Main Unit Software User's Guide

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CHANGE RECORD

Version		Date	Changed Paragraphs	Remarks
Issue	Rev			
1	0	2004-05-05	All	New document
1	1	2005-02-03	3.5.3 and 9.3.4.2 (TOF mode integration time defined wrong in both cases)	

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ACRONYMS AND DEFINITIONS

EEPROM	Electrically Erasable Programmable Read-Only Memory
HK	Housekeeping
IMA	Ion Mass Analyser
MCP	Microchannel plate
MU	Main Unit
NPD	Neutral Particle Detector
NPI	Neutral Particle Imager
PROM	Programmable Read-Only Memory
S/C	Spacecraft
SGICD	Mars Express Space / Ground Interface Control Document, Issue 2
SW, S/W	Software
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TC	Telecommand
TM	Telemetry

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1 GENERAL

1.1 Software in general

ASPERA-4 Main Unit software is responsible for operating Main Unit according to the telecommands. It will, depending on its mode and received telecommands, produce telemetry. It has also a small server for communications with IMA. This server converts telecommands form spacecraft to form known by IMA. It also convert telemetry sent by IMA to a form known by the spacecraft.

The software is run on a MIL-STD-1750 type microprocessor and is written in C (using POSIX threads) and partly in assembler. Compilers used are m1750-gcc version 1.4.3b2 by XGC Software. Package includes also version gas (gnu assembler) for MIL-STD-1750.

Software described in this Users Guide is the version R-4.8.0, in other words Aspera-4/VenusExpress version of the software.

1.2 Startup procedure

When the experiment boot it will perform a short self-check. If an anomaly is detected (like watchdog reset), the Main Unit will inform the s/c with an event report packet at the end of the boot process. After a short self-check, the s/w will start basic services (TM, limited TC, HK).**.** At this point an event (with eid=40001) is nominally sent. User must next idetify how to proceed by sending command 'select boot mode' to inform s/w from there on to stay at safe mode or to continue with default boot module. If this command is not sent for 17 hours S/W tries to load so called PROM module and executes that. Prom module is module providing MU housekeeping and full IMA services (except memory services of tc type 6). All MU services applicable for safe mode are also available in this mode.

If the default boot module is choosed, s/w can't be loaded from PROMs. It will instead try to load a replacement from a module in EEPROM, starting from address 0x10000 or higher. If the module can't be loaded from EEPROM or ROM, the experiment will enter safe mode (actually stay in safe mode). If **valid** module is found it will be loaded and started. The end status of this process is sent as an event.

If the s/w was loaded successfully, an event report will be generated to show that the experiment has booted properly. Pending error messages from the boot process will be sent.

S/W will verify wether the boot process isrunned due the watchdog reset or power-on. In case of watchdog reset an event is generated (40004).

1.3 Shutdown procedure

There aren't any strict s/w requirements for shutdown. Only after Patch EEPROM command it's recommended to wait long enough to receive an event reporting about successful EEPROM programming. This is to ensure that EEPROM does have valid content.

1.4 On commands

1.4.1 General

One fundamental aspect of the ASPERA-44 Main Unit is the way it uses commands (both telecommands and internal commands). Telecommands can be classified in many ways, but most fundamental is division to direct and indirect telecommands. Direct commands are command with type

255 or under 193. These commands are executed immediately after they have been detected in telecommand input buffer. Indirect commands are forwarded (after verifying command structure) to a specific process, command handler for later execution. Telecommands TC(192,21) and TC(193,11) fall into both categories. If s/w is in safe mode (or some broken state) these commands are used as direct commands. However, in normal situation these are treated as indirect. Indirect commands are handled via a specific `telecommand` table 'Telecommand table' is table that specifies most of the telecommands and most of the restrictions of . It contains also information about functions to be called when an indirect command is found. Due to this table it's relatively easy to change the way some command behave without compiling and reprogramming all of the s/w. It is also important to note that indirect commands, i e commands found only in telecommand table, are not available in safe mode.

