*
CURRENT MODE (0x0 .. 0xB)	*11*
CURRENT PRESUMMING	*12*
CURRENT COMPRESSION	*13*
NEW MODE (0x0 .. 0xB)	*14*
NEW PRESUMMING	*15*
NEW COMPRESSION	*16*

Tab. 5.1-9. – Operating fields

LOG_CODE = OPERATING	*10*
COMMAND ID (0x10 .. 0x30)	*11*
TRANSITION TYPE	*12*
TRANSACTION ID	*13*
00	*14*
00	*15*
00	*16*

Tab. 5.1-10. – Time fields

LOG_CODE = TIME	*10*
(0x128)	*11*
PREVIOUS TIME (SECONDS)	*12*
PREVIOUS TIME (FRACTIONAL PART)	*13*
(0x129)	*14*
NEW TIME (SECONDS)	*15*
NEW TIME (FRACTIONAL)	*16*

Tab. 5.1-11. – Command Execution fields

LOG_CODE = EXEC	*10*
COMMAND ID (0x10 .. 0x30)	*11*
EVENT_ANOMALY	*12*
00	*13*
00	*14*
00	*15*
00	*16*

Tab. 5.1-12. – SW Event fields

LOG_CODE = SW Event	*10*
SW Event Code	*11*
Parameter 1	*12*
Parameter 2	*13*
00	*14*
00	*15*
00	*16*

Relevant fields in these formats are:

SW Event Code	This field is used to specify the Event type: 0x64 = OST Problems Parameter 1 = OST Line Parameter 2 = OST Parameter number in error 0x65 = EEPROM Boot/Loader Code Checksum Error 0x66 = EEPROM Program Code Checksum Error 0x67 = RAM Program Code Checksum Error Parameter 1 = Expected Checksum Parameter 2 = Calculated Checksum 0x68 = Monitor Error Parameter 1 = Item ID (see next table) Parameter 2 = Item Value 0x69 = SW Version Parameter 1 = SW Version Parameter 2 = SW Release
Item ID	This field is the first parameter for the Monitor error (see below): 1 = DES_TEMP (Internal DES Temperature) 2 = DES_5V (DES Digital 5V Supply) 3 = DES_12V (DES Analog 12V Supply) 4 = DES_2V5 (DES Digital 2V5 Supply) 5 = RX_TEMP (Internal RX Temperature) 6 = TX_TEMP (Internal TFE Temperature) 7 = TX_LEV (TFE output power level) 8 = TX_CURR (internal TFE primary power current)
Event Anomaly	0x1 = EVT_OUT_OF_RANGE (PT or ODT out of range) 0x2 = EVT_MISSING_OST (OST not uploaded) 0x3 = EVT_NO_OST_START (OST Start Time Empty) 0x4 = EVT_OST_TOO_EARLY (OST Start Time is too early) 0x5 = EVT_OST_TOO_FAR (OST Start Time is too far in the future, i.e. more than TBD seconds from OBT) 0x6 = EVT_OST_INVALID_PRI (PRI value not defined) 0x7 = EVT_OST_INVALID_PH (Invalid phase compensation method) 0x8 = EVT_OST_INVALID_MODE (Invalid operating mode) 0x9 = EVT_OST_INVALID_OST_DURATION (OST duration is not an integer multiple of presumming value 0xA = EVT_OST_INVALID_TOPO_VAL (Topography validity field is greater than maximum validity value stored in PT) 0xB = EVT_OST_INVALID_SLOPE (Invalid Slope value) 0xC = EVT_OST_INVALID_N_ENTRIES (field N_Entries inside the CMD has value 0 or greater than the value stored in PT). This error code is valid for OST and ODT errors on number of entries. 0xD = EVT_OST_INVALID_LENGTH (Mismatch between N_Entries field and actual number of OST loaded) 0xE = EVT_INVALID_HK_ENABLE_FORMAT (The TLM_SEL field in HK_EN CMD is invalid) 0xF = EVT_INVALID_CMD Not a valid command field inside Restart CMD 0x10 = EVT_INVALID_PARTITION Invalid partition inside Restart CMD 0x11 = EVT_INVALID_ADDRESS Try to patch a write protected EEPROM memory location.

