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MARS EXPRESS

Space / Ground
Interface Control Document

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CHANGE RECORD SHEET

Date	Issue No.	Rev. No.	Pages Affected	Description/Authority	CR No.
19-Jun-98	Draft 0		All	Draft issue for ITT	---
10-May-99	Issue 1		All	Issue for MARS EXPRESS SRR, based on Rosetta SGICD (RO-ESC-IF-5002) Issue 2	---
10-Sep-99	Issue 1.1			Major update for MEX GSRQR - Updated Distribution List - Updated List of Open points - All: Specific Rosetta data (mission, Payload, frequencies, MGA, station usage, etc.) removed - Included Project comments (DMC Lotus Note from 18-Jun-99) - 2.1.4: Modulation updated - 2.1.5: TM bit rates updated - 2.2.3: Ranging updated - 4.1.1: SC uplink parameters updated in S-Band and X-Band added - 4.1.2: SC downlink parameters updated in S-Band and X-Band - 4.1.2: Telemetry Modulation index corrected - 4.2.2 Perth parameters updated (including Maser) - 4.2.3 – 4.2.5: DSN 34/70m and SRT parameters updated - 4.3.1: required link performance corrected - 4.3.3: link budget for maximum distances updated - 5.1.2.1: add reference to table A2.22 - 5.2.1.4: VC0 and VC1 clarified - 5.2.1.4: VC2 suppressed - 6.1.2.1: add explanation on Pad usage	R-DCR1,7 R-DCR#4 R-DCR#2 R-DCR#6 R-DCR#17 R-DCR#20 R-DCR#17

				Major update for MEX GSRQR (cont'd for Appendices): - Appendix 2.1: Service 1, TM(1,2) and TM(1,8) updated - Appendix 2.3: Service 1, TC(3,1) and TC(3,3) updated - Appendix 2.3: Service 3, TC(2,3) updated - Appendix 2.5: Service 5 body and, TM(5,3) updated - Appendix 2.6: Service 6 major update - Appendix 2.7: Service 7, TC(7,1) updated - Appendix 2.10: Service 10, TC(10,3) updated - Appendix 2.13: Service 13 major update - Appendix 2.15: Service 15 major update - Appendix 2.16: Service 16 major update - Appendix 2.21: inserted new Private PL service TC(255,1) - Appendix 2.22: updated table header and alignment of TM responses on Serv. 10 and 20 - Appendix 2.22: updated Serv.13 summary according to text change - Appendix 3: Added CPDU and SREM APID - Appendix 4.6: Added XOR algorithm - Appendix 6.3.5 updated for DSP 21020 - Appendix 6.3.6-7: PFC of PTC 9 an 10 updated	R-DCR#17 R-DCR#17 R-DCR#21 R-DCR#17 R-DCR#11 R-DCR#9 R-DCR#17 R-DCR#9,13 R-DCR#10 R-DCR#14 R-DCR#19 R-DCR#17 R-DCR#9,13 R-DCR#18 R-DCR#11 R-DCR#17 R-DCR#5
8-Nov-99	Issue 1.2			Updates after MEX GSRQR - Applicable documents: made CCSDS Packet Telemetry applicable. - §4.2.1: Updated Kourou ADV Axial ratio - §4.2.5: updated X-Band EIRP of SRT - §5.1.1: flag and explained the cases where CCSDS TM standard supersedes ESA TM standard (§5.1.1.1: PUS Version; §5.1.1.2: Grouping flags) - Packet Error Control moved	GSRQR_0044 GSRQR_0023 GSRQR_0044 GSRQR_00

				from §5.1.1 to §5.1.2 - §5.2.1.4: added that VC1 frame may have to be completed by several idle packets - §5.2.1.7, §5.2.1.13: flagged that extended VC counter is ESA-specific, not CCSDS standard. - Appendix 11: added figure to clarify TM bit rates Updates to keep up with ROSETTA: - Appendix 2.11,2.12: updated (11,1) and (12,9) titles - Appendix 2.13: updated description of (13,9), (13,16) - Appendix 2.15: updated APID1 and Time1 meaning - Appendix 2.22: updated table to reflect Appendix body. - Appendix 6.3.5: updated table and PC(5,1) Other updates: - Reference doc: added SDR - §2.1.5: Added intermediate TM bit rates (medium and high) - Appendix 2.21: pre-allocated private Services per PL - Appendix 3: allocated PIDs to Beagle	47 GSRQR_0044,0048 GSRQR_0045 R-DCR#22 R-DCR#22 R-DCR#22 R-DCR#22 PDR doc. (SDR §9.3) IPDRs Beagle-2 Ops meeting 4-Nov-99
20-Dec-99	Issue 2.0		ALL ALL x x x §1.2.3 §2 §2.1.4 §2.2.3 §3.1.3	- Removed visual indication of MEX and Rosetta specific text (when accepted). - Removed remaining references to turbo-coding - Applicable doc #6: put CCSDS TM standard back to Reference document (pending R-DCR) - Reference doc #1: Updated MEX OIRD version to Contract Issue (1.1) - Reference doc #7: put CCSDS Channel coding back to Draft (pending R-DCR #29) - Added Beagle-2 as packetised end-user - Added X-Band uplink - Clarified that PSK modulation applied to bit rates strictly greater than 52 ks/s i.e. starting at 65 ks/s and above - Removed details on ranging tone frequency (pending R-DCR #29) - Added X-Band uplink for	

				Antenna Switching	
			§4.2.6.2	- Removed NASA DSN 26m Station diagram (pending R-DCR #31 for generic diagram)	
			§4.3.1	- Specified TM frame error rate to 10^{-5} for symbol rates 65 ks/s and above	
			§4.3.3	- Minimum information rate reqt on LGA put back to 16 bps	
			§5.1	- Note on CCSDS TM standard removed (pending R-DCR)	
			§5.1.1.2	- Grouping flags left free for PL, but fixed to 11Bin for the rest.	
			§5.2.1. 5.2.1.13	- Removed recommendation not to use secondary header for Cross-Operations (pending R-DCR)	
			A2.1	- TM(1,2): defined specific MEX FIDs and EIDs	
			A2.6	- TC(6,2): modified description of SSMM Memory Ids	
			A2.13	- Put whole Service 13 (File Transfer) TBD (rejecting R-DCR #9, 13)	
			A2.15	- Tx(15,7-13): specified that compression identifier field is unused (but present) on MEX – TC(15,14-16) removed ("copy functions")	
			A2.16	- Removed reference to (Rosetta-specific) "System Interface Requirement Spec"	
			A2.20	- Tx(20,13): Removed reference to Navigation Camera	
			A2.21	- Removed RSE, added VMC. Extended ASPERA range to 191-195	
			A2.22	- Put Service 13 TBD; Removed TC(15,14-16); Made Services 17 and 20 Optional for Payload	
			A3	- Removed RSE and SREM, added VMC	

Revisions are normally indicated by a vertical bar at the outside border.

The generation of Issue 2.0 in a common ESA/MMS meeting has streamlined the presentation of the document. As it is a commonly agreed baseline version (2.0), there are no change bars. The visual differences with Rosetta and the Mars Express specificities have been neutralised in order to restart from a "clean" document.

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APPLICABLE DOCUMENTS

1. Packet Telemetry Standard, PSS-04-106, Issue 1, January 1988
2. Packet Telecommand Standard, PSS-04-107, Issue 2, April 1992
3. Telemetry Channel Coding Standard, PSS-04-103 Issue 1, September 1989
4. Ranging Standard, PSS-04-104, Vol. I, Issue 2, March 1991
5. Radio Frequency and Modulation Standard, PSS-04-105 Issue 2.4, November 1996

REFERENCE DOCUMENTS

1. MARS EXPRESS Operations Interface Requirements Document (ME-OIRD), ME-ESC-RS-5004, Issue 1.1 (contract version).
2. ESA Telecommand Decoder Specification, PSS-04-151
3. Deep Space Network/Flight Project Interface Handbook NASA/JPL 810.5, Volume I: Existing DSN Capabilities, Revision D, February 1995
4. CCSDS Packet Telemetry, CCSDS 102.0-B-4, November 1995
5. Packet Utilisation Standard (PUS), PSS-07-101, Issue 1, May 1994
6. S + S/X Band Coherent Transponder Specification, ESA PSS-48, Issue 1, March 1979
7. Draft CCSDS Recommendation for Telemetry Channel Coding (Updated to Include Turbo Codes), Revision 4, May 1998
8. CCSDS Telecommand Part 2 Data Routing Service, CCSDS 202.0-B-2, November 1992
9. (Rosetta RD9)NOT APPLICABLE TO MEX
10. MARS EXPRESS High-Level Requirements for the SRT, MEXSRT-SYS-REQ, Draft 0.2, 20-Apr-99.
11. MARS EXPRESS Project Service Level Agreement (NASA Interface), Draft 0.4, 1-Feb-99
12. MARS EXPRESS Spacecraft Design Report, MEX-MMT-TN-0216, Issue 2.0 14-Oct-99

1 INTRODUCTION AND SCOPE

1.1 Scope

The ESA Radio Frequency and Modulation Standard **[AD-5]**, requires to control the spacecraft/ground station interface a) in a definitive and formal specification of the RF interface; b) by means of Link Budget Tables regularly updated to keep track of the development of the spacecraft and ground station(s). The hardware interface compatibility will be demonstrated by Spacecraft/Ground station compatibility tests, to be documented by the Compatibility Test Plan and the related Compatibility Test Results Report.

This Space / Ground Interface Control Document (SGICD) defines the relevant ***parameters for the interface between the MARS EXPRESS spacecraft and the ground station(s)***, as well as the list of standards and other documents applicable to this interface, and shall act as the source document for all data to be used in the preparation of the Link Budget Tables.

The ESA Packet Telemetry and Telecommand Standards **[AD-1]** and **[AD-2]**) address the transport of telemetry and telecommand data between user applications on the ground and user applications on-board the satellite, and the intermediate transfer of this data through the different elements of the ground and space segments.

The Space/Ground ICD serves to complement and extend the Packet Telemetry and Telecommand Standards by defining all the mission specific details of the various interface levels, and in addition the ***Application-Level*** interface between ground and on-board applications.

This document describes procedures and ***the data structures for telemetry and telecommand packets*** to be implemented for support of the operational requirements defined in the MARS EXPRESS Operations Interface Requirements Document **[RD-1]**. Being tailored especially for MARS EXPRESS, this document supersedes the ESA Packet Utilisation Standard (PUS) from which it is derived. The MARS EXPRESS space and ground segment will support all and only the data structures defined in this document.

The document will be agreed between the ESA MARS EXPRESS Project Manager, the appointed ESOC representative and the Prime Contractor. Upon approval the document will be controlled by the ESA MARS EXPRESS Project Manager to whom any updates or changes to any parameters contained in it shall be submitted.

For each of the major project reviews, the Prime Contractor (in association with his subcontractors) shall supply ESA with updated information concerning the spacecraft performance or confirmation that no change has occurred from the previous review. This shall be achieved through submittal of respective compliance tables.

1.2 Operations Scenario

1.2.1 Nominal Mission Operations

The mission operations of the MARS EXPRESS spacecraft and its payload
will be conducted under control of the MARS EXPRESS Mission Operations Centre (MEMOC) at the European Space Operations Centre (ESOC). This task includes spacecraft operations required for all phases of the mission: the interplanetary cruise phase, the Mars insertion orbit and the ejection of the lander, the combined spacecraft and payload operations during the Mars orbiting

phase, and the mission operations during delivery of data from Beagle-2 and possibly other landers from other Mars missions.

Throughout the complete mission duration (from launch up to the end of mission, when ground contact to the spacecraft/payload is terminated), facilities and services will be provided to the scientific community for planning and execution of scientific data acquisition, and the generation and provision of the complete raw-data sets to the Principal Investigators (PIs).

Interaction with the spacecraft will be by monitoring and analysis of telemetered data and the uplink of commands to effect the necessary operations. Most commands will be stored on board for later execution at a defined time, others may be intended for execution in «near-real-time». In both cases, it may also be necessary to control subsystem and experiment equipment using low-level commands or high-level commands (i.e. via on-board applications or On-Board Control Procedures).

Telemetry and telecommands will also be required for on-board software management functions, including:

- control of, and communication with, on-board processes (such as an on-board telemetry monitor)
- loading and dumping of on-board memories
- control of on-board Mission Time Line.

All telecommands must be appropriately verified in telemetry at acceptance and execution.

Telemetry data will be required in order to verify the execution of all mission operations and will also be required for:

- routine on ground health monitoring of the subsystems and the experiments;
- reporting to the ground any anomalous events detected on-board and any actions taken autonomously by the on-board systems;
- performance evaluation on the ground for the purposes of long-term trend analysis and feedback into the mission planning cycle.

1.2.2 Contingency Operations

In the event of unforeseen on-board events, actions will be necessary to investigate and correct anomalies utilising the available telemetry and command functions. In addition, it may be necessary to modify on-board software in order to compensate for on-board failures or anomalous performance.

1.2.3 Packet Distribution

The following telemetry and telecommand packet categories exist:

- those generated on the ground and up linked to the spacecraft
- those generated by on board applications and down linked to the ground
- those generated on board and routed to other on board applications (and to the ground if necessary)

These packet categories are to be routed to or from the following classes of on board end users:

Packetised end users

* TC packets are routed via the Data Management System (DMS) to the user application. The TC packets are then decoded by the user application.
* TM packets are generated by the user application and passed to the DMS for downlink to the ground, distribution to other on board users, or on-board analysis, or storage and compression.
* Packetised users may have more than one Process ID (PID)
* The DMS may have more than one PID for itself and several for non packetised users it is serving (see below)

Non packetised end users

* TC packets are decoded by the DMS software and the data content routed to the user as discrete commands either On/Off or memory (register) load
* TM packet data is acquired by the DMS on discrete lines and packetised by the DMS software for downlink to the ground, distribution to other on board users, or on-board analysis, or storage and compression.
* Non packetised users are likely to have only one Process ID

An exception to the above exists in the case of high priority CPDU commands which are decoded by the CPDU and routed directly to end users as discrete (pulse) commands.

The packetised end-users for MARS EXPRESS are the following platform units:

- DMS
- AOCMS
- STR
- SSMM

The instruments control units:

- ASPERA
- HRSC
- OMEGA
- PFS
- SPICAM
- MARSIS

The data relay unit:

- MARESS

The Lander:

- Beagle-2

2 TELECOMMUNICATION SYSTEM

The telecommunication system supports the functions of tracking, telecommand and telemetry for each phase of the mission.

The spacecraft telecommunication subsystem consists of a redundant set of transponders using S-Band and X-Band for the uplink, and S-Band and X-Band for the downlink. Depending on the mission phase, the transponder can be routed via RF switches to different antennas. The telecommunication subsystem provides hot redundancy for the receiving function and cold redundancy for the transmitting function. On request simultaneous S-Band/X-Band downlink will be provided, however, if this is not possible from a power budget point of view, only one single downlink frequency either S-Band (near earth mission phases) or X-Band will be used.

The associated ground network consists of a number of stations, which support some or all of the mission phases. A full description of the station utilisation will be found in Section 4 together with the appropriate specification of spacecraft and ground stations.

The satellite telecommunication subsystem will be allocated with its dedicated frequency in the S-/X-Band frequency range. The frequency assignments have been requested from the Frequency Management Office.

2.1 Down Link

2.1.1 Frequencies

The satellite telecommunication subsystem will be allocated for a Category B Mission with a down link frequency in the 2291.666 –2299.814 MHz frequency band for S-band, as well as in the 8402.777 –8440.802 MHz frequency band for X-band, as follows:

- S-Band 2296.482 MHz (DSN CH 18)
- X-Band 8420.432 MHz (DSN CH 18)

2.1.2 Telemetry Channel Formats

The telemetry will follow the Packet Telemetry Standard, PSS-04-106 **[AD-1]** without Source Packet segmentation as mentioned in [RD-4] and the Telemetry channel coding standard **[AD-3**].

2.1.3 Ranging Signal

The ranging signal is defined in section 2.2.3.

2.1.4 Modulation

The telemetry modulation scheme is PCM/PSK/PM on a square wave subcarrier for transmitted symbol rates as high as 52.4288 ks/s. With the baseline concatenated encoding, two subcarrier

frequencies shall be used, 8.192 kHz for the low bit rates and 262.144 kHz for the high bit rates as shown in section 2.1.5.

For transmitted symbol rates starting at 65.536 ks/s (and above) the telemetry modulation scheme shall be PCM/SP-L directly on the carrier.

The ranging signal in the ranging channel of the transponder directly phase modulates (PM) the downlink carrier. When simultaneous ranging and telemetry is performed, the two signals are added prior to phase modulation of the downlink carrier.

2.1.5 Telemetry Bit Rates

For the baseline concatenated encoding, the following transmitted symbol rates (fs) shall be supported.

Concatenated encoding

fb = information rate [bps]
fs = data rate at convolutional encoder input [bps]
fs' = transmitted symbol rate [sps]
fsc = subcarrier frequency [Hz]
N = subcarrier frequency/transmitted symbol rate ratio

fs'	fs	fb	fsc	N
524288.0000	**262144.0000**	**228530.5796**	**N/A**	**note 2**
419430.4000	209715.2000	182838.0122	**N/A**	**note 2**
349525.3333	174762.6667	152365.0102	**N/A**	**note 2**
262144.0000	**131072.0000**	**114265.2898**	**N/A**	**note 2**
209715.2000	104857.6000	91419.0061	**N/A**	**note 2**
174762.6667	87381.3333	76182.5051	**N/A**	**note 2**
131072.0000	**65536.0000**	**57132.6349**	**N/A**	**note 2**
104857.6000	52428.8000	45709.5031	**N/A**	**note 2**
87381.3333	43690.6667	38091.2525	**N/A**	**note 2**
65536.0000	**32768.0000**	**28566.3224**	**N/A**	**note 2**
52428.8000	26214.4000	22853.0539	262144	5
43690.6667	21845.3333	19044.2116	262144	6
32768.0000	16384.0000	14283.1587	262144	8
26214.4000	13107.2000	11426.5270	262144	10
21845.3333	10922.6667	9522.1058	262144	12
16384.0000	8192.0000	7141.5794	262144	16
13107.2000	6553.6000	5713.2635	262144	20
10922.6667	5461.3333	4761.0529	262144	24
8192.0000	4096.0000	3570.7897	262144	32

6553.6000	3276.8000	2856.6317	262144	40
5461.3333	2730.6667	2380.5265	262144	48
4096.0000	2048.0000	1785.3948	262144	64
3276.8000	1638.4000	1428.3159	262144	80
2730.6667	1365.3333	1190.2632	262144	96
2048.0000	1024.0000	892.6974	262144	128
1638.4000	819.2000	714.1579	262144	160
1365.3333	682.6667	595.1316	8192	6
1024.0000	512.0000	446.3487	8192	8
819.2000	409.6000	357.0790	8192	10
682.6667	341.3333	297.5658	8192	12
512.0000	256.0000	223.1744	8192	16
341.3333	170.6667	148.7829	8192	24
256.0000	128.0000	111.5872	8192	32
170.6667	85.3333	74.3915	8192	48
128.0000	64.0000	55.7936	8192	64
85.3333	42.6667	37.1957	8192	96
64.0000	32.0000	27.8968	8192	128
42.6667	21.3333	18.5979	8192	192
32.0000	16.0000	13.9484	8192	256
21.3333	10.6667	9.2989	8192	384

Note 2: SP-L direct modulation of the carrier.

(*)
Where the following conventions apply:

fb = information rate [bps]
fs = data rate at convolutional encoder input [bps], including R-S check symbols and synchronisation marker
fs' = transmitted symbol rate [sps]
fsc = subcarrier frequency [Hz]
N = subcarrier frequency/transmitted symbol rate ratio

For details on the above mentioned bit/symbol rate definition, see Appendix 11.

2.1.6 Coding

The coding will be concatenated for the downlink (Reed Solomon R-S 255,223 with interleaving depth I = 5, and convolutional rate ½ with constraint length k = 7).

The insertion of the synchronisation marker shall be consistent with the selected code (see [RD-7].)

2.2 Up-Link (On-Board Reception)

2.2.1 Frequencies

The satellite telecommunication subsystem will be allocated with an uplink frequency in the 2110.243 - 2117.746 MHz frequency band at S-Band.

- S-Band 2114.676 MHz (DSN CH 18)

The satellite telecommunication subsystem will be allocated with an uplink frequency in the 7145-7190 MHz frequency band at X-Band

- X-Band 7166.936 MHz (DSN 18)

The ratio of uplink and downlink frequencies for the transponders will be for a Category B Mission as follows:

$f_u/f_d = 221/240$ (S-/S- Band)

$f_u/f_d = 221/880$ (S-/X- Band)

$f_u/f_d = 749/880$ (X-/X- Band)

2.2.2 Telecommand Format Standard

The telecommand format will follow the Packet Telecommand Standard, PSS-04-107 **[AD-2]**.

2.2.3 Ranging Signal

For the ESA ground station(s) the ranging signal is in accordance with the Ranging Standard **[AD-4]**. The selected tone frequency is TBD.

For the NASA DSN ground station(s) the ranging signal is in accordance with **[RD-3]** (TRK-30, Revision E).

2.2.4 Modulation

The telecommand modulation scheme is PCM/PSK/PM on a sinusoidal subcarrier. The selected subcarrier frequency is 16 kHz.

The ranging signal directly phase modulates (PM) the uplink carrier. For simultaneous ranging and telecommand, the two signals are added prior to phase modulation of the uplink carrier.

2.2.5 Telecommand Bit Rates

The following telecommand bit rates shall be used, i.e.

i) 7.8125 bps
ii) 15.625 bps
iii) 250 bps
iv) 1 kbps
v) 2 kbps

3 OPERATIONAL UTILISATION

3.1 Operational Modes

3.1.1 Modulation Modes

The telecommunication subsystem shall support the following modes for the up link:

- unmodulated carrier
- command
- ranging
- command and ranging

The following operational modes shall be supported for the downlink:

- unmodulated carrier
- telemetry
- ranging
- telemetry and ranging

3.1.2 Transponder Modes

The transponder shall be operable both in coherent and in non-coherent mode depending on the lock status of the receiver. The transponder mode shall be capable of being set by telecommand.

In the coherent mode, the transmitter shall operate coherent to the receiver as soon as the receiver is locked. If the receiver loses lock, the transmitter shall go to non-coherent and return to the coherent mode, after the receiver gets locked.

In the non-coherent mode, the transmitter shall remain non-coherent, until it receives a telecommand to go coherent and the receiver indicates the lock of the uplink signal.

3.1.3 Antenna Switching

For X-Band downlink, the HGA shall be switchable to TWT 1 resp. 2.
For X-Band uplink, the HGA shall be switchable to RX 1 resp. 2.

In S-Band, it shall be ensured, that one diplexer is routed to the HGA
the other diplexer can be routed to either LGA 1 or LGA 2.

It shall be possible to route LGA 1 to diplexer 1 resp. 2 while LGA 2 is routed to diplexer 2 resp. 1.
In principal any combination of antenna connection to transponder shall be possible.

3.2 Command Operations Procedure (COP-1)

The Command Operations Procedure COP-1 shall be supported. Within COP-1, the packet telecommand services AD and BD shall be supported in parallel. In order to overcome the limitations imposed by the COP-1 protocol on deep space missions the BD service together with a

higher level file transfer protocol defined in this ICD as Service 13, will normally be used for background commanding. This means that any command except service 2 subtype 3 (CPDU command) may be uplinked as part of a command file via service 13 using the BD service, this file will, when complete be released to the appropriate handler for further processing.

4 PERFORMANCE

4.1 Spacecraft

The 4 following tables 4-1A, 4.1B, 4-2 and 4-3 are taken from the Rosetta spacecraft as a first approximation, and have to be adapted to the MARS EXPRESS platform

4.1.1 Up Link Parameters (On-Board Reception)

The up link parameters are summarised in Table 4-1A and 4-1B:

Table 4-1A: S-band Uplink Spacecraft Parameters

		NOM	ADV	FAV
Antenna gain[dBi]	LGA	-2.0	-2.0	-1.5
	HGA	29.5	29.5	29.7
Polarisation		RHC	RHC	RHC
Axial ratio[dB]	LGA	4.0	4.0	3.5
	HGA	1.4	1.4	1.2
Pointing losses	LGA	0.15	0.2	0.1
	HGA	0	0	0
Circuit losses [dB]	LGA	3.4	3.4	3.0
	HGA	3.4	3.4	3.0
Antenna noise temperature[°K]	LGA	60	60	60
	HGA	60	60	60
Receiver noise figure [dB]		2.0	2.0	1.5
Ranging bandwidth (double-sided) [MHz]		3.0	3.3	2.7
Loop bandwidth at threshold (double-sided) [Hz]		20	24	16
Receiver telecommand threshold at 300°K [dBm]		-146	-146	-146
Implementation losses [dB]	Carrier	1.1	1.5	0.8
	Telecommand	1.5	1.6	1.1
	Ranging	1.5	1.6	1.2
Modulation index [rad]	Telecommand	0.1 to 1.4	(*) ±5%	(*) ±5%
	Ranging	0.1 to 1.4	(*) ±5%	(*) ±5%

(*) plus or minus to be taken favourable or adverse as required by the computed parameters, e.g. +5% is favourable to the telecommand recovery but adverse for the carrier and ranging recovery.

Table 4-1B: X-band Uplink Spacecraft Parameters

		NOM	ADV	FAV
Antenna gain[dBi]	HGA	40.0	40.0	40.2
Polarisation		RHC	RHC	RHC
Axial ratio[dB]	HGA	1.5	1.5	1.4
Pointing losses [dB]		0.2	0.5	0.1
Circuit losses [dB]	HGA	3.1	3.1	2.5
Antenna noise temperature[°K]	HGA	60	60	60
Receiver noise figure [dB]		2.1	2.1	2.1
Ranging bandwidth (double-sided) [MHz]		3.0	3.3	2.7
Loop bandwidth at threshold (double-sided) [Hz]		20	24	16
Receiver telecommand threshold at 300°K [dBm]		-145	-145	-145
Implementation losses [dB]	Carrier	1.1	1.5	0.8
	Telecommand	1.5	1.6	1.1
	Ranging	1.5	1.6	1.2
Modulation index [rad]	Telecommand	0.1 to 1.4	(*) ±5%	(*) ±5%
	Ranging	0.1 to 1.4	(*) ±5%	(*) ±5%

(*) plus or minus to be taken favourable or adverse as required by the computed parameters, e.g. +5% is favourable to the telecommand recovery but adverse for the carrier and ranging recovery.

Down Link Parameters

The down link parameters are summarised in Table 4-2 for S-Band and in Table 4-3 for X-Band

Table 4-2: S-Band Downlink Spacecraft Parameters

		NOM	ADV	FAV
Transmitter output power [dBm]		37.0	37.0	37.5
Circuit losses [dB]	LGA	3.1	3.1	3.0
	HGA	3.1	3.1	3.0
Antenna gain[dBi]	LGA	-2.0	-2.0	-1.5
	HGA	29.5	29.5	29.7
Pointing losses [dB]	LGA	0.15	0.2	0.1
	HGA	0	0	0
Polarisation		RHC	RHC	RHC
Axial ratio[dB]	LGA	4.0	4.0	3.5
	HGA	1.4	1.4	1.2
Modulation index[rad]	Telemetry	0 to 1.2655	(*) ±10%	(*) ±10%
	Ranging	0.01 to 0.7	(*) ±10%	(*) ±10%

(*) plus or minus to be taken favourable or adverse as required by the computed parameters, e.g. +10% is favourable to the telemetry recovery but adverse for the carrier and ranging recovery.

Table 4-3: X-Band Downlink Spacecraft Parameters

		NOM	ADV	FAV
Transmitter output power [dBm]		48.1	48.1	48.2
Circuit losses [dB] HGA		2.4	2.4	2.2
Antenna gain[dBi]	HGA	41.4	41.4	41.6
Pointing losses [dB]	HGA	0.2	0.5	0.1
Polarisation		RHC	RHC	RHC
Axial ratio[dB]	HGA	1.4	1.4	1.2
Modulation index[rad]	Telemetry	0 to 1.2655	(*) ±10%	(*) ±10%
	Ranging	0.01 to 0.7	(*) ±10%	(*) ±10%

(*) plus or minus to be taken favourable or adverse as required by the computed parameters, e.g. +10% is favourable to the telemetry recovery but adverse for the carrier and ranging recovery.

4.1.2 Transponder Requirements

The requirements to be satisfied by the transponder are comprised in the Radio Frequency and Modulation Standard **[AD-5]** and the Ranging Standard **[AD-4]**. The detailed requirements to be applied to the transponder shall be agreed with the ESA project office. General guidelines can be found in the S + S/X Band Coherent Transponder Specification **[RD-6]**.

4.2 Ground Stations

The performance characteristics together with the foreseen equipment configurations for the ESA ground stations are depicted in paragraph 4.2.1 to 4.2.2.

The NASA DSN ground station performance characteristics are defined in the 'Deep Space Network/Flight Project Interface Handbook' NASA/JPL 810.5, (Volume I: Existing DSN Capabilities) **[RD-3]**. An excerpt of those parameters required for link budget calculations is given in paragraph 4.2.3.

The performance characteristics together with the foreseen equipment configurations for the ASI Sardinia ground station (SRT) are depicted in paragraph 4.2.5.

The MARS EXPRESS requirements for this ground station are defined in [RD-10] (Mars Express High-Level Requirements for the SRT, MEX-SRT-SYS-REQ).