Further division is made to classify commands as safe and hazardous. Hazardous commands must be followed immediately by TC(191,255) containing sequence count of hazardous command. Hazardous commands can't be run from macros.

1.4.2 On acknowledgments

The ASPERA-4 MU provides only telecommand acceptance acknowledgment for itself. For IMA, acknowledgments are provided by using execution acknowledgments. When an IMA related telecommand is found, the Main Unit will send an acceptance acknowledgment to the s/w (if acknowledgement is requested in the telecomamnd headers) and then it forwards the command to IMA. If execution acknowledgment is - requested in the telcoomand headers (applicable only for IMA) IMA will send an acknowledgment to the Main Unit which is waiting for that. This will then be forwarded to the s/c. Although this process is more acceptance than execution type of acknowledgment, it has to be used. Due to the acceptance acknowledgment time-out criteria (20s) and the 32-second acquisition period of IMA, it is not possible to have acceptance acknowledgments on IMA.

1.4.3 On error conditions

Error conditions are reported as event packets. If the error is such that automatic recovery process in the MU s/w cannot be executed, the software will shut down erroneous services. S/w won't enter safe mode unless it's absolutely necessary.

2 USING IMA

2.1 General

IMA commands (type 194 and 195, and memory management sevice 6 for PID 62) are first received in MU. MU convert commands to valid IEEE1355 link packets and then send these to IMA. There is separate command queues for MU and IMA and MU specific commands are executed simulataneosly with command transmission to IMA. Therefore, if for some reason IMA fails to receive command at all MU can be commanded withourt furher problems. The command acknowledgments scheme is explained in chapter 1.4.2.

2.2 IMA Server

There is separate serverfor IMA. It works in parallel to other parts of the software and does not require any specific modes on MU. Acquisition period of 16 sec and is independent of MU modes. Also, TM sent by IMA is reformatted (to standard ESA packets) in parallel with other activities in MU. IMA command sent to MU will be passed to IMA server so that other MU commands can be executed before IMA command is really transmitted to IMA. To allow parallel TM and TC handling for IMA and MU there is a buffer for both IMA TC and TM.

3 TELECOMMANDS

3.1 General

The general structure of telecommands is defined in SGICD.

3.2 Field descriptions

Field name	*Form*	*Description*
Parameter	=X	Parameter is constant with value X
	X => Y	Parameter can vary in range from X to Y
	(X) * n	X is repeated n times

Parameters are listed in the same order that they appear in the telecommand or telemetry packet so that first parameter to be sent is listed first.

Some terminology: Immediate response means immediate answer for the telecommand, like event reporting about success of the command. Related effect is effect that can be seen in telemetry, but it is not not immediate answer for the command. Exapmles of this are starting of generation of some packet type, changed reference field in housekeeping packet or change in monitor value in hoousekeeping packet.

NOTE: Related effect is often something that can't be seen at all in some cicumstances. For example, changing NPI bias voltage can't be seen in hk or science data packets if these are not generated at all.

3.3 Telecommand set Part I - commands defined in SGICD

3.3.1 TC(3,5) Enable HK Packet generation

Generic description			
Acronym		aspmHKEnable	
Type **Subtype** **16 bit parameters**	3 5 1	**PID** **Packet Category**	61 12
General description			
Description **Note**		Enable HK generation in ASPERA-4 Main Unit Only housekeeping packet generation of Main Unit can be switched on by this TC	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	2	=0	
Response Immediate response Related effect		 Generation of MU HK report packet TM(3,25) starts	

3.3.2 TC(3,6) Disable HK Packet generation

Generic description			
Acronym		aspmHKDisable	
Type	3	**PID**	61
Subtype	6	**Packet Category**	12
16 bit parameters	1		
General description			
Description		Disable HK generation in ASPERA-4 Main Unit	
Note		Only housekeeping packet generation of Main Unit can be switched off by this TC	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	2	0	
Response			
Immediate response			
Related effect		Generation of MU HK report packet TM(3,25) stops	