SRQI.-5.1/050 Dump Telemetry Format

[AD.1] SHR-DES-3.4.3-0430
[AD.1] SHR-DES-3.4.3-0435

The specialised layout of Dump Telemetry shall therefore adhere to the format in Tab.5.1-15.

EOR

Tab. 5.1-15. – TLM_DMP Telemetry Format

MSB 32 … 25	24 … 21	20 … 17	16 … 9	8 … *LSB* 1	
C= 0, Seg = 0, TR Type = 00010					*1..5 MROSP Header*
Start of Telemetry	FMT_ID 0xD	S_M_ID	SECONDS (part 1)		*6*
SECONDS (part 2)			FRACT_SEC		*7*
TLM_COUNTER					*8*
FMT_LENGTH			Filler = 0000		*9*
TARGET_MEM					*10*
START_ADDR					*11*
N_LOCATIONS					*12*
DUMP_DATA	DUMP_DATA	DUMP_DATA	DUMP_DATA		….
DUMP_DATA	DUMP_DATA	DUMP_DATA	Padding		….
CHECKSUM		End of Telemetry			

Relevant fields in this format are:

TARGET_MEM — Bit selection logic to define the single target for the patch:
Bit 0: SPV_EEPROM (1=Selected, 0=Unselected)
Bit 1: SPV_Prog (1=Selected, 0=Unselected)
Bit 2: SPV_Data (1=Selected, 0=Unselected)
Bit 3 to 31: unused, set to 0

START_ADDR — Start address (first location) of the first dumped word.

N_LOCATIONS — Number of consecutive locations dumped starting from START_ADDRESS (included).

DUMP_DATA — N_LOCATIONS of contiguous data word being dumped. The number of bytes dumped for each location depend on the memory type (4 bytes for SPV_Data or 6 bytes for SPV_EEPROM and SVP_PROG).

Padding — Sequence of 0 or 2 bytes set to 0x0 to pad the overall length of the command to a multiple of 32 bits.

DES SW will generate a number of TLM_DMP packets basing on limits for the TM packets size. Large dump requests will be handled with multiple TLM_DMP packets.

The data with a 32 bits format (i.e. the Parameter Table) in the EEPROM or Program Area (48 bits) are left aligned (the first 32 bits). The layout of the dump data is the same.
If the required locations, starting from a start address, exceeds the memory size the result is the following: after the last memory address location the dumped data are the data with address 0 until to the number of the required locations.

SRQI.-5.1/055 Boot Report Telemetry Format

[AD.1] SHR-DES-3.4.3-0430
[AD.1] SHR-DES-3.4.3-0435

The specialised layout of Boot Report Telemetry shall therefore adhere to the format in Tab.5.1-16.

EOR

Tab. 5.1-16. – TLM_BRT Telemetry Format

MSB 32 … 25	24 … 21	20 … 17	16 … 9	8 … *LSB* 1	
C= 0, Seg = 0, TR Type = 00010					*1..5 MROSP Header*
Start of Telemetry	FMT_ID 0xB	S_M_ID	Filler = 0000		*6*
Filler = 0000			Filler = 0000		*7*
Filler = 0000					*8*
FMT_LENGTH			Filler = 0000		*9*
BOOT_REPORT					*10*
RAM_ADDRESS					*11*
…					
CHECKSUM			End of Telemetry		

Relevant fields in this format are:

BOOT_REPORT — Define the boot report type:
0: PROGRAM RAM_CHECK
1: DATA RAM_CHECK

RAM_ADDRESS — address of the wrong RAM location

Padding — Sequence of 0 or 2 bytes set to 0x0 to pad the overall length of the command to a multiple of 32 bits.

This packet is sent by the DES SW during Boot phase in case of errors for the program and data RAM checks (see 5.3 paragraph).

SRQI.-5.1/060 Command Telemetry Format

[AD.1] SHR-DES-3.4.3-0440
[AD.1] SHR-DES-3.4.3-0445

The specialised layout of Command Telemetry shall therefore adhere to the format in Tab.5.1-7.