4.2.1 Kourou 15m, French Guyana				
Geographical Co-ordinates:	Longitude East [deg]	-52.80		
	Latitude North [deg]	5.25		
UPLINK	Antenna polarisation	LHC or RHC		
	Antenna gain [dB]	$48.5_{S\text{-}Band}$		
DOWNLINK	Antenna polarisation	any		
	Antenna gain [dB]	$49.2_{S\text{-}Band}$ $60.0_{X\text{-}Band}$		
TIMING system synchronisation to UTC	[microsec]	5.0		
UPLINK		NOM	ADV	FAV
EIRP (2 kW HPA)	S-Band [dBW]	81.00	80.00	81.00
Pointing Loss	[dB]	0.05	0.12	0.00
Axial Ratio	[dB]	0.50	1.00	0.00
DOWNLINK				
Effective G/T at 10° elevation	S-Band [dB/K]	29.85	29.50	30.20
	X-Band [dB/K]	38.00	37.50	38.00

Pointing Loss	S-Band [dB]	0.03	0.05	0.00
	X-Band [dB]	0.10	0.40	0.00
Axial Ratio	[dB]	0.50	1.25	0.00
PLL bandwidth $2B_L$ continuous 0.3 - 3000	[Hz]	NOM	+20%	-20%
TM demodulation technological losses	[dB]	0.40	0.50	0.30
Ranging Tone Loop Bandwidth	[rad/sec]	10^{-3} to 1.5		
Required Ranging Loop S/N	[dB]	19.00	19.00	19.00
Required C/N in PLL for no data degradation	[dB]	NO CODING:		10
	[dB]	CONVOLUTIONAL:		15
	[dB]	CONCATENATED:		17
Required TM E_b/N_0	[dB]	see ESA PSS-04-103 **[AD-3]**		
STATION EQUIPMENT:	Low Noise Amplifier	FET $55K_{S\text{-}Band}$ 100-K $FET_{X\text{-}Band}$		
	Receiver	IFMS		
	Demodulators	IFMS		
	Telemetry	TMP4		
	Decoders	CDS2A		
	Telecommand	TCE Mark IV		
	Tracking	MPTS Mark III / IFMS		
	Data Communications	ISS Node		
	Timing System	CESIUM + GPS		
	Station Control	STC2, FEC4, MCM3		

4.2.2 Perth 35m, Australia				
Geographical Co-ordinates:	Longitude East [deg]	115.88 (TBC)		
	Latitude North [deg]	-31.80 (TBC)		
UPLINK	Antenna polarisation	LHC or RHC		
	Antenna gain [dB]	$55.0_{S\text{-}Band,}$ $64.3_{X\text{-}Band}$		
DOWNLINK	Antenna polarisation	Any		
	Antenna gain [dB]	$56.0_{S\text{-}Band}$, $68.0_{X\text{-}Band}$		
TIMING system synchronisation to UTC	[microsec]	5.0		
UPLINK		NOM	ADV	FAV
EIRP (2 kW HPA) at 10° elevation	S-Band [dBW]	87.00	86.00	87.00
(20 kW HPA) at 10° elevation		97.00	96.00	97.00
(2 kW HPA) at 10° elevation	X-Band [dBW]	97.0	96.0	97.6
(20 kW HPA) at 10° elevation		107.0	106.0	107.6
Pointing Loss	[dB]	0.10	0.20	0.00
Axial Ratio	[dB]	0.50	1.00	0.00
DOWNLINK				
Effective G/T at 10° elevation	S-Band [dB/K]	37.5	37.0	38.0
	X-Band [dB/K]	50.1	49.6	50.1
Pointing Loss	S-Band [dB]	0.10	0.20	0.00
	X-Band [dB]	0.30	0.40	0.00
Axial Ratio	[dB]	0.50	1.00	0.00
PLL bandwidth $2B_L$ continuous 0.3 - 3000	[Hz]	NOM	+20%	-20%
TM demodulation technological losses	[dB]	0.40	0.50	0.30
Ranging Tone Loop Bandwidth	[rad/sec]	10^{-3} to 1.5		
Required Ranging Loop S/N	[dB]	19.00	19.00	19.00
Required C/N in PLL for no data degradation	[dB]	NO CODING:		10
	[dB]	CONVOLUTIONAL:		15
	[dB]	CONCATENATED:		17
Required TM E_b/N_0	[dB]	see ESA PSS-04-103 **[AD-3]**		
STATION EQUIPMENT:	Low Noise Amplifier	20-K HEMT		
	Receiver	IFMS		
	Demodulators	IFMS		
	Telemetry	TMP4		
	Decoders	CDS2A		
	Telecommand	TCE Mark IV		
	Tracking	MPTS Mark III / IFMS		
	Data Communications	ISS Node		
	Timing System	H-Maser + GPS		

Station Control	STC2, FEC4, MCM3

4.2.3 NASA/DSN, 34 m (BWG)				
Geographical Co-ordinates:	Longitude East [deg]	according **[RD-3]**		
	Latitude North [deg]			
UPLINK	Antenna polarisation	LHC or RHC		
	Antenna gain at 10° elevation [dB]	$55.2_{S\text{-}Band}$, $66.8_{X\text{-}Band}$		
DOWNLINK	Antenna polarisation	any		
	Antenna gain at 10° elevation [dB]	$56.9_{S\text{-}Band}$ $68.2_{X\text{-}Band}$		
TIMING system synchronisation to UTC	[microsec]	TBD		
UPLINK		NOM	ADV	FAV
EIRP at 10° elevation	S-band [dBW]	98.0	97.0	98.0
	X-band [dBW]	108.8	108.3	108.8
Pointing Loss	S-band [dB]	0.1	0.2	0.0
	X-band [dB]	0.3	0.4	0.0
Axial Ratio	S-band [dB]	1.0	1.2	0.8
	X-band [dB]	1.0	1.2	0.8
DOWNLINK				
Effective G/T at 10° elevation	S-Band [dB/K]	40.5	39.5	40.5
	X-Band [dB/K]	50.1	49.6	50.1
Pointing Loss	S-Band [dB]	0.10	0.20	0.00
	X-Band [dB]	0.30	0.40	0.00
Axial Ratio	S-band [dB]	1.0	1.2	0.8
	X-Band [dB]	0.8	1.0	0.8
PLL bandwidth $2B_L$	[Hz]	0.2-1000	0.2-1000	0.2-1000
TM demodulation technological losses	[dB]	0.5	0.6	0.4
Required Ranging S/N_0	[dBHz]	-10	-10	-10
Required C/N in PLL	[dB]	NO CODING:		10
	[dB]	CONVOLUTIONAL:		15
	[dB]	CONCATENATED:		15
Required TM E_b/N_0	[dB]	see ESA PSS-04-103 **[AD-3]**		
STATION EQUIPMENT:	Low Noise Amplifier	Station equipment see **[RD-3]**		
	Receiver			
	Demodulators			
	Telemetry			
	Decoders			
	Telecommand			
	Tracking			
	Data Communications			
	Timing System			

Station Control	

4.2.4 NASA/DSN, 70 m				
Geographical Co-ordinates:	Longitude East [deg]	according **[RD-3]**		
	Latitude North [deg]			
UPLINK	Antenna polarisation	LHC or RHC		
	Antenna gain at 10° elevation [dB]	$61.7_{S\text{-}Band,}$ $72.2_{X\text{-}Band}$		
DOWNLINK	Antenna polarisation	Any		
	Antenna gain at 10° elevation [dB]	$62.3_{S\text{-}Band}$ $73.1_{X\text{-}Band}$		
TIMING system synchronisation to UTC	[microsec]	TBD		
UPLINK		NOM	ADV	FAV
EIRP at 10° elevation	S-band [dBW]	117	117	117
	X-band [dBW]	114.9	114	115.2
Pointing Loss	S-band [dB]	0.1	0.2	0.0
	X-band [dB]	0.3	0.4	0.0
Axial Ratio	S-band [dB]	1.0	1.2	0.8
	X-band [dB]	1.0	1.2	0.8
DOWNLINK				
Effective G/T at 10° elevation	S-Band [dB/K]	46.9	45.9	46.9
	X-Band [dB/K]	56.7	55.7	56.7
Pointing Loss	S-Band [dB]	0.10	0.20	0.00
	X-Band [dB]	0.30	0.40	0.10
Axial Ratio	S-band [dB]	1.0	1.2	0.8
	X-Band [dB]	0.8	1.0	0.8
PLL bandwidth $2B_L$	[Hz]	0.1-500	0.1-500	0.1-500
TM demodulation technological losses	[dB]	0.5	0.6	0.4
Required Ranging S/N_0	[dBHz]	-10	-10	-10
Required C/N in PLL for no data degradation	[dB]	NO CODING:		10
	[dB]	CONVOLUTIONAL:		15
	[dB]	CONCATENATED:		15
Required TM E_b/N_0	[dB]	see ESA PSS-04-103 **[AD-3]**		
STATION EQUIPMENT:	Low Noise Amplifier	Station equipment see **[RD-3]**		
	Receiver			
	Demodulators			
	Telemetry			
	Decoders			
	Telecommand			
	Tracking			
	Data Communications			

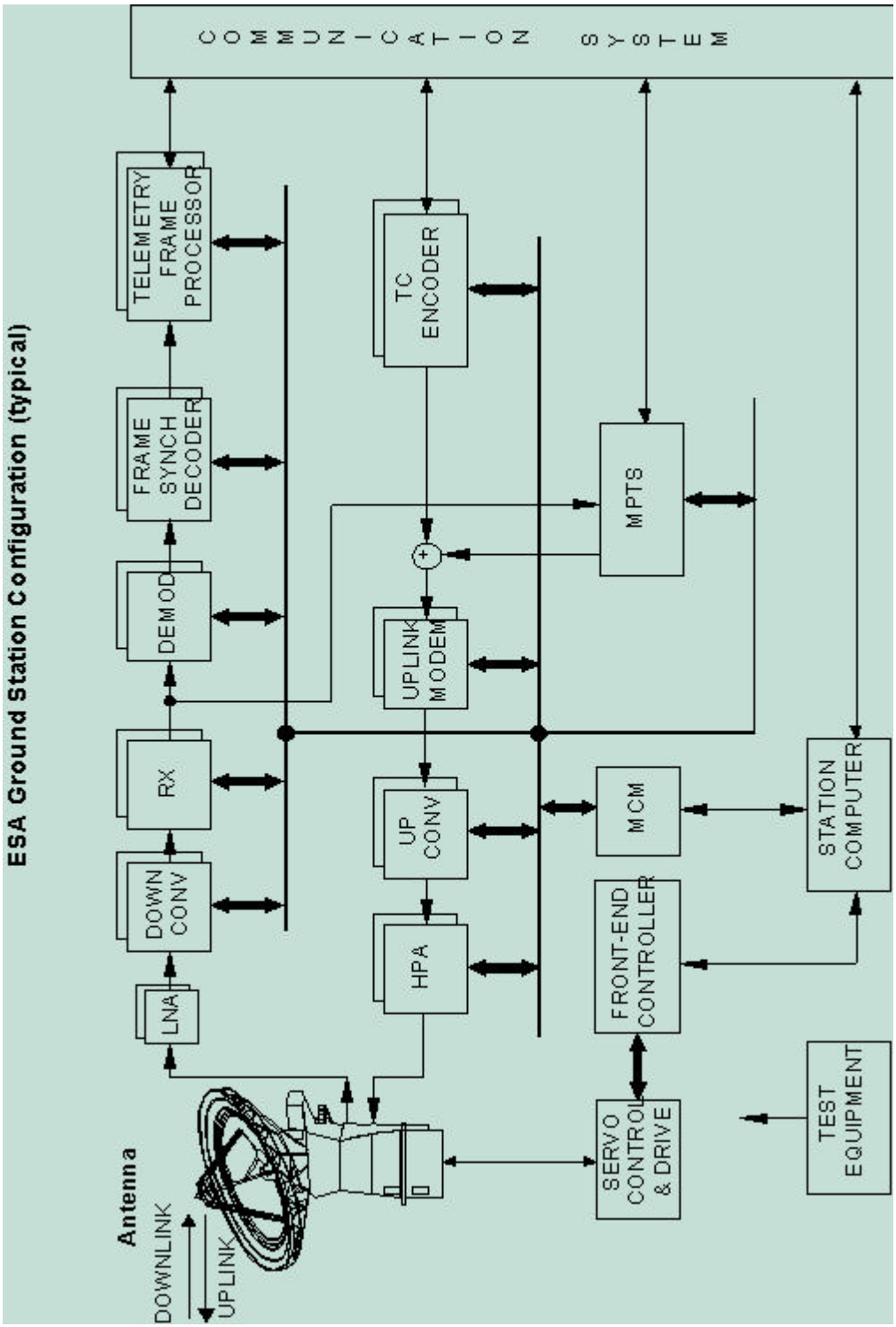
Timing System Station Control	

4.2.5 ASI/SRT		**TBC**		
Geographical Co-ordinates:	Longitude East [deg]	TBD		
	Latitude North [deg]	TBD		
UPLINK	Antenna polarisation	LHC or RHC		
	Antenna gain at 10° elevation [dB]	$TBD_{S\text{-}Band,}$ $TBD_{X\text{-}Band}$		
DOWNLINK	Antenna polarisation	RHC		
	Antenna gain at 10° elevation [dB]	$TBD_{S\text{-}Band}$ $TBD_{X\text{-}Band}$		
TIMING system synchronisation to UTC	[microsec]	TBD		
UPLINK		NOM	ADV	FAV
EIRP at 10° elevation	S-band [dBW]	100.4 dBW	TBD	TBD
	X-band [dBW]	110.4	TBD	TBD
Pointing Loss (included in EIRP)	[dB]	0	0	0
Axial Ratio	S-band [dB]	0.5	TBD	TBD
	X-band [dB]	TBD	TBD	TBD
DOWNLINK				
Effective G/T at 10° elevation	S-Band [dB/K]	41	TBD	TBD
	X-Band [dB/K]	53.5	TBD	TBD
Pointing Loss (included in G/T)	S-Band [dB]	0	0	0
	X-Band [dB]	0	0	0
Axial Ratio	S-band [dB]	0.5	TBD	TBD
	X-Band [dB]	0.5	TBD	TBD
PLL bandwidth $2B_L$	[Hz]	TBD	TBD	TBD
TM demodulation technological losses	[dB]	0.4	0.4	TBD
Required Ranging S/N_0	[dBHz]	TBD	TBD	TBD
Required C/N in PLL for no data degradation	[dB]	NO CODING:		10
	[dB]	CONVOLUTIONAL:		15
	[dB]	CONCATENATED:		17
Required TM E_b/N_0	[dB]	see ESA PSS-04-103 **[AD-3]**		

STATION EQUIPMENT:	Low Noise Amplifier	TBD
	Receiver	TBD
	Demodulators	TBD
	Telemetry	TBD
	Decoders	TBD
	Telecommand	TBD
	Tracking	TBD
	Data Communications	TBD
	Timing System	TBD
	Station Control	TBD

4.2.6 Station Configuration

4.2.6.1 ESA Ground Station



4.2.6.2 NASA/DSN Ground Station

TBD

4.2.6.3 ASI/SRT Ground Station

To be provided.

4.3 Required Links

4.3.1 Required Link Performance

The link budgets shall be computed as defined in ESA PSS-04-105 **[AD-5]**, that means including nominal, adverse, favourable, mean - 3 sigma and worst case RSS (Root Sum Square). The minimum values of those margins shall be:

- nominal: $\geq$ 3 dB
- RSS worst case: $\geq$ 0 dB
- mean - 3 sigma: $\geq$ 0 dB

The link budget margins shall be computed under the following assumptions:

- Telemetry :
  - For "low" symbol rates up to 52.4288 ks/s (corresponding to the sub-carrier modulation scheme): telemetry bit error rate associated with 99.99% of transfer frame delivery for concatenated coding (probability of frame loss = 10^{-4});
  - For "high" symbol rates starting at 65.536 ks/s and above (corresponding to the SP-L direct carrier modulation scheme): telemetry bit error rate associated with 99.999% of transfer frame delivery for concatenated coding (probability of frame loss = 10^{-5});

- Telecommand : The requirements of ESA PSS-04-105, chapter 5 are applicable.

- Ranging : see ESA PSS-04-104, Volume I **[AD-4]** .

4.3.2 Ground Station Network

The ground station network to support the required telemetry, telecommand and tracking links shall be as follows:

Station	**LEOP**	**Cruise**	**Mars capture**	**Aerobraking (TBC)**	**Science**
Kourou 15m	**Yes**	**No**	**No**	**No**	**No**
Perth 35m	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Sardinia	**TBC**	**TBC**	**TBC**	**TBC**	**TBC**
DSN 34m	**Yes**	**No**	**Yes**	**Yes**	**Potential add-on**
DSN 70m	**No**	**Potential emergency S-Band back-up only**			
Note: Science = Commissioning, Mars Operations					

4.3.3 Link Budget Formats and Definitions

Any link budget calculations shall be presented in a standard format as specified in Annex 10, and shall further include summary tables and graphical presentations for both uplink and downlink.

The following link budgets for maximum up/down link distances (minimum bit rates) shall be verified for both ranging on and off:

Uplink	**S-Band**			**X-Band**	
	LGA **16 bps**		**HGA** **2000 bps**		**HGA** **2000 bps**
Kourou 15m	**(1)**		**(1)**		**N/A**
Perth 35m	**1.1 AU**		**2.7 AU**		**2.7 AU**
Sardinia SRT	**1.6 AU**		**2.7 AU**		**2.7 AU**
DSN 34m	**1.1 AU**		**2.7 AU**		**2.7 AU**
DSN 70m	**2.7 AU**		**2.7 AU**		**2.7 AU**
Downlink (*)	**S-Band**			**X-Band**	
	LGA **9.2 bps**		**HGA** **74.4 bps**		**HGA** **28566 bps**
Kourou 15m	**(1)**		**(1)**		**(1)**
Perth 35m	**0.2 AU**		**2.7 AU**		**2.7 AU**
Sardinia SRT	**0.3 AU**		**2.7AU**		**2.7 AU**
DSN 34m	**0.2 AU**		**2.7 AU**		**2.7 AU**
DSN 70m	**0.55AU**		**2.7 AU**		**2.7 AU**

(1) Maximum distance

(*) Information bit rates (fb) are indicated in this table.

4.4 RF Compatibility Test

To confirm RF compatibility between the spacecraft and the ground segment, an RF suitcase model shall be provided by the contractor, comprising flight representative hardware (EM units) sufficient to test all up- and down-links for both functional and performance characteristics. This shall include verification of all telemetry, telecommand and ranging functions, and combination thereof, as well as spectral analyses and link budget verification.

The RF suitcase shall be delivered to ESOC at*L-12 months*, and shall be available for at least 6 months. Together with the RF suitcase model, a RF suitcase description and operations manual shall be delivered, such that operation of the suitcase by ESOC technical personnel is possible without the need for assistance from Industry.

The RF detailed suitcase requirements and interfaces are described in TBD document. The suitcase shall include at least the following:

- a TTC subsystem including the RF switch(es);
- those data handling subsystem units required for the generation of telemetry. The telemetry shall contain transfer frames in the same layout as during flight with representative packets;
- those data handling subsystem units required for the reception of commands, including the support of lower level protocols, e.g. COP-1.

5 TELEMETRY STRUCTURE

5.1 Telemetry Source Packet

All telemetry source packets must conform to the structure defined in **[AD-1]** and shown in Figure 5.1-1 below.

SOURCE PACKET HEADER (48 bits)							**PACKET DATA FIELD (VARIABLE)**	
PACKET ID				PACKET SEQUENCE CONTROL		PACKET LENGTH	DATA FIELD HEADER	SOURCE DATA
Version Number	Type	Data Field Header Flag	Application Process ID	Segment-ation Flags	Source Sequence Count			
3	1	1	11	2	14			
16				16		16	80	Variable

Figure 5.1-1. Telemetry Source Packet Fields

5.1.1 Source Packet Header

5.1.1.1 Packet ID

Version Number:
The Version Number must be set to $000'_{BIN}$ (The specification in this document is consistent with [RD-4] and supersedes [AD-1]) for all telemetry issued on-board. The ground segment shall reject with an alarm any packet received with a version number other than zero.

Type:
For telemetry source packets, the type must be set to zero.

Data Field Header Flag:
This indicates the presence or absence of a Data Field Header and must be set to 1 except for Time Packets and for Idle Packets where it is set to 0 (see Service 10 sub type 2 and Appendices 7 and 8).

Application Process ID (APID):
The Application Process ID uniquely identifies the on board source of the packet.
The application ID (APID) is structured into two fields:

- The Process ID (PID) which defines the application which is the source of the telemetry packet.

- The category which identifies different categories of packets to be processed by the addressee.

The choice of Application Process ID values (PIDs and categories) across the spacecraft subsystems and experiments are given in Appendix 3.
Two Application Process ID's have been reserved for special purposes, namely the Standard Spacecraft Time Source Packet and the Idle Packet. Their use and data structure are provided in Appendices 7 and 8 respectively.

5.1.1.2 Packet Sequence Control

Segmentation [Grouping] Flags:

These two bits shall be set to '$11'_{BIN}$ indicating "no segmentation", except for Payload where these 2 bits can be left free and set according to the rules fixed for the relevant APID (see also [RD-4]).

Source Sequence Count:
Used to represent the actual Sequence Count. A separate source sequence count is maintained for each Application Process ID and shall be incremented by 1 whenever the source (APID) releases a packet. Therefore the counter corresponds to the order of release of packets by the source and enables the ground to detect missing packets, the ground segment shall issue an alarm for each missing block of packets detected. Ideally, this counter should never re-initialise, however under no circumstances shall it "short-cycle" (i.e. have a discontinuity other than to a value zero). The counter wraps around from 2^{14}-1 to zero, and shall start at zero at power on of the unit or on start of the application generating the packet data.

5.1.1.3 Packet Length

The Packet Length field specifies the number of octets contained within the Packet Data Field. The number is an unsigned integer "C" where

C = (Number of octets in Packet Data Field) - 1

For MARS EXPRESS, the maximum length of a Telemetry Source Packet Data Field is 4106 octets, this includes 4096 source data and 10 data field header. This is required in order to make the packet acquisition an even number of Octets so 16 bit acquisition on the OBDH bus can be used via a serial channel.

5.1.1.4 Packet Error Control

Moved to 5.1.2.3

5.1.2 Packet Data Field

5.1.2.1 Data Field Header

The data field header is preceded by the source packet header and followed by source data and error control in the telemetry packet, refer to figure 5.1-1. All data field headers have the same basic structure, as follows:

SCET Time	PUS Version	Checksum Flag	Spare	Packet Type	Packet Subtype	Pad
48 bits	3 bits	1 bit	4 bits	8 bits	8 bits	8 bits
Mandatory	mandatory	mandatory	mandatory	mandatory	mandatory	mandatory

Time:
This defines the time that the acquisition of the data in the packet was initiated (must be the first field according to the Packet TM Standard), or another time such that the acquisition time can be calculated by the ground segment using data supplied in the MARS EXPRESS Users Manual.
The time code format shall be as defined in Appendix 6.

Note: The structure of the time field allows the identification of non-synchronised time.

PUS Version:
PUS version = TM_dest_ID (TM destination identifier)
This field is used within the DMS software and the AOCMS software to define the routing/destination of the TM packets received from other packet end-user (i.e. to Ground, DMS SW, AOCMS SW or several of these destinations)
The following rules shall be followed for the elaboration of this field:

Rule 1:- For solicited TM packet (telemetry packet in response to a command) the same PUS version than the one contained in the TC packet shall be copied in the telemetry packet.

Rule 2: For unsolicited TM packet (telemetry packet not in response to a command), the following codes for the TM destination shall be used
- 0 : for TM packet to be processed only by Ground
- 1 : for TM packet to be processed only by the DMS software
- 2 : for TM packet to be processed both by the Ground and the DMS software
- 3 : for TM packet to be processed only by the AOCMS software
- 4 : for TM packet to be processed both by the Ground and the AOCMS software and possibly the DMS software

For Payloads, the code to be used is "0"(TM destination = Ground only for category = Private-science, and "2"(TM destination = Ground and DMS software) for all other packet categories.

For SSMM, the code to be used is "2"(TM destination = Ground and DMS) or "1"(TM destination = DMS only) according to the category (see note 2)

For STR, the default code to be used is "3"(TM destination = AOCMS only) or "4"(TM destination = Ground and AOCMS) according to the category as defined in the STR requirements specification. All categories of packets for which default code of TM destination is "3" can have their TM destination forced to "4" and possibly restored to "3" according to a ground request sent by a private TC. This TC changes the TM destination of all packets of these categories at the same time (all categories of packets for which default code of TM destination is "3").

For the DMS software, the code to be used is set to "0" (TM destination = Ground only), except for category EVENT for which the code to be used is set to "2".

For the AOCMS software, the code to be used is "2" (TM destination = Ground and DMS) or "1" (TM destination = DMS only) according to the category (see note 2). All categories of packets for which default code of TM destination is "1" can have their TM destination forced to "2" and possibly restored to "1" according to a ground request sent by a private TC

For the Firmware , the code to be used is according to the category (see note 2)

Note 2 : Case of SSMM, AOCMS SW and Firmware for unsolicited TM packets

- the code "2" is used for category "EVENT", "FUNC NON CYCLIC", "HK", "FILE
- the code "1" is used for category "FUNC CYCLIC"
- the code "0" is used for category "PRIVATE (science data)".

Checksum Flag :
Not Used = '0'$_{BIN}$
No Packet error control field for telemetry is base lined for MARS EXPRESS, should a unit plan to include this field in its private telemetry services, this field should still be set to zero and another unit specific flag be included in the services data segment.

Spare
Set to all zeros, i.e. '0000'$_{BIN}$.

Packet Type
This indicates the type to which the telemetry source packet relates. The telemetry source packet types applicable to MARS EXPRESS are as given in Appendix 2. The numbering scheme is detailed in section A1.3.

Packet Sub-type:
Together with the Type, the Sub-type uniquely identifies the nature of the telemetry contained within the telemetry source packet.

Pad:
Pad = TC_answ_tok (TC answer token)
This field is used within the DMS software and the AOCMS software as an additional routing information for TM packets received from other packet end users, to the local application within the DMS or AOCMS software
The following rules shall be followed for the elaboration of this field:

Rule 1:- For solicited TM packet (telemetry packet in response to a command, see table §A2.22)) the same Pad value than the one contained in the TC packet shall be copied in the telemetry packet.

Rule 2: For unsolicited TM packet (telemetry packet not in response to a command), the PAD shall be set to zero

The relationship between Telecommand and Telemetry Packet Types and Subtypes and the packet based users (Firmware, DMS software, AOCMS software, STR, SSMM, Payload) to which they apply is given in Appendix 2.

The same Packet Type and Subtype definitions shall apply to all applications using the service.

5.1.2.2 Source Data

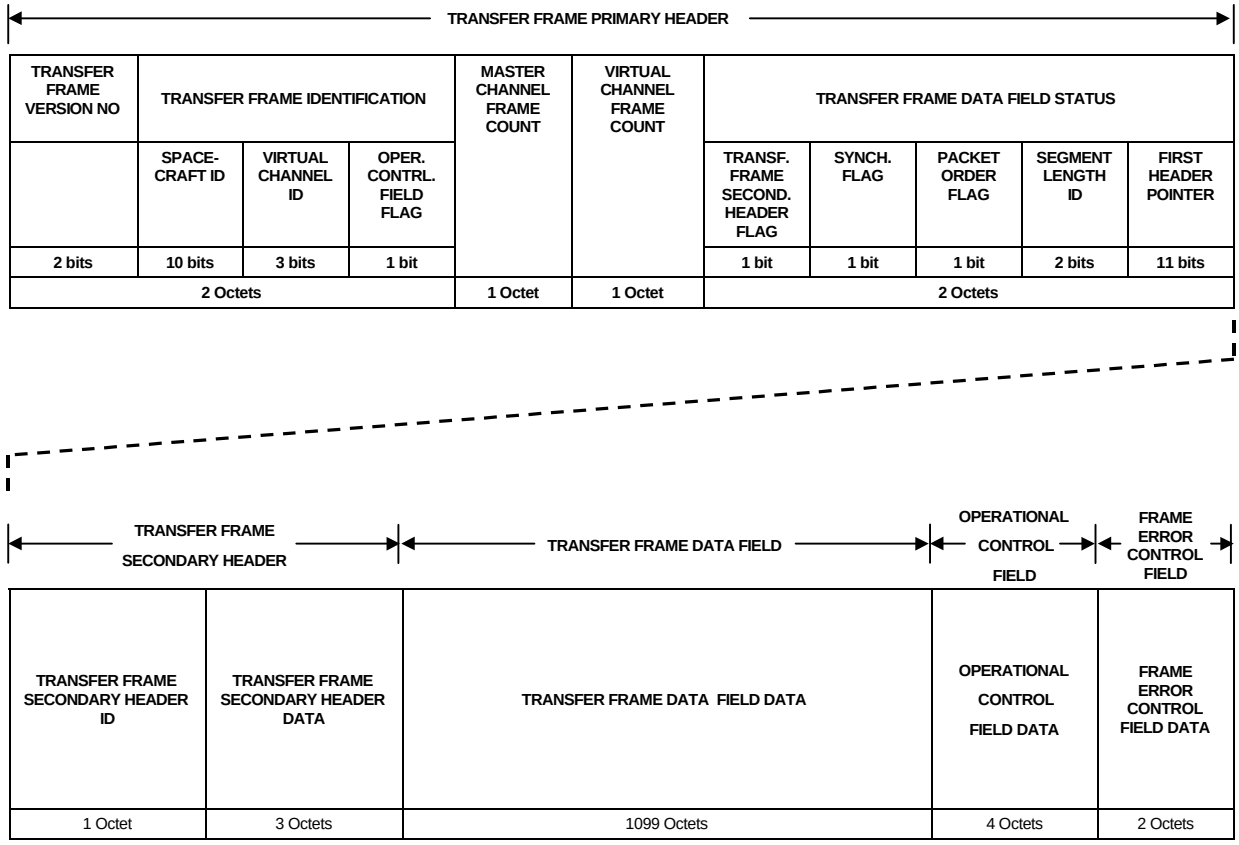
The packet source data constitutes the data element of the telemetry reports to the ground.

5.1.2.3 Packet Error Control

This is not baseline for MARS EXPRESS telemetry packets. (See checksum flag section 5.1.2.1)

5.2 Telemetry Transfer Frame

All telemetry Transfer Frames must conform to the structure defined in **[AD-1]** with the remarks listed here below.



5.2.1.1 Transfer Frame Length

The only allowed frame length (before encoding) shall be 1115 octets (i.e. 8920 bits).

5.2.1.2 Version Number

The Version Number shall be set to 00_{BIN}.

5.2.1.3 Spacecraft ID

The following Telemetry Spacecraft Identification (TM S/C ID) has been assigned:

	HEX	DEC
Orbiter Flight Model	**037**	**55**
Lander Beagle 2	**038**	**56**

5.2.1.4 Virtual Channel ID

Data sources on board will be allocated a virtual channel number to identify them to the ground processing facilities as follows:

VC0 Real Time Telemetry (Real Time packets directly from CDMU)
VC1 Play Back Telemetry (Play Back packets from SSMM)
VC2 Not Required
VC3 Not Required
VC4 Not Required
VC5 Not Required
VC6 Not Required
VC7 Idle Frames (A full frame where the data field is filled with random data)

Virtual Channel ID 7 shall contain only Idle Frames[1] while other Virtual Channels may contain Idle Packets if no data is available when they have to be transmitted.
It shall be possible to downlink any combination of VCs independent of the selected bit rate.

It shall be possible to downlink partially filled frames by completing the frame with an idle packet.

The priority scheme for downlinking of VCs will be:

1. VC0 Real Time Telemetry (RT) - When ready or when time packet should be sent
2. VC1 Play Back Telemetry (PB) - When ready and no VC0 available
3. VC7 Idle Frames - When neither VC0 nor VC1 is available

Note: If a VC1 frame is not completely filled with real data, the VC1 frame shall be filled up with one (or more) idle packet(s) and sent before VC7 begins to send idle frames.

[1] The term «Idle Frame» meaning a Transfer Frame containing (only) Idle Data in its Transfer Frame Data Field, though widely used is not in the official CCSDS Terminology. In fact, a Transfer Frame containing (only) Idle Data in its Transfer Frame Data Field, can still carry non-idle information outside the Transfer Frame Data Field and then be used for «active» purposes (e.g. extraction of the CLCW in the OCF for the Telecommand protocol; reference Time for time calibration procedures).

5.2.1.5 Operational Control Field Flag

The Operational Control Field Flag shall be set to 1 and a Command Link Control Word (CLCW) shall be inserted in the Operational Control Field (OCF) for all frames.

5.2.1.6 Master Channel Frame Count Field

The Master Channel Frame Count field shall contain a sequential binary count (modulo 256) of each Transfer Frame transmitted within the MARS EXPRESS specific Master Channel. A re-setting of the MASTER CHANNEL FRAME COUNT before reaching 255 shall not take place unless it is unavoidable. Any case when it is unavoidable shall be documented in the MEUM (MARS EXPRESS User Manual).

5.2.1.7 Virtual Channel Frame Count Field

The Virtual Channel Frame Count field shall contain a sequential binary count (modulo 256) of each Transfer Frame transmitted through a specific Virtual Channel of a Master Channel. A re-setting of the Virtual Channel Frame Count before reaching 255 shall not take place unless it is unavoidable. Any case when it is unavoidable shall be documented in the MEUM.

5.2.1.8 Secondary Header Flag

The Secondary Header shall always be set to one indicating a secondary header shall be inserted in the frame.

5.2.1.9 Data Field Synchronisation Flag

The Data Field Synchronisation Flag shall be set to zero; i.e. octet-synchronised and forward-ordered Telemetry Source Packet or Idle Data (only for VC7) shall be inserted in the Transfer Frame Data Field.

5.2.1.10 Packet Order Flag

The Packet Order Flag shall be set to zero. The Packet sequence count order shall be **forward**.

5.2.1.11 Segment Length Identifier

Being the Data Field Synchronisation Flag set to zero, the Segment Length Identifier shall be set to 11_{BIN}.

5.2.1.12 First Header Pointer

Being the Synchronisation Flag set to zero, the First Header Pointer shall contain information on the position of the first Telemetry Source Packet within the Transfer Frame Data Field; i.e. the binary representation of the location of the first octet of the first Packet Primary Header. *The locations of any subsequent headers within the same Transfer Frame Data Field will be determined by calculating these locations using the Packet Data Length Field.*

If no Packet Primary Header starts in the Transfer Frame Data Field, the First Header Pointer shall be set to «11111111111»$_{BIN}$.

For Idle Frames (VC7) the First Header Pointer shall be set to «11111111110»$_{BIN}$.

5.2.1.13 Secondary Header

A Transfer Frame Secondary Header shall be inserted in all frames. This shall contain a header and an expansion of the virtual channel frame counter.

Secondary Header ID

The secondary header ID be 8 bits in length and shall indicate the version number and the header length for MARS EXPRESS, this shall be set to 00000011$_{BIN.}$

Secondary Header Data

The secondary header data shall be a 3 Octet field containing an additional 24 bits of the virtual channel frame count as defined in [AD-1].

5.2.1.14 Operational Control Field

The Operational Control Field shall be inserted in each frame and it shall contain the CLCW (i.e. the Type-Flag shall be set to zero) with the format defined in **[AD-2]**.

CONTROL WORD TYPE "0"	CLCW VERSION "00"	STATUS FIELD	COP IN EFFECT	VIRTUAL CHANNEL IDENTIFICATION	SPARE
1	2	3	2	6	2

(ALWAYS "0" FOR CLCW)

FLAGS					FARM B COUNTER	SPARE	REPORT VALUE
NO RF AVAIL	NO BIT LOCK	LOCK-OUT	WAIT	RETRANSMIT			
1	1	1	1	1	2	1	8

The values of the (Telecommand) VC Identifiers inserted in the CLCWs shall be consistent with those used for the Telecommand Frames.

The CLCW Standard Insertion Scheme No. 2 defined in **[AD-2]** shall be applied.

5.2.1.15 Frame Error Control Word

The Frame Error Control Word shall be inserted in each frame..

6 TELECOMMAND STRUCTURE

6.1 Telecommand Source Packets

All telecommand source packets (except those for distribution by the CPDU) must conform to the structure defined in **[AD-2]** and shown in Figure 6.1-1 below.