3.3.3 TC(6,2) Load memory using absolute addresses

Generic description				
Acronym			aspmMEMLoad	
Type	6		**PID**	61
Subtype	2		**Packet Category**	12
16 bit parameters	varies			
General description				
Description			Load memory to an absolute address	
Note			Any patch to be loaded to EEPROM must be loaded to mass memory. It can be transferred to EEPROM by TC (193,10) which is available only in safe mode.	
Parameter description				
Name		***Size (bytes)***	***Value***	***Note***
Memory id		1	0x80 => 0x83	0x80: N/A 0x81: RAM 0x82: N / A 0x83: MASSMEMORY
Number of blocks (=nb)		1	1=>	Number of blocks to load
Data block (repeated nb times)	Address	4	0 => 0x7FFFF	Address of first word in block
	Length of block (=lb)	2	1 => 0xffff	Number of words in this block
	Data	2*lb	(1=> 0xffff) * lb	lb times data words
Response				
Immediate response				
Related effect				

3.3.4 TC(6,5) Dump memory using absolute addresses

Generic description			
Acronym		AspmMEMDump	
Type **Subtype** **16 bit parameters**	6 5 varies	**PID** **Packet Category**	61 12
General description **Description** **Note**		Dump memory from an absolute address	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Memory id	1	0x80 => 0x83	0x80: ROM 0x81: RAM 0x82: EEPROM 0x83: MASMEMORY
Number of blocks (=nb)	1	1=>	Number of blocks to dump
Data block (repeated nb times) Address	4	0 => 0x7FFF	Address of first word in block
Length of block (=lb)	2	1 => 0xffff	Number of words in this block
Response Immediate response Related effect		At least one memory dump report packet TM(6,6)	

3.3.5 TC(9,1) Accept Time update

Generic description			
Acronym		AspmTime	
Type **Subtype** **16 bit parameters**	9 1 0	**PID** **Packet Category**	61 12
General description **Description** **Note**		Accept time update	
Name	*Size (bytes)*	*Value*	*Note*
None	-	-	
Response Immediate response Related effect		The clock is updated	

3.3.6 TC(17,1) Request connection test response

Generic description			
Acronym		aspmConn	
Type	17	**PID**	61
Subtype	1	**Packet Category**	12
16 bit parameters	0		
General description			
Description		Test Connection	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	-	-	-
Response			
Immediate response		Connection Test Report TM(17,2)	
Related effect			

3.3.7 TC(20,1) Enable Science Report Packet Generation on RTU Link

Generic description			
Acronym		aspmSCIEnable	
Type	20	**PID**	61
Subtype	1	**Packet Category**	12
16 bit parameters	0		
General description			
Description		Enable Science report packet generation in Main Unit. Set instrument in scientific mode.	
Note		This command must be executed before Scanner can be operated or science data can be produced. This is due to fact that timing of Scanner is tightly coupled with handling of measurement modes.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	-	-	-
Response			
Immediate response			
Related effect		Generation of Science data will be enabled. All scanner operations can be performed after execution of this command.	

3.3.8 TC(20,2) Disable Science Report Packet Generation on RTU Link

Generic description			
Acronym		AspmSCIDisable	
Type	20	**PID**	61
Subtype	2	**Packet Category**	12
16 bit parameters	0		
General description			
Description		Disables Science report packet generation in Main Unit.	
Note		Science data production will be disabled. Data that has already been measured will be handled and sent.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	-	-	-
Response			
Immediate response			
Related effect		Generation of Science data will be disabled.	

3.4 Telecommand set Part II - commands of type 191

3.4.1 TC(191,1) Switch ELS +30V on/off

Generic description			
Acronym		aspmELS30	
Type	191	**PID**	61
Subtype	1	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Switch ELS +30V on/off	
Note		The +30V for ELS controls the high voltages of the deflection plates and MCP.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
On/off	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		Corresponding power indicator changes in HK packet.	