EOR

Tab. 5.1-17. – TLM_CMD Telemetry Format

MSB 32 … 25	*24 … 21*	*20 … 17*	*16 … 9*	*8 … LSB 1*	
C= 0, Seg = 0, TR Type = 00010					*1..5 MROSP Header*
Start of Telemetry	FMT_ID 0xC	S_M_ID	SECONDS (part 1)		*6*
SECONDS (part 2)			FRACT_SEC		*7*
TLM_COUNTER					*8*
FMT_LENGTH			Filler = 0000		*9*
CMD_STATUS	00h		CMD_LENGTH		*10*
CMD_DATA	CMD_DATA		CMD_DATA	CMD_DATA	*11*
CMD_DATA	CMD_DATA		CMD_DATA	Padding	…
CHECKSUM			End of Telemetry		…

Relevant fields in this format are:

CMD_STATUS	Flags providing details about command reception and handling status
CMD_LENGTH	Number of consecutive bytes dumped constituting the content of the command buffer
CMD_DATA	N bytes of contiguous command data dumped.
Padding	0 to 3 bytes added to the N bytes dumped in order to obtain a dump size multiple of 32 bits.

Note 1: the max number of dumped command data is XXX.
Note 2: the dumped command data contains all the TC fields starting from the IP/UDP (see 3.1 paragraph).

5.2. SCIENTIFIC TELEMETRY

SRQI.-5.2/010 SHARAD Science Telemetry Pkts Format

[AD.1] SHR-DES-3.4.5-0500
[AD.1] SHR-DES-3.4.5-0505
[AD.1] SHR-DES-3.4.5-0510
[AD.1] SHR-DES-3.4.5-0515
[AD.1] SHR-DES-3.4.5-0520
[AD.1] SHR-DES-3.4.5-0530
[AD.1] SHR-DES-3.4.5-0540

The specialised layout of SHARAD SD Telemetry shall therefore adhere to the format in Tab.5.2-1 and Tab. 5.2-2.

The MRSOP Header shall provide two bits to manage the segmentation of the Science Data sent to the SSR.

EOR

Tab. 5.2-1. – MROSP SD Telemetry Format

MSB 32 … 25	24 … 21	20 … 17	16 … 9	8 … *LSB* 1	
C= 0, Seg = **var**, TR Type = **00001**					*1..5 MROSP Header*
Start of Telemetry	FMT_ID	S_M_ID	SECONDS (part 1)		*6*
SECONDS (part 2)			FRACT_SEC		*7*
TLM_COUNTER					*8*
FMT_LENGTH			Filler = 0000		*9*
SCIENCE_DATA_FORMAT					….
CHECKSUM			End of Telemetry		*953*

Relevant fields in this format are:

Start of Telemetry	Fixed bits pattern (value = 0x7E)
FMT_ID	SD Telemetry format (value = 0x0)
S_M_ID	DES' State, or Mode, at the moment of TLM generation.
SECONDS	Integer seconds part of the Time Tag associated to the format.
FRACT_SEC	Fractional seconds part of the Time Tag associated to the format.
TLM_COUNTER	Sequential counter value of the SD Telemetry formats generated.
FMT_LENGTH	Length of format (Header and Trailer not included).
CHECKSUM	16 bit checksum of the whole SD Telemetry format. Header included, Trailer and MROSP Header not included. The CRC formula is CRC-16 polynomial: $x^{16} + x^{15} + x^2 + 1$.
End of Telemetry	Fixed bit pattern (value 0xFF7E).

SRQI.-5.2/020 SHARAD Science Data Format

[AD.1] SHR-DES-3.4.5-0570
[AD.1] SHR-DES-3.4.5-0580
[AD.1] SHR-DES-3.4.5-0590
[AD.1] SHR-DES-3.4.5-0600
[AD.1] SHR-DES-3.4.5-0605
[AD.1] SHR-DES-3.4.5-0608

The Science Data Format shall be based on a Header section and a Data section.
The Header section provides additional information, called Ancillary Data, for each Data Block generated by SHARAD. This information includes time references, orbital parameters, processing parameters, etc., which are needed in order to perform relevant data processing on Ground.
The Data section contains:

- for Science packet: the result of the 3600 samples processing performed by the DES.
- for Tracking packet: a subset of 100 float values (32 bit) extracted from the tracking algorithm as defined in SHR-PROC-3.1.9.3-0040

The layout of Science Data shall therefore adhere to Tab. 5.2-2, Tab 5.2-3, Tab 5.2-4, Tab 5.2-5, Tab 5.2-6, Tab 5.2-7 and Tab 5.2-8.