<table>
<tr><th colspan="8">PACKET HEADER (48 bits)</th><th colspan="3">PACKET DATA FIELD (VARIABLE)</th></tr>
<tr><td colspan="5">PACKET ID</td><td colspan="2">PACKET SEQUENCE CONTROL</td><td>PACKET LENGTH</td><td>DATA FIELD HEADER</td><td>APPLIC-ATION DATA</td><td>PACKET ERROR CONTROL</td></tr>
<tr><td rowspan="2">Version Number</td><td rowspan="2">Type</td><td rowspan="2">Data Field Header Flag</td><td colspan="2">APID</td><td rowspan="2">Sequence Flags</td><td rowspan="2">Sequence Count</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>PID</td><td>PCAT</td></tr>
<tr><td>3</td><td>1</td><td>1</td><td>7</td><td>4</td><td>2</td><td>14</td></tr>
<tr><td colspan="7">16</td><td>16</td><td>32</td><td>Variable</td><td>16</td></tr>
</table>

Figure 6.1-1. Telecommand Packet Fields

6.1.1 Packet Header

6.1.1.1 Packet ID

Version Number:
The Version Number must be set to 000_{BIN} for all commands.

Type:
This bit distinguishes between telecommand packets and telemetry source packets. For telecommand packets, the type = 1.

Data Field Header Flag:
This indicates the presence of the Data Field Header when set to 1.
For MARS EXPRESS all commands except CPDU (2,3) commands will have a data field header.

Application Process ID:
.
The application ID (APID) is structured into two fields:

- The Process ID (PID) which defines the application which the telecommand is addressed to.
- The Packet category (PCAT) is fixed to decimal 12.

The choice of Process ID values across the spacecraft subsystems and experiments are given in Appendix 3.

6.1.1.2 Packet Sequence Control

Sequence Flags:
For MARS EXPRESS these 2 bits are set to "11", which means "stand-alone" packet.

Sequence Count: (14 bits)
This field is provided to identify a particular telecommand packet so that it can be traced within the end-to-end telecommand system. The field is divided into two parts as follows:

> **Source part (3 M.S. bits) Identifies** the command source and processing to be performed on the sequence count as follows:
>
> Source is the ground, time line or an on-board application running in the DMS.
> 000 = Ground all sources (maintained by ground)
> 001 = Mission Time Line (maintained by ground)
> 010 = DMS all sources except mission time line (maintained by DMS on-board)
> 011 = AOCMS all sources (maintained by AOCMS on-board
> 100-111 = Spare
>
> **Sequence part (11 bits)** Used to represent the actual Sequence Count. The Sequence Count is maintained by the telecommand source for each Application Process ID. The sequence count shall be incremented by 1 whenever a command is generated with that Application Process ID. The counter wraps around from "full-scale" to zero.

When an acknowledgement of a packet is required (see "Ack" field in the data field header below), it is mandatory that the Sequence Control field are included in the telemetry acknowledge packet as the identifier of the telecommand packet being acknowledged.
No check is to be performed by the addressed application regarding sequence counter, the application should accept commands regardless of the sequence counter.

6.1.1.3 Packet Length

The Packet Length field specifies the number of octets contained within the Packet Data Field. The number is an unsigned integer "C" where

> C = (Number of octets in Packet Data Field) - 1

Maximum length of a Telecommand source packet data field is 242 octets, this includes 4 data field header, 236 application data and 2 packet error control. However for some telecommand types that have to be contained inside the application data field of another command type, the maximum size of the packet will be further restricted to a maximum size depending on the final definitions of services containing full definitions of other packet commands e.g. 11, 5, 12, and other services defined in this ICD.

6.1.2 Packet Data Field

6.1.2.1 Data Field Header

The data field header is preceded by the packet header and followed by application data and error control in the telecommand packet, refer to figure 6.1-1. The data field header is defined as follows:

PUS Version	Checksum type	Ack	Packet type	Packet subtype	Pad
3 bits	1 bits	4 bits	8 bits	8 bits	8 bits
mandatory	mandatory	mandatory	mandatory	mandatory	mandatory

PUS Version:
PUS version 1 = TM_dest_ID

This field is used by the DMS software and the AOCMS software to define the destination processor (Ground, DMS SW, AOCMS SW or several of these destinations) for the TM packets which are direct responses to this command.
Note: The following codes shall be used
- 0 : for TM packet to be processed only by Ground
- 1 : for TM packet to be processed only by the DMS software
- 2 : for TM packet to be processed both by the Ground and the DMS software
- 3 : for TM packet to be processed only by the AOCMS software
- 4 : for TM packet to be processed both by the Ground and the AOCMS software

Note : "DMS software"(code 1) excludes OBCPs, and "Ground"(code 0) includes also MTL and generally OBCPs, . The only exception is when an OBCP which sends a TC to a packet end-user, wants to process the TM that answers this TC. In that case, TM_dest_ID will be set to "2" (to ground and DMS) and not to "0"as for other "Ground"generated TC packets.

Checksum Type:
This indicates the presence of a Packet Error Control Field at the end of the Packet Data Field and is always set to 1.

Ack:
This field indicates the acknowledgements required in the form of telemetry packets to verify acceptance and execution of this telecommand packet.

The bit settings defined for MARS EXPRESS are as follows (with bit zero as start of the data field header):

- bit 7 = Acceptance of packet by application
  (0= no acknowledge report required, 1= acknowledge report required)
- bit 6 = 0 Not used (Acknowledge start of execution)
- bit 5 = 0 Not used (Acknowledge progress of execution)
- bit 4 = Acknowledge completion of execution
  (0= no acknowledge report required, 1= acknowledge report required)

All applications, which receive telecommands, must generate acknowledgements as specified in the telecommand message.

It shall be possible to control the routing of acknowledgement packets to the ground regardless of the command source.

The Load Mission Time Line Command TC (11,4) and the encapsulated Telecommand packet shall be acknowledged separately, depending on the Ack flag of the command.

Packet Type:
This identifies the type of packet as given in the Appendix 2. The numbering scheme is detailed in section A1.3.

Packet Subtype:
The packet type together with the Packet Subtype indicates the function of the packet.

The relationship between Telecommand and Telemetry Packet Types and Subtypes and the users to which they apply is given in Appendix 2.

Pad:
Pad = TC_answ_tok (TC answer token)
This field is used within the DMS software and the AOCMS software to identify the local software application to which the telemetry packet solicited by the command shall be routed.
The following rules shall be followed for the elaboration of this field:

Rule 1: For TC packet generated by the Ground (including MTL) the Pad value shall be set to zero.

Rule 2:- For TC packet generated within the DMS software or within the AOCMS software, the value is determined internally by the DMS software or the AOCMS software
In all case, the same Pad value than the one contained in the TC packet shall be copied by the addressee in the Pad field of the TM packet in response.

In all case, the same Pad value than the one contained in the TC packet shall be copied by the addressee in the Pad field of the TM packet in response.

The same Packet Type and Subtype definitions shall apply to all applications.

6.1.2.2 Application Data

The telecommand application data constitutes the data element of the command.

6.1.2.3 Packet Error Control

The Packet Error Control field provides an error detection code (checksum) in the packet, allowing the receiving application to verify the integrity of the telecommand packet data.

The checksum shall be calculated over the complete packet less the final 16 bits Packet Error Control field.

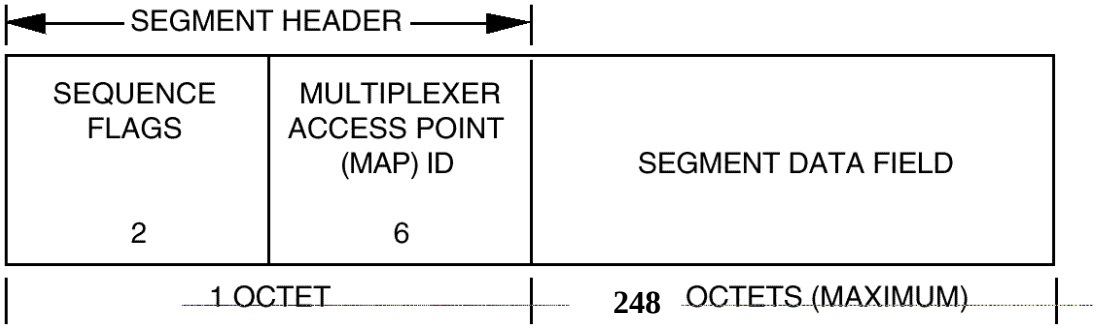
Appendix 4 provides a specification of the checksum method selected (CRC checksum).

6.2 Telecommand Segments

The Telecommand Segment defined in **[AD-2],** and shown in the figure below, shall be used as TC Frame Data Unit (i.e. the data unit transferred from the Segmentation Layer to the Transfer layer to be inserted in the Frame Data Field of the Telecommand Frame).

The Segment Header contains the following two fields:

- Sequence Flags (Bits 0,1), and
- Multiplexer Access Point (MAP) Identifier (Bits 2 through 7)



6.2.1 Sequence Flags

There shall be no command packet segmentation for MARS EXPRESS, so the sequence flags shall be set to 11_{BIN}

6.2.2 Multiplexer Access Point (MAP) Identifier

MAP IDs shall be used to route the telecommands from the decoder depending on the type of handling required for the command e.g. DMS software or Command Pulse Distribution Unit. MAP IDs shall not be used to address the currently active DMS processor.

6.2.3 Packet Aggregation

The Segment Data Field contains all or a portion of the higher layer TC User Data Unit, i.e. (in the MARS EXPRESS context) a TC Packet or an aggregation of TC Packets.

In order to maximise the throughput of commands on the uplink, packet aggregation will be used where possible **[RD-8].** Aggregation is a CCSDS concept where several complete packets can be put into a single segment. Therefore at the start of a segment there will always be the start of a packet, the length of the first packet will define the start position of the next packet.

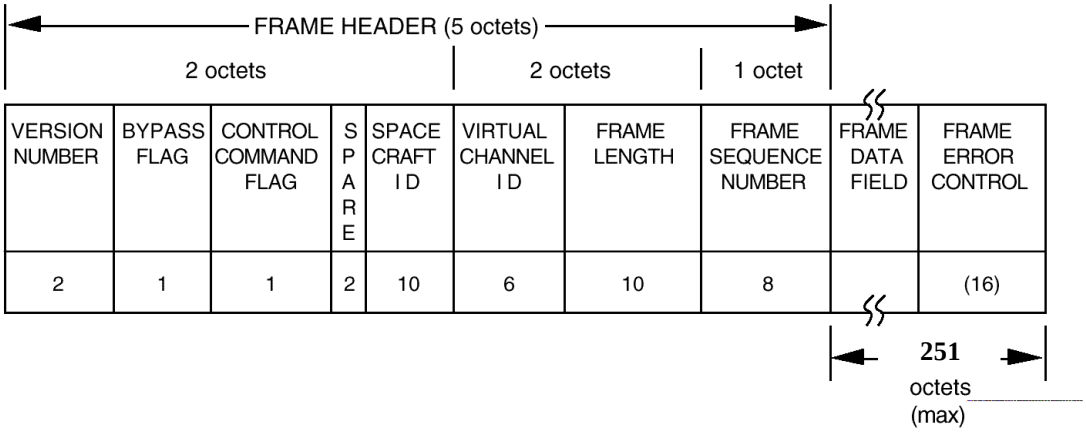
Segment Data Field		
Packet #1	Packet #2	Packet #3

(« Packet Length » of packet #1)+7octets = Start address Octet of Packet #2

Start address Octet of Packet #2+(«Packet Length » of packet #2)+7octets =
Start address Octet of Packet #3

6.3 Telecommand Frame

The Telecommand Frame must conform to the structure defined in **[AD-2]**.



6.3.1 Spacecraft ID

The following Telecommand Spacecraft Identification (TC S/C ID) has been assigned:

	HEX	DEC
Orbiter Flight Model	**037**	**55**
Lander Beagle 2	**038**	**56**

6.3.2 Virtual Channel ID

Only two Virtual Channels Identifiers shall be used addressing the two on-board decoders. The suggested values are Zero and One. These two values shall be used consistently in the CLCWs.

6.3.3 Frame Length

This 10-bit field contains a length count «C» which equals one fewer than the total octets in the TC Transfer Frame. The count is measured from the first bit of the FRAME HEADER to the last bit of the FRAME ERROR CONTROL FIELD (if present), or the last bit of the FRAME DATA FIELD if the error control is omitted. The size of this field limits the maximum length of a TC Transfer Frame to 1024 octets. The length count «C» is expressed as:

«C» = (Total Number of Octets) - 1

Note that, though **[RD-8]** allows to use this field entirely, i.e. up to a maximum frame length of 1024 octets, the maximum frame length allowed by **[AD-2]** and applicable to MARS EXPRESS is 256 octets. Therefore the first two bits of the Frame Length field (Reserved Field B in [AD-2]) must always be set to 00_{BIN}, leaving an effective "ESA Frame Length Field" of 8 bits.

6.4 Telecommand Lower Layers

All the telecommand lower layers data structures and procedures must conform to the structure defined in **[AD-2]**.

Appendix 1 CONVENTIONS

A1.1 Bit Numbering Conventions

The following convention shall be used to identify each bit in an N-bit field :

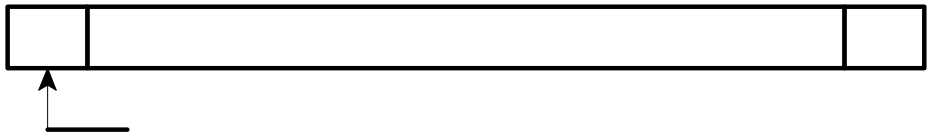


Figure A1.1 Bit numbering

Note about the first bit transmitted:

In all case except on the link IEEE1355, the first bit transmitted = MSB (i.e. in the following case : space to ground link, OBDH bus, MACS bus, RS422 link, and all other serial links)

In the particular case of the link IEEE1355, the first bit transmitted = LSB (cf. spec RO.DSS.IS.1001 §3.7.5)

However this is transparent to the space-ground link.

1) The first bit in the field (starting from the left) is defined to be "Bit 0" and will be represented as the left most justified bit in a figure. The next bit is called "Bit 1", and so on, up to "Bit N-1", the bits being represented in this order from left to right in a figure.

2) If the N-Bit field is to be interpreted as "Unsigned Integer" value, Bit 0 is the MSB and Bit N-1 is the LSB.

3) If the N-Bit field is to be interpreted as "Signed Integer" value, Bit 0 indicates the sign with Bit 0 = 0 corresponding to a positive number and Bit 0 = 1 corresponding to a negative number.

4) Adjacent groups of bits are described in terms of octets and words.

5) Octet = 1 byte = 8 bits (1 word = 2 octets = 16 bits).

A1.2 Field Alignment Conventions

The following convention shall be used to construct packet parameter fields:

1) Parameters with a length longer or equal 16 bits shall be word aligned, i.e. the LSB shall coincide with the word boundary.

2) Parameters with a length shorter than 16 bits shall not be allowed to span over word boundaries.

3) Parameters with a length shorter than 16 bits shall be right-adjusted within the occupied 16-bit word, leaving any required padding-bits in the most significant bits of the 16-bit word.

4) If more than one parameter is held in a single word the parameters shall be right adjusted.

A1.3 Packet Numbering Conventions

Packet class and function is provided by packet type and packet subtype, included in the data field header of the packet.
The Packet Type numbering scheme is devised to provide correlation between TC packets and the resulting TM packets and is therefore non-contiguous: there are cases where for a certain TC type, there is no corresponding TM type. Appendix 2 provides a complete cross-reference table down to sub-type level.

To make identification simpler, service type and subtype are represented by two numbers, separated by a comma, for example, TC (1,1) is a telecommand packet type 1, subtype 1 and TM (1,2) is a telemetry packet type 1, subtype 2. Subtype numbers within a service shall be unique.

Appendix 2 TM AND TC PACKET TYPES AND SUBTYPES

The ESA Packet Utilisation Standard (PUS) has been used to generate the standard services together with other packet services identified from the MARS EXPRESS top level design.

PAD Pads are used to align fields at word boundaries and to comply with an existing software interface, all pads shall be set to zero, unless specified in this ICD.

A summary of all defined Types and subtypes is given in the cross reference table in section A2.22.

IMPORTANT NOTE

The body of Appendix 2 describes the formal structure and contents to be respected for TM and TC exchanged between the Ground and the intelligent packet end-users on-board, when applicable.

The summary table in Appendix 2.22 describes when (for which unit) this is applicable.

It must be noted a Service may be implemented (e.g. because of Rosetta heritage) but not used on Mars Express. In this case the Service will remain available (including on the Ground side) and may be activated, should the need appear.

To implement a given Ground-Spacecraft function, the preference should be given to the Generic Services (if they can support the function) over the use of a Private Service.

A2.1 Service 1 TC Verification

Objective

To allow the command source to verify identified commands at acceptance and/or execution by asking the addressed application to generate service type 1 reports in the telemetry stream.

Description

The command source can set two bits in the command packet header, one asks for an acceptance report; the other an execution report, the two bits can be set to any value. Packet Users use these bits to generate the required reports, the DMS software will time out (20 seconds TBC) on a requested acceptance report and perform a standard pre-defined procedure, no systematic on-board check is done for the execution report this may be done by the sending OBCP if required. For Non Packet Users the DMS software strips out the data from the packet and issues this on the BUS for the RTU, it will generate a success acceptance report if it is requested. An acceptance report is generated immediately after completion of checks on validity of the packet header; an execution report after internal verification of TC execution.

Service 1 is used to verify that the addressed application has received and executed the packet Tele-command addressed to it. The type of response required is coded in the Ack field contained in the Tele-command packet header. For MARS EXPRESS the response required is restricted to:-

- No Response (report not required)
- Acceptance Success or Failure (service report sub type 1 or 2 required)
- Execution Completion Success or Failure (service report sub type 7 or 8 required)

The type of response required for each command depends on the function of the command and is coded with the command definition in the MESDB.

Notes

When issuing a command to the RTU for distribution to a user the DMS shall:-

- For Non Packet based users
  Distribute the commands data field to the correct RTU address selected by using the information in the data field, and generate an acceptance success telemetry packet, if this is requested in the commands Ack field.
- For Packet based users
  Distribute the whole packet to the correct RTU address or the internal DMS application selected by using the application process ID, and if an acceptance telemetry packet is requested set a time out counter to expect a response within (20 seconds TBC). Should no response be received the DMS software will generate an event packet to inform higher levels of the error.

All response packets will be stored onboard and down linked on request.

Telemetry (1,1) Telecommand Acceptance Report - Success.

Function/Description

TBW.

Structure

Process ID : ALL
Packet Cat. : 1 (Acknowledge)
Type : 1
Subtype : 1
Source Data : See below

Tele-Command Packet ID	Tele-Command Sequence Control
Unsigned Integer	Unsigned Integer
2 octets	2 octets

Parameters Meaning

Tele-Command Packet ID **:** Is a full 16-bit copy of the Packet ID fields of the command being reported on

Tele-Command Sequence Control: Is a full 16-bit copy of the Packet Sequence Control fields of the command being reported on

Parameters Values/Range

N/A.

Remarks

Telemetry (1,2) Telecommand Acceptance Report - Failure.

Function/Description

TBW.

Structure

Process ID : ALL
Packet Cat. : 1 (Acknowledge)
Type : 1
Subtype : 2
Source Data : See below

Tele-Command Packet ID	Tele-Command Sequence Control	Failure Code	Parameters
Unsigned Integer	Unsigned Integer	Unsigned Integer	Optional
2 Octets	2 Octets	2 Octets	Any size

Parameters Meaning

Tele-Command Packet ID **:** Is a full 16-bit copy of the Packet ID fields of the command being reported on.

Tele-Command Sequence Control: Is a full 16-bit copy of the Packet Sequence Control fields of the command being reported on.

Failure Code **:** For Mars Express standard failure codes are used (see below).

Parameters **:** Complementary information relating to a specific failure code.

Parameters Values/Range

Tele-Command Packet ID **:** N/A.

Tele-Command Sequence Control: N/A.

Failure Code **:**

1 = Incomplete Packet (Failed to receive whole packet within time out period (8 seconds for OBDH bus, others TBD)).

2 = Incorrect check sum.

3 = Incorrect application ID in the TC packet header.

4 = Invalid command code.

5 = Command can not be executed at this time (incorrect status of application to allow command execution).

6 = Packet data field inconsistent.

7 = Others TBD (*).

Parameters **: TBD.**

(*) Should any additional codes for a specific application be required they will be allocated by the project for each specific application.

Remarks

1) Parameters standardisation for FID of TM(1,2) and (1,8)

The parameters to be used for the above defined standard failure are the following :

Failure Code and meaning	Parameter 1 (*)	Parameter 2 (*)	Parameter 3 (if any)	Parameter 4 (if any)
1 : Incomplete packet within time-out (1)	Packet type from the received TC (2)	Packet sub-type from the received TC (2)	Length in the packet header of the received TC (2)	Number of received octets
2 octets	1 octet	1 octet	2 octets	2 octets
2 : Incorrect check-sum (CRC)	Packet type from the received TC	Packet sub-type from the received TC	Received checksum	Computed checksum
2 octets	1 octet	1 octet	2 octets	2 octets
3 : Incorrect APID	Packet type from the received TC	Packet sub-type from the received TC		
2 octets	1 octet	1 octet		
4 : Invalid Command code	Packet type from the received	Packet sub-type from the received	Application specific	Application specific

	TC	TC		
2 octets	1 octet	1 octet	2 octets	2 octets

5 : Command cannot be executed at this time	Packet type from the received TC (*)	Packet sub-type from the received TC (*)	To be defined case by case	
2 octets	1 octet	1 octet	TBD	

6 : Data field inconsistent (3)	Packet type from the received TC (*)	Packet sub-type from the received TC (*)	Position in octet of the first inconsistent parameter	Received value of the first inconsistent parameter
2 octets	1 octet	1 octet	1 octet	1 octet

(1) : concern only the packet based user connected to the OBDH bus, i.e. payload. The other packet based users received the packets all at once, i.e. within only one TC segment from ground for the DMS SW, or within only one exchange for equipments connected to an IEEE1355 link.

(2) : the parameters will be significant only if they have been received. Otherwise, it will be set to zero.

(3) : this FID may be advantageously replaced by dedicated FID, specific to each inconsistent data, with specific parameters

(*) Note : Type and sub-type of the received TC, as parameters 1 and 2, is useful to investigate which TC has been sent e.g. when the emitter of the TC is an OBCP.

2) FID and EID allocation

The proposed ranges is the following :

Assigment		Ranges in decimal value		Remarks
		Min	Max	
Not used		0	0	
Reserved		1	1 000	Used for FID standard error codes only
SSMM		1 001	2 000	
STR		2 001	3 000	
Spare		3 001	4 000	
Firmware		4 001	4 100	Specific to
Spare		4 101	10 000	each
DMS		10 001	20 000	user
AOCMS		20 001	30 000	
PF		30 001	40 000	
Payload				
	Aspera	40 001	40 500	
	HRSC	40 501	41 000	
	Maress	41 001	41 500	
	Marsis	41 501	42 000	
	Omega	42 001	42 500	
	PFS	42 501	43 000	
	Spare	43 001	43 500	
	SPICAM	43 501	44 000	
	Beagle-2	44 001	44 500	
	VMC	44 501	47 500	
	Spare	47 501	48 000	
	Spare	48 001	55 500	
	spare	55 501	59 999	
Ground	Power/Pyro SCOE	60 000	60 255	
	TMTC SCOE	60 256	60 511	
	TT&C SCOE	60 512	60 767	
	I-BOB	60 768	61 023	
	AOCMS / SCOE	61 024	61 279	
	Spacecraft Interface Simulator	61 280	61 535	
	Instruments SCOE (details TBD)	61 536	64 000	
	MCS	64 001	65 000	
	Spare	65 001	65 535	

Telemetry (1,7) Telecommand Execution Completion Report - Success.

Function/Description

TBW.

Structure

Process ID : 0 to 50 (optional for 51 to 116)
Packet Cat. : 1 (Acknowledge)
Type : 1
Subtype : 7
Source Data : See below

Tele-Command Packet ID	Tele-Command Sequence Control
Unsigned Integer	Unsigned Integer
2 octets	2 octets

Parameters Meaning

Tele-Command Packet ID **:** Is a full 16-bit copy of the Packet ID fields of the command being reported on

Tele-Command Sequence Control: Is a full 16-bit copy of the Packet Sequence Control fields of the command being reported on

Parameters Values/Range

N/A.

Remarks

Telemetry (1,8) Telecommand Execution Completion Report - Failure.

Function/Description

TBW.

Structure

Process ID : ALL
Packet Cat. : 1 (Acknowledge)
Type : 1
Subtype : 8
Source Data : See below

Tele-Command Packet ID	Tele-Command Sequence Control	Failure Code	Parameters
Unsigned Integer	Unsigned Integer	Unsigned Integer	Optional
2 Octets	2 Octets	2 Octets	Any size

Parameters Meaning

Tele-Command Packet ID : Is a full 16-bit copy of the Packet ID fields of the command being reported on.

Tele-Command Sequence Control: Is a full 16-bit copy of the Packet Sequence Control fields of the command being reported on.

Failure Code : For Mars Express standard failure codes are used (see below).

Parameters : Complementary information relating to a specific failure code

Parameters Values/Range

Tele-Command Packet ID : N/A.

Tele-Command Sequence Control: N/A.

Failure Code **:** 1 = The correct commanded status was not achieved

2 = Others TBD (*)

Parameters **:** **TBD.**

(*) Should any additional codes for a specific application be required they will be allocated by the project for each specific application.

Remarks

The same parameter standardisation and FID allocation apply than the one described for TM(1,2).

A2.2 Service 2 Device Command Distribution

Objective

To allow the distribution of discrete commands to other users.

Description

On/Off and Register Load commands (sub types 1&2) are handled by the DMS software, the commands are distributed to the user, no packet protocol is used, only the data segment of the packet is sent to the addressed user.
CPDU (sub type 3) allows the command decoder to directly issue pulse commands over a dedicated harness.

NOTE: A response from the user using service 1 reports to service 2 commands is not possible.

Service 2 is used to distribute

- on/off commands
- register load commands
- CPDU commands

On/Off or Register load commands Sub types 1 & 2

The commands are unpacked from the relevant delivery packet by and application in the DMS software. If more than one command is contained in the packet they are unpacked and sent in the same order as contained in the packet. Service 1 reporting (TC Verification) is only supported for acceptance of the packet (sub types 1 or 2). The packet is checked for the standard failure codes as defined in service 1, and for consistency (correct number of entries in the data field), should any error occur the whole packet is rejected with a service 1 sub type 2 report, and no commands contained in the packet will be issued.

Telecommand (2,1) Distribute On/Off Commands.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 2
Subtype : 1
Application Data : See below

PAD	N	R	PAD	Peripheral address	PAD	PAD	Operation Code	Channel selection address
	unsigned integer	enumerated		unsigned integer			enumerated	unsigned integer
1 Octet	1 Octet	1 Bit	7 Bits	5 Bits	3 Bits	4 Bits	4 Bits	1 Octet

< ---------- Repeated N Times ---------- >

Parameters Meaning

N : Is the number of commands contained in the packet

Command (on two words) : address information of the command, as it is extracted from the information of the MARS EXPRESS Spacecraft Data Base. This address is composed of :

R : Route : indicate if the DMS software has to use the uplinked address to generate the real RTU address (peripheral address) or to update this address with the current configuration, thus to issue the command on the currently selected route (main or redundant). This concerns only the peripheral address.

Peripheral address : RTU channel address.

Operation code : represent the type of the OBDH command: LPC, HPC or EPC

Channel selection address : specified the selected output channel in the RTU for this bus coupler address.

Parameters Values/Range

N	**:**	unsigned integer on 8 bits in the range 1 to 58 - TBC (58 commands maximum due to the limited length of the TC packet)
R (Route)	**:**	• 0 :indicate to issue the command on the currently selected route according to the current configuration • 1 :indicate to force the command to the uplinked address.
Peripheral address	**:**	unsigned integer as it is extracted from the MESDB
Operation code	**:**	• 0001 : LPC (Low power command) • 0010 : HPC (High power command) • 0011 : EPC (Extended High power command)
Channel selection address	**:**	unsigned integer as it is extracted from the MESDB for that command

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (2,2) Distribute Register Load Commands.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 2
Subtype : 2
Application Data : See below

PAD	N	R	PAD	Peripheral Address	ML	Data to be loaded
	unsigned integer	Enumerated		unsigned integer	unsigned integer	
1 Octet	1 Octet	1 Bit	7 Bits	5 Bits	3 Bits	2 Octets

< ---------- Repeated N Times ---------- >

Parameters Meaning

N : Is the number of commands contained in the packet

Command (on two words) : address information of the command, as it is extracted from the information of the MARS EXPRESS Spacecraft Data Base. This address is composed of :

R : Route : indicate if the DMS software has to use the uplinked address to generate the real RTU address (peripheral address) or to update this address with the current configuration, thus to issue the command on the currently selected route (main or redundant). This concerns only the peripheral address.

Peripheral address : RTU channel address.

ML : Memory (or register) load address: designed the 16 bits register to be loaded

Data to be loaded : is the data to be loaded into the addressed register. Its detailed format is specific to the register, and is detailed within the MESDB

Parameters Values/Range

N	**:**	unsigned integer on 8 bits in the range 1 to 58 - TBC (58 commands maximum due to the limited length of the TC packet)
R (Route)	**:**	• 0 :indicate to issue the command on the currently selected route according to the current configuration • 1 :indicate to force the command to the uplinked address.
Peripheral address	**:**	unsigned integer as it is extracted from the MESDB
ML	**:**	unsigned integer as it is extracted from the MESDB for that command
Data to be loaded	**:**	its detailed format is specific to the register, and is detailed within the MESDB

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (2,3) Distribute CPDU Commands.

Function/Description

CPDU commands are pulse commands of a specified duration issued directly on dedicated lines from the packet Tele-command decoder, and as such can only be issued by direct ground command and not from an DMS software application. Because no DMS software is involved, no service 1 (TC Verification) can be provided for these commands. For a further definition of the handling of these commands refer to the packet Tele-command decoder specification. A MAP address of 0 should be used in the segmentation layer to address the CPDU.

Note: CPDU (subtype 3) does not have a data field header and exists within one segment.

Structure

Process ID : 31
Packet Cat. : 12
Type :
Subtype : } **None (no Data Field Header)**
Application Data : See below

Output line ID	PAD	Duration
enumerated		Enumerated
1 Octet	5 Bits	3 Bits

< ---Repeated up to 4 (TBC) times (*)--- >

Parameters Meaning

Output line ID **:** indicate the output line to which the command pulse is to be issued

Duration **:** indicate the duration of the pulse.

(*) The number of CPDU commands contained within the packet is derived from the segment (or frame) length contained in the Frame header, or derived from the packet length contained in the packet header. The maximum number of commands in one telecommand packet of service (2,3) is 4 (TBC).

Parameters Values/Range

Output line ID **:** is extracted from a list which indicate all CPDU command and their ID.

Duration **:** is in accordance with the «Telecommand Decoder Specification» §9.2.3 :

- 000 = 1 x D (with D between 10 and 15 ms)
- 001 = 2 x D
- 010 = 4 x D
- 011 = 8 x D
- 100 = 16 x D
- 101 = 32 x D
- 110 = 64 x D
- 111 = 128 x D

The exact value of D depends on the spacecraft implementation.

Verification/Effect on Telemetry

TBW.

Remarks

This specific telecommand shall not have a Data Field Header.

A2.3 Service 3 Housekeeping Reporting

Objective

This service controls the generation of housekeeping report packets from all packet-based users and the generation of report packets from non-packet based users via the DMS software.

Description

Generation start, stop, frequency and content of housekeeping report packets are controlled by this service.

The housekeeping data reporting sub-service samples sets of housekeeping parameters in accordance with a set of reporting definitions stored onboard. There will be a pre-defined set of such definitions onboard (designed by the satellite manufacturer) as deemed appropriate for the housekeeping monitoring of the mission. However, these definitions may be modified, deleted and new definitions may be added by the ground at any time.

A Structure Identification (SID) is associated with each distinct reporting definition and associated housekeeping report packet. The SID will be used on the ground, together with the Application Process ID, Service Type and Sub-type to identify the housekeeping report packet and to interpret its content.

- Data Collection

Each reporting definition has an associated data collection interval, which is the time interval over which the housekeeping parameters are sampled. Parameters within a reporting definition may be either simply commutated (sampled once per collection interval) or super-commutated (sampled more than once). Super-commutated parameters are sampled regularly in time at a rate, which is determined onboard from the combination of the data collection interval and the parameter commutation index.

- Housekeeping Report Packet Generation

Only one mode of generating housekeeping report packets exist for MARS EXPRESS: the periodic mode, where a housekeeping report packet is generated with a specified frequency.

The requests for selecting the mode of housekeeping report packet generation are part of this service, but the requests for disabling and enabling the transmission of housekeeping report packets to the ground are part of the Packet Transmission Control Services 14&15.

- Parameter Sampling Times

It is required that the absolute (as well as relative) sampling times of parameters in housekeeping-parameter reports can be determined to a given (TBD) accuracy on the ground.
The parameter sampling times (e.g. time offsets with respect to packet time) may be deducible from knowledge of the onboard parameter sampling mechanism. This shall be the normal method used for MARS EXPRESS.

Service Requests and Reports

Operations performed by commands within this service, act on the H.K report identified by the process ID in the command header and the SID within the data field.