3.4.2 TC(191,2) Set ELS Screen Grid Voltage

Generic description			
Acronym		AspmELSGrid	
Type	191	**PID**	61
Subtype	2	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set ELS Screen grid voltage	
Note		Screen grid value define the minimum energy of particles detected by ELS.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
Grid voltage	1	0 => 0xFF	Sets screen grid reference voltage
Response			
Immediate response			
Related effect		Set screen grid reference fields in HK telemetry packet and in ELS Engineering Information packet.	

The MU generate a voltage which is linear from 0 to +5 V. These values are represented by the parameter limits 0x0000 and 0x00FF respectively.

3.4.3 TC(191,3) Set ELS Deflection Voltage

Generic description			
Acronym		aspmELSDef1	
Type	191	**PID**	61
Subtype	3	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set ELS deflection plate voltage and deflection power supply range.	
Note		Set a constant value for deflection plate voltage.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	3 bits (msb)	=0	
ELS HV Supply Range	1 bit	0 => 1	0 = Low, 1 = High
Deflection voltage	12 bits (lsb)	0 => 0x0FFF	
Response			
Immediate response			
Related effect		Set ELS deflection reference to a constant value, reflected in ELS Engineering telemetry packet.	

The Deflection HV supply range has two states, low range and high range. The control of each supply voltage is generated by the MU. The values linearly range from 0 to +5 V and are represented by the parameter limits of 0x0000 and 0x0FFF respectively.

3.4.4 TC(191,4) Enable ELS High Voltages

Generic description			
Acronym		AspmELSHV	
Type	191	**PID**	61
Subtype	4	**Packet Category**	12
16 bit parameters	1	**Hazardous**	Yes
General description			
Description		Switch ELS High voltages off/on	
Note		Command must be verified with TC(191,255)	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
On/off	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		ELS high voltage enable telemetry state changes in HK packet.	

3.4.5 TC(191,5) Set ELS MCP Bias Voltage

Generic description			
Acronym		AspmELSMcp	
Type	191	**PID**	61
Subtype	5	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set ELS MCP bias voltage	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	=0	
MCP bias voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		ELS MCP bias reference field is reflected in HK packet and in ELS Engineering Information packet.	

The MU generates a reference voltage to control the ELS MCP voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.6 TC(191,7) Switch IMA +30V on/off

Generic description			
Acronym		aspmIMA30	
Type	191	**PID**	61
Subtype	7	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Switch IMA +30V on/off	
Note		The +30V for IMA controls the high voltages of the deflection and MCP.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
IMA +30V	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		IMA +30V power state indicator field changes in HK packet.	

3.4.7 TC(191,9) Switch IMA on/off (±5V and ±12V on/off)

Generic description			
Acronym		AspmIMApow	
Type	191	**PID**	61
Subtype	9	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Switch IMA ±5V and ±12V on/off	
Note		Switch on low voltage power to IMA	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
IMA ± 5V and ±12V	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		IMA ±12V and ±5V power state indicator field change in HK packet.	

3.4.8 TC(191,10) Switch NPD Heaters on/off

Generic description			
Acronym		AspmNPDheaters	
Type	191	**PID**	61
Subtype	10	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Switch NPD Start surface heaters on/off	
Note		Activate NPD heaters to control the temperature of the NPD instrument. Simultaneously for both NPD1 and NPD2.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
NPD Heaters on/off	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		NPD heater status field changes in HK packet.	

3.4.9 TC(191,11) Switch NPD1 +30V on/off

Generic description			
Acronym		aspmNPD130	
Type	191	**PID**	61
Subtype	11	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Switch NPD1 +30V on/off	
Note		The +30V for NPD1 controls the high voltages of the deflection and MCP supplies.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
NPD +30V on/off	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		Power indicator field changes in HK packet.	