EOR

Tab. 5.2-2. – Science Data Format

MSB 32 — *LSB 1*	
Ancillary data Header	*10-17 Common to Science and Tracking Data*
Ancillary Data	*18-52(Science) 18-37(Tracking)*
Data	*53-502 (Science 4bit compression) 53-727 (Science 6bit compression) 53-952 (Science 8bit compression) 38-137(Tracking)*

The Header Science Data shall be organised in two main fields:
Ancillary Data Header as in Table 5.2-3 and 5.2-4;
Ancillary Data. This block contains orbital data and parameters concerning the Scientific Processing and the Tracking function. In order to optimise the content of the Ancillary Data in the two different cases, two formats shall be implemented for the Ancillary Data. The fields are: Science Data Ancillary Data Format, and Tracking Data Ancillary Data Format
as in Table 5.2-5 and 5.2-6 for Scientific telemetry, or Table 5.2-7 and 5.2-8 for Tracking telemetry.

Tab. 5.2-3. – Science Ancillary Data Header Layout

MSB *32*	*25*	*24*	*17*	*16*	*9*	*8*	*LSB* *1*	
SCET (part 1)								*10*
SCET (part 2)				Spare		OST Line		*11*
OST								*12*
								13
								14
								15
Spare		Data Block ID						*16*
Scientific Data Source Counter				FLAGS		SLAVE Status		*17*

Tab. 5.2-4. – Science Ancillary Data Header Fields (sizes and details)

Field	N° Bits	Description	Remarks
SCET	48	Start Time. This Time is used to indicate the execution time of the OST first line.	
Spare	8	Set to 0	
OST Line	8	This field is used to indicate the number of OST entry.	The maximum number of lines, foreseen is 100.
OST	128	It is the whole OST line.	A single OST line indicates the execution of ea single Sub Measurement Mode.
Spare	8	Set to 0	
Data Block ID	24	It is used to specify the order that a Data Block is acquired inside the Data Take.	
Scientific Data Source Counter	16	It is used to count the Tracking Data Block	This counter is activated only if the Tracking Data Acquisition flag is set.
Scientific Data Type	1	This field is used to indicate the type of data acquired. 0 = Tracking Data 1 = Science Data	
Segmentation Flags	2	This field is used in case of the Data Take segmentation. 00 = first Data Block of Data Take 01 = continuation Data Block 10 = last Data Block of Data Take. 11 = No Segmentation	The segmentation shall be executed also in case of the Tracking Data acquisition
Spare flag bits	5	Set to 0	Available for updates
Slave Status	8	Report FPGA SLAVE_STATUS register Bit 0: Reserved for Test Bit 1: 1= OK, 0= FIFO full Bit 2: 0= OK, 1= TC Over Run Bit 3: 0= OK, 1= Error DMA	

Tab. 5.2-5. – Science Ancillary Data Layout

MSB 32 … 25	24 … 17	16 … 9	8 … LSB 1	
Spare	Data Block First PRI			18
Time Data Block (part 1)				19
Time Data Block (part 2)		SDI Bit-Field		20
time (n)				21
Radius(n)				22
V_T (n)				23
V_r(n)				24
Latitude(n)				25
Time				26
Δtime				27
Latitude				28
Radius				29
Tangential_Velocity				30
Radial_Velocity				31
Start Latitude				32
C_0				33
C_1				34
C_2				35
C_3				36
C_4				37
C_5				38
C_6				39
S_0				40
S_1				41
S_2				42
S_3				43
S_4				44
S_5				45
S_6				46
S_7				47
Δ_{Slope}				48
Topography				49
Φ_{00}				50
Receive Window Opening Time				51
Receive Window Position				52

Tab. 5.2-6. – Science Ancillary Data Fields (sizes and details)