Telecommand (3,1) Clear and Replace a Housekeeping Report Packet Descriptor.

Function/Description

This telecommand allows to redefine the content of an already defined house keeping telemetry packet. Warning : the current items of the housekeeping report packet definition are discarded. To clear a housekeeping report packet descriptor, the ground may use this TC packet by defining a packet length and a number of cell equal to zero.

For definition of new housekeeping report packet descriptions, the available spare SIDs shall be used.

If the full description of the packet cannot be contained in the maximum sub-type 1 TC packet size, this command shall be followed by sub-type 3 commands to complete the packet definition.

Structure

Process ID : 1 and 11
Packet Cat. : 12 (Private)
Type : 3
Subtype : 1
Application Data : See below

				Parameter ID			
Not Used	**SID**	**TM Packet length**	**N**	**Type**	**Size (in the data pool)**	**Group in the data pool**	**Offset in the group**
	enume-rated	unsigned integer	unsigned integer	enume-rated	unsigned integer	unsigned integer	unsigned integer
1 Octet	1 Octet	2 Octets	2 Octets	1 bit	5bits	10 bits	2 Octets

< ---------- Repeated N Times ---------->

Parameters Meaning

SID : Current structure identification. It allows to define precisely the content of the packet to be cleared and replaced

TM Packet Length : Total length of the new packet as defined in section 5.1.1.3

N : Number of parameter Ids in the new packet (limited to 25)

Parameter ID : represents the parameter ID and is composed of :

Type : defines if the parameter has to be included within the TM packet on 16 bits words (e.g. floating point, 16 bits SW parameter, SD16 HW parameter), or on one octet (e.g. analogue TM, thermistor analogue, bi-level, SD8 for hardware parameter, each of them stored in the SW data pool on the LS byte of a 16 bits word)

Size : defines the number of octets of the parameter (or parameters) within the group.

Group : defines the group in the on-board data pool to which belongs the parameter (or parameters)

Offset within the group : defines the position of the parameter (or the first parameter) within the group

Parameters Values/Range

SID : **TBW.**

TM Packet Length : As defined in section 5.1.1.3

N : N/A.

Type : N/A.

Size : Size = 1 for parameters to be inserted in the TM packet in only one octet
Size ≥ 2 by step of 2 for parameters to be inserted in 16 bits words (i.e. an even number)

Group : N/A.

Offset within the group : N/A

Verification/Effect on Telemetry

N.A.

Remarks

Note 1: Only a packet descriptor for which the packet generation is currently disabled can be updated via this sub-type.

Note 2: For the SID's contained in the AOCMS software, the already existing SID's should not be replaced since they may be used within the DMS software (or else it is necessary the ground maintains the coherency with the SID descriptors contained within the DMS software for these SID's).

Telecommand (3,3) Add to an already defined Housekeeping Report Packet Descriptor.

Function/Description

This telecommand allows to add parameters to an already defined housekeeping packet definition. The new definitions are added after the already defined ones.

Structure

Process ID : 1 and 11
Packet Cat. : 12 (Private)
Type : 3
Subtype : 3
Application Data : See below

				Parameter ID			
Not Used	**SID**	**New TM Packet length**	**N**	**Type**	**Size (in the data pool)**	**Group in the data pool**	**Offset within the group**
	enume-rated	Unsigned integer	unsigned integer	enume-rated	unsigned integer	unsigned integer	unsigned integer
1 Octet	1 Octet	2 Octets	2 Octets	1 bit	5 bits	10 bits	2 Octets

< ---------- Repeated N Times ---------- >

Parameters Meaning

SID : Current structure identification. It allows to define precisely the content of the packet to be extended

TM Packet Length : Total length of the new packet as defined in section 5.1.1.3

N : Number of parameter Ids in the new packet (limited to 25)

Parameter ID : represents the parameter ID and is composed of :

Type : defines if the parameter has to be included within the TM packet on 16 bits words (e.g. floating point, 16 bits SW parameter, SD16 HW parameter), or on one octet (e.g. analogue TM, thermistor analogue, bi-level, SD8 for hardware parameter, each of them stored in the SW data pool on the LS byte of a 16 bits word)

Size : defines the number of octets of the parameter (or parameters) within the group.

Group	**:**	defines the group in the on-board data pool to which belongs the parameter (or parameters)
Offset within the group	**:**	defines the position of the parameter (or the first parameter) within the group

Parameters Values/Range

SID	**:**	**TBW.**
TM Packet Length	**:**	As defined in section 5.1.1.3
N	**:**	N/A.
Type	**:**	N/A.
Size	**:**	Size = 1 for parameters to be inserted in the TM packet in only one octet Size ≥ 2 by step of 2 for parameters to be inserted in 16 bits words (i.e. an even number)
Group	**:**	N/A.
Offset within the group	**:**	N/A

Verification/Effect on Telemetry

N.A.

Remarks

Telecommand (3,5) Enable Housekeeping Report Packet Generation.

Function/Description

TBW.

Structure

Process ID : 1 to 20 and 51 to 116
Packet Cat. : 12 (Private)
Type : 3
Subtype : 5
Application Data : See below

PAD	SID
	Enumerated
1 Octet	1 Octet

Parameters Meaning

SID **:** Defines the housekeeping report addressed by this command.

Parameters Values/Range

SID **:** Depending on addressed Process Id (each Housekeeping packet source is free to define its values/ranges of SID).

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (3,6) Disable Housekeeping Report Packet Generation.

Function/Description

TBW.

Structure

Process ID : 1 to 20 and 51 to 116
Packet Cat. : 12 (Private)
Type : 3
Subtype : 6
Application Data : See below

PAD	SID
	Enumerated
1 Octet	1 Octet

Parameters Meaning

SID **:** Defines the housekeeping report addressed by this command.

Parameters Values/Range

SID **:** Depending on addressed Process Id (each Housekeeping packet source is free to define its values/ranges of SID).

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (3,25) Housekeeping Report Packet.

Function/Description

TBW.

Structure

Process ID : 1 to 20, 26 to 29 and 31 to 116 (PID 25, SSMM, only on private TC request)
Packet Cat. : 4 (Housekeeping)
Type : 3
Subtype : 25
Source Data : See below

PAD	SID	Parameters
	Enumerated	
1 Octet	1 Octet	Variable

Parameters Meaning

SID : Defines the housekeeping report addressed by this command.

Parameters : This field consists of a sequence of values of simply commutated housekeeping parameters followed by a sequence of fixed arrays of records and/or parameter values. The sequence of parameter values and arrays is the same as in the housekeeping parameter report definition request (see Sub-types 1 & 3 above). For each packet it is defined in MESDB.

Parameters Values/Range

SID : Defines the housekeeping report addressed by this command.

Parameters : As defined in MESDB for each packet.

Remarks

For ground processing purposes, the SID, together with the Application Process ID, Service Type and Sub-type implicitly identifies the structure of the parameter field.

Telecommand (3,27) Modify Housekeeping Report Packet Generation Frequency.

Function/Description

This telecommand allows to set a new sub-cycle to the generation of a Housekeeping telemetry packet. This allows the ground to control the frequency of the generation of the telemetry packet. The base cycle is the one of the function in charge of activating the telemetry packet building (e.g. on the 8Hz or 1 Hz task), and the sub-cycle defines if the telemetry packet is generated on each cycle of the base frequency, or on 1 cycle on N.
e.g. Sub-cycle = 1 means that the packet is emitted at every cycle, 5 means that the packet is emitted once upon 5 cycles..

Structure

Process ID : 1 to 20
Packet Cat. : 12 (Private)
Type : 3
Subtype : 27
Application Data : See below

PAD	SID	Sub-cycle
	Enumerated	Unsigned integer
1 octet	1 octet	2 octets

Parameters Meaning

SID **:** Structure identification. It defines precisely the content of the packet to be modified (which parameter at which location)

Sub-cycle **:** frequency of the generation of the telemetry packet**on** the base frequency associated to the generation of this packet, i.e. number of cycle on the base frequency before generating the telemetry packet

Parameters Values/Range

SID **:** Defines the housekeeping report addressed by this command.

Sub-cycle **:** **TBW.**

Verification/Effect on Telemetry

TBW.

Remarks

Concerned software : both DMS SW & AOCMS SW

A2.4 Service 4 Deleted.

This service has been deleted.

A2.5 Service 5 Events Reporting

Objective

The service provides three functions, Progress reporting, Anomaly reporting and Critical Events Log control.

Description

Normal progress of an on-board process is reported via sub type 1. Depending on the process, reporting points will defined during its design, for key points a time out in the DMS software may be defined.
Anomaly or error reporting is split into three levels, low/Warning (Sub Type 2), medium/Ground action (Sub Type 3) and high/On-board action (Sub Type 4).
The use of the different levels will be defined during the design of the process issuing them. Typically low will just be stored for down link to ground, high will always have a pre-defined response by the DMS software to recover the anomaly. The DMS software events monitor may monitor all event reports.

All Telemetry Packets including the event reports are normally stored in packet data stores in the SSMM.

Critical (medium/Ground action (Sub Type 3) and high/On-board action (Sub Type 4)) events are stored additionally as packets in the Critical Events Log that is held by the DMS in a protected memory, so if the DMS function is rebooted or switched to another processor the information is available, even if the normal packet stores of events in the SSMM is lost due to an anomalous event on-board. The ground can request a dump of the critical events log, if so the packets are put into the real time virtual channel. The log will be a circular buffer of TBD size, in which new event packets overwrite the old ones. In any case the service allows the ground to clear the log erasing all old packets at any time by command. The packets of sub types 3&4 are stored in the Critical Events Log as separate packets.

Event reports will be one of the prime methods used to control day to day operations during the mission both to report normal progress, warnings, errors requiring ground action or autonomous actions performed on-board.

The same EID (Event Identifier) allocation applies than the one described for TM(1,2).

Telemetry (5,1) Normal/Progress Report.

Function/Description

Used to indicate progress points in a process or action that requires some time to complete, points shall be agreed when the process is defined.

Structure

Process ID : 1 to 20 and 25 to 116
Packet Cat. : 7 (Event)
Type : 5
Subtype : 1
Source Data : See below

EID	Parameters
Enumerated	Any
2 Octets	Variable

Parameters Meaning

EID : Event ID identifies uniquely the event within the whole spacecraft system. The EID value will be assigned by the project authority.

Parameters : This field provides complementary information about the event. The structure of this field is uniquely identified by PID, Category, Subtype and EID.

Parameters Values/Range

EID : Values >60000, are reserved for ground.

Parameters : As defined in MESDB for each packet.

Remarks

Telemetry (5,2) Error/Anomaly Report - Warning.

Function/Description

Used to report that an unexpected event has been detected on-board.

The allocation of the severity level will be agreed during the design of the system and or sub-system together with any response required by on-board or ground action.

Structure

Process ID : 1 to 20 and 25 to 116
Packet Cat. : 7 (Event)
Type : 5
Subtype : 2
Source Data : See below

EID	Parameters
Enumerated	Any
2 Octets	Variable

Parameters Meaning

EID : Event ID identifies uniquely the event within the whole spacecraft system. The EID value will be assigned by the project authority.

Parameters : This field provides complementary information about the event. The structure of this field is uniquely identified by PID, Category, Subtype and EID.

Parameters Values/Range

EID : Values >60000, are reserved for ground.

Parameters : As defined in MESDB for each packet.

Remarks

Telemetry (5,3) Error/Anomaly Report - Ground Action.

Function/Description

- Used to indicate an error that requires action from a higher level authority or to report that an autonomous action has been performed on-board.

The allocation of the severity level will be agreed during the design of the system and or sub-system together with any response required by on-board or ground action.

Structure

Process ID : 1 to 20 and 25 to 50 (optional for 51 to 116)
Packet Cat. : 7 (Event)
Type : 5
Subtype : 3
Source Data : See below

EID	Parameters
Enumerated	Any
2 Octets	Variable

Parameters Meaning

EID : Event ID identifies uniquely the event within the whole spacecraft system. The EID value will be assigned by the project authority.

Parameters : This field provides complementary information about the event. The structure of this field is uniquely identified by PID, Category, Subtype and EID.

Parameters Values/Range

EID : Values >60000, are reserved for ground.

Parameters : As defined in RSDB for each packet.

Remarks

Telemetry (5,4) Error/Anomaly Report - On-board Action.

Function/Description

Used to indicate an error that requires action from a higher level authority or to report that an autonomous action has been performed on-board. Three levels of severity are foreseen:-

- Warning (Sub Type 2)
- Ground action (Sub Type 3)
- On-board action (Sub Type 4)

The allocation of the severity level will be agreed during the design of the system and or sub-system together with any response required by on-board or ground action.

Structure

Process ID : 1 to 20 and 25 to 50 (optional for 51 to 116)
Packet Cat. : 7 (Event)
Type : 5
Subtype : 4
Source Data : See below

EID	Parameters
Enumerated	Any
2 Octets	Variable

Parameters Meaning

EID : Event ID identifies uniquely the event within the whole spacecraft system. The EID value will be assigned by the project authority.

Parameters : This field provides complementary information about the event. The structure of this field is uniquely identified by PID, Category, Subtype and EID.

Parameters Values/Range

EID : Values >60000, are reserved for ground.

Parameters : As defined in MESDB for each packet.

Remarks

Telecommand (5,5) Read Critical Events Log.

Function/Description

The contents of the critical events log is put into telemetry via VC0 as separate event telemetry packets in chronological order.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 5
Subtype	: 5
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (5,7) Clean Critical Events Log.

Function/Description

The Critical events log is cleaned e.g. the store is written with zeros.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 5
Subtype	: 7
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N.A

Verification/Effect on Telemetry

TBW.

Remarks

A2.6 Service 6 Memory Management

Objective

To allow a standard way to Load, Dump and Check on-board memory of a unit.

Description

The service supports scatter load and dump as well as block load and dump. In order to avoid having to dump an area of memory after a load the service provides a check function this will check sum an area and downlink the result in the corresponding report TM packet. Scattered loading of selected non-contiguous locations by means of a single TC will be possible.

This service allows on-board memory to be loaded or patched from ground and also to be dumped to ground, it does not control the readout of stores or files from the SSMM this is done by service 13&15.
Only one method of addressing the memory is supported:-

- Absolute address. This allows the user to specify a real address start loading or dumping from.

An additional sub service is to allow the ground to ask the on-board to run a memory check on a part of memory, again only one type of addressing is supported.

Telecommand (6,2) Load Memory Using Absolute Addresses.

Function/Description

This telecommand allows the ground to load data or code within the RAM or EEPROM memory..

Structure

Process ID : 1 to 50 (optional for 51 to 116)
Packet Cat. : 12 (Private)
Type : 6
Subtype : 2
Application Data : See below

Memory ID	N	Start Address	Length of block	Data
Enumerated	Unsigned integer	Unsigned integer	Unsigned integer	Variable 2 octet string
1 Octet	1 Octet	4 Octets	2 Octets	Variable in 2 Octets

< ---------- Repeated N Times ---------- >

Parameters Meaning

Memory ID : identifies the destination memory

N : number of blocks to be loaded. This field is systematically present, even in case it is equal to 1 and there is only one block

Start address : defines the address, of the first word to be loaded. The other words will be loaded consecutively from this first address.

Length of the block : number of 48, 40, 32, or 16 bits words to be loaded (dependant of the memory width of the memory type). This information allows in particular to define the end of the block to be loaded, and to find the header of the next block to be loaded.

EEPROM patch data have to be embedded in pseudo-TM packets, such that they can later (at boot-up) be loaded into RAM via the established Firmware protocol. This format is described in the Private Firmware Services (section TBD).

Data : data to be loaded within the block from the defined start address

Parameters Values/Range

Memory ID (enumerated) : For the DMS and the AOCMS software, and the Firmware

Memory ID	*Memory type*	*Memory size and width*		
$1_{decimal}$:	Processor RAM memory	1024k	*	16 bits
$2_{decimal}$:	Processor EEPROM memory	512k	*	16 bits
$3_{decimal}$:	Nominal SGM RAM memory	64k	*	16 bits
$4_{decimal}$:	redundant SGM RAM memory	64k	*	16 bits
$5_{decimal}$:	nominal SGM EEPROM memory	64k	*	16 bits
$6_{decimal}$:	redundant SGM EEPROM memory	64k	*	16 bits
$7_{decimal}$: *	nominal CDMU PROM	512k	*	16 bits
$8_{decimal}$: *	redundant CDMU PROM	512k	*	16 bits
$9_{decimal}$: *	Firmware PROM	32k		16 bits

For the STR

Memory ID	*Memory type*	*Memory size and width*		
21_{decima} :	DSP MCM program RAM memory	128k	*	48 bits
$22_{decimal}$:	DSP MCM data RAM memory	128k	*	32 bits
$23_{decimal}$: *	DSP PROM	8k	*	48 bits
$24_{decimal}$:	EEPROM memory	256k (TBC)	*	32bits

For the SSMM (TBC)

Memory ID	*Memory type*	*Memory size and width*		
31_{decima} :	Computer MCM program memory	TBD	*	TBD
$32_{decimal}$:	Computer MCM data memory	TBD	*	TBD
$33_{decimal}$:*	Computer PROM	TBD	*	TBD
$34_{decimal}$:	Computer EEPROM	TBD	*	TBD
$35_{decimal}$:*	Mass Memory Bank 1	4 Gbit	*	32 bits
$36_{decimal}$:*	Mass Memory Bank 2	4 Gbit	*	32 bits
$37_{decimal}$:*	Mass Memory Bank 3	4 Gbit	*	32 bits
$38_{decimal}$:*	Spare		*	
$39_{decimal}$:	Computer data memory	TBD	*	TBD

For the Payloads

Memory ID	*Memory type*	*Memory size and width*
TBD.	**TBD.**	**TBD.**

From 40 to 255 : Additional memory IDs as required by specific units

(*) Reserved for Subtype 5.

N : unsigned integer from 1 to 29, depending of the memory word width.

In case the PID of the telecommand is a PM Firmware in service mode, the number of block N is limited to 1.

Start address : on two words. It is an unsigned parameter which represent the first address, to be loaded.

Length of the block : unsigned integer

Note : the EEPROM is organised in Address Block of 128 words each (of 16 bits). When loading in the (SGM or PM) EEPROM, the ground shall only send blocks that fits in one Address Block of the maximum size of 128 words

Data : structure according to the memory width defined as follows :

For 16 bits memory width :

Data word
2 octets

For 32 bits memory width :

Most Significant Word	Least Significant Word
2 octets	2 octets

For 40 bits memory width :

Not Used	Most Significant Byte	Middle Data Word	Least Significant Word
1 octet	1 octet	2 octets	2 octets

For 48 bits memory width :

Most Significant Word	Middle Data Word	Least Significant Word
2 octets	2 octets	2 octets

Verification/Effect on Telemetry

TBW.

Remarks

In case the PID of the telecommand is a PM Firmware in service mode, the number of block N is limited to 1.

In case the PID is DMS or AOCMS Software the number of blocks N is limited to 5.

Telecommand (6,5) Dump Memory Using Absolute Addresses.

Function/Description

This telecommand allows the ground to request a dump from PROM, RAM or EEPROM memory**.**

Structure

Process ID : 1 to 50 (optional for 51 to 116)
Packet Cat. : 12 (Private)
Type : 6
Subtype : 5
Application Data : See below

Memory ID	N	Start Address	Length
Fixed string	Unsigned Integer	Unsigned Integer	Unsigned Integer
1 Octet	1 Octet	4 Octets	2 Octets

< ---------- Repeated N Times ---------- >

Parameters Meaning

Memory ID **:** identifies the memory to be dumped

N **:** number of blocks to be dumped. This field is systematically present, even in case it is equal to 1 and there is only one block

Start address **:** defines the address of the first word to be dumped. The other words will be dumped consecutively from this first address.

Length of the block **:** number of 48,40,32 or 16 bits words to be dumped.

Parameters Values/Range

See Sub type 2

Verification/Effect on Telemetry

TBW.

Remarks

In case the PID of the telecommand is a PM Firmware in service mode, the number of block is limited to 1.

The length of the area to be dumped is not limited by the size of the maximum TM packet size. The DMS SW will generate, as a result of the TC (6,5), as many TM dump packets (6,6) as required to cover the entire commanded dump area.

In case the PID is DMS or AOCMS Software the number of blocks N is limited to 5.

Telemetry (6,6) Memory Dump Using Absolute Addresses Report.

Function/Description

This is the response in the telemetry from a TC Sub Type 5.

Structure

Process ID : 1 to 50 (optional for 51 to 116)
Packet Cat. : 9 (Dump)
Type : 6
Subtype : 6
Source Data : See below

Memory ID	N	Start Address	Length of dump block	Data
Enumerated	Unsigned Integer	Unsigned Integer	Unsigned integer	Variable 2 Octet string
1 Octets	1 Octet	4 Octets	2 Octets	Variable

<---------- repeated N times ---------- >

Parameters Meaning

Memory ID : identifies the destination memory

N : number of blocks to be dumped. This field is systematically present, even in case it is equal to 1 and there is only one block

Start address : defines the address, of the first word dumped. The other words are dumped consecutively from this first address.

Length of the block : number of 48, 40, 32, or 16 bits words dumped (dependant of the memory width of the memory type). This information allows in particular to define the end of the block dumped, and to find the header of the next block dumped.

Data : data dumped within the block from the defined start address

Parameters Values/Range

See Subtype 2.

Remarks

There are no constraints imposed on how to break-down the dump area into TM dump packets.

Telecommand (6,9) Check Memory Using Absolute Addresses.

Function/Description

This telecommand allows the ground to request a checksum of one or more areas of PROM, or RAM, or EEPROM memory.

Structure

Process ID : 1 to 50 (optional for 51 to 116)
Packet Cat. : 12 (Private)
Type : 6
Subtype : 9
Application Data : See below

Memory ID	N	Start Address	Length
Enumerated	Unsigned Integer	Unsigned Integer	Unsigned Integer
1 Octet	1 Octet	4 Octets	2 Octets

<---- Repeated N Times ---->

Parameters Meaning

Memory ID : identifies the destination memory

N : number of blocks to be checked. This field is systematically present, even in case it is equal to 1 and there is only one block

Start address : defines the address, of the first word to be checked. The other words will be checked consecutively from this first address.

Length of the block : number of 48, 40, 32, or 16 bits words to be checked (dependant of the memory width of the memory type

Parameters Values/Range

See Subtype 2.

Verification/Effect on Telemetry

TBW.

Remarks

In case the PID of the telecommand is a PM Firmware in service mode, the number of block is limited to 1.

In case the PID is DMS or AOCMS Software the number of blocks N is limited to 5.

Telemetry (6,10) Memory Check Using Absolute Addresses Report.

Function/Description

This is the response in the telemetry from a TC Sub Type 9.

Structure

Process ID : : 1 to 50 (optional for 51 to 116)
Packet Cat. : 7 (Event)
Type : 6
Subtype : 10
Source Data : See below

Memory ID	N	Start Address	Length	Checksum
Enumerated	Unsigned Integer	Unsigned Integer	Unsigned Integer	Fixed Bit String (16 bits)
1 Octet	1 Octet	4 Octets	2 Octets	2 to 6 octets

< ---------- Repeated N Times ---------- >

Parameters Meaning

Memory ID : identifies the destination memory

N : number of blocks to be checked. This field is systematically present, even in case it is equal to 1 and there is only one block

Start address : defines the address, of the first word to be checked. The other words will be checked consecutively from this first address.

Length of the block : number of 48, 40, 32, or 16 bits words checked (dependant of the memory width of the memory type). This information allows in particular to define the end of the block, and to find the header of the next block.

Checksum : Result of any checksum algorithm applied to the selected memory area.

Parameters Values/Range

Memory ID	**:**	see subtype 2.
N	**:**	see subtype 2.
Start address	**:**	see subtype 2.
Length of the block	**:**	see subtype 2.
Checksum	**:**	Any value.

Remarks

Checksum algorithms allocation:

Memory ID 1 to 9	(Firmware, DMS, AOCS) - XOR Rotate(see appendix 4).
Memory ID 21 to 24	(STR) -ISO Checksum (cf. PUS ref.5 appendix A3)
Memory ID 31 to 39	(SSMM) - CRC(see appendix 4).
Memory ID 192 to 255	(Payload) - CRC or XOR Rotate (plus others TBD on approval) (see appendix 4).

Checksum field size is dependent on the checksum algorithm and defined by the Memory ID .

A2.7 Service 7 OBCP Management

Objective

Many of the autonomous and automatic functions required on-board will be implemented as On-Board Control Procedures using a simple Spacecraft Control Language. This service controls the execution of these OBCPs

Description

A number of OBCPs may be executed in parallel, in order to maintain timing relationship between OBCPs and allow predictability in execution a single instruction from each OBCP is executed in a cyclic manner with waits for empty slots. OBCPs used for error recovery can be executed in a special slot that allows execution even when all normal slots are busy.
Apart from the normal functions of Start, Stop, Suspend and Resume other functions of the service allow communication with a running OBCP as well report available OBCPs. One other function of the service is to edit an existing OBCP. The objective of this function is to reduce the uplink time if an OBCP has to be changed.
No facility is provided in this service to load a new OBCP. This is handled by service 13, the general file transfer service.

On Board Control Procedures are implemented using a simple language that is interpreted on-board by the DMS software. These OBCPs are used to:-

- perform standard operational actions normally performed by ground in a step by step way, however this can not be done for MARS EXPRESS because of the long delay between tele-command transmission and telemetry reception.
- perform autonomous actions on-board to recover from faults detected that can not wait for ground action.

In order that recovery OBCPs are not held up due to normal ops OBCPs occupying all available resources of the interpreter, a number of recovery slots (10 TBC) are kept available.
Service 7 manages the starting, suspending and stopping of OBCPs from ground.

Telecommand (7,1) Start OBCP.

Function/Description

To load the selected OBCP into a free execution slot and to start execution.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 7
Subtype : 1
Application Data : See below

OBCP Name	Pad	Priority	Offset	Length	Parameters
Enumerated		Enumerated	Unsigned integer	Unsigned integer	Variable
2 Octets	1 Octet	1 Octet	2 Octets	2 Octets	Variable 2 Octet string

Parameters Meaning

OBCP Name : Defines the name of the concerned OBCP. The name of an OBCP is identical to the name of the SSMM file which contains it (if any).

Priority : Defines the priority of the concerned OBCP

Offset : This defines the position of the first parameter to be loaded within a complete parameters table associated to the OBCP within the on-board software.

Length : This defines the length in 16 bits words of the parameters to be loaded.

Parameters : Is the value of the consecutive parameters to be used as input by this OBCP.

Parameters Values/Range

OBCP Name: : TBW

Priority : 0 = Normal
1 = Emergency

Offset: : TBW

Length: : TBW

Parameters: : TBW

Verification/Effect on Telemetry

TBW.

Remarks

The OBCP is loaded from the SSMM and executed.

If the OBCP is not found in SSMM, it is searched for in RAM. If the OBCP is not found in SSMM nor RAM, the command is rejected with generation of an execution failure report TM packet (1,8).

The start of the OBCP will be reported by a normal progress event packet.

If the OBCP interpreter has a free slot the OBCP is started otherwise the request is rejected and a warning event packet is generated.

If the OBCP is already running then the request is rejected and a warning event packet is generated.

Telecommand (7,2) Stop OBCP.

Function/Description

Normally OBCPs will run to completion. The OBCP is stopped at its next execution cycle and removed from the list of active OBCPs regardless of whether it is active or suspended.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 7
Subtype : 2
Application Data : See below

OBCP Name
Enumerated
2 Octets

Parameters Meaning

OBCP Name **:** Defines the name of the concerned OBCP. The name of an OBCP is identical to the name of the SSMM file which contains it (if any).

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (7,3) Suspend OBCP.

Function/Description

The OBCP execution will be suspended at the start of its next cycle.
The request will be rejected unless the OBCP is in an active state.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 7
Subtype : 3
Application Data : See below

OBCP Name
Enumerated
2 Octets

Parameters Meaning

OBCP Name **:** Defines the name of the concerned OBCP. The name of an OBCP is identical to the name of the SSMM file which contains it (if any).

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (7,4) Resume OBCP.

Function/Description

The OBCP will start from the suspend point at the start of its next cycle.
The request will be rejected unless the OBCP is in a suspended state.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 7
Subtype : 4
Application Data : See below

OBCP Name
Enumerated
2 Octets

Parameters Meaning

OBCP Name **:** Defines the name of the concerned OBCP. The name of an OBCP is identical to the name of the SSMM file which contains it (if any).

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (7,6) Communicate Parameters to an OBCP.

Function/Description

This telecommand allows to modify the parameters used by an OBCP.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 7
Subtype : 6
Application Data : See below

OBCP Name	Offset	Length	Parameters
Enumerated	Unsigned integer	Unsigned integer	Variable
2 octets	2 Octets	2 Octets	Variable 2 Octet string

Parameters Meaning

OBCP Name : Defines the name of the concerned OBCP. The name of an OBCP is identical to the name of the SSMM file which contains it (if any).

Offset : This defines the position of the first parameter to be loaded within a complete parameters table associated to the OBCP within the on-board software.

Length : This defines the length in 16 bits words of the parameter to be loaded.

Parameters : Is the value of the consecutive parameters to be used as input by this OBCP.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (7,10) Report List of OBCPs.

Function/Description

The request generates a telemetry packet sub type 11 containing the names and checksums of all OBCPs contained in RAM of the addressed processor.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 7
Subtype	: 10
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Note: In order to downlink the list of OBCPs contained in the SSMM, the private SSMM command "List Files" shall be used (SSMM file name is identical to the OBCP name).

Telemetry (7,11) OBCPs List Report.

Function/Description

The list of OBCPs stored on board in the addressed processor's memory.

Structure

Process ID : 1 to 10
Packet Cat. : 3 (Table)
Type : 7
Subtype : 11
Source Data : See below

PAD	N	OBCP Name	OBCP Checksum
Unsigned Integer	Unsigned Integer	Unsigned Integer	Unsigned Integer
1 octet	1 octet	2 Octets	2 Octets

< ---------- Repeated N Times ---------- >

Parameters Meaning

N : **TBW.**

OBCP Name : Defines the name of the concerned OBCP. The name of an OBCP is identical to the name of the SSMM file which contains it (if any).

OBCP checksum : The checksum is calculated on ground by the OBCP pre-compiler and uplinked together with the OBCP code.

Parameters Values/Range

TBW.

Remarks

A2.8 Service 8 Application Programs Management

Objective

Tasks that can not be implemented by OBCPs will be implemented by application programs written in the selected high level language e.g. the DMS software or AOCS, for these the standard MARS EXPRESS software requirements apply.

Description

The standard controls are used: Start, Stop, and Communicate with a running application program. All application programmes can be protected such that if the processor has a switch over to another processor or a reboot the application program will continue execution from its current execution point using the same data as the original.

Service 8 allows the user to start, stop, these programs, the loading of new ones will be handled with service 6.

Telecommand (8,1) Start Application Program.

Function/Description

TBW.

Structure

Process ID : 1 to 20
Packet Cat. : 12 (Private)
Type : 8
Subtype : 1
Application Data : See below

Name of Application Program	Offset	Length	Parameters
Enumerated	Unsigned Integer	Unsigned Integer	Enumerated
2 Octets	2 Octets	2 Octets	Variable Octet String

Parameters Meaning

TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (8,2) Stop Application Program.

Function/Description

TBW.

Structure

Process ID : 1 to 20
Packet Cat. : 12 (Private)
Type : 8
Subtype : 2
Application Data : See below

Name of Application Program
Enumerated
2 Octets

Parameters Meaning

TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (8,6) Communicate with an Application Program.

Function/Description

This sub type provides the service of passing parameters to a running application program

Structure

Process ID : 1 to 20
Packet Cat. : 12 (Private)
Type : 8
Subtype : 6
Application Data : See below

Name of Application Program	Offset	Length	Parameters
Enumerated	Unsigned Integer	Unsigned Integer	Enumerated
2 Octets	2 Octets	2 Octets	Variable Octet String

Parameters Meaning

TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

A2.9 Service 9 Time Synchronisation

Objective

This service handles the spacecraft time distribution on-board

Description

A DMS software application will manage time distribution on a regular basis to all powered packet based units, in addition an OBCP or another DMS software on-board process can request the application to send a time update to a user.

Service 9 is used to synchronise the on-board time between the DMS and other packet based users on-board. A command packet does this to the relevant user containing the on-board time of the next time broadcast pulse.
In addition the ground or an on-board application/OBCP can by command cause the DMS software to send a time update command to nominated users.

Telecommand (9,1) Accept Time Update.

Function/Description

On reception of TC (9,2) the DMS software will gate the time of each Time Broadcast Pulse (TBP), read out the time add the offset between TBPs and send this via this command to the user. Time synchronisation will take place as part of the turn on procedure for packet based users and on period base to packet based users that are currently powered.

Under normal circumstances the ground will never issue this command only the DMS software will.

Structure

Process ID : 1 to 10 and 25 to 116
Packet Cat. : 12 (Private)
Type : 9
Subtype : 1
Application Data : See below

Onboard Time at next TBP
CUC Time
6 Octets

Parameters Meaning

Onboard Time at next TBP : On-board time at next Time Broadcast Pulse.