3.4.10 TC(191,12) Set NPD1 Bias Voltage

Generic description			
Acronym		aspmNPD1bias	
Type	191	**PID**	61
Subtype	12	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPD1 bias voltage	
Note		Set the value of the MCP bias supply for NPD1.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPD1 bias voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD1 bias reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPD1 MCP Bias voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.11 TC(191,13) Set NPD1 Deflection Voltage

Generic description			
Acronym		aspmNPD1defl	
Type	191	**PID**	61
Subtype	13	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPD1 deflection voltage	
Note		Set the value of the deflection voltage for NPD1.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPD1 Deflection voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD1 deflection supply reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPD1 Deflection voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.12 TC(191,14) Set NPD1 Start MCP Bias Voltage

Generic description			
Acronym		aspmNPD1start	
Type	191	**PID**	61
Subtype	14	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPD1 start MCP bias voltage	
Note		Set the bias reference for the NPD1 start MCP.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPD1 Start MCP bias voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD1 start MCP bias reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPD1 Start MCP Bias voltage. The range varies linearly from 0 to +5 volts and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.13 TC(191,15) Set NPD1 Stop MCP Bias Voltage

Generic description			
Acronym		aspmNPD1stop	
Type	191	**PID**	61
Subtype	15	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPD1 stop MCP Bias Voltage	
Note		Set the bias reference for the NPD1 stop MCP.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPD1 Stop MCP bias voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD1 stop MCP bias reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPD1 Stop MCP Bias voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.14 TC(191,16) Switch NPD2 +30V on/off

Generic description			
Acronym		aspmNPD230	
Type	191	**PID**	61
Subtype	16	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Switch NPD2 +30V on/off	
Note		The +30V for NPD2 controls the high voltages of the deflection and MCP supplies.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
NPD2 +30V on/off	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		Power indicator fields changes in HK packet.	

3.4.15 TC(191,17) Set NPD2 Bias Voltage

Generic description			
Acronym		AspmNPD2bias	
Type	191	**PID**	61
Subtype	17	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPD2 bias voltage	
Note		Set the value of the MCP bias supply for NPD2.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPD2 Bias voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD2 bias reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPD2 Bias voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.16 TC(191,18) Set NPD2 Deflection Voltage

Generic description			
Acronym		aspmNPD2defl	
Type	191	**PID**	61
Subtype	18	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPD2 deflection voltage	
Note		Set the value of the deflection voltage for NPD2.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPD2 Deflection voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD2 deflection supply reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPD2 Deflection voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.17 TC(191,19) Set NPD2 Start MCP Bias Voltage

Generic description			
Acronym		aspmNPD2start	
Type	191	**PID**	61
Subtype	19	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPD2 start MCP bias voltage	
Note		Sets the bias reference for the NPD2 start MCP.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPD2 Start mcp bias voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD2 start MCP bias reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPD2 Start MCP Bias voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.18 TC(191,21) Switch NPI +30V on/off

Generic description			
Acronym		aspmNPI30	
Type	191	**PID**	61
Subtype	21	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Switch NPI +30V on/off	
Note		The +30V for NPI controls the high voltages of the deflection and MCP supplies.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
NPI +30V on/off	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		Power indicator field changes in HK packet.	

3.4.19 TC(191,22) Set NPI Bias Voltage

Generic description			
Acronym		aspmNPIBias	
Type	191	**PID**	61
Subtype	22	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPI bias voltage	
Note		Set the value of the MCP bias supply for NPI.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPI Bias voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPI bias reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPD2 Stop MCP bias voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.20 TC(191,23) Set NPI Deflection Voltage

Generic description			
Acronym		aspmNPIdefl	
Type	191	**PID**	61
Subtype	23	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPI deflection voltage	
Note		Set the value of the deflection voltage for NPI.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
NPI Deflection voltage	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPI deflection supply reference and monitor fields change in HK packet.	

The MU generates a reference voltage to control the NPI Bias voltage. The range varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively.

3.4.21 TC(191,24) Set NPI Deflection Switch

Generic description			
Acronym		aspmNPIswitch	
Type	191	**PID**	61
Subtype	24	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set NPI Deflection switch on/off	
Note		Turn on/off NPI deflection voltage.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
NPI Deflection switch on/off	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		NPI deflection switch indicator telemetry point changes in HK packet.	