Field	N° Bits	Description	Remarks
Spare	8	Set to 0	
Data Block First PRI	24	First PRI counter of the single Data Block	The PRI counter shall be reset at the end of Operational Mode
Time Data Block	48	Time used to indicate the Data Block acquisition time	Time relevant of the first PRI
SDI Bit-Field	16	Code indicating the extracted bit-field for the required compression	See **[AD.3]** §. 5.2.3.4.2.10
time (n)	32	Orbital Parameters reference time	Time provide by S/C each 2 sec.
Radius(n)	32	S/C altitude wrt Mars Centre	Provided by S/C relevant at Time(t)
V_T (n)	32	S/C tangential velocity component	Provided by S/C relevant at Time(t)
V_r(n)	32	S/C radial velocity component	Provided by S/C relevant at Time(t)
Latitude(n)	32	S/C Latitude	Provided by S/C relevant at Time(t)
Time	32	WPF Block Time	See **[AD.2]** §. 3.1.8.2.1
Δtime	32	Interpolation parameter	See **[AD.2]** §.3.1.8.2.1);
Latitude	32	Interpolated Latitude	
Radius	32	Interpolated Radius	
Tangential_Velocity	32	Interpolated Tangential Velocity	
Radial_Velocity	32	Interpolated Radial Velocity	
Start Latitude	32	Reference Latitude for polynomial coeff.	Inserted in the PT
c_0, c_1,…, c_6	7x32	Topography Polynomial coeff.	Inserted in the PT
s_0, s_1,…, s_7	8x32	Surface Slope Polynomial coeff.	Inserted in the PT
Δ_{Slope}	32	Computed Surface Slope	By polynomial interpolation
Topography	32	Computed Topography	By polynomial interpolation
Φ_{00}	32	DCG phase compensation step	
Receive Window Opening Time	32	Receive Window opening time	Ahead of 10 us wrt the computed time
Receive Window Position	32	S/C Mars Surface in Km	

Tab. 5.2-7. – Tracking Ancillary Data Layout

MSB 32 … 25	24 … 17	16 … 9	8 … LSB 1	
Spare	Data Block First PRI			18
Time Data Block (part 1)				19
Time Data Block (part 2)		Spare		20
Receive Window Opening Time				21
Spare	C_LOL	Spare	E_C	22
P_ec				23
Spare	Left_Win	Spare	Right_Win	24
Spare	Ini_ind	Spare	Last_ind	25
Thr				26
Spare	Min_ind_th	Spare	Max_ind	27
Inc_thr				28
Xp				29
DXp				30
Epsilon				31
Spare				32
Spare				33
Spare				34
Spare				35
Spare				36
Spare				37

Tab. 5.2-8. – Tracking Ancillary Data Fields (sizes and details)

Field	N° Bits	Description	Remarks
Spare		Set to 0	
Data Block First PRI	24	First PRI counter of the single Data Block	The PRI counter shall be reset at the end of Operational Mode
Time Data Block	48	Time used to indicate the Data Block acquisition time	Time relevant of the first PRI
Receive Window Position	32	Receive Window opening time	Ahead of 10 us wrt the computed time
C_LOL	12	The index that shows the state of tracking	
E_C	12	The index that correct the wanted position of the echo	
P_ec	32	The measure of the echo position	
Left_win	12	The left dimension of the window used for the measure of the echo position	
Right_win	12	The right dimension of the window used for the measure of the echo position	
Ini_{ind}	12	The initial position of the of the window used for the measure of the echo position	
$Last_{ind}$	12	The final position of the of the window used for the measure of the echo position	
Thr	32	The threshold value	
Min_ind_th	12	The initial position of the of the window used for the measure of the threshold	
Max_ind_th	12	The final position of the of the window used for the measure of the threshold	
Inc_{THR}	32	The value of the increase of the threshold.	
Xp	32	A state of alfa beta filter	
dXp	32	The first difference evaluated by the alfa beta filter	
Epsilon	32	The input of the alfa beta filter	

5.3. DISCRETE TELEMETRIES

SRQI.-5.3/010 SHARAD Discrete TMs

[AD.1] SHR-DES-3.2.2-0400
[AD.1] SHR-DES-3.2.2-0410

The DES shall provide 4 optocoupled, driver configuration, discrete output lines, toward the S/C, according to the configuration shown in Figure 5.3-1.