Parameters Values/Range

Onboard Time at next TBP : CUC Time (see T field definition in appendix 7)

Verification/Effect on Telemetry

TBW.

Remarks

Note that this TC is not applicable to AOCMS. Time synch for AOCMS in ensured by direct access to the master SCET counter information.

Telecommand (9,2) Send Time to User.

Function/Description

This command instructs DMS to start the time synchronisation procedure with the addressed user by sending a TC (9,1).

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 9
Subtype : 2
Application Data : See below

Update Period	Not Used	PID
Unsigned Integer		Enumerated
2 Octets	9 bits	7 bits

Parameters Meaning

Update Period : Is the number of 8 second TBPs between time updates to the user.

PID : This field identifies the addressed user. It shall be copied into the Process ID field of the TC (9,1) to be sent to the user.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (9,3) Stop Time Update to User.

Function/Description

This command stops the time synchronisation procedure started with TC(9,2).

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 9
Subtype : 3
Application Data : See below

Not Used	PID
	Enumerated
9 bits	7 bits

Parameters Meaning

PID **:** Identifies the user as defined in sub type 2.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

A2.10 Service 10 Time Reference Management

Objective

To allow the on-board time to be reported to the ground time management system.

Description

The on-board time is sent at a regular rate to the ground in Virtual Channel 0, the time is gated with a fixed position of the VC0. The rate can be changed by command in order to match the down link bit rate.
An additional function many used during system level AIV is to change the on-board time, this is to allow the time stamping of telemetry packets with a real time of day.

- Control the frequency that time report packets are inserted in Virtual Channel 0 on the downlink.
- Update the On-Board time from ground

Telecommand (10,1) Change Time Report Packet Generation Rate.

Function/Description

The time report packet is generated by DMS at a sub frequency of the Virtual Channel generation frequency. Due to the operations concept for MARS EXPRESS the time packet generation rate may also be the VC0 rate.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 10
Subtype : 1
Application Data : See below

	S-Field	
PAD	**Not Used**	**Time Report Generation Frequency**
Unsigned Integer	Unsigned Integer	Unsigned integer
1 Octet	4 Bits	4 Bits

Parameters Meaning

Time Report Generation Frequency : specifies the desired frequency of generation of the Time Report packet in telemetry.

Parameters Values/Range

Time Report Generation Frequency : Generation Rate

bits 4,5,6,7 = 0000 : rate = not used

bits 4,5,6,7 = 0001 : rate = not used

bits 4,5,6,7 = 0010 : rate = not used

bits 4,5,6,7 = 0011 : rate = not used

bits 4,5,6,7 = 0100 : rate = 16 frames (time source packet at 1 frame on 16)

bits 4,5,6,7 = 0101 : rate = 32 frames (time source packet at 1 frame on 32)

bits 4,5,6,7 = 0110 : rate = 64 frames (time source packet at 1 frame on 64)

bits 4,5,6,7 = 0111 : rate = 128 frames (time source packet at 1 frame on 128)

bits 4,5,6,7 = 1000 : rate = 256 frames (time sourcepacket at 1 frame on 256)

Generation rate at the value 0000 (rate = 1: time source packet at all frames) should not be used, since in this case the time source packet should represent the time of the first bit of the transfer frame of VC0 containing that time source packet, whereas this time is taken only when this frame is sending, so already elaborated and complete. In consequence, the consecutive time source packet can not be introduce within the same frame, and will be always delayed by one frame (that would not be correct relatively to the datation).

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (10,2) Time Report.

Function/Description

The time report will contain the onboard time at the generation time of a significant bit of the channels sync paten. See appendix 7 for a full definition of this packet.

The time report packet is placed in the next Virtual Channel 0 according to the commanded frequency.

Structure

Process ID : 0
Packet Cat. : 0 (Time)
Type :
Subtype : } **None (no Data Field Header)**
Source Data : See below

S-Field		P -Field	T -Field
PAD	**Generation Rate**	**P-Field**	**Onboard Time**
	Unsigned Integer	Unsigned Integer	CUC Time
4 Bits	4 Bits	1 Octet	6 Octets

Parameters Meaning

Generation Rate : See Sub Type 1
P-field : Preamble field : this field defines the spacecraft time format
Onboard Time : OBT as defined in Appendix 7

Parameters Values/Range

Generation Rate : See Sub Type 1
P-field : This field has a fixed value of 00101110_{BIN}
Onboard Time : See Appendix 7

Remarks

Note: The time packet is defined as service 10 sub type 2 in this ICD, however the standard time packet shall not have a data field header and the Data Field Header Flag shall be set to zero.

Telecommand (10,3) Change On-board Time.

Function/Description

The on-board time (whole seconds part) is changed at the next TBP (Time Broadcast Pulse), the fractional part of the on-board time is not affected. It also starts a cycle of time updates to all packet-based users that are enabled for time update.

Structure

Process ID : 1
Packet Cat. : 12 (Private)
Type : 10
Subtype : 3
Application Data : See below

SCET shift
Relative CUC Time in seconds
4 Octets

Parameters Meaning

SCET shift **:** The SCET shift is added to the current SCET, this enables the SCET to be changed both forward and backward.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

This command is normally used on ground only (during AIV test).Any impact of using it in orbit is under ground responsibility. So no consistency with the MTL (or other time stamped information) is to be considered for the on-board software development.

A2.11 Service 11 Mission Timeline Management

Objective

To allow the ground to maintain the mission timeline or an on-board recovery procedure to recover the timeline after a failure.

Description

The timeline is a list of commands in time order, the commands are executed when their time matches the on-board time. In order to allow only valid commands to be executed depending on the current on-board status and not the status when the commands were uplinked, commands can be assigned to sub-schedules that can be inhibited or enabled. The functions include the normal maintenance functions Add, Delete, Clear and Report content, the DMS shall maintain the list so that even during maintenance the list is active such that commands can be executed at the correct time.
An additional function is to allow the commands to be time shifted, e.g. all or selected blocks can have their time modified by an offset.

This service provides the capability to command onboard units using telecommands pre-loaded onboard the spacecraft and released at their due time. To achieve this, the Service maintains an onboard command schedule called the Mission Time Line (MTL) and ensures the timely execution of telecommands contained therein.

The Service maintains a command schedule, which contains telecommand packets, and they're associated scheduling information. In order to reduce both the on-board and ground complexity in managing the MTL for MARS EXPRESS only a sub set of the PUS defined capabilities is required, this sub set is detailed here.

The Service User(s) can request the following activities:

- Enable the scheduling of all, or a subset of, the telecommands in the Command Schedule (e.g. belonging to a sub schedule ID)
- Disable the scheduling of all, or a subset of, the telecommands in the Command Schedule;
- Add telecommands to the Command Schedule;
- Delete all, or a subset of, the telecommands in the Command Schedule (e.g. the telecommands becoming due for release within a specified time period, etc.);
- Time shift all, or a subset of, the telecommands in the Command Schedule;
- Report on all, or a subset of, the telecommands in the Command Schedule.

It shall not be possible for inconsistencies to exist as a direct result of the processing of a Service User request. Thus, the Onboard Scheduling Service will refuse to perform a request in its entirety if this would create an inconsistency in the Command Schedule. The Service User(s) is (are) responsible for ensuring that inconsistencies which can only be detected during the scheduling activity will never occur.

The Onboard Scheduling Service maintains a Command Schedule consisting of telecommand packets together with their scheduling attributes. The scheduling attributes of a telecommand indicate:

- The execution time;
- The sub-schedule ID with which the telecommand is associated;

Execution time
All times contained in the MTL for MARS EXPRESS are absolute time relating to the spacecraft time and are specified to a seconds resolution. The scheduling of an event relative to the spacecraft time (elapsed time after a specific spacecraft time) for MARS EXPRESS is handled by an OBCP started by a MTL command.

Sub-schedule ID
Specifies a unit or command group that the command is associated with. This enables commands to specific user or group to be enabled or disabled without stopping the whole MTL, this means that when a command time is reached if its Sub-schedule ID is disabled it will not be executed. In addition commands can be enabled or disabled by reference to the command Application process ID.

There are two ways of enabling or disabling the release of a subset of the telecommands in the MTL. The subsets are specified according to selection criteria (e.g. those telecommands with specified destination Application Processes).

Telecommand (11,1) Enable Release of Selected TeleCommand.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 11
Subtype : 1
Application Data : See below

PAD	Sub-schedule ID	PAD	Application Process ID
	Enumerated		Enumerated
1 Octet	1 Octet	5 Bits	11 Bits

Parameters Meaning

Sub-schedule ID : The identification of the sub-schedule(s) to be enabled.

Application Process ID : The identification of the destination Application Process IDs to be enabled.

Parameters Values/Range

When the Service Provider receives this request, then:

if **sub-schedule ID** and **application process ID** is zero : the command is applicable to the whole MTL.

if **sub-schedule ID** = zero and **application process ID** is > zero : the command is applicable to the application process

if **sub-schedule ID** > zero and **application process ID** is = zero : the command is applicable to the schedule ID

if **sub-schedule ID** > zero and **application process ID** is > zero : the command is rejected

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (11,2) Disable Release of Selected Telecommands.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 11
Subtype : 2
Application Data : See below

PAD	Sub-schedule ID	PAD	Application Process ID
	Enumerated		Enumerated
1 Octet	1 Octet	5 Bits	11 Bits

Parameters Meaning

Sub-schedule ID : The identification of the sub-schedule(s) to be disabled.

Application Process ID : The identification of the destination Application Process IDs to be disabled.

Parameters Values/Range

See Subtype 1.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (11,3) Reset Command Schedule.

Function/Description

When the Service Provider receives this request it clears all entries in the Command Schedule. The Command Schedule is disabled by this way: all sub-schedules ID are disabled and all Application Processes ID are enabled; The actions performed should be the same as at boot up so the status of the MTL is the same in both cases.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 11
Subtype	: 3
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (11,4) Insert Telecommands in Command Schedule.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 11
Subtype : 4
Application Data : See below

Execution Time	PAD	Sub-schedule ID	Telecommand packet
CUC Time		Unsigned integer	
4 Octets	1 Octet	1 Octet	Variable Octet String

Parameters Meaning

Execution time : Specifies the SCET for execution of the command.

Sub-schedule ID : The sub-schedule ID with which the following telecommand is associated. The sub-schedule ID cannot take the value 0.

Telecommand Packet : This is a standard telecommand packet of any Service type and sub-type. It should be noted that this can be a telecommand destined for an onboard scheduling Service, either this one or a Service implemented in another Application Process, e.g. a request to enable or disable sub-schedules ID within the Command Schedule

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (11,5) Delete Telecommands by Application Process ID and Sequence Counter.

Function/Description

When this request is received, all telecommands, which satisfy the selection criteria defined by the Application Process ID, Sequence Count and the Number of Telecommands, are deleted. An error occurs if the first telecommand to be deleted is not found in the Command Schedule.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 11
Subtype : 5
Application Data : See below

PAD	Application Process ID	PAD	Sequence Count	PAD	Number of commands
	Enumerated		Unsigned integer		Unsigned integer
5 Bits	11 Bits	2 Bits	14 Bits	1 Octet	1 Octet

Parameters Meaning

Application Process ID : Relates to an application process ID of a command stored in the mission time line

Sequence count : The sequence count is the one contained within the command stored in the MTL, it specifies the start sequence count related to the Application Process ID where the deletion is to start.

Number of commands : Specifies the number of commands with the same application process ID starting from the sequence counter to delete. If the actual number of commands contained in the mission time line are less than the number specified the existing commands are deleted.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

The doublet (Application Process ID, Sequence Count) uniquely identifies a telecommand packet. These parameters correspond to the packet header fields of each telecommand packet.

If an error is detected during the processing of a request, nothing is deleted.

Telecommand (11,6) Delete Telecommands over Time Period.

Function/Description

When this request is received the telecommands are deleted when they fit the specified criteria

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 11
Subtype : 6
Application Data : See below

PAD	Range	Time tag 1	Time tag 2	PAD	Sub-schedule ID	PAD	Application Process ID
	Enumerated	CUC Time	CUC Time		Enumerated		Enumerated
14 Bits	2 Bits	4 Octets	4 Octets	1 Octet	1 Octet	5 Bits	11 Bits

Parameters Meaning

Range : Indicates the type of time range delimited by Time Tag 1 and Time Tag 2.

Depending on value of range the time tag fields are used or not.

Time Tag 1 : The earliest absolute time if Range is "Between" or "After". The latest absolute time if Range is "Before".

Time Tag 2 : The latest absolute time if Range is "Between". This parameter is present but not used if Range is not "Between".

Sub-schedule ID : The identification of the sub-schedule(s) to be addressed.

Application Process ID : The identification of the destination Application Process IDs to be addressed.

Parameters Values/Range

Range : 0 = "All" : range is from the beginning to the end of the Command schedule.

1 = "Between" : range is between Time Tag 1 and Time Tag 2 inclusive.

2 = "Before" : range is less than or equal to Time Tag 1.

3 = "After" : range is greater than or equal to Time Tag 1.

Time Tag 1 **:** N/A.

Time Tag 2 **:** N/A.

Sub-schedule ID & Application Process ID :

if **sub-schedule ID** and **application process ID** is zero	:	the command is applicable to all commands within the time range.
if **sub-schedule ID** = zero and **application process ID** is > zero	:	the command is applicable to the application process within the time range
if **sub-schedule ID** > zero and **application process ID** is = zero	:	the command is applicable to the schedule ID within the time range
if **sub-schedule ID** > zero and **application process ID** is > zero	:	the command is rejected

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (11,8) Time-Shift Telecommands over Time Period.

Function/Description

The time-shift request contains the time offset to be added (which may be a positive or negative value) and specifies the group of telecommands to which this time-offset is to be applied.

When this request is received the release times in the Command Schedule are modified (by adding the specified time offset) for those telecommands which meet the selection criteria defined by the specified Application Process ID. The modified commands are re-sorted within the mission time line to maintain time order.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 11
Subtype : 8
Application Data : See below

PAD	Range	Time tag 1	Time tag 2	Time Offset	PAD	Sub-schedule ID	PAD	Application Process ID
	Enumerated	CUC Time	CUC Time	CUC Time*		Enumerated		Enumerated
14 Bits	2 Bits	4 Octets	4 Octets	4 Octets	1 Octet	1 Octet	5 Bits	11 Bits

(*) : see Appendix 6 section A6.3.7 - Relative time in seconds

Parameters Meaning

Range : Indicates the type of time range delimited by Time Tag 1 and Time Tag 2.

Depending on value of range the time tag fields are used or not.

Time Tag 1 : The earliest absolute time if Range is "Between" or "After". The latest absolute time if Range is "Before".

Time Tag 2 : The latest absolute time if Range is "Between". This parameter is present but not used if Range is not "Between".

Time Offset : A positive or negative interval of time expressed in the length and format of relative time defined for the Service or mission (since it is the relative time between the new and the old values of release time).

Sub-schedule ID : The identification of the sub-schedule(s) to be addressed.

Application Process ID : The identification of the destination Application Process IDs to be addressed.

Parameters Values/Range

Range **:** 0 = "All" : range is from the beginning to the end of the Command schedule.

1 = "Between" : range is between Time Tag 1 and Time Tag 2 inclusive.

2 = "Before" : range is less than or equal to Time Tag 1.

3 = "After" : range is greater than or equal to Time Tag 1.

Time Tag 1 **:** N/A.

Time Tag 2 **:** N/A.

Sub-schedule ID & Application Process ID :

if **sub-schedule ID** and **application process ID** is zero	:	the command is applicable to all commands within the time range.
if **sub-schedule ID** = zero and **application process ID** is > zero	:	the command is applicable to the application process within the time range
if **sub-schedule ID** > zero and **application process ID** is = zero	:	the command is applicable to the schedule ID within the time range
if **sub-schedule ID** > zero and **application process ID** is > zero	:	the command is rejected

Verification/Effect on Telemetry

TBW.

Remarks

The Scheduling Service will refuse to time-shift a telecommand if its new absolute time would falls in the past.

An error occurs if the first telecommand to be time-shifted is not found or if the new time of the commands has already expired.
If an error is detected during the processing of a request, nothing is time-shifted.

Telecommand (11,9) Report Command Schedule in Detailed Form over Time Period.

Function/Description

When this request is received, a Report is generated containing those telecommands in the Command Schedule which meet the selection criteria defined.

The Report contains all information relating to the commands to be reported on, together with a list of schedule IDs and Application process ID enabled

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 11
Subtype : 9
Application Data : See below

PAD	Range	Time tag 1	Time tag 2
	Enumerated	CUC Time	CUC Time
14 Bits	2 Bits	4 Octets	4 Octets

Parameters Meaning

Range : Indicates the type of time range delimited by Time Tag 1 and Time Tag 2.

Depending on value of range the time tag fields are used or not.

Time Tag 1 : The earliest absolute time if Range is "Between" or "After". The latest absolute time if Range is "Before".

Time Tag 2 : The latest absolute time if Range is "Between". This parameter is present but not used if Range is not "Between".

Parameters Values/Range

Range : 0 = "All" : range is from the beginning to the end of the Command schedule.

1 = "Between" : range is between Time Tag 1 and Time Tag 2 inclusive.

2 = "Before" : range is less than or equal to Time Tag 1.

3 = "After" : range is greater than or equal to Time Tag 1.

Time Tag 1 **:** N/A.

Time Tag 2 **:** N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (11,10) Detailed Schedule Report.

Function/Description

The report contains information on telecommands currently contained in the MTL. The information is ordered according to the times of telecommand release.

Only those telecommands are reported for which the time of release has not yet expired.

Structure

Process ID : 1 to 10
Packet Cat. : 3 (Table)
Type : 11
Subtype : 10
Source Data : See below

				Status Information				
PAD	**Sequence Flags**	**N**	**PAD**	**Sub-schedule ID status**	**AP-ID status**	**Schedule ID**	**Execution - Time**	**Command packet**
		Unsigned Integer		enume-rated	enumerated	Unsigned integer	CUC Time	Variable Octet String
1 Octet	2 Bits	6 Bits	6 Bits	1 bit	1 bit	1 Octet	4 Octets	Variable

< ---------- Repeated N Times ---------- >

Parameters Meaning

Sequence Flags : For schedules which do not fit in one telemetry packet, this field identifies the first, continuation or last telemetry packet related to the same schedule report.

N : Count of the number of whole MTL entries reported in this telemetry packet

Sub-schedule ID status : **TBW.**

AP-ID status : **TBW.**

Schedule ID : **TBW.**

Execution Time : **TBW.**

Command packet : **TBW.**

Parameters Values/Range

Sequence Flags	**:**	10 = fist packet of the report
		00 = continuation packet of the report
		01 = Last packet of the report
N	**:**	N/A.
Sub-schedule ID status	**:**	1= sub-schedule ID is enabled
		0= sub-schedule ID is disabled
AP-ID status	**:**	1= application process ID is enabled
		0= application process ID is disabled
Schedule ID	**:**	**TBW.**
Execution Time	**:**	N/A.
Command packet	**:**	N/A.

Remarks

Note that telecommands may be released between the reception of the Service Request and the completion of the Service Report. However, the report contains a consistent view, which reflects the situation at the report packet time.

A2.12 Service 12 On-board Monitoring

Objective

The service shall be able to monitor, report and take action on the telemetry acquired from other sources and its own telemetry.

Description

Two types of monitoring are foreseen: Parameter and Event.

1. Parameter allows a single parameter contained in the on-board data pool to be monitored against a limit set or an expected status value. When an error is repeated for a configurable number of consecutive times the monitor reports, via a specified event packet. To achieve this, the Service maintains a parameter monitoring list and checks parameters according to the information contained therein.

2. Event allows the monitor to check for an event packet and react with a specified action if it is received. To achieve this, the Service maintains a event monitoring list and checks parameters according to the information contained therein.

Telemetry source packets and telecommand packets relating to the Onboard Monitoring Service are denoted by Service Type = 12.

Parameter Monitoring

A Parameter Monitoring List is maintained which contains the parameter monitoring information, drives the parameter monitoring activity and the generation of event packets.

The ground segment can modify or report the contents of the Monitoring List using Service Requests to:

- reset the Monitoring List;
- add parameters to, or delete parameters from, the Monitoring List;
- modify the monitoring information of parameters in the Monitoring List;
- enable or disable the monitoring of parameters in the Monitoring List;
- report the monitoring information for all parameters in the Monitoring List;
- Allow the ground to also modify attributes of the Onboard Monitoring Service
- the maximum reporting delay for the Out-of-limit Report. An event packet should be issued with no greater delay than this after a new check transition has occurred.

The Onboard Monitoring Service maintains static monitoring information for each parameter to be monitored, which is provided by the ground by means of Service Requests. The parameter monitoring information specifies:

- the identification of the onboard parameter to be monitored;
- A parameter may be defined in the list more than once with a different limit set;
- whether the monitoring of the parameter is enabled or disabled;
- the limits to be used
- the command to be issued
- the monitoring interval for the parameter, expressed in units of <DIAG_MIN_INTERV>.
- a "filter". For a limit-check or an expected-value-check, this indicates the number of successive samples of the parameter which must fail (or succeed) the check in order to produce an event packet and any recovery action.

For a Limit-check, a low-limit value and a high-limit value are specified, both values specify the last accepted value before an error is declared. For an Expected-value-check, an expected value is specified as the same value in both low and high limits.

Event Monitoring

An Event Monitoring List is maintained which contains the event monitoring information, drives the event monitoring activity and the generation of recovery actions (tele-commands).

The ground segment can modify or report the contents of the Monitoring List using Service Requests to:

- reset the Monitoring List;
- add entries to, or delete entries from, the Monitoring List;
- modify the recovery information of entries in the Monitoring List;
- enable or disable the recovery action in the Monitoring List;
- report the information for all parameters in the Monitoring List;

The Monitoring List

The Onboard Monitoring Service maintains static monitoring information for each event to be monitored, which is provided by the ground by means of Service Requests. The event monitoring information specifies:

- the identification of the event to be monitored;
- The recovery action required;
- whether the recovery is enabled or disabled;

Telecommand (12,1) Enable Monitoring of Parameters.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 12
Subtype : 1
Application Data : See below

PAD	N	Monitoring ID
	Unsigned integer	Enumerated
1 Octet	1 Octet	2 Octets

<-- repeated N times -->

Parameters Meaning

N : Number of IDs contained in this command.

Monitoring ID : The entry in the monitoring table that should be enabled.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

An error report is generated if one of the IDs is not in the monitor table. However, the processing of the remaining IDs in the same command are not affected.

Telecommand (12,2) Disable Monitoring of Parameters.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 12
Subtype : 2
Application Data : See below

PAD	N	Monitoring ID
	Unsigned integer	Enumerated
1 Octet	1 Octet	2 Octets

<-- repeated N times ->

Parameters Meaning

N : Number of IDs contained in this command.

Monitoring ID : The entry in the monitoring table that should be disabled

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (12,4) Clear Parameter Monitoring List.

Function/Description

When the DMS receives this request, it clears all entries in the Monitoring list, no further monitoring is performed.

This command acts on the ground accessible monitoring list only.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 12
Subtype	: 4
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (12,5) Add/Modify Parameters to Monitoring List.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 12
Subtype : 5
Application Data : See below

Monitoring ID	Type	Frequency	State	PAD	Family ID
enumerated	enumerated	enumerated	enumerated		enumerated
2 Octets	2 Bits	2 Bits	1 Bit	3 Bits	1 Octet

Parameter ID	Filter	Min/Mask	Max/Expected value	Command definition
	Unsigned integer			
4 Octets	2 Octets	4 Octets	4 Octets	Variable

Each entry in the command is of variable length depending on the TC packet contained in the entry, only whole entries will be placed in the command.

Parameters Meaning

Monitoring ID : Identifier of the monitoring to be added/changed.

Type : defines the type of monitoring.

Frequency : defines the activation frequency of the monitoring

State : defines the initial state (enabled or disabled) of the added monitoring

Family : defines the family of the monitoring. In case of triggering of a monitoring, all the monitoring(s) belonging to the same family are temporarily disabled, until the end of the recovery action

Parameter ID : gives the location in the data pool of the first ***16 bits word*** containing the parameter to be monitored. The detailed description of this field is contained under service 3.

Filter : gives the number of successive failure of the specified check, performed on the parameter, before monitoring triggering

Min/Mask : **Min* :** For analogue values (Monitoring Types "00", "01" and "10") gives the minimum value against which the parameter is checked.

Mask : For digital values (Monitoring Type "11") the field contains a mask used to isolate the useful bits of the parameter.

Max/Expected value : **Max* :** For analogue values (Monitoring Types "00", "01" and "10") gives the maximum value against which the parameter is checked.

Expected Value :** For digital values (Monitoring Type "11") gives the expected value against which the parameter is checked.

Command definition : identifies the telecommand which has to be activated on the triggering of this monitoring. So it contains the TC packet ID and length (the TC Packet Sequence Control field will be filled by DMS at the time of TC issue), and the data field including data field header but excluding the packet error control field. The maximum allowed size of the Command Definition is TBD.

(*) : Min & Max - If the parameter is between the min. & max. values (inclusive), the check is correct and the current filter is reset.

(**) : Expected Value - if the parameter is equal to this value, thecheck is correct and the current filter is reset.

Note : The meaning of the Min Max fields for monitoring is depending on the type of monitoring:

Unsigned or signed 16 bit integer (analogue monitoring)

PAD	Min value	PAD	Max value
2 Octets	2 Octets	2 Octets	2 Octets

Floating point

Min floating point value	Max floating point value
4 Octets	4 Octets

Digital

PAD	Mask	PAD	Expected value
2 Octets	2 Octets	2 Octets	2 Octets

Parameters Values/Range

Monitoring ID : **TBW.**

Type	**:**	00 : Unsigned integer 16 bits 01 : Signed integer 16 bits 10 : Floating point 32 bits 11 : Digital monitoring
Frequency	**(TBC):**	00 : 32 Hz 01 : 8 Hz 10 : 1 Hz 11 : 1/16 Hz
State	**:**	0=disabled 1=enabled
Family	**:**	**TBW.**
Parameter ID	**:**	detailed structure identical to those described in service 3
Filter	**:**	**TBW.**
Mask	**:**	Boolean on several bits, if the bit of the mask is to the 1 value the corresponding bit of the parameter is selected for the monitoring, if the bit of the mask is to the 0 value the corresponding bit of the parameter is not selected for the monitoring. The unused bits have to be set to zero.
Expected value	**:**	Boolean on several bits
Min and Max values	**:**	Depending on type

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (12,6) Delete Parameters from Monitoring List.

Function/Description

When the DMS receives this request, it removes the corresponding monitoring information, if any, from the Monitoring List (the entry becomes free).

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 12
Subtype : 6
Application Data : See below

Monitoring ID
Enumerated
2 Octets

Parameters Meaning

TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

A standard error occurs if the Monitoring ID is not in the Monitoring List.

Telecommand (12,8) Report Current Parameter Monitoring List.

Function/Description

When the DMS receives this request, it issues a report with the current static contents of the Monitoring List.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 12
Subtype	: 8
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (12,9) Current Parameter Monitoring List Report.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 3 (Table)
Type : 12
Subtype : 9
Application Data : See below

PAD	Sequence Flags	N	Monitoring ID	Type	Frequency	State	T	PAD	Family ID
		Unsigned Integer							
1 Octet	2 Bits	6 Bits	2 Octets	2 Bits	2 Bits	1 Bit	1 Bit	2 Bits	1 Octet

< ---------- Repeated N Times ---------->

Parameter ID	Filter	Min/Mask	Max/Expected value	Command definition
4 Octets	2 Octets	4 Octets	4 Octets	Variable

< ---------- Repeated N Times ---------->

Parameters Meaning

Sequence Flags : For monitoring lists which do not fit in one telemetry packet, this field identifies the first, continuation or last telemetry packet related to the same monitoring list report.

N : Count of the number of whole monitoring items reported in this telemetry packet

Monitoring ID : Identifier of the monitoring item.

Type : defines the type of monitoring.

Frequency : defines the activation frequency of the monitoring

State : defines the current state (enabled or disabled) of the monitoring item.

T : Indicates that the monitoring has triggered.

Family : defines the family of the monitoring. In case of triggering of a monitoring, all the monitoring(s) belonging to the same family are temporarily disabled, until the end of the recovery action

Parameter ID : gives the location in the data pool of the first ***16 bits word*** containing the parameter to be monitored. The detailed description of this field is contained under service 3.

Filter : gives the number of successive failure of the specified check, performed on the parameter, before monitoring triggering

Min/Mask : **Min* :** For analogue values (Monitoring Types "00", "01" and "10") gives the minimum value against which the parameter is checked.

Mask : For digital values (Monitoring Type "11") the field contains a mask used to isolate the useful bits of the parameter.

Max/Expected value : **Max* :** For analogue values (Monitoring Types "00", "01" and "10") gives the maximum value against which the parameter is checked.

Expected Value :** For digital values (Monitoring Type "11") gives the expected value against which the parameter is checked.

Command definition : identifies the telecommand which has to be activated on the triggering of this monitoring. So it contains the TC packet ID and length (the TC Packet Sequence Control field will be filled by DMS at the time of TC issue), and the data field including data field header but excluding the packet error control field. The maximum allowed size of the Command Definition is TBD.

(*) : Min & Max - If the parameter is between the min. & max. values (inclusive), the check is correct and the current filter is reset.

(**) : Expected Value - if the parameter is equal to this value, the check is correct and the current filter is reset.

Parameters Values/Range

Sequence Flags :
10 = fist packet of the report
00 = continuation packet of the report
01 = Last packet of the report

N : N/A.

Monitoring ID : **TBW.**

Type :
00 : Unsigned integer 16 bits
01 : Signed integer 16 bits
10 : Floating point 32 bits
11 : Digital monitoring

Frequency (TBC) :
00 : 32 Hz
01 : 8 Hz
10 : 1 Hz
11 : 1/16 Hz

State	**:**	0=disabled 1=enabled
T	**:**	0=disabled 1=enabled
Family	**:**	**TBW.**
Parameter ID	**:**	detailed structure identical to those described in service 3
Filter	**:**	**TBW.**
Mask	**:**	Boolean on several bits, if the bit of the mask is to the 1 value the corresponding bit of the parameter is selected for the monitoring, if the bit of the mask is to the 0 value the corresponding bit of the parameter is not selected for the monitoring. The unused bits have to be set to zero.
Expected value	**:**	Boolean on several bits
Min and Max values	**:**	Depending on type

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (5,x.) Out of Limit Report.

Function/Description

The Out-of-limit Report is the only Provider-Initiated Report. This report is an Event report of service 5 with the sub type set as per the definition in the monitoring list. This report is sent when the value has been in error for the specified number of consecutive times, giving the information of which limit has been crossed. The report is not reissued if the value stays out side the same limit.

Structure

Process ID : 1 to 10
Packet Cat. : 7.
Type : 5.
Subtype : 2, 3 or 4 (depending on monitoring ID).
Source Data : See below

Event ID	Parameter ID	Monitoring ID	PAD	Limit Status	Parameter Value	Limit value or Expected value
Unsigned Integer		Unsigned Integer		Deduced	Deduced	Deduced
2 Octets	4 Octets	2 Octets	1 octet	1 Octet	4 Octets	4 Octets

Note 1 : Parameter value and Limit value are on 4 octets in order to be able to transmit floating point parameters

Parameters Meaning

Event ID : **TBW.**
Parameter ID : **TBW.**
Limit set Number : **TBW.**
Limit Status : This value indicates the limit crossed.
Parameter Value : Current value of the monitored parameter
Limit value : **TBW.**

Note 2 : the layout of the Parameter value and Limit value fields are according to the Min/Mask and Max/Expected value fields of TC(12,5)

Parameters Values/Range

Event ID : N/A.
Parameter ID : N/A.

Monitoring ID : N/A.

Limit Status : Value 0 = NA
Value 1 = Low limit
Value 2 = High limit
Value 3 = Expected value

Parameter Value : N/A.

Limit value : N/A.

Remarks

Telecommand (12,10) Enable Recovery Action.

Function/Description

When the DMS receives this request the recovery action in the entry identified is enabled, so if a matching event message is received the recovery is actioned.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 12
Subtype : 10
Application Data : See below

PAD	Event sub type	Event ID
	Unsigned Integer	Unsigned Integer
1 Octet	1 Octet	2 Octets

Parameters Meaning

TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

An error is flagged if the entry is not in the list. However, the processing of the remaining parameters is not affected.

Telecommand (12,11) Disable Recovery Action.

Function/Description

When the DMS receives this request the recovery action in the entry identified is disabled, so if a matching event message is received the recovery is not actioned.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 12
Subtype : 11
Application Data : See below

PAD	Event sub type	Event ID
	Unsigned Integer	Unsigned Integer
1 Octet	1 Octet	2 Octets

Parameters Meaning

TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

An error is flagged if the entry is not in the list. However, the processing of the remaining parameters is not affected.

Telecommand (12,14) Clear Event Monitoring List.

Function/Description

When the DMS receives this request, it sets the Service monitoring status to "Disabled" and clears all entries in the Monitoring list, no further monitoring is performed.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 12
Subtype	: 14
Application Data	: None.

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (12,15) Add Events to Monitoring List.