3.4.22 TC(191,25) Set Scanner Setup

Generic description			
Acronym		aspmSCANSetup	
Type	191	**PID**	61
Subtype	25	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Defines the operation of the Scanner.	
Note		Scanner +30V on/off and select IRQ operation	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	12 bits	=>0	
Scanner error handler	1 bit	0 => 1	0=enabled, 1=disabled
Auto-switchoff mode	1 bit	0 => 1	0=enabled, 1=disabled
Scan IRQ	1 bit	0 => 1	0=disabled, 1=enabled
Scanner +30V on/off	1 bit	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect		Scanner +30V power state indicator telemetry point changes in HK packet.	

3.4.23 TC(191,26) Set Scanner Voltages

Generic description			
Acronym		aspmSCANVolts	
Type	191	**PID**	61
Subtype	26	**Packet Category**	12
16 bit parameters	3	**Hazardous**	No
General description			
Description		Set Scanner voltages and currents	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
VREFMC	1	0 => 0xFF	
Coast current	1	0 => 0xFF	
Ramp current	1	0 => 0xFF	
Threshold CW	1	0 => 0xFF	
Threshold CCW	1	0 => 0xFF	
Threshold Wheel	1	0 => 0xFF	
Response			
Immediate response			
Related effect		Scanner voltage and current reference telemetry points change in HK packer.	

The MU generates voltages to control different Scanner functions. The ranges varies linearly from 0 to +5 V and the values are represented by the parameter limits of 0x000 and 0x00FF respectively. All except VREFMC are passed to Scanner controller board as digital values.

3.4.24 TC(191,27) Scanner String Heaters

Generic description			
Acronym		aspmSCANStrHeat	
Type	191	**PID**	61
Subtype	27	**Packet Category**	12
16 bit parameters	1	**Hazardous**	Yes
General description			
Description		Release scanner locking mechanism by using string heater 1 or 2 for 15sec. Hazardous command on database level.	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Pad	14 bits	= 0	
Stringheater	2 bits	0x1 => 0x2	Number of string heater to be used. 0 = N / A 1 = String Heater 1 2 = String Heater 2 3 = N / A
Response			
Immediate response			
Related effect		Scanner locking mechanisms should be released. The release can be verified by trying to initialize Scanner (i e by rotating it)	

3.4.25 TC(191,30) Enable ASPERA-4 Main Unit watch dog

Generic description			
Acronym		AspmWatchdog	
Type	191	**PID**	61
Subtype	30	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description **Note: May contain disable option**		Enable Watchdog timer *Watchdog cannot be disabled. * With current version of s/w wd is enabled as a default	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Security code	2	=0x2704	
Response			
Immediate response			
Related effect			

3.4.26 TC(191,32) NPD1 High Voltage Switch

Generic description			
Acronym		aspmNPD1switch	
Type	191	**PID**	61
Subtype	32	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Enable NPD1 high voltage	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
NPD1 HV	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect			

3.4.27 TC(191,33) NPD2 High Voltage Switch

Generic description			
Acronym		aspmNPD2switch	
Type	191	**PID**	61
Subtype	33	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Enable NPD2 high voltages	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
NPD2 HV	2	0 => 1	0=off, 1=on
Response			
Immediate response			
Related effect			

3.4.28 TC(191,34) Set NPD1 Counter Thresholds

Generic description			
Acronym		aspmNPD1Tresholds	
Type	191	**PID**	61
Subtype	34	**Packet Category**	12
16 bit parameters	2	**Hazardous**	No
General description			
Description		Set NPD1 counter thresholds	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Start	1	0 => 0xFF	
Stop0	1	0 => 0xFF	
Stop1	1	0 => 0xFF	
Stop2	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD1 start count and stop count fields change in the NPD1 Science packets.	

3.4.29 TC(191,35) Set NPD2 Counter Thresholds

Generic description			
Acronym		aspmNPD2Tresholds	
Type	191	**PID**	61
Subtype	35	**Packet Category**	12
16 bit parameters	2	**Hazardous**	No
General description			
Description		Set NPD2 counter thresholds	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Start	1	0 => 0xFF	
Stop0	1	0 => 0xFF	
Stop1	1	0 => 0xFF	
Stop2	1	0 => 0xFF	
Response			
Immediate response			
Related effect		NPD2 start count and stop count fieldschange in the NPD2 Science packets.	