The 4 discrete lines shall be used to generate the following signals that will be used by S/C to monitor SHARAD operations:

SHR_RUNNING (DES_TM_1), provides indication that SHARAD has correctly performed its power up sequence and it is working.
SHR_ALIVE (DES_TM_2) provides a pulsed indication that SHARAD software is running.
SHR_OPERATING (DES_TM_3) provides indication that SHARAD is performing measurements.
SHR_SAFE (DES_TM_4) provides indication that SHARAD software transitioned into Safe/Idle State.

EOR

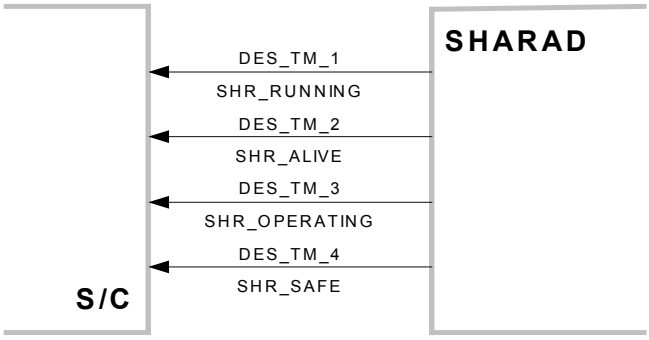

Figure 5.3-1. – Discrete TMs

SRQI.-5.3/020 Boot and Discrete Telemetry

The DES SW shall modify the TM Discrete lines levels during the boot activity as depicted in table 5.3.1 (the lines value are referred to the end of related step).

EOR

Tab. 5.3.1. – Boot and Discrete TM lines

Step	Description	R	S	A	O
0	DES in switch-off status	D	D	D	D
1	**Set-up**: ○ DSP registers configuration ○ HW Reset ○ FPGA registers configuration ○ RUN Discrete TM activation	U	D	D	D
2	**Start_Mode**: ○ Start mode detection: ○ Warm: a RAM location shall be used to store the Warm Restart info (**after this step the Program code stored in RAM shall be executed**) ○ Watchdog: an FPGA register shall be checked to detect a watchdog event ○ Normal The start up mode shall be written in a dedicated DSP register.	U	D	D	D
3	**BOOT_Checksum** The Checksum of the BOOT / LOADER area shall be checked, if the value is wrong the Safe line shall be activated and the Run line deactivated.	U	D	U	U
4	**RAM_Check** The RAM location shall be checked and a dedicated TM sent to inform about errors	U	D	D	U
5	SW-Reload Timeout A timeout (15 seconds)shall be provided to allow a Code Reload. A dedicated TC shall be defined to require the code reload. ○ RAM_Space: 64 Kwords of RAM memory without errors shall be searched. If fails the Run line shall be deactivated and a TM packet sent. ○ Prog_Upload: after 10 seconds acquisition and copy (in RAM) of PROG_SW thought dedicated TCs ○ Reload_Check: checksum of uploaded code shall be verified ○ RAM_to_EEPROM: Copy of PROG_SW from RAM to EEPROM Reboot	U U U U	U D U D	U U U U	D D D D
6	**PROG_ Checksum** checksum of EEPROM PROG SW code shall be verified. If the value is wrong the Safe line shall be activated.	U	U	D	D
7	**Version_Check** The code version shall be checked to handle the diagnostic program execution.				
8	**Copy** Program e Data shall be copied from EEPROM to RAM				

Note1: Up means physical value 5V, Down means 0V.

SRQI.-5.3/030 Details about Boot and Discrete Telemetry

The DES SW shall be able to identify the current boot activity / error detection using the TM Discrete lines (see table 5.3.3).