Function/Description

When the Service Provider receives this request, it adds the event monitoring information to the Monitoring List, and sets the event monitoring status to "Disabled". Should the entry be already defined in the monitoring list the information in the list is updated only if the current entry is disabled.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 12
Subtype : 15
Application Data : See below

PAD	Event sub type	Event ID	Data Pool Parameter	PAD	Parameter Length	Recovery Action
	Unsigned Integer	Unsigned Integer	Enumerated		Enumerated	Enumerated
1 Octet	1 Octet	2 Octets	2 Octets	1 Octet	1 Octet	Packet Tele-Command

Parameters Meaning

Event sub type : Defines, together with Event ID, the entry in the Monitoring list.

Event ID : Defines, together with Event sub type, the entry in the Monitoring list.

Data Pool Parameter : The parameter where the application data from the service 5 event packet is placed so the recovery action if it is an OBCP or application code can recover it.

Parameter Length : The length of the parameter in the data pool, should match the application area of the event packet, if not the first part of the application data is taken until the data pool parameter if full.

Recovery Action : Full Packet tele-command to start the recovery action.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

If an error is detected during the processing of the monitoring information for a given event, this event is not added or updated in the Monitoring List

Telecommand (12,16) Delete Events from Monitoring List.

Function/Description

When the DMS receives this request, it removes its corresponding monitoring information, if any, from the Monitoring List (the entry becomes free).

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 12
Subtype : 16
Application Data : See below

PAD	Event sub type	Event ID
	Unsigned Integer	Unsigned Integer
1 Octet	1 Octet	2 Octets

Parameters Meaning

TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

A standard error occurs if the event is not in the Monitoring List

Telecommand (12,18) Report Current Event Monitoring List.

Function/Description

When the DMS receives this request, it issues a report with the current static contents of the Monitoring List.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 12
Subtype	: 18
Application Data	: None.

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (12,19) Current Event Monitoring List Report.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 3 (Table)
Type : 12
Subtype : 19
Source Data : See below

PAD	Sequence Flags	N	Event Monitoring Status	Event sub type	Event ID	Data Pool Parameter
		Unsigned Integer	Unsigned Integer	Unsigned Integer	Unsigned Integer	Enumerated
1 Octet	2 Bits	6 Bits	1 Octet	1 Octet	2 Octets	2 Octets

PAD	Parameter Length	Recovery Action
	Enumerated	Enumerated
1 Octet	1 Octet	Packet Tele-Command

Parameters Meaning

Sequence Flags : For monitoring lists which do not fit in one telemetry packet, this field identifies the first, continuation or last telemetry packet related to the same monitoring list report.

N : Count of the number of whole monitoring items reported in this telemetry packet

Event Monitoring Status : This indicates whether the recovery of the corresponding entry is enabled or disabled.

Event sub type : **TBW.**

Event ID : **TBW.**

Data Pool Parameter : **TBW.**

Parameter Length	**:**	**TBW.**
Recovery Action	**:**	**TBW.**

Parameters Values/Range

Sequence Flags	**:**	10 = fist packet of the report 00 = continuation packet of the report 01 = Last packet of the report
N	**:**	N/A.
Event Monitoring Status:		0=disabled 1=enabled
Event sub type	**:**	**TBW.**
Event ID	**:**	**TBW.**
Data Pool Parameter	**:**	**TBW.**
Parameter Length	**:**	**TBW.**
Recovery Action	**:**	**TBW.**

Remarks

A2.13 Service 13 Large Data Transfer

TBD

A2.14 Service 14 Packet Real-Time Downlink Control

Objective

To control the amount of data that is sent in real-time to ground during a pass.

Description

Normal transmission of Telemetry to ground will be via replay of packet stores from the SSMM. Selection of real-time downlinking of data will be done on a packet basis.
Enabled application process ID's are placed in the real time transfer frame VC0, the frame is down linked when full or the transmission of a time packet is required.

Telecommand (14,1) Enable Downlink of Selected Packets by APID.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 14
Subtype : 1
Application Data : See below

PAD	Application Process ID
	Unsigned Integer
5 Bits	11 Bits

Parameters Meaning

Application Process ID : Application Process ID of packet to enable for Real-Time downlink transmission (in VC0 frames)

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

The application process ID is placed in the routing table for real-time down link.

Telecommand (14,2) Disable Downlink of Selected Packets by APID.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 14
Subtype : 2
Application Data : See below

PAD	Application Process ID
	Unsigned Integer
5 Bits	11 Bits

Parameters Meaning

Application Process ID : Application Process ID of packet to enable for Real-Time downlink transmission (in VC0 frames)

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

The entry for this application process ID is removed from the routing table for downlink in VC0. An Application Process ID of zero is not allowed to be disabled as this is the time packet.

Telecommand (14,3) Report Real-Time Downlink Routing Table.

Function/Description

TBW.

Structure

Process ID	: 1 to 10
Packet Cat.	: 12 (Private)
Type	: 14
Subtype	: 3
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (14,4) Real-Time Downlink Routing Table Report.

Function/Description

The report contains all the application process IDs that are enabled for down link in real-time, at the time of the request (14,3).

Structure

Process ID : 1 to 10
Packet Cat. : 3 (Table)
Type : 14
Subtype : 4
Source Data : See below

PAD	N	PAD	Application Process ID
	Unsigned Integer		Unsigned Integer
1 Octet	1 Octet	5 Bits	11 Bits

< ---------- Repeated N Times ---------- >

Parameters Meaning

TBW.

Parameters Values/Range

TBW.

Remarks

A2.15 Service 15 On-Board Telemetry Storage and Retrieval

Objective

This service controls the storage to and the retrieval of telemetry packets from the SSMM. This service allows to select the packets to be stored in each store, together with selecting which stores are downlinked. Definition of packet store types and other files types within the SSMM are part of the SSMM private service.

Description

Packets are stored and retrieved in designated packet stores in the SSMM, a packet store may be storing data and retrieving old data for downlinking at the same time. Simultaneous downlinking of data from more than one packet store will be supported by a priority scheme. Data will still be kept in the packet store after downlinking until erased by specific ground command.
Packets are stored in Packet Stores in the order that they arrive at the packet store router in the DMS, or on the direct links to the SSMM. Packets are retrieved from packet stores by just dumping the oldest data first (e.g. FIFO) or by application process ID and sequence counter or by application process ID and packet time. It is not possible to define storage of the same packet to more than one store at the same time.

For retrieval this service only covers extraction of packets for placing on the downlink, retrieval from a packet store to another on-board user is covered in the SSMM private service.

Packet stores and associated use of pointers is shown in figure (**TBD**).

Telecommand (15,1) Start Storage of Packets in a Store.

Function/Description

Storage in the addressed packet store is enabled using a predefined definition of application process IDs to be stored in it.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 15
Subtype : 1
Application Data : See below

Store File Name
Unsigned integer
2 Octets

Parameters Meaning

Store File Name : Packet store identifier to a pre defined packet store.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (15,2) Stop Storage of Packets in a Store.

Function/Description

Storage in the addressed packet store is stopped.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 15
Subtype : 2
Application Data : See below

Store File Name
Unsigned integer
2 Octets

Parameters Meaning

Store File Name : Packet store identifier to a pre defined packet store.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (15,3) Add APID to Packet Store Definition.

Function/Description

The Packet is added to the store definition

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 15
Subtype : 3
Application Data : See below

Store File Name	Application Process ID
Unsigned integer	Enumerated
2 Octets	2 Octets

Parameters Meaning

Store File Name : Packet store identifier to a pre defined packet store.

Application Process ID : TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (15,4) Remove APID from Packet Store Definition.

Function/Description

The Packet is removed from the store definition.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 15
Subtype : 4
Application Data : See below

Store File Name	Application Process ID
Unsigned integer	Enumerated
2 Octets	2 Octets

Parameters Meaning

Store File Name : Packet store identifier to a pre defined packet store.

Application Process ID : TBW.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (15,5) Report Packet Store Definition.

Function/Description

TBW.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 15
Subtype : 5
Application Data : See below

Store File Name
Unsigned integer
2 Octets

Parameters Meaning

Store File Name **:** Packet store identifier to a pre defined packet store.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (15,6) Packet Store Definition Report.

Function/Description

The report contains all application process IDs that are enabled for storage in this packet store.

Structure

Process ID : 1 to 10
Packet Cat. : 3 (Table)
Type : 15
Subtype : 6
Source Data : See below

Store File Name	PAD	N	Application Process ID
Unsigned integer		Unsigned Integer	Enumerated
2 Octets	1 Octet	1 Octet	2 Octets

<---Repeated N Times--->

Parameters Meaning

Store File Name : Packet store identifier to a pre defined packet store.
N : **TBW.**
Application Process ID : **TBW.**

Parameters Values/Range

TBW.

Remarks

Telecommand (15,7) Downlink Packet Stores Contents for Packet Range.

Function/Description

TBW.

Structure

Process ID : 25
Packet Cat. : 12 (Private)
Type : 15
Subtype : 7
Application Data : See below

Store File Name	Destination User	Read Command ID	Pad	Down Link Priority	Application Process ID 1	Source Sequence 1
Unsigned integer	Fixed CharString	Enumerated		Unsigned Integer	Enumerated	Unsigned Integer
2 Octets	2 Octet	2 Octets	1 Octet	1 Octet	2 Octets	2 Octets

Application Process ID 2	Source Sequence 2	Pad	Compression Identifier
Enumerated	Unsigned Integer		Unsigned Integer
2 Octets	2 Octets	1 Octet	1 Octet

Parameters Meaning

Store File Name : File identifier.

Destination user : Specifies the receiver (user) of the file.

Read Command ID : The ID of the Read Command, among all other read operations, identifies the read command independently of the packet stores and has to be unique across all the SSMM files. Since many simultaneously read operations can be ongoing from the file, it is possible to separate them to, for example, just stop the read operation for a specific user.

Down Link Priority : This number defines the down link priority, the store with the highest priority is emptied first. If two or more stores have the

same priority the packets from the stores are interleaved on a one to one basis. The highest priority is zero.

Application Process ID 1 & Source Sequence 1 : Specifies the start point in the store for the downlink. If an exact match can not be made with the sequence counter the next highest one is taken as the start point.

If no start point is given (APID 1 and Sequence count 1 fields set to zero), the downlink starts from the current TFG read pointer.

Note: the "current TFG read pointer" is defined as the read pointer location reached at the end of the execution of the last read action, started by a TC 15,7 with APID 1 and Sequence Count 1 = 0, with destination TFG. The current TFG read pointer is equal to the *Free Pointer* when the packet previously pointed by the read pointer is deleted by command service 15 subtypes 10 or 11 or by overwriting.

The *Free Pointer* indicates the oldest written packet which has not been deleted by command service 15 subtypes 10 or 11 or by overwriting.

Application Process ID 2 & Source Sequence 2 : Specifies the stop point in the store. If an exact match can not be made with the sequence counter the next highest one is taken as the stop point.

If no stop point is given (APID 2 and Source Sequence 2 = 0) or if the stop point is not found, the retrieval continues to be enabled. This means that any new packets added to the packet store will automatically be retrieved until a Stop Retrieval command is received or until the whole file is removed or until an appropriate packet (defining the stop point) is written into the file.

Any range specified is inclusive.

All packets contained in the store over the selected range are downlinked.

Note: the selection criteria can be ambiguous, as it can happen that two packets with the same APID and Source Sequence Counter are stored in the packet store. The SSMM will use the first packet in the packet store, starting from the current Free Pointer, that matches the selection criteria.

Compression Identifier : Not used on MARS EXPRESS (placeholder).

Parameters Values/Range

Store File Name : **TBW.**

Destination user : The following users of the SSMM is defined:

- 0000 TFG (Ground)
- 0001 DMS PM

- 0002 Other PM
- 0003 EGSE/Instrument 4 (Spare Instrument)
- 0004 Instrument 1
- 0005 Instrument 2
- 0006 Instrument 3

Read Command ID : The value "$FFFF_{hex}$"is reserved for the Stop command, so it can not be used within TC(15,7) and TC(15,9). The Read Command ID has to be unique among all ongoing read operations across all SSMM files.

Application Process ID 1 & Source Sequence 1 : **TBW.**

Application Process ID 2 & Source Sequence 2 : **TBW.**

Down Link Priority : **TBW.**

Compression Identifier : Not used on MARS EXPRESS (placeholder).

Verification/Effect on Telemetry

TBW.

Remarks

It is possible to give in a 15,7 telecommand a read command ID which is the same as the store file name only if there are not two or more commands with different selection parameters accessing the same file.

This command should be used only to send packet stores and data with packet structure to the TFG and it should not be used to send the contents of plain files without packet structure. The private command "read plain files" shall be used in this case (service 162, subtype 6).

Telecommand (15,8) Stop Retrieval from a Packet Store.

Function/Description

TBW.

Structure

Process ID : 25
Packet Cat. : 12 (Private)
Type : 15
Subtype : 8
Application Data : See below

Read Command ID
Enumerated
2 Octets

Parameters Meaning

Read Command ID **:** The identification of the read operation to be stopped.

No more packets will be retrieved and placed on the downlink, the read pointer stays with its current value. If Read Command ID value is "$FFFF_{hex}$," all read operations in progress on all packet stores are stopped.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (15,9) Downlink Packet Store Contents for Time Period.

Function/Description

TBW.

Structure

Process ID : 25
Packet Cat. : 12 (Private)
Type : 15
Subtype : 9
Application Data : See below

Store File Name	Destination User	Read Command ID	Pad	Down Link Priority	Read Command ID	Application Process ID 1	Time 1
Unsigned Integer	Fixed CharString	Enumerated		Unsigned Integer	Enumerated	Enumerated	CUC Time in second
2 Octets	2 Octet	2 Octets	1 Octet	1 Octet	2 Octets	2 Octets	4 Octets

Application Process ID 2	Time 2	Pad	Compression Identifier
Enumerated	CUC Time in second		Unsigned Integer
2 Octets	4 Octets	1 Octet	1 Octet

Parameters Meaning

Store File Name : File identifier.

Destination user : Specifies the receiver (user) of the file.

Down Link Priority : This number defines the down link priority, the store with the highest priority is emptied first. If two or more stores have the same priority the packets from the stores are interleaved on a one to one basis. The highest priority is zero.

Read Command ID : The identification of the Read Command that uniquely, among all other read operations, identifies the command. Since many simultaneously read operations can be ongoing from the same file, you must be able to separate them to, for example, just stop the read operation for a specific user.

Application Process ID 1 & Time 1 : Specifies the start point in the store for the downlink. If an exact match can not be made with the time the next highest one for the APID1 is taken as the start point.

If no start point is given (APID 1 and Time 1 fields set to zero), the downlink starts from the current TFG read pointer.

Application Process ID 2 & Time 2 : Specifies the stop point in the store. If an exact match can not be made with the time the next highest one for the APID2 is taken as the stop point.

If no stop point is given (APID 2 and Time 2 = 0) or if the stop point is not found, the retrieval continues to be enabled. This means that any new packets added to the packet store will automatically be retrieved until a Stop Retrieval command is received or until the whole file is removed or until an appropriate packet (defining the stop point) is written into the file.

Any range specified is inclusive.

All packets contained in the store over the selected range are downlinked.

Note: the selection criteria can be ambiguous, as it can happen that two packets with the same APID and Time are stored in the packet store. The SSMM will use the first packet in the packet stored, starting from the current Free Pointer, that matches the selection criteria.

Compression Identifier : Not used on MARS EXPRESS (placeholder).

Parameters Values/Range

Store File Name : **TBW.**

Destination user : The following users of the SSMM is defined:

- 0000 TFG (Ground)
- 0001 DMS PM
- 0002 Other PM
- 0003 EGSE/Instrument 4 (Spare Instrument)
- 0004 Instrument 1
- 0005 Instrument 2
- 0006 Instrument 3

Down Link Priority : **TBW.**

Read Command ID : The value "$FFFF_{hex}$"is reserved for the Stop command, so it can not be used within TC(15,7) and TC(15,9). The Read Command ID has to be unique among all ongoing read operations across all SSMM files.

Application Process ID 1 : **TBW.**

& Time 1

Application Process ID 2 : TBW.

& Time 2

Compression Identifier : Not used on MARS EXPRESS (placeholder).

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (15,10)Delete Packet Stores Contents up to Specified Packet.

Function/Description

TBW.

Structure

Process ID : 25
Packet Cat. : 12 (Private)
Type : 15
Subtype : 10
Application Data : See below

Store File Name	Application Process ID	Source Sequence
Unsigned Integer	Enumerated	Unsigned Integer
2 Octets	2 Octets	2 Octets

Parameters Meaning

Store File Name : File identifier.

Application Process ID & Source Sequence : Specifies the end point in the store for the deletion. If an exact match can not be made with the sequence counter the next lowest one is taken as the last packet to be deleted.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

All packets contained in the store older than the selected packet are deleted. Older means stored before the selected packet.

If the specified Application Process Id is not found in the packet store no data is deleted and an execution failure report, if required, is raised via service 1.

If both APID and Source Sequence count equal "$FFFF_{hex}$", the whole file is removed (i.e. the filename is no longer understood by the SSMM) and the memory banks are powered off if the removed file is the only user of these banks. The file can only be removed if the protection type of the file indicates that it is not protected against removal of the whole file.

Telecommand (15,11) Delete Packet Stores Contents up to Specified Time.

Function/Description

TBW.

Structure

Process ID : 25
Packet Cat. : 12 (Private)
Type : 15
Subtype : 11
Application Data : See below

Store File Name	Application Process ID	Time
Unsigned integer	Enumerated	CUC time in second
2 Octets	2 Octets	4 Octets

Parameters Meaning

Store File Name : File identifier .

Application Process ID & Time : Specifies the end point in the store for the deletion. If an exact match can not be made with the time the next lowest one is taken as the last packet to be deleted.

Time : Time is the full packet time field

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

All packets contained in the store older than the selected packet are deleted. Older means stored before the selected packet.

If the specified Application Process Id is not found in the packet store no data is deleted and an error report is raised via service 1.

If both APID and Time equal "$FFFF_{hex}$", the whole file is removed (i.e. the filename is no longer understood by the SSMM) and the memory banks are powered off if the removed file is the only user of these banks. The file can only be removed if the protection type of the file indicates that it is not protected against removal of the whole file.

Telecommand (15,12) Report Storage Catalogue.

Function/Description

TBW.

Structure

Process ID : 25
Packet Cat. : 12 (Private)
Type : 15
Subtype : 12
Application Data : See below

Store File Name
Unsigned integer
2 Octets

Parameters Meaning

Store File Name **:** File identifier.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

The report is sent as sub type 13

Telemetry (15,13) Storage Catalogue Report.

Function/Description

TBW.

Structure

Process ID : 25
Packet Cat. : 3 (Table)
Type : 15
Subtype : 13
Source Data : See below

Store File Name	Application Process ID 1	Time 1	Sequence counter 1	Application Process ID 2	Time 2	Sequence counter 2
Unsigned integer	Enumerated	CUC time in second	Unsigned integer	Enumerated	CUC time in second	Unsigned integer
2 Octets	2 Octets	4 Octets	2 Octets	2 Octets	4 Octets	2 Octets

Size of file	Protection type	File type	Free Pointer	TFG read Pointer	Write Pointer	Margin size	Creation time
Unsigned integer	Unsigned integer	Enumerated	Unsigned integer	Unsigned integer	Unsigned integer	Unsigned integer	CUC time
4 Octets	1 octet	1 Octet	4 octets	4 octets	4 octets	4 octets	4 octets

Inode Number in MM A	Inode Number in MM B	Inode Number in MM C	Physical allocation in MM A	Physical allocation in MM B	Physical allocation in MM C
Unsigned integer	Unsigned integer	Unsigned integer	Unsigned integer	Unsigned integer	Unsigned integer
2 Octets	2 Octets	2 Octets	2 Octets	2 Octets	2 Octets

Parameters Meaning

Store File Name : File identifier.

Application Process ID, time & sequence count : gives information about the oldest (1) and the newest (2) packet in the store. For plain files, these fields are set to "$FFFF_{hex}$".

Size of File : gives the allocated SSMM memory for the file (in Bytes).

Protection type : Determines the protection type of the file (protected or not against removal) :

00 – File is not protected against removal
01 – File is protected against removal

File type : gives the type of file:

00 – Plain File
This is a file containing non packetised data (as far as the SSMM is aware of).

01 – Cyclic Packet Store
This is a file containing packetised data, in which, when the file is full, storage of new packets overwrites the oldest packets.

02 – Non-Cyclic Packet Store
This is a file containing packetised data, in which, when the file is full, storage of new packets is prevented, to avoid overwriting of old data.

Free pointer : gives the position of the free pointer within the file. The free pointer is reported (in bytes) relative to the beginning of the file.

TFG read pointer* : gives the position of the TFG read pointer within the file The TFG read pointer reported (in bytes) relative to the beginning of the file.

Write pointer* : gives the position of the Write pointer within the file. The write pointer reported (in bytes) relative to the beginning of the file.

Margin size : Determines the margin size for the file (in bytes).

Creation time : Determines the time of the creation of the file (in seconds)

Inode Number in MM A : Determines which Inode (if any) that has been allocated for the file in MM A. If no Inode has been allocated for the file in MM A, this field is set to "$FFFF_{hex}$".

Inode Number in MM B : Determines which Inode (if any) that has been allocated for the file in MM B. If no Inode has been allocated for the file in MM B, this field is set to "$FFFF_{hex}$".

Inode Number in MM C : Determines which Inode (if any) that has been allocated for the file in MM C. If no Inode has been allocated for the file in MM C, this field is set to "$FFFF_{hex}$".

Physical allocation in MM A : Specifies which Memory Banks the Packet Store allocates in Mass Memory Module A. The two octets define a 4 bits bit field where each bit of the field indicates if the packet store is allocated in the corresponding memory bank or not. The definition of this bit field is illustrated by the figure below **.

Physical allocation in MM B : The definition of the Physical allocation in MM B is identical to the definition of the Physical allocation in MM A above, with the only difference being that the banks does refer to the banks of Mass Memory Module B.

Physical allocation in MM C : The definition of the Physical allocation in MM C is identical to the definition of the Physical allocation in MM A above, with the only difference being that the banks does refer to the banks of

Mass Memory Module C.

(*) The ground by comparing write pointer with down linked candetermine if any data not TFG read pointer is available.

(**) Physical allocation in MM:

MSB							LSB	MSB							LSB
1st octet								2nd octet							
PAD												Bank 3	Bank 2	Bank 1	Bank 0
0	0	0	0	0	0	0	0	0	0	0	0	x	x	x	x

X = 1 if the packet store is allocated in the bank,
X = 0 if the packet store is not allocated in the bank.

Parameters Values/Range

TBW.

Remarks

A2.16 Service 16 On-Board Traffic Management

Objective

Control the selection of nominal or redundant branches for the routing of packets to and from payload instruments

Description

Service 16 is used to control the routing of packets in the DMS to or from the payload instruments. The need is to define the selection of the nominal or redundant P/L branch for Payload access (TC packets sending to, and TM packets acquisition from a payload).

This control is obtained by telecommands from the ground defining for each Payload instrument, the nominal or redundant branch to be used.

The DMS SW has to contain the correspondence tables defining the OBDH addresses to be used to access a given payload, i.e.:

- the channel address for TM packets to be fetched from a payload using the polling function, and
- the "user selection" memory load for TC packets destined to a payload managed by the TC router,

Standard routing tables will be loaded as part of the DMS PROM program.

Full tables maintenance will only be performed by use of service 6 (memory patch and dump).

Telecommand (16,1): Define nominal/redundant branch for a payload instrument data transfer

Function/Description

This TC allows to define the branch (nominal or redundant) to be used, between the RTU and a payload, to acquire TM packets from a payload and to send TC packets to this payload.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 16
Subtype : 1
Application Data : See below

Payload instrument	Pad	Nominal / Redundant branch
Enumerated		Enumerated
1 octet	7 bits	1 bit

Parameters meaning

Payload instrument : the name of the payload instrument to which is associated the selection of the branch to be used.

Nominal/Redundant branch: the selection of the nominal or redundant branch, to be used to acquire TM packets from and to send TC packet to, this payload instrument

Parameters Values/Range

Payload instrument :

Payload instrument	Code (decimal)
ASPERA	01
HRSC	02
MARESS	03
MARSIS	04
OMEGA	05
PFS	06
SPICAM	07
BEAGLE-2 (TBC)	08
VMC (TBC)	09

	10
	11
	12

Nominal/Redundant branch: 0 : redundant branch
1 : nominal branch

Verification/Effect on Telemetry

Remarks

Telecommand (16,2): Enable/Disable TM polling from Payload instrument

Function/Description

This TC allows to enable (start) or disable (stop) the TM packets polling from a defined payload instrument. It is used after switching on, and before switching off this instrument. It may be used also in particular cases of errors of the payload instrument TM packet generation such as TM block exceeded, or packet length incorrect within a TM block.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 16
Subtype : 2
Application Data : See below

Payload instrument	Pad	TM polling
Enumerated		Enumerated
1 octet	7 bits	1 bit

Parameters meaning

Payload instrument : the name of the payload instrument on which it is required to enable or disable the TM packets polling.

TM polling : status of enabling or disabling of the TM packets polling

Parameters Values/Range

Payload instrument : see list and code in TC(16,1)

TM polling : 0 : disabling (stopping) TM packets polling
1 : enabling (starting) TM packets polling

Verification/Effect on Telemetry

Remarks

Telecommand (16,3): Enable/Disable TC sending to Payload instrument

Function/Description

This TC allows to enable (authorise) or disable (inhibit) the TC packets sending to a defined payload instrument. It is used after switching on, and before switching off this instrument.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 16
Subtype : 3
Application Data : See below

Payload instrument	Pad	TC sending
Enumerated		Enumerated
1 octet	7 bits	1 Bit

Parameters meaning

Payload instrument : the name of the payload instrument on which it is required to enable or disable the TC packets sending.

TC sending : status of enabling or disabling of the TC packets sending

Parameters Values/Range

Payload instrument : see list and code in TC(16,1)

TC sending : 0 : disabling (inhibition) TC packets sending
1 : enabling (authorisation) TC packets sending

Verification/Effect on Telemetry

Remarks

A2.17 Service 17 Connection Test

Objective

Allow a test to be performed on a packet telemetry source to verify that the unit is still functioning.

Description

Some users will not produce telemetry packets on a regular basis so service 17 allows the link between DMS and packetised users to be tested. The service is like a network «PING», due to the autonomous nature of operations for MARS EXPRESS the service supports a timeout and event packet generation.

Telecommand (17,1) Request Connection Test Response.

Function/Description

On reception of TC (17,3), DMS sends this TC (17,1) to the addressed user.
The addressed user is required to respond with a telemetry report (17,2).

Structure

Process ID	: All
Packet Cat.	: 12 (Private)
Type	: 17
Subtype	: 1
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

If no response is received by the service within a specified time period, the service sends an event packet (service type 5).

Telemetry (17,2) Connection Test Response Report.

Function/Description

This TM packet is sent to DMS by a user after having received TC (17,1).

Structure

Process ID	: All
Packet Cat.	: 7 (Event)
Type	: 17
Subtype	: 1
Source Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Remarks

Telecommand (17,3) Request Connection Test.

Function/Description

This telecommand initiates the Connection Test service in DMS. On reception of TC (17,3), DMS sends a TC (17,1) to the selected PID and starts a timer. The addressed user is required to respond with a TM report (17,2) within the specified Time out.

Structure

Process ID : 1 to 10
Packet Cat. : 12 (Private)
Type : 17
Subtype : 3
Application Data : See below

Not Used	PID	PAD	Time out
	Enumerated		Unsigned integer
9 bits	7 bits	1 Octet	1 Octet

Parameters Meaning

PID **:** The destination process ID for the test command.

Time out **:** Time out in seconds.

Parameters Values/Range

PID **:** **TBW.**

Time out **:** **TBW.**

Verification/Effect on Telemetry

TBW.

Remarks

If no response is received in the specified time out, the service reports an error via service 5 sub type 3.

A2.18 Service 18 Context Transfer (DMS ←→ USER)

Objective

Allow a packet-based user to store its operational context in the SSMM during time when they are powered down.

Description

The context service is used to allow a packet based unit to store its current operational status in the SSMM before being powered down, this context can then be down loaded back to the unit at power on. The service can be used at other times when required. The context is limited in two ways:-

1. A unit may only have one context stored in the SSMM at any one time.
2. The size of the context is limited to the data area size of a single telemetry packet.

The unit via service 1 sub type 7 or 8 indicates the completion of the down load.

Telecommand (18,1) Report Context.

Function/Description

This allows the DMS software to ask for the units current context file.

Structure

Process ID	: 1 to 10 (optional for 11 to 20 and 51 to 116)
Packet Cat.	: 12 (Private)
Type	: 18
Subtype	: 1
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

Telemetry (18,2) Context Report.

Function/Description

The context report is contained in a single telemetry packet.

Structure

Process ID : 1 to 10 (optional for 11 to 20 and 51 to 116)
Packet Cat. : 11 (Context)
Type : 18
Subtype : 2
Source Data : See below

Context Information
Format is unit specific
Variable

Parameters Meaning

Context Information : Unit specific

Parameters Values/Range

N/A.

Remarks
The size of the context is limited to a "Max TM packet data area size".

Telecommand (18,3) Accept Context.

Function/Description

The context is down loaded to the unit in a number of telecommand packets each containing one segment of the context information contained in the relevant context file issued from one TM packet of sub-type 2.

Structure

Process ID : 1 to 10 (optional for 11 to 20 and 51 to 116)
Packet Cat. : 12 (Private)
Type : 18
Subtype : 3
Application Data : See below

PAD	Segment Number	Context Information
	Unsigned Integer	Format is unit specific
1 Octet	1 Octet	Variable

Parameters Meaning

Segment Number : Indicates the segment of the context array.

Context Information : Unit specific

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

The segment length is defined by the packet length.

A2.19 Service 19 Information Distribution (DMS → USER)

Objective

Allow packet-based users to exchange information.

Description

Information of defined types is placed into dedicated packets and distributed by the DMS software to the required users. The information is generated directly by the DMS software or by event (service 5) TM packets from other users, this information is placed in the DMS data pool. The event monitor or another on-board application (e.g. MTL, OBCP) can control when the information is distributed by a command to this service. The service then distributes the information to the specified users. Different types of information is defined by sub types 10 to 255, the sub type is controlled by the MARS EXPRESS project authority.

Telecommand (19,1) Initiate Information Distribution.

Function/Description

This command defines what information is to be distributed and to whom, together with which information type is to be used.

Structure

Process ID : 1 to 10 (optional for 51 to 116)
Packet Cat. : 12 (Private)
Type : 19
Subtype : 1
Application Data : See below

PAD	N1	Parameter ID	Information type	N2	Not used	Process ID
	Unsigned Integer	Enumerated	Unsigned Integer	Unsigned Integer		Enumerated
1 Octet	1 Octet	4 Octets	1 Octet	1 Octet	9 bits	7 bits
		<- repeated -> N1 times			<----------repeated----------> N2 times	

Parameters Meaning

N1 : Number of parameters to be contained in the information packet.

Parameter ID : Parameters to be placed in the information packet.

Information type : Sub type to be used in the information packet this defines to the receiving application the data structure of the packet. (10-255).

N2 : Number of Applications to be addressed for this information.

Process ID : Destination Process IDs to be used for the distribution.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

TBW.

Remarks

Telecommand (19,10 to 255) Information Distribution Sub Types 10 to 255.

Function/Description

TBW.

Structure

Process ID : 1 to 10 (optional for 51 to 116)
Packet Cat. : 12 (Private)
Type : 19
Subtype : 10 to 255
Application Data : See below

Information
Sub-Type specific

Parameters Meaning

Information **:** The information is in the same order as the parameters are specified in subtype 1.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

No length is given, as the sub type defines the length.

A2.20 Service 20 Science Data Transfer

Objective

Control the collection of science data via the RTU or high-speed link to the SSMM.

Description

Collection can be enabled or disabled. Not included in this service is the dialog between the DMS and SSMM required to control the sending of science data over the High Speed Link directly from the user to the SSMM, this will be handled by DMS and/or SSMM as a private service.

Telecommand (20,1) Enable Science Report Packet Generation on RTU Link.

Function/Description

TBW.

Structure

Process ID : 51 to 116
Packet Cat. : 12 (Private)
Type : 20
Subtype : 1
Application Data : See below

Not Used	PID
	Enumerated
9 bits	7 bits

Parameters Meaning

PID **:** is the Process ID of the science TM packet to be enabled.

Parameters Values/Range

TBW.

Verification/Effect on Telemetry

N/A.

Remarks

The PID in the TC header can be different from the one in the Data Field, since one user can decide to control different TM PIDs with a single TC PID.

Telecommand (20,2) Disable Science Report Packet Generation on RTU Link.

Function/Description

TBW.

Structure

Process ID : 51 to 116
Packet Cat. : 12 (Private)
Type : 20
Subtype : 2
Application Data : See below

Not Used	PID
	Enumerated
9 bits	7 bits

Parameters Meaning

PID **:** is the Process ID of the science TM packet to be disabled.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

The PID in the TC header can be different from the one in the Data Field, since one user can decide to control different TM PIDs with a single TC PID.