Note: To understand the BOOT / Reload activities behaviour the following items must be considered:

- *The Discrete TM Lines value changes*
- *The time between events*
- *The commands sent by MRO*

EOR

Tab. 5.3.2. – Boot activities and TM Discrete lines

Case 1: Start without errors

Step	Description	R	S	A	O
0	DES in Switch-off status	U	U	U	U
1	Set-up, Start_Mode, BOOT_Checksum, RAM_Check, RAM_Space	U	D	D	D
2	15 seconds (SW_Reload Timeout)	U	D	D	D
3	PROG_Checksum, Version_Check, Copy, Start_Program	U	D	UD	D

Case 2: BOOT checksum error

Step	Description	R	S	A	O
0	DES in Switch-off status	U	U	U	U
1	Set-up, Start_Mode	U	D	D	D
2	BOOT_Checksum : ERROR	D	U	D	D

Case 3: RAM Corruption

Step	Description	R	S	A	O
0	DES in Switch-off status	U	U	U	U
1	Set-up, Start_Mode, BOOT_Checksum	U	D	D	D
2	RAM_Check: ERROR	U	D	U	U

Case 4: PROG checksum error

Step	Description	R	S	A	O
0	DES in Switch-off status	U	U	U	U
1	Set-up, Start_Mode, BOOT_Checksum, RAM_Check, RAM_Space	U	D	D	D
2	15 seconds (SW_Reload Timeout)	U	D	D	D
3	PROG_Checksum: ERROR	D	U	D	D

Note: Up means physical value 5V, Down means 0V.

SRQI.-5.3/040 SW Reload and Discrete Telemetry

The DES SW shall be able to identify the current activity / error detection, during Boot SW Reload, using the TM Discrete lines (see table 5.3.4).

Note: To understand the BOOT / Reload activities behaviour the following items must be considered:

- *The Discrete TM Lines value changes*
- *The time between events*
- *The commands sent by MRO*

EOR

Tab. 5.3.3. – SW Reload activities and TM Discrete lines

Case 1: SW-Reload without errors

Step	Description	R	S	A	O
0	DES in Switch-off status	U	U	U	U
1	Set-up, Start_Mode, BOOT_Checksum, RAM_Check, RAM_Space	U	D	D	X
2	TC request before 15 seconds (SW_Reload Timeout)	U	D	U	X
3	Prog_Upload, Reload_Check, RAM_to_EEPROM	U	D	U	X
4	Reboot (see Case 1)				

Case 2: SW-Reload with RAM space error

Step	Description	R	S	A	O
0	DES in Switch-off status	U	U	U	U
1	Set-up, Start_Mode, BOOT_Checksum, RAM_Check	U	D	D	X
2	RAM_Space: ERROR	U	U	U	X

Case 3: SW-Reload with Reload_Check error:

Step	Description	R	S	A	O
0	DES in Switch-off status	U	U	U	U
1	Set-up, Start_Mode, BOOT_Checksum, RAM_Check, RAM_Space	U	D	D	X
2	TC request before 15 seconds (SW_Reload Timeout)	U	D	U	X
3	Prog_Upload	U	D	U	X
4	Reload_Check: ERROR	D	U	D	X

Note1: Up means physical value 5V, Down means 0V.

Note2: X mean that its value should be Up or Down

6. TIME SYNCRONISATION

The S/C C&DH generates a TIME UPDATE Command followed by a discrete line timing pulse which marks the instant of validity of the time value contained in the preceding Command.

SRQI.-6/010 S/C Time Format

[AD.1] SHR-DES-3.4.3-0500 The DES shall receive from the S/C the time update value (format in Fig. 6-1).

EOR

***Note**:This format provides an accuracy of about 15.26 μsec. Overall S/C OBT accuracy with respect to UTC is **100 msec** with correlation between S/C OBT and UTC reconstructed to an uncertainty of less than **15 msec**. The S/C OBT time reference starts from **1980/01/01-00:00:00.0** (i.e., at that epoch the number of seconds is zero).*

The value of the fractional seconds field provided with a TIME_UPDATE command may not be zero.

48 bit	
Number of seconds	**Fractional seconds**
32 bit	*16 bit*

Fig. 6-1. Time Update Format

SRQI.-6/020 S/C Time Line

[AD.1] SHR-DES-3.2.2-0470 The DES_TIME_TICK discrete line is used by S/C to provide a timing reference after a TIME UPDATE Command.

EOR