Telemetry (20,3) Science Report on RTU Link.

Function/Description

TBW.

Structure

Process ID	: 51 to 116
Packet Cat.	: 12 (Private)
Type	: 20
Subtype	: 3
Source Data	: Layout of the data area is experiment specific

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Remarks

Telecommand (20,10)Enable Science Report Packet Generation on High Speed Link.

Function/Description

TBW.

Structure

Process ID : 28, 29 and from 51 to 116
Packet Cat. : 12 (Private)
Type : 20
Subtype : 10
Application Data : See below

Not Used	PID
	Enumerated
9 bits	7 bits

Parameters Meaning

PID **:** is the Process ID of the science TM packet to be enabled.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

N/A.

Remarks

The PID in the TC header can be different from the one in the Data Field, since one user can decide to control different TM PIDs with a single TC PID.
This TC is sent on the RTU link for payload. Only science data (20,13) is sent over the SSMM High Speed link.

Telecommand (20,11) Disable Science Report Packet Generation on High Speed Link.

Function/Description

TBW.

Structure

Process ID	: 28, 29 and from 51 to 116
Packet Cat.	: 12 (Private)
Type	: 20
Subtype	: 11
Application Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Verification/Effect on Telemetry

TBW.

Remarks

The experiment will continue sending science data over the High-Speed link until the next packet boundary, it then stops science generation and informs the DMS via sub type 12. This TC is sent on the RTU link for payload. Only science data (20,13) is sent over the SSMM High Speed link.

Telemetry (20,12) Report Science Data Generation Stopped at Packet Boundary.

Function/Description

This report allows the DMS software to shutdown the SSMM packet file at a packet boundary, thus ensuring only whole packets are contained in a packet store. This sub type is sent on the RTU link for payload. Only science data (20,13) is sent over the High Speed link.

Structure

Process ID	: 28, 29 and from 51 to 116
Packet Cat.	: 7 (Event)
Type	: 20
Subtype	: 12
Source Data	: None

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Remarks

Telemetry (20,13) Science report on High Speed link.

Function/Description

This is the only packet type that is sent over the High Speed link, all other packet types are sent over the normal experiment RTU link for payload.

Structure

Process ID	: 28, 29 and from 51 to 116
Packet Cat.	: 12 (Private)
Type	: 20
Subtype	: 13
Source Data	: Layout of the data area is experiment specific.

Parameters Meaning

N/A.

Parameters Values/Range

N/A.

Remarks

A2.21 Service 128-255 Private Services

Objective

Identifies all private services of packet based users.

Description

The packet based users will require a number of functions to be specified and utilised via dedicated TM/TC packets.
Service type ranges are allocated as follows:

128	Firmware	
129	Spare	
130 to 139	DMS & AOCMS software	
140 to 149	STR software	See details in MEX.MMT.IF.????
150 to 159	Spare	
160 to 169	SSMM software	See details in MEX.MMT.IF.0365
170 to 190	Spare	
191 to 195	ASPERA	
196 to 200	HRSC	
201 to 205	MARESS	
206 to 210	MARSIS	
211 to 215	OMEGA	
215 to 220	PFS	
221 to 225	Spare	
226 to 230	SPICAM	
231 to 235	Beagle-2 (TBC)	
236 to 240	VMC (TBC)	
241 to 254	Payload Spare	

Sub-types for each of the service types are freely allocated by the user within the range 1 to 255.

255 Coordinated Payload

This service contains commands common and applicable to the payload only and which are not under the scope of any other service. For the moment only sub type 1 (Reset Telemetry Output Buffer) is allocated.

A2.22 Services Types and Subtypes Cross-reference Table

This Table provides a cross-reference between telemetry and telecommand packet types and subtypes and indicates to which users they apply.

FIRM= Firmware in service mode, DMS= DMS s/w, AOC= AOCMS s/w, STR= STR s/w, SSMM= SSMM s/w, P/L= Payload s/w.

Y= applicable, N/A= not applicable, O= optional, M=mandatory.

Note 1: In this table, the telemetry which are on the same line than a telecommand are considered as being a response to this telecommand. Therefore, they shall follow the routing rules for “Solicited TM packets” concerning the TM_destination_ID (PUS version field) and TC_answer_token (Pad field) of the data field header.

Note 2: All telemetry of service 1 are also considered as a response to the telecommand they acknowledge. Therefore, they shall also follow the routing rules for “Solicited TM packets”.

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
		Service 1: TC Verification															
									1	Telecommand Acceptance Report - Success	Y	Y	Y	Y	Y	M	ACK
									2	Telecommand Acceptance Report - Failure	Y	Y	Y	Y	Y	M	ACK
									7	Telecommand Execution Completion Report - Success	Y	Y	Y	Y	Y	O	ACK
									8	Telecommand Execution Completion Report - Failure	Y	Y	Y	Y	Y	O	ACK
		Service 2: Device Command Distribution															

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
	1	Distribute On/Off Commands	N/A	Y	N/A	N/A	N/A	N/A									
	2	Distribute Register Load Commands	N/A	Y	N/A	N/A	N/A	N/A									
* direct decoder TCs	**3**	Distribute CPDU Commands	N/A	Y*	N/A	N/A	N/A	N/A									
		Service 3: Housekeeping Reporting															
	1	Clear and replace a Housekeeping Report Packet descriptor	N/A	Y	Y	N/A	N/A	N/A									
	3	Add to an already defined Housekeeping Report Packet descriptor	N/A	Y	Y	N/A	N/A	N/A									
	5	Enable Housekeeping Report Packet Generation	N/A	Y	Y	N/A	N/A	M									
	6	Disable Housekeeping Report Packet Generation	N/A	Y	Y	N/A	N/A	M									
* Only on Private TC request									**25**	Housekeeping Report Packet	N/A	Y	Y	Y	Y*	M	HK
	27	Modify Housekeeping Report Packet Generation Frequency.	N/A	Y	Y	N/A	N/A	N/A									
		Service 5: Events Reporting															
									1	Normal/Progress Report	N/A	Y	Y	Y	Y	M	EVENT
									2	Error/Anomaly Report - Warning	N/A	Y	Y	Y	Y	M	EVENT
									3	Error/Anomaly Report - Ground Action	N/A	Y	Y	Y	Y	O	EVENT
									4	Error/Anomaly Report - On-board Action	N/A	Y	Y	Y	Y	O	EVENT
	5	Read Critical Events Log	N/A	Y	N/A	N/A	N/A	N/A									
	7	Clean Critical Events Log	N/A	Y	N/A	N/A	N/A	N/A									

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
		Service 6: Memory Management															
	2	Load Memory using Absolute Addresses	Y	Y	Y	Y	Y	O									
	5	Dump Memory using Absolute Addresses	Y	Y	Y	Y	Y	O	**6**	Memory Dump using Absolute Addresses Report	Y	Y	Y	Y	Y	O	DUMP
	9	Check Memory using Absolute Addresses	Y	Y	Y	Y	Y	O	**10**	Memory Check using Absolute Addresses Report	Y	Y	Y	Y	Y	O	EVENT
		Service 7: OBCP Management															
	1	Start OBCP	N/A	Y	N/A	N/A	N/A	N/A									
	2	Stop OBCP	N/A	Y	N/A	N/A	N/A	N/A									
	3	Suspend OBCP	N/A	Y	N/A	N/A	N/A	N/A									
	4	Resume OBCP	N/A	Y	N/A	N/A	N/A	N/A									
	6	Communicate Parameters to an OBCP.	N/A	Y	N/A	N/A	N/A	N/A									
	10	Report list of OBCPs	N/A	Y	N/A	N/A	N/A	N/A	**11**	OBCPs List Report	N/A	Y	N/A	N/A	N/A	N/A	TABLE
		Service 8: Application Programs Management															
	1	Start Application Program	N/A	Y	Y	N/A	N/A	N/A									
	2	Stop Application Program	N/A	Y	Y	N/A	N/A	N/A									
	6	Communicate with an Application Program	N/A	Y	Y	N/A	N/A	N/A									
		Service 9: Time Synchronisation															

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
	1	Accept Time Update	N/A	Y	N/A	Y	Y	M									
	2	Send Time to user	N/A	Y	N/A	N/A	N/A	N/A									
	3	Stop Time update to user	N/A	Y	N/A	N/A	N/A	N/A									
		Service 10: Time Reference Management															
	1	Change Time Report Packet generation rate	N/A	Y	N/A	N/A	N/A	N/A									
									2	Time Report	N/A	Y	N/A	N/A	N/A	N/A	TIME
	3	Change On-Board Time	N/A	Y	N/A	N/A	N/A	N/A									
		Service 11: Mission Timeline Management															
	1	Enable Release of Selected Telecommands	N/A	Y	N/A	N/A	N/A	N/A									
	2	Disable Release of Selected Telecommands	N/A	Y	N/A	N/A	N/A	N/A									
	3	Reset Command Schedule	N/A	Y	N/A	N/A	N/A	N/A									
	4	Insert Telecommands in Command Schedule	N/A	Y	N/A	N/A	N/A	N/A									
	5	Delete Telecommands by Application Process ID and Sequence Count	N/A	Y	N/A	N/A	N/A	N/A									
	6	Delete Telecommands over Time Period	N/A	Y	N/A	N/A	N/A	N/A									
	8	Time-Shift Telecommands over Time Period	N/A	Y	N/A	N/A	N/A	N/A									
	9	Report Command Schedule in Detailed Form over Time Period	N/A	Y	N/A	N/A	N/A	N/A	**10**	Detailed Schedule Report	N/A	Y	N/A	N/A	N/A	N/A	TABLE
		Service 12: On-board Monitoring															
		Parameter Monitoring															

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
	1	Enable Monitoring of Parameters	N/A	Y	N/A	N/A	N/A	N/A									
	2	Disable Monitoring of Parameters	N/A	Y	N/A	N/A	N/A	N/A									
	4	Clear Parameter Monitoring List	N/A	Y	N/A	N/A	N/A	N/A									
	5	Add/Modify Parameters to Monitoring List	N/A	Y	N/A	N/A	N/A	N/A									
	6	Delete Parameters from Monitoring List	N/A	Y	N/A	N/A	N/A	N/A									
	8	Report Current Parameter Monitoring List	N/A	Y	N/A	N/A	N/A	N/A	**9**	Current Parameter Monitoring List Report	N/A	Y	N/A	N/A	N/A	N/A	TABLE
		Event Monitoring															
	10	Enable Recovery Action	N/A	Y	N/A	N/A	N/A	N/A									
	11	Disable Recovery Action	N/A	Y	N/A	N/A	N/A	N/A									
	14	Clear Event Monitoring List	N/A	Y	N/A	N/A	N/A	N/A									
	15	Add Events to Monitoring List	N/A	Y	N/A	N/A	N/A	N/A									
	16	Delete Events from Monitoring List	N/A	Y	N/A	N/A	N/A	N/A									
	18	Report Current Event Monitoring List	N/A	Y	N/A	N/A	N/A	N/A	**19**	Current Event Monitoring List Report	N/A	Y	N/A	N/A	N/A	N/A	TABLE
		Service 13: Large Data Transfer															
		Service 14: Packet Real-Time Downlink Control															
	1	Enable Downlink of Selected Packets by APID	N/A	Y	N/A	N/A	N/A	N/A									
	2	Disable Downlink of Selected Packets by APID	N/A	Y	N/A	N/A	N/A	N/A									
	3	Report Real-Time Downlink Routing Table	N/A	Y	N/A	N/A	N/A	N/A	**4**	Real-Time Downlink Routing Table Report	N/A	Y	N/A	N/A	N/A	N/A	TABLE

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
		Service 15: On-board Telemetry Storage and Retrieval															
	1	Start Storage of Packets in a store	N/A	Y	N/A	N/A	N/A	N/A									
	2	Stop Storage of Packets in a store	N/A	Y	N/A	N/A	N/A	N/A									
	3	Add APID to Packet Store Definition	N/A	Y	N/A	N/A	N/A	N/A									
	4	Remove APID from Packet Store Definition	N/A	Y	N/A	N/A	N/A	N/A									
	5	Report Packet Store Definition	N/A	Y	N/A	N/A	N/A	N/A	**6**	Packet Store Definition Report	N/A	Y	N/A	N/A	N/A	N/A	TABLE
	7	Downlink Packet Store Contents for Packet Range	N/A	N/A	N/A	N/A	Y	N/A									
	8	Stop Retrieval from a Packet Store	N/A	N/A	N/A	N/A	Y	N/A									
	9	Downlink Packet Store Contents for Time Period	N/A	N/A	N/A	N/A	Y	N/A									
	10	Delete Packet Stores Contents up to Specified Packet	N/A	N/A	N/A	N/A	Y	N/A									
	11	Delete Packet Stores Contents up to Specified Time	N/A	N/A	N/A	N/A	Y	N/A									
	12	Report Storage Catalogue	N/A	N/A	N/A	N/A	Y	N/A	**13**	Storage Catalogue Report	N/A	N/A	N/A	N/A	Y	N/A	TABLE
		Service 16: On-board Traffic Management															
	1	Define nominal/redundant branch for payload instrument transfer	N/A	Y	N/A	N/A	N/A	N/A									
	2	Enable/Disable TM polling from payload instrument	N/A	Y	N/A	N/A	N/A	N/A									
	3	Enable/Disable TC sending to payload instrument	N/A	Y	N/A	N/A	N/A	N/A									
		Service 17: Connection Test															
	1	Request Connection Test Response	Y	Y	Y	Y	Y	O	**2**	Connection Test Response Report	Y	Y	Y	Y	Y	O	EVENT

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
	3	Request Connection Test	N/A	Y	N/A	N/A	N/A	N/A									
		Service 18: Context Transfer (DMS <-> User)															
	1	Report Context	N/A	Y	O	N/A	TBD	O	**2**	Context Report	N/A	Y	O	N/A	TBD	O	CONTEXT
	3	Accept Context	N/A	Y	O	N/A	TBD	O									
		Service 19: Information Distribution (DMS -> User)															
	1	Initiate Information Distribution	N/A	Y	N/A	N/A	N/A	O									
	10 to 255	Information Distribution sub types 10 to 255	N/A	Y	N/A	N/A	N/A	O									
		Service 20: Science Data Transfer															
	1	Enable Science Report Packet Generation on RTU Link	N/A	N/A	N/A	N/A	N/A	O									
									3	Science Report on RTU Link	N/A	N/A	N/A	N/A	N/A	O	PRIVATE
	2	Disable Science Report Packet Generation on RTU Link	N/A	N/A	N/A	N/A	N/A	O									
	10	Enable Science Report Packet Generation on High Speed Link	N/A	N/A	N/A	N/A	N/A	O									
									13	Science Report on High Speed Link	N/A	N/A	N/A	N/A	N/A	O	PRIVATE
	11	Disable Science Report Packet Generation on High Speed Link	N/A	N/A	N/A	N/A	N/A	O	**12**	Report Science Data Generation Stopped at Packet Boundary	N/A	N/A	N/A	N/A	N/A	O	EVENT

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
		Service 128: Private Services Firmware															
	n	Firmware Private Telecommand n	Y	N/A	N/A	N/A	N/A	N/A	**n**	Firmware Private Telemetry n	Y	N/A	N/A	N/A	N/A	N/A	FUNC
		Service 129: Private Services (Spare)															
	n	Private Telecommand n	N/A	N/A	N/A	N/A	N/A	N/A	**n**	Private Telemetry n	N/A	N/A	N/A	N/A	N/A	N/A	FUNC
		Service 130 to 139: Private Services DMS & AOCMS software															
	n	DMS & AOCMS Private Telecommand n	N/A	Y	Y	N/A	N/A	N/A	**n**	DMS & AOCMS Private Telemetry n	N/A	Y	Y	N/A	N/A	N/A	FUNC
		Service 140 to 149: Private Services STR software															
	n	STR Private Telecommand n	N/A	N/A	N/A	Y	N/A	N/A	**n**	STR Private Telemetry n	N/A	N/A	N/A	Y	N/A	N/A	FUNC
		Service 150 to 159: Private Services - SPARE															
		Service 160 to 169: Private Services SSMM software															
	n	SSMM Private Telecommand n	N/A	N/A	N/A	N/A	Y	N/A	**n**	SSMM Private Telemetry n	N/A	N/A	N/A	N/A	Y	N/A	FUNC
		Service 170 to 191: Private Services (Spare)															
	n	Private Telecommand n	N/A	N/A	N/A	N/A	N/A	N/A	**n**	Private Telemetry n	N/A	N/A	N/A	N/A	N/A	N/A	FUNC

Comments/ Remarks	ST	Telecommand	FIRM	DMS	AOC	STR	SSMM	P/L	ST	Telemetry	FIRM	DMS	AOC	STR	SSMM	P/L	pkt cat
		Service 191 to 255: Private Services Payload															
	n	Payload Private Telecommand n	N/A	N/A	N/A	N/A	N/A	M	**n**	Payload Private Telemetry n	N/A	N/A	N/A	N/A	N/A	M	FUNC

Appendix 3 APPLICATION PROCESS ID ASSIGNMENT

The following table provides the global allocation of APIDs to the various users within the MARS EXPRESS Project (TBC).

The Application Process ID (APID) for MARS EXPRESS is structured into two fields:

The least significant **4-bits** within the APID form a field called «**Packet Category**». This field identifies different categories of TM packets, which the ground typically processes in different ways and for which a separate accounting is required to be kept. For telecommands this field should be set to decimal '12' (PRIVATE).

The most significant **7 bits** of the APID form a field called «**Process ID**». This field identifies in general terms the process generating the TM packet (or which the TC packet is addressed to). For example a unit on-board can be assigned many Process IDs and use them to define different packets of the same category from different processes running in the same unit.

The tables below show the proposed Process IDs and Packet Categories assignment. The TM/TC Packets Table in Appendix 1xxx maps the Packet Categories to Service Types (for TM packets).

Process ID (decimal)	**Example allocation**
0	**TIME**
1-10	DMS
11-20	AOCMS
21	FIRMWARE in SM of PM1
22	FIRMWARE in SM of PM2
23	FIRMWARE in SM of PM3
24	FIRMWARE in SM of PM4
25	SSMM
26	STR1
27	STR2
28	Spare
29	Spare
30	Firmware in Boot Load Mode
31	CPDU
32-40	Spare for Avionics
41-50	Platform (to be allocated)
51-60	Spare
61-65	ASPERA
66-70	HRSC
71-75	MARESS
76-80	MARSIS
81-85	OMEGA
86-90	PFS
91-95	Spare

Packet Category (decimal)	**meaning**
0	TIME
1	ACKNOWLEDGE
2	Spare
3	TABLE
4	HK
5	FUNCTIONAL CYCLIC (high frequency measurement)
6	FUNCTIONAL NON CYCLIC (ad-hoc measurement)
7	EVENT
8	Spare
9	DUMP
10	FILE TRANSFER
11	CONTEXT
12	PRIVATE (science)
13	spare
14	Reserved OCC/EGSE
15	IDLE

96-100	SPICAM
101-105	Beagle-2 (TBC)
106-110	VMC (TBC)
111-120	Spare
121-126	OCC/EGSE reserved
127	Idle

Please note these allocations are provisional until the design of all units is better defined.

For non packet units, the functions performed by the DMS software (packet handling) shall be assigned different AP IDs from functions performed for the non packet unit.

Appendix 4 THE CHECKSUM ALGORITHMS

A4.1 Cyclic Redundancy Code Specification

The Packet Error Control Field is a 16-bit field, which occupies the two trailing octets of a TC Packet.

The purpose of this field is to provide a capability for detecting errors which may have been introduced into the frame by the lower protocol layers during the transmission process and may have remained undetected.

The standard error detection encoding/decoding procedure, which is described in detail in the following paragraphs, produces a 16 bit Packet Check Sequence (PCS) which is placed in the Packet Error Control Field.

This code is intended only for error detection purpose and shall not be used for error correction.

The characteristics of the PCS are those of a cyclic redundancy code (CRC) and are generally expressed as follows:

a) The generator polynomial is $G(x) = X^{16} + X^{12} + X^5 + 1$

b) Both encoder and decoder are initialised to the "all-ones" state for each Packet.

c) PCS generation is performed over the entire Packet including the Packet Header less the final 16-bit PCS.

d) The code has the following capabilities when applied to an encoded block of less than 32768 bits (2^{15} bits) :

- All error sequences composed of an odd number of bit errors will be detected
- All error sequences containing two bit errors anywhere in the coded block will be detected
- If a random error sequence containing an even number of bit errors (greater than or equal to four) occurs within the block, the probability that the error will be undetected in approximately 2^{15} (or 3×10^{-5}).
- All single error bursts spanning 16 bits or less will be detected provided no other errors occur within the block.

For blocks longer than 4096 bits, the specified performance cannot be guaranteed.

A4.2 Encoding Procedure

The encoding procedure accepts an (n-16)-bit message and generates a systematic binary (n, n-16) block code by appending a 16-bit Packet Check Sequence (PCS) as the final 16 bits of the block. This PCS is inserted into the Packet Error Control Field. The equation for PCS is:

$$PCS = [X^{16}. M(X) + X^{(n-16)}. L(X)] \text{ MODULO } G(X)$$

Where

M (X) is the (n-16)-bit message to be encoded expressed as a polynomial with binary coefficients, n being the number of bits in theencoded message (i.e. the number of bits in the complete Packet).

L (X) is the pre-setting polynomial given by:

$$L(X) = S^{15}_{i=0} Xi \qquad \text{(all "1" polynomial of order 15)}$$

G (X) is the CCITT Recommendation V.41 generating polynomial given by:

$$G(X) = X^{16} + X^{12} + X^5 + 1$$

Where + is the modulo 2 addition operator (exclusive OR)

Note that the encoding procedure differs from that of a conventional cyclic block encoding operation in that the $X^{(n-16)}$. L (X) term has the effect of presenting the shift register to an all ones state (rather than a conventional all zeros state) prior to encoding.

A4.3 Decoding Procedure

The error detection syndrome, S (X) is given by

$$S(X) = (X^{16} . C^*(X) + X^n . L(X) \text{ MODULO } G(X)$$

Where C*(X) is the received block in pdynomial form.

S (X) is the syndrome polynomial which will be zero if no error has been detected.

A4.4 Verification of Compliance

The binary sequences defined in this section are provided to the designers of packet systems as samples for testing and verification of a specific CRC error detection implementation.

All data are given in hexadecimal notation. For a given field (data or CRC), the left most hexadecimal character contains the most significant bit (i.e. bit 0 of the CCSDS convention).

DATA	Packet Check Sequence (CRC)
00 00	1D 0F
00 00 00	CC 9C
AB CD EF 01	04 A2
14 56 F8 9A 00 01	7F D5

A4.5 Possible realisations of Packet Check Sequence Encoders/Decoders

CRC encoders and decoders can be implemented in hardware as well as in software. A possible H/W implementation of an encoder and decoder is described in **[AD-1]** and **[AD-2]**. A C-language version is provided in **[RD-3]**.

A4.6 XOR Rotate Algorithm

XOR rotate algorithm :

The following algorithm is applied for the checksum of TM(6,10) for a memory area between "StartAddr" and "EndAddr"

Init part :

Checksum = $F900_{hexa}$
Addr = StartAddr

Body part :

While Addr < (EndAddr + 1) **Loop**
Checksum = *Rotate_Left* (Checksum, 1) **Xor** *Contents* (Addr)
Addr = Addr + 1
End Loop

Where :

Rotate_Left (Checksum, 1) rotates the checksum 1 bit to the left
Contents (Addr) defines the value of the memory cell Addr
Checksum is a 16 bits val

Appendix 5 ACRONYMS AND GLOSSARY OF TERMS

A5.1 Acronyms

Acronym	Description
ACK	Acknowledgement
AD	Applicable Document
AIU	AOCMS Interface Unit
AOCMS	Attitude & Orbit Control and Measurement Subsystem
AOCS	Attitude & Orbit Control Subsystem
APID	Application Process Identifier
ASPERA	APERA-3 experiment (energetic neutral atoms analyser)
CDMU	Central Data Management Unit
CCSDS	Consultative Committee for Space Data Systems
CLCW	Command Link Control Word
CLTU	Command Link Transfer Unit
COP1	Command Operation Procedure number 1
CPDU	Command Pulse Distribution Unit
CRC	Cyclic Redundancy Code
CUC	CCSDS Unsegmented time Code
DEC	Decimal
DMS	Data Management System
DSN	Deep Space Network
EEPROM	Electrically Erasable PROM
EID	Event Identifier
EPC	Extended high Power Command
EPS	Electrical Power Subsystem
ESA	European Space Agency
FID	Function Identifier
FID	Failure Identifier
FIFO	First In First Out
FUNC	AOCMS sensors Functional measurement

Acronym	Description
HEX	Hexadecimal
HGA	High Gain Antenna
HK	Housekeeping
HL	High Limit
HPC	High Power Command
HRSC	High Resolution Stereo Camera
HS	High Speed link
ICD	Interface Control Document
ID	Identifier
ISO	International Standards Organisation
LGA	Low Gain Antenna
LL	Low Limit
LPC	Low Power Command
LSB	Least Significant Bit
MAP	Multiplexed Access Point
MARESS	MArs RElay Sub-System
MARSIS	MARSIS experiment (sub-surface sounding radar)
MEOIRD	MARS EXPRESS Operations Interface Requirements Document
MESDB	MARS EXPRESS Spacecraft Data Base
MEUM	MARS EXPRESS Users Manual
MID	Memory Identifier
MINT	Monitoring Interval
MOC	Mission Operations Centre
MSB	Most Significant Bit
MSSW	Mission Specific Software
MTL	Mission Time Line
N/A	Not Applicable
OBCP	On Board Control Procedure
OCF	Operational Control Field
OMEGA	Observatoire pour la Minéralogie, lEau, les Glaces et l'Activité
PB	Play Back
PCS	Packet Check Sequence

Acronym	Description
PFS	Planetary Fourier Spectrometer
PID	Process Identifier
PROM	Programmable Read Only Memory
PSS	Procedures, Specifications and Standards
PUS	Packet Utilisation Standard
RCS	Reaction Control Subsystem
RAM	Random Access Memory
RF	Radio Frequency
RL	Register Load
RLA	Register Load Address
ROM	Read Only Memory
RSE	Radio Science Experiment
RSS	Root Sum Square
RT	Real Time
RTU	Remote Terminal Unit
SASW	Standard Application Software
S/C	Space-Craft
SCET	Space-Craft Elapsed Time
SCL	Spacecraft Control Language
SDU	Service Data Unit
SGM	Safe-Guard Memory
SID	Structure Identifier
SOC	Science Operations Centre
SPICAM	SPectroscopic Investigation of the Characteristics of the Atmosphere of Mars
SSMM	Solid State Memory Mass
TBC	To Be Confirmed
TBD	To Be Defined
TBP	Time Broadcast Pulse
TBW	To Be Written
TC	Telecommand
TID	Task Identifier
TM	Telemetry

Acronym	Description
UTC	Universal Time Constant
VC	Virtual Channel

A5.2 Glossary of Terms

Application process	A continuous series of actions to bring about a result for a user. Such process may be on-board or on ground. Usually an application process can be associated with a subsystem or instrument. An application process can receive TC packets and/or generate TM packets.
Application data	Data destined to an on-board application process, encapsulated in a TC packet.
Application Process ID	An 11 bit address field. The APID of a TM packet identifies the application process which generated the packet. The APID of a TC packet identifies the application process which will receive the packet. An APID is unique across the system. The application process ID is divided into two fields Process ID and Packet Category
Channel	Physical input or output line(s).
(Functional) parameter	Variable that controls the result of a command, task or process.
FID	Function identifier, identifies a function of a task and defines the structure of the parameter field in the packet. The same FID may be used by different APIDs.
Packetised end user	On-board user which decodes TC packets and encodes TM packets. An packetised end user may have more than one application process.
MID	Memory identifier, identifies a memory within an application. The same MID may be used by different APIDs.
Non packetised end user	On-board user which does not decode TC packets or encode TM packets.
Parameter ID	Identifier that uniquely identifies a parameter across the system. The same PID may not be used by different APIDs.
Process	See application process.
Register	A set of binary memory cells, fixed by design, to which data can be written and/or data can be read from.
SID	Structure identifier, defines the structure of the parameter field in the packet. The same SID may be used by different APIDs.
Source Data	Data generated by an on-board application process, encapsulated in a TM packet.
TID	Task identifier, identifies a task within an application.The same TID may be used by different APIDs.
Task	A definite amount of actions to bring about a result for a user. One or more tasks may be active simultaneously within a process.

Appendix 6 PARAMETER TYPES AND STRUCTURES

A6.1 Introduction

This appendix defines the terminology to be used for any packet description referred to in section 5 or 6.

Each field in a telecommand or telemetry packet described in this document is designed to hold a parameter value. Each parameter field has a type, defining the set of values that can be assigned to the parameter. The MARS EXPRESS parameter types are defined below.

This appendix defines the physical encoding rules for each type, i.e. the permitted lengths of the parameter fields and the internal format used to encode values. This appendix does not define the conversion of data parameters into physical or engineering units or user messages.

When defining telecommand and telemetry packets only parameter types defined in this document shall be allowed.

A6.2 Encoding formats of parameter types

The parameter type defines the range of possible parameter values. A given parameter type can vary in format and length. Each combination of parameter type and encoding format has an associated parameter code, which defines the type and its physical encoding.

The parameter code shall be used whenever a definition of a parameter field is required. The parameter codes shall be applicable to both telecommand and telemetry data.

The parameter code PC, is defined as follows:

Parameter Type Code (PTC)	Parameter Format Code (PFC)
4 bits	4 bits

The parameter code is written as (PTC, PFC) in the tables below.

A6.3 Parameter type definitions

A6.3.1 Boolean

Parameter Type	PTC	PFC	Length	Value/Range
Boolean	1	0	1 bit	0 = false, 1 = true

A6.3.2 Enumerated Parameter

Enumerated parameters are parameters with distinct integer values only involved in logical operations (as opposed to numeric operations). The values that such a parameter can take are discrete and un-ordered. An error code is a typical example.

Parameter Type	PTC	PFC	Length
Enumerated Parameter	2	1	1 bit
	2	2	2 bits
	2	3	3 bits
	2	4	4 bits
	2	5	5 bits
	2	6	6 bits
	2	7	7 bits
	2	8	8 bits
	2	12	12 bits
	2	16	16 bits

A6.3.3 Unsigned Integer

Parameter Type	PTC	PFC	Length	Value/Range
Unsigned Integer	3	0	4 bits	{0...15}
	3	1	5 bits	{0...31}
	3	2	6 bits	{0...63}
	3	3	7 bits	{0...127}
	3	4	8 bits	{0...255}
	3	5	9 bits	{0...511}
	3	6	10 bits	{0...1023}
	3	7	11 bits	{0...2047}
	3	8	12 bits	{0...4095}
	3	9	13 bits	{0...8191}
	3	10	14 bits	{0...16383}
	3	11	15 bits	{0...32767}
	3	12	2 octets	{0...65536}
	3	13	3 octets	{0...2exp24 - 1}

Parameter Type	PTC	PFC	Length	Value/Range
	3	14	4 octets	{0...2exp32 - 1}

A6.3.4 Signed Integer

Parameter Type	PTC	PFC	Length	Value/Range
Signed Integer	4	0	4 bits	{-8...7}
	4	1	5 bits	{-16...15}
	4	2	6 bits	{-32...31}
	4	3	7 bits	{-64...63}
	4	4	8 bits	{-128...127}
	4	5	9 bits	{-256...255}
	4	6	10 bits	{-512...511}
	4	7	11 bits	{-1024...1023}
	4	8	12 bits	{-2048...2047}
	4	9	13 bits	{-4096...4095}
	4	10	14 bits	{-8192...8191}
	4	11	15 bits	{-16384...16383}
	4	12	2 octets	{-32768...32767}
	4	13	3 octets	{-2exp23...2exp23 - 1}
	4	14	4 octets	{-2exp31...2exp31 - 1}

A6.3.5 Real

Parameter Type	PTC	PFC	Length	Sign	Exponent	Fraction
Real	5	1	4 octets	bit 0	bit 1 - bit 8	bit 9 - bit 31
	5	2	4 octets	N/A	bit24 -bit31	bit 0 - bit 23

Two formats for real numbers shall be allowed:

PC(5,1): 32-bit single format according to ANSI/IEEE Std 754-1985.
(used also for internal parameter of DSP21020)

PC(5,2) 32-bit single format according to MIL-STD-1750-A used also for interface of DSP21020 with AIU/AOCMS-SW).

PC(5,1):

Fraction and exponent shall be interpreted as unsigned integers and their values inserted in the formulas given below to determine the value of the parameter.

Fraction is added to a binary 1 to generate the mantissa. To increase the precision of the real number the first bit of the mantissa is assumed to be '1'. This is possible since the mantissa should always be normalised, i.e. the mantissa is left shifted and the exponent decremented until a '1' is found in the most significant bit. The resulting range of the mantissa is $(1.0000...)_{DEC}$ to $(1.9999...)_{DEC}$.

To increase the range at the small end, fraction is added to a binary 0 as the binary fraction when the exponent equals zero.

The following rules shall apply to the interpretation of parameters of type real:

Exponent	Fraction	Value
255	<>0	not a defined number
255	0	(-1)^(sign) * infinity
< >255, <>0	any	(-1)^(sign) * 2^(exponent-127) * (1.fraction)
0	<>0	(-1)^(sign) * 2^(-126) * (0.fraction)
0	0	0

Examples:

1/ sign = 0
exponent = 127
fraction = 110 0000 0000 0000 0000 0000
value = $-1^0 * 2^{(127-127)} * (1.110\ 0000\ 0000\ 0000\ 0000\ 0000)_{BIN} = 1.75_{DEC}$

2/ sign = 0
exponent = 0
fraction = 110 0000 0000 0000 0000 0000
value = $-1^0 * 2^{(0-126)} * (0.110\ 0000\ 0000\ 0000\ 0000\ 0000)_{BIN} = 2^{-126} * 0.75_{DEC}$

PC(5,2)

The fraction and the mantissa are to be interpreted as two's complement numbers. The range is form ± 1.5*10^-39 to ± 1.7*10^-38.

A6.3.6 Time

Parameter Type	PTC	PFC	Length	Coarse	Fine	Format
Time	9	0	var.	N/A	N/A	CUC / CDS
	9	17	6 octets	4	2	CUC
Time in seconds	9	6	4 octets	4	0	CUC in seconds

The format is CCSDS Unsegmented Time Code, CUC, as defined in **[AD1]** without P-field.

Note: A packet end user that cannot provide in telemetry a time synchronised with SCET shall flag this by setting the MSB of the Time Field to "1". In this case the meaning of the rest of the field is user specific.

A6.3.7 Relative Time

Parameter Type	PTC	PFC	Length	Coarse	Fine	Format
Relative Time	10	17	6 octets	4	2	Relative CUC Signed integer
Relative Time in seconds	10	6	4 octets	4	0	Relative CUC in seconds signed integer

The format is CCSDS Unsegmented Time Code, CUC, as defined in **[AD1]** without P-field.

Appendix 7 STANDARD SPACECRAFT TIME SOURCE PACKET

The Standard Spacecraft Time Source Packet shall be used to transport the regular Spacecraft Elapsed Time samples to ground for time correlation with UTC by the ground segment during periods of ground contact. Its structure is defined in **[AD-1]** and it is shown in figure A7.1 below.

SOURCE PACKET HEADER (48 bits)							**PACKET DATA FIELD (64 bits)**		
PACKET ID				PACKET SEQUENCE CONTROL		PACKET LENGTH	S-FIELD	P-FIELD	T- FIELD
Version Number	Type	Data Field Header Flag	Application Process ID	Segment-ation Flags	Source Sequence Count				
3	1	1	11	2	14				
16				16		16	8	8	48

Figure A7.1 Standard Spacecraft Time Source Packet Fields

The time carried by the T-field of the packet shall relate to the instant of occurrence of the leading edge of the first bit of the attached synchronisation marker of the telemetry transfer frame of virtual channel "0" with a virtual channel frame count of "0".

The field contents of the Standard Spacecraft Time Source Packet header and data field are specified below:

Packet ID

Version Number :
The version number must be set 000_{BIN} [2].

Type :
The type must be set to zero.

Data Field Header Flag :
The data field header flag must be set to zero. Nodata field!

Application Process ID :
The Application process ID shall be set to all zeros.

[2] The specification in this document is consistent with [RD-4] and supersedes [AD-1] with respect to the Version Number.

Sequence Control

Segmentation [Grouping] Flags
The segmentation flags must be set to "11".

Source Sequence Count
The source sequence count of the time packet must be incremented by 1 whenever the source releases a packet. Ideally, this counter should never re-initialise, however, under no circumstances shall it "short-cycle" (i.e. have a discontinuity other than to a value zero).
The counter wraps around from 2^{14} -1 to zero.

Packet Length
The packet length field specifies the number of octets contained within the Packet Data Field. The number is an unsigned integer "C" where:

C = (Number of octets in Packet Data Field) - 1

In this case, the number of octets is eight (i.e. C=7).

It should be noted that the actual length of the entire Standard Spacecraft Time Source Packet, including the Packet Header, is 6 octets longer.

S-Field
Bits 0 through 3 are not used and must be set to zeros.
Bits 4 through 7 shall be set to a value corresponding to the generation frequency of a Standard time packet

Spacecraft Time Source Packet.

P-Field
Must be set to "00101110" to indicate that the following time format consists of 4 coarse time octets and 2 fine time octets.

T-Field
This field will contain the Spacecraft Elapsed Time, consistent with the CCSDS Unsegmented Time Code (CUC) format.

Bits 0 through 31 must contain the coarse Spacecraft Elapsed Time as an unsegmented binary count of seconds.

Bits 32 through 47 must contain the fine Spacecraft Elapsed Time as an unsegmented binary power of subseconds.

Appendix 8 IDLE PACKET STRUCTURE

The idle packet will be used to fill the telemetry transfer frame when a frame has to be transmitted and an insufficient number of source packets are available to complete the transfer frame. This may be the case when the source data rate is low compared to the frame period. Its structure is as shown in figure A8.1 below.

<table>
<tr><th colspan="6">SOURCE PACKET HEADER (48 bits)</th><th>PACKET DATA FIELD (VARIABLE)</th></tr>
<tr><td colspan="4">PACKET ID</td><td colspan="2">PACKET SEQUENCE CONTROL</td><td>PACKET LENGTH</td><td>FILLER PATTERN</td></tr>
<tr><td>Version Number</td><td>Type</td><td>Data Field Header Flag</td><td>Application Process ID</td><td>Segment-ation Flags</td><td>Source Sequence Count</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>3</td><td>1</td><td>1</td><td>11</td><td>2</td><td>14</td></tr>
<tr><td colspan="4">16</td><td colspan="2">16</td><td>16</td><td>Variable</td></tr>
</table>

Figure A8.1 Idle Packet Fields

The field contents of the Idle Packet header and data field are specified below:

Packet ID

Version Number
The version number must be set to 000_{BIN} [3].

Type
The type must be set to zero.

Data Field Header Flag
The data field header flag must be set to zero.

Application Process ID
The Application process ID must be set to all ones.

Sequence Control

Segmentation [Grouping] Flags
The segmentation flags must be set to "11".

Source Sequence Count
The source sequence count of the idle packet must be incremented by 1 whenever the source releases a packet. Ideally, this counter should never re-initialise, however, under no

[3] The specification in this document is consistent with [RD-4] and supersedes [AD-1] with respect to the Version Number.

circumstances shall it "short-cycle" (i.e. have a discontinuity other than to a value zero). The counter wraps around from 2^{14} -1 to zero.

Packet Length

The packet length field specifies the number of octets contained within the Packet Data Field. The number is an unsigned integer "C" where:

C = (Number of octets in Packet Data Field) - 1

The length of the packet may be freely chosen by the user. It should be noted that the actual length of the entire Idle Packet, including the Packet Header, is 6 octets longer.

Filler Pattern

The content of the Idle Packet datafield shall be random data.

Appendix 9 ON-BOARD DATA COMPRESSION

NOT APPLICABLE TO MARS EXPRESS

Appendix 10 LINK BUDGET FORMAT

LINK ID : P30SH1k
DATE : 01-08-97 09:18
ORBIT : MOP
STATION : Perth 30-m
ALTITUDE (1000km): 120000 (0.80 AU)
ELEVATION (deg): 10

TELECOMMAND BIT RATE (kb/sec) : 1.00
TELEMETRY BIT RATE (kb/sec) : 1.00
RS (1) or CONCAT. CODING (2) : 2
RANGING : No

BASIC UPLINK (1/2)

	NOM	ADV	FAV	MEAN	VAR	PDF
G/S TX POWER.....dBW	33.00	33.00	33.00	33.00	0.00	TRI
CIRCUIT LOSS.....dB	0.20	0.60	0.00	0.30	0.03	UNI
TX ANT GAIN.....dBi	54.30	53.70	54.60	54.15	0.07	UNI
G/S ANT TX AXIAL RAT..dB	0.50	1.00	0.00			
POINTING LOSS.....dB	0.10	0.12	0.00	0.06	0.00	UNI
EIRP G/S.....dBW	87.00	85.98	87.60	86.79	0.10	
FREQUENCY.....GHz	2.11	2.11	2.11	2.11		
SLANT RANGE.....1000*km	120005	120005	120005	120005		
PATH LOSS.....dB	260.51	260.51	260.51	260.51		
ATMOSPHERIC LOSS.....dB	0.20	0.25	0.10	0.18	0.00	GAU
IONOSPHERIC LOSS.....dB	0.00	0.00	0.00	0.00	0.00	GAU
COPOLAR ANT-GAINS(Y=1/N=0)?	1					
POLARISATION MISMATCH.dB	0.01	0.03	0.00	0.01	0.00	UNI
TOTAL PROPAG. LOSS....dB	260.72	260.78	260.61	260.70	0.00	
POW.-FLUX at S/C.dBm/m^2	-115.58	-116.60	-114.98	-115.79		
RX ANT GAIN.....dBi	29.00	29.00	29.00	29.00	0.00	TRI
POINTING LOSS (*)..dB	0.00	0.00	0.00	0.00	0.00	TRI
S/C ANT RX AXIAL RAT..dB	1.00	1.00	1.00			
ANTENNA NOISE TEMP.....K	60.00	60.00	60.00			
ANTENNA/FEED VSWR.....:1	1.00	1.00	1.00			
VSWR LOSS.....dB	0.00	0.00	0.00	0.00	0.00	TRI
CABLE PHYSICAL TEMP....K	290.00	330.00	240.00			
CABLE LOSS.....dB	0.00	0.00	0.00	0.00	0.00	UNI
CIRCUITS TEMPERATURE...K	290.00	330.00	240.00			
RFDU CIRCUIT LOSS.....dB	3.00	3.00	3.00	3.00	0.00	UNI
TOTAL CIRCUIT & CABLE LOSS.....dB	3.00	3.00	3.00			
DIPL. CIRCUIT LOSS....dB	0.00	0.00	0.00	0.00	0.00	UNI
RECEIVER NOISE FIGURE.dB	2.50	2.50	2.00			
REF SYSTEM TEMP (**).K	515.70	515.70	459.62			
RX SYSTEM TEMP (***)..K	400.43	420.38	319.41			
RX SYSTEM TEMP (***)dBK	26.03	26.24	25.04	25.64	0.04	GAU
S/C RX G/T.....dB/K	-0.03	-0.24	0.96			
RX POWER (***).....dBm	-117.72	-118.80	-117.01	-117.91	0.10	
THEOR CAR THRSH(**)dBm	-148.47					
CAR ACQ THRSH (**).dBm	-150.00	-150.00	-150.00			
THEOR TC THRSH(**).dBm	-126.26					
TC RX THRSH (**).dBm	-147.00	-147.00	-147.00			
REQ RX POWER (***).dBm	-147.00	-147.00	-147.00	-147.00		
RX POWER MARGIN.....dB	29.28	28.20	29.99	29.09	0.10	
MEAN-3*SIGMA.....dB	28.15					
MARGIN - w.c. RSS..dB	28.56					
RX S/No.....dBHz	54.85	53.56	56.55	55.05	0.14	

*) POINTING LOSS may be included in RX ANTENNA GAIN.

**) Reference at Diplexer/RFDU Interface, 290 K input noise temperature.

***) Reference at Diplexer/RFDU Interface.

P30SH1k **PAGE 2/4**

LINK ID :
DATE : 01-08-97 09:18
ORBIT : MOP ALTITUDE (1000km): 120000
STATION : Perth 30-m ELEVATION (deg): 10

TELECOMMAND BIT RATE (kb/sec) : 1.000 RANGING : No
TELEMETRY BIT RATE (kb/sec) : 1.00 with CONCAT. CODING : Yes

UPLINK (2/2)

	NOM	ADV	FAV	MEAN	VAR	PDF
RX S/No.....dBHz	54.85	53.56	56.55	55.05	*0.14*	
MODULATION INDICES (*)						
TELECOMMAND.....rad pk	*1.00*	1.05	0.95	(sine)		
RANGING (RNG).....rad pk	*0.00*	0.00	0.00			
RNG, sine(1) or sqre(2):	*1*					
CARRIER RECOVERY						
CARRIER SUPPRESSION...dB	2.32	2.58	2.08	2.33	0.01	TRI
BPL (1), non-coh AGC (2)						
or coherent AGC (3) ?	*3*					
AGC INPUT BNDWDTH..kHz	*3.00*	3.30	2.70			
PLL-BDW 2*Blo (**)...Hz	*20.00*	24.00	16.00			
THRSHD C/N in 2*Blo...dB	*10.00*	(common Definition)				
PLL DAMPING (**).....	*0.71*	0.78	0.64			
Effect PLL DAMPING.....	0.71	0.78	0.64			
Effect PLL-BDW 2*Bl...Hz	20.00	24.00	16.00			
Max ACQ SWEEP RATE.kHz/s	0.03	0.02	0.04	0.03		
Effect PLL-BDW 2*Bl.dBHz	13.01	13.80	12.04	12.95	0.13	TRI
BP-LIMT SYSTEM LOSS...dB	0.00	0.00	0.00	0.00	0.00	TRI
IMPLEMENTATION LOSS...dB	*1.50*	*2.00*	*1.00*	1.50	0.04	TRI
REQ C/N in PLL-BDW....dB	*10.00*	10.00	10.00	10.00		
CARRIER MARGIN.....dB	28.02	25.17	31.43	28.27	0.32	
MEAN-3*SIGMA.....dB	26.57					
MARGIN - w.c. RSS..dB	26.79					
TELECOMMAND RECOVERY						
MODULATION LOSS.....dB	4.12	4.45	3.81	4.13	0.02	TRI
IMPLMENT LOSS (***)..dB	*1.50*	*2.00*	*1.00*	1.50	0.04	TRI
BIT RATE.....kb/s	1.000	1.000	1.000			
BIT RATE.....dBHz	30.00	30.00	30.00	30.00		
REQ Eb/No (****)..dB	*9.60*	9.60	9.60	9.60		
TELECOMMAND MARGIN....dB	9.63	7.50	12.14	9.83	0.20	
MEAN-3*SIGMA.....dB	8.49					
MARGIN - w.c. RSS..dB	8.67					
TRANSPD RANGING-CHANNEL						
TC in RNG-Vdbd ? Y=1/N=0	*0*					
TONE MODULATION LOSS..dB	No RG	No RG	No RG			
RNG NOISE BNDWIDTH...kHz	*3000.00*	3300.00	2700.00			
RNG NOISE BNDWIDTH..dBHz	64.77	65.19	64.31			
IMPLEMENTATION LOSS...dB	*1.46*	*1.60*	*1.20*			
S(Tone)/N in Videobd..dB	No RG	No RG	No RG			
S(TC)/N in RG-Videobd.dB	N.A.	N.A.	N.A.			

*) ADV and FAV Cases refer HERE to the Carrier Recovery !
Variation of the Preset Indices is +/- 5 % .
**) Reference at Carrier Acquisition Threshold.
***) Demod Loss until TC Video Output; TC Decoder Loss not included.
****) Includes TC Decoder Implementation Losses.

LINK ID : P30SH1k **PAGE 3/4**

DATE : 01-08-97 09:18

ORBIT : MOP ALTITUDE (1000km): 120000

STATION : Perth 30-m ELEVATION (deg): 10

TELECOMMAND BIT RATE (kb/sec) : 1.00 RANGING : No

TELEMETRY BIT RATE (kb/sec) : 1.00 with CONCAT. CODING : Yes

BASIC DOWNLINK (1/2)

	NOM	ADV	FAV	MEAN	VAR	PDF
S/C TX POWER.....dBW	*6.90*	*6.90*	*6.90*	6.90	0.00	TRI
DIPL. CIRCUIT LOSS....dB	*0.00*	*0.00*	*0.00*			
RFDU CIRCUIT LOSS.....dB	*3.00*	*3.00*	*3.00*			
CABLE LOSS.....dB	*0.00*	*0.00*	*0.00*			
VSWR, overall.....:1	*1.00*	*1.00*	*1.00*			
VSWR LOSSES.....dB	0.00	0.00	0.00			
TOTAL LOSS.....dB	3.00	3.00	3.00	3.00	0.00	UNI
S/C TX ANT GAIN.....dBi	*29.00*	*28.50*	*29.50*	29.00	0.04	TRI
S/C ANT TX AXIAL RAT..dB	*1.00*	*1.00*	*1.00*			
POINTING LOSS (*)..dB	*0.00*	*0.00*	*0.00*	0.00	0.00	TRI
EIRP S/C.....dBW	32.90	32.40	33.40	32.90	*0.04*	
FREQUENCY.....GHz	2.29	2.29	2.29	2.29		
SLANT RANGE.....1000*km	120005	120005	120005	120005		
PATH LOSS.....dB	261.22	261.22	261.22	261.22		
ATMOSPHERIC LOSS.....dB	0.20	0.25	0.20	0.23	0.00	GAU
IONOSPHERIC LOSS.....dB	*0.00*	*0.00*	*0.00*	0.00	0.00	GAU
COPOLAR ANT-GAINS(Y=1/N=0)?	*1*					
POLARISATION MISMATCH.dB	0.01	0.03	0.00	0.01	0.00	UNI
TOTAL PROPAG. LOSS....dB	261.44	261.50	261.42	261.46	*0.00*	
FLUX at G/S.....dBm/m^2	-169.68	-170.18	-169.18	-169.68	*0.04*	
POWER FLUX DENS..dBW/m^2	-201.78	-200.78	-202.90	(in 4 kHz)		
MAXIM FLUX DENS..dBW/m^2	-151.50	-151.50	-151.50	(S- or X-Bnd)		
FLUX MARGIN.....dB	50.28	49.28	51.40			
G/S RX ANT GAIN.....dBi	56.00	55.50	56.00	55.75	0.02	UNI
POINTING LOSS.....dB	*0.10*	*0.20*	*0.00*	0.10	0.00	UNI
G/S ANT RX AXIAL RAT..dB	*0.50*	*1.00*	*0.00*			
SYSTEM NOISE TEMP....dBK	18.50	18.50	18.00	18.25	0.01	GAU
RX G/T.....dB/K	37.50	37.00	38.00	37.50	*0.03*	
RX S/No.....dBHz	37.46	36.30	38.58	37.44	*0.07*	
S/N in RANGING BANDWIDTH						
S(Tone)/N in Videobd..dB	No RG	No RG	No RG			
S(TC)/N in RG-Videobd.dB	N.A.	N.A.	N.A.			
MODULATION INDICES (**)						
TELEMETRY (TM)....rad pk	*1.00*	1.10	0.90			
TM, sine(1) or sqre(2) :	*2*					
RANGING (sine)....rad pk	*0.00*	0.00	0.00			
RANG. TONE effec..rad pk	0.00	0.00	0.00			
TC in RG-Videobd..rad pk	0.00	0.00	0.00			
NOISE INDEX.....	0.00	0.00	0.00			

*) POINTING LOSS may be included in TX ANTENNA GAIN.

**) ADV and FAV Cases refer HERE to the Carrier Recovery !

Variation of the Preset Indices is +/- 10 % .

LINK ID : P30SH1k **PAGE 4/4**

DATE : 01-08-97 09:18

ORBIT : MOP ALTITUDE (1000km): 120000

STATION : Perth 30-m ELEVATION (deg): 10

TELECOMMAND BIT RATE (kb/sec) : 1.00 RANGING : No

TELEMETRY BIT RATE (kb/sec) : 1.00 with CONCAT. CODING : Yes

DOWNLINK (2/2)

	NOM	ADV	FAV	MEAN	VAR	PDF
RX S/No.....dBHz	37.46	36.30	38.58	37.44	*0.07*	
CARRIER RECOVERY						
CARRIER SUPPRESSION...dB	5.35	6.87	4.13	5.45	0.31	TRI
PLL BANDWIDTH 2*Bl...Hz	*10.00*	12.00	8.00			
PLL BANDWIDTH.....dBHz	10.00	10.79	9.03	9.94	0.13	TRI
REQ LOOP S/N.....dB	*17.00*	17.00	17.00	17.00		
CARRIER MARGIN.....dB	5.12	1.64	8.42	5.05	0.52	
MEAN-3*SIGMA.....dB	2.89					
MARGIN - w.c. RSS..dB	3.26					
TELEMETRY RECOVERY						
TLM MODULATION LOSS...dB	1.50	2.12	1.00	1.54	0.05	TRI
DEMODULATOR TECH LOSS.dB	*0.40*	*0.50*	*0.30*	0.40	0.00	TRI
BIT RATE.....kb/s	1.00	1.00	1.00			
BIT RATE.....dBHz	30.00	30.00	30.00	30.00		
CONCAT CODING GAIN(*).dB	*9.70*	9.70	9.70			
CODING RATE 1/R.....	2.29					
REQ Eb/No (PFL=1.E-5).dB	*2.80*	2.80	2.80	2.80		
TELEMETRY MARGIN.....dB	2.76	0.88	4.48	2.70	0.13	
MEAN-3*SIGMA.....dB	1.63					
MARGIN - w.c. RSS..dB	1.81					
TONE RECOVERY						
TONE MODULATION LOSS..dB	No RG	No RG	No RG	No RG		
IMPLEMENTATION LOSS...dB	0.00	0.00	0.00	0.00		
REQ S(Tone)/N.....dB	*19.00*	19.00	19.00	19.00		
MAX REQ LOOP-BDW(**).mHz	No RG	No RG	No RG	No RG		
COMB. CARR. JITTER (***)						
RX TRSPD-PLL JITT...deg	0.51	0.71	0.34	0.49		
TRANSMT CARR. JITT...deg	2.00	*3.00*	*1.00*	2.00		
JITT BDW 2*B (****)...Hz	*5.00*	*10.00*	*3.00*	6.50		
RX COMBD CARR JITT...deg	3.31	5.04	2.21	3.53		

*) PFL=Probability of Frame Loss. Transfer Frame Length is FS=1275 Octets, and Interleaving Depth is I=5.

**) The required MINIMUM Loop-Bandwith supported by MPTS is 1.25 mHz; the MAXIMUM Loop-Bandwidth (two-sided) is 1880 mHz.

***) Coherent transponder mode assumed for RX COMBD CARR JITTer at G/S.

****) 2*B is the bandwidth of the jitter from the TX chain or a HPA.

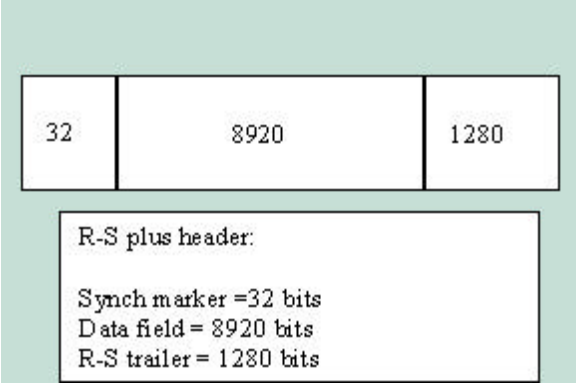
END of *P30SH1k*

Appendix 11 TELEMETRY BIT/SYMBOL RATE DEFINITION

The on-board functions that concur to the generation of the transmitted telemetry frame are pictorially depicted in fig. A11.1 below.

A11.1 Concatenated encoding

Frame structure before convolutional encoding:



Defining: fs = data rate at convolutional encoder input
fb = information bit rate

yields:

$$f_s / f_b = (32 + 8920 + 1280) / 8920 = 10232 / 8920 \cong 1.147085$$

Example: fs=32.768 kb/s corresponds to an information rate fb=28.56632 kb/s

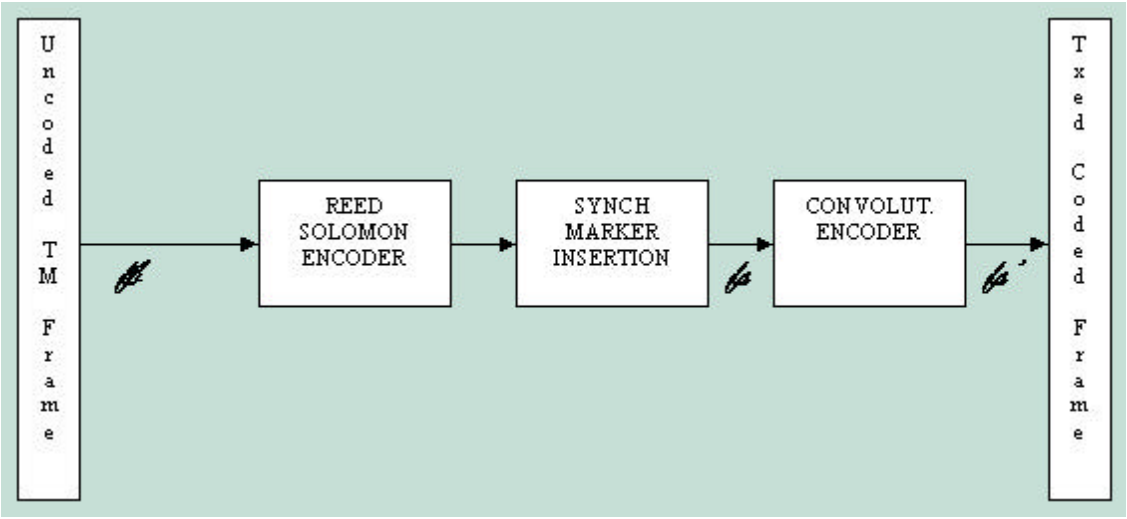


Fig. A11.1 – On-board Coded Frame Generation Scheme

Frame structure after convolutional encoding:

The structure is the same as before. However, the rate ½ convolutional encoder doubles every bit. Therefore, the frame length will be twice as long or 20464 symbols.

Moreover, what counts is the symbol rate at the modulator input or at the convolutional encoder output. For the standard rate ½ code, this is given by:

$$f_{s'} / f_b = 2\ f_s / f_b = 2 * 10232 / 8920 \cong 2.29417$$

where fs'is the transmitted symbol rate.

Example: the information rate fb=28.56632 kb/s above given corresponds to a transmitted symbol rate fs≒65.536 ks/s.

A11.2 Turbo encoding

NOT APPLICABLE TO MARS EXPRESS

Appendix 12 LIST OF POINTS KNOWN AS OPEN IN THIS ISSUE

The following list is not a list of formal actions (see Minutes of Meetings) but an overview of the document actual status. This is intended to help the reader in assessing and the custodian in maintaining this large document (through formal DCR process).

Open first in Issue	Section	Description	Status (20-Dec-99)
1.2	ALL	Packet / Frame definition of Beagle operations and other landers.	OPEN
2.0	ALL	Is the transponder a packet end-user (as indicated at SWRR); if yes, impact on SGICD.	OPEN
2.0	2.1.4	Exact subcarrier frequency (to 1Hz accuracy)	→ OPEN: MMT to provide value
1.1	2.1.5	The 65ksps TM rate (and above) has to be SP-L modulated; cannot be on sub-carrier for transmission (only for ground testing on Rosetta)	→ OPEN: MMS to check if this raises a commonality problem with Rosetta (testing?)
2.0	2.1.5	Is concatenated encoding supported above 64 kbps (or 52 kbps)? SGICD requires concatenated encoding for all rates.	→ OPEN: MMS to check whether there are no HW limitations due to Rosetta
1.1	2.1.5	Reduce the available "low" TM data rates to a smaller set including emergency cases (like: 16, 8, 4, 2, 0.5 kbps), in particular to reduce testing	→ ESOC to investigate. To be agreed with Matra. Also check with Rosetta
2.0	2.1.5	In view of the Safe Mode, is the information rate 4.6 bps also possible (mini symbol rate at ground station is 10 sps, TBC)	→ ESOC to investigate. Also to be checked with Matra (TFG capability).
1.2	2.1.5	Are all the 10 high bit rates proposed feasible and acceptable? Should the TM bit rates proportional to 32 / 7 be included in the high part of the range (to optimise data return)?	→ OPEN. Impact on test
1.0	2.2.3	Ranging signal definition: Values in SP/L mode TBD (Simulations to be done for higher rates when defined)	→ ESOC to update (EV).
1.1	2.2.5	TC at 500 bps also (MMS Design Report). Check whether all the Rosetta inherited values are needed for MEX.	→ ESOC to check with Matra
2.0	3.2	The required operation of AD and BD services in parallel within COP-1 can	→ Rosetta project to provide value (100 ms?) for minimum

Open first in Issue	Section	Description	Status (20-Dec-99)
		only be performed with interleaving with deadband /TC overwrite problem)	interval between AD and BD (to be added by MCS)
2.0	4.1	Some Spacecraft Uplink/Downlink parameters are slightly different/less favourable than in MEX-MMT-TN-0466 (Link budgets) Issue 1, Oct-99 (HGA S-Band uplink gain reduced by 0.5 dB, HGA X-Band downlink gain reduced by 0.4 dB).	→ MMT to justify / update link budgets.
2.0	4.2.1	Kourou Axial Ratio 1.25, SC is 1.5	→ MMT to check
1.0	4.2.5, 4.2.6.3	Characteristics and configuration of Sardinia Ground Station to be completed	→ ASI to provide missing info
2.0	4.3.1	TM frame error rate should be 10^{-5} for high symbol rates(starting at 65536 ks/s) (and stay 10^{-4} for the low symbol rates comparable to Rosetta ones)	→ To be discussed/implemented with MMT (impact on AIV)
1.0	4.3.2	Ground Stations usage	→ ESOC to update , based on various factors, in particular: - SRT availability - Kourou X-Band uplink availability - Design critical phases (MOI) with ESA stations only
1.1	4.3.3	MMS Baseline for LEOP = full coverage. Kourou and Perth not enough.	→ ESA to confirm with available stations (DSN 34m).
1.0	4.3.3	Link budget for maximum distances	→ Confirmation by MMS needed
1.2	4.3.3	X-Band uplink on ESA/15m (TBC) and SRT	→ ESOC to update
1.0	4.4	RF suitcase specification in TBD document	→ ESA to provide Spec and Usage Plan shared with Rosetta
1.1	A2.13	Service 13 (File Transfer) completely TBD (compatibility with DSS SSMM)	→ Pending investigation results (MMS, ESA) on "copy" function
1.1	A2.15	Service 15 (On-Board Storage and Retrieval) major update ROS DCR #9) compatible with DSS SSMM?	→ Pending investigation results (MMS, ESA) on "copy" function
2.0	A2.16, A2.21, A3	VMC to be considered or not in SGICD?	→ MEX Project to confirm
2.0	A2.22	Should Service 19 (Info Distribution) be	→ To be discussed ESA/MMS

Open first in Issue	Section	Description	Status (20-Dec-99)
		made mandatory for the instruments which actually require info from DMS DataPool (ASPERA, PFS, HRSC)?	
1.1	A10	Appendix 10: Link budget format to be changed to be aligned on Rosetta	→ ESOC to include Rosetta DCR #10
1.0	2.1.1	Request for allocation of Downlink freq. (S/X)	CLOSED
1.1	2.1.1	Include Downlink frequency values for both USO and nominal mode (tolerance due to internal USO archi.)	CLOSED
1.0	2.1.2,4,5,6	Use of turbo-coding	CLOSED
1.0	2.1.5	High symbol / bit rates incomplete	CLOSED
1.0	2.2.1	Usage of X-Band uplink	CLOSED – Now baseline (sep-99)
1.0	2.2.1	Request for allocation of Uplink frequencies (S/X)	CLOSED
1.0	4.1	Spacecraft Uplink/Downlink parameters to be updated for the MARS EXPRESS Platform (as per PDR level)	CLOSED
1.1	4.3.3	Which bit rate is supported by Perth at maximum MEX distance? Assumption from Spacecraft Design Report (May-99, Fig 12.3/A) was 32768 bps data rate (28566 bps info rate). 39 kbps announced in SDR Oct-99 Issue	CLOSED - PDR confirmed 28566 bps info rate correct
1.0	5.2.1.4	Use of VC2	CLOSED – Rejected. Impact on SC not acceptable
1.0	A 2.1-21	Several TC/TM detailed points TBC or TBD	CLOSED Normal work (running action)
1.1	A2.1	The parameter values for TM(1,2) (payload EIDs and FIDs) have to be adapted to MEX payload	CLOSED
1.0	A2.13, A2.22	Applicability of Large Data Transfer TM/TC (Service 13) to SSMM. Compatibility with Rosetta	CLOSED by MMS "SSMM SW and TC/TM ICD" made applicable to Dornier SSMM
1.1	A2.16	The parameter values for TC(16,1) (payload Ids) have to be adapted to MEX payload	CLOSED
1.0	A2.18, A2.22	Applicability of Context Transfer DMS <-> User TM/TC (Service 18) to SSMM	CLOSED – Easier to keep it in DMS SW than remove it, whether it is used or not
1.1	A2.19, A2.22	Applicability of Information Distribution	CLOSED – Easier to keep it in DMS SW than remove it, whether it is

Open first in Issue	Section	Description	Status (20-Dec-99)
		DMS <-> User TM/TC (Service 19)	used or not
1.1	A2.21	Allocation of Private Services to Payload	CLOSED
1.0	A 9	Compression algorithms	CLOSED – No compression at system level

For traceability the Closed points are kept at the bottom of the above table (greyed area).