3.4.30 TC(191,255) Confirm Hazardous Command

Generic description			
Acronym		aspmLaunch	
Type	191	**PID**	61
Subtype	255	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Confirms previous hazardous command.	
Note		This command must follow immediately after command to be confirmed (i e this must be next command).	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Packet Type	1	191 => 193	Packet type of the confirmable command.
Packet Subtype	1	0 => 255	Packet subtype of the confirmable command.
Response			
Immediate response			
Related effect			

3.5 Telecommand set Part III - commands of type 192

3.5.1 TC(192,1) Select ELS mode

Generic description			
Acronym		aspmELSmode	
Type	192	**PID**	61
Subtype	1	**Packet Category**	12
16 bit parameters	2	**Hazardous**	No
General description			
Description		Select ELS measurement mode.	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Spare	1 bit		
Rice Compression Enabled	1 bit	0 => 1	0=disabled, 1=enabled
Log Compression Enabled	1 bit	0 => 1	0=disabled, 1=enabled
Energy Compression	2 bits	0 => 2	0 = 1 step 1 = 2 steps 2 = 4 steps
Time Compression	3 bits	0 =>4	0 = 1 sweep 1 = 2 sweeps 2 = 4 sweeps 3 = 8 sweeps 4 = 16 sweeps
Sweep Table Number	5 bits		
PAD	1 bit	0	
Deflection Voltage Sweep Disabled	1 bit	0 => 1	
None	1 bit	0 => 1	0 = inactive 1 = active
Sector Mask	2	0 => 0xFFFF	
Response			
Immediate response			
Related effect		ELS information changes in the HK packet and the ELS Science telemetry packet	

3.5.2 TC(192,6) Set NPI Mode

Generic description			
Acronym		aspmNPImode	
Type	192	**PID**	61
Subtype	6	**Packet Category**	12
16 bit parameters	3	**Hazardous**	No
General description			
Description		Set NPI measurement mode	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Stepping Mode	1	0=>255	0 = normal mode (no voltage stepping) 1-255 = number of samples in one step
Accumulation Time	4 bits	0 => 15	Accumulation Time (n) so that one period is 31.25ms * (2 ^ n)
PAD	1 bit	0	
Log Compression Enabled	1 bit	0 => 1	0=disabled, 1=enabled
Rice Compression Enabled	1 bit	0 => 1	0=disabled, 1=enabled
None	1 bit	0 => 1	0 = inactive, 1 = active
Sector Mask	4	0 => 0xFFFFFFFF	
Response			
Immediate response			
Related effect		NPI information changes in the HK packet and the NPI Science telemetry packet	

3.5.3 TC(192,7) Set NPD Mode

Generic description			
Acronym		aspmNPDmode	
Type	192	**PID**	61
Subtype	7	**Packet Category**	12
16 bit parameters	3	**Hazardous**	No
General description			
Description		Set NPD measurement mode	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Integration Factor	4 bits		Not used
Accumulation Time	4 bits		TOF mode: Integration time 0.5s * (2 ^ n) Other modes: Accumulation Time (n) so that one period is 31.25ms * (2 ^ n)
PAD	1 bit	0	
Measurement Mode	3 bits	0 => 3	0 = Raw Array Mode 1 = Bin Matrix Mode 2 = TOF Mode 3 = PHD Mode
Log Compression Enabled	1 bit	0 => 1	0=disabled, 1=enabled
Rice Compression Enabled	1 bit	0 => 1	0=disabled, 1=enabled
NPD2 active	1 bit	0 => 1	0=inactive, 1=active
NPD1 active	1 bit	0 => 1	0=inactive, 1=active

Generic description			
NPD1 Bin Matrix Reduction Tables	2	0 => 0x0FFF	Bits 12-15 = PAD Bits 8 – 11 = Dir 2 Bits 4 – 7 = Dir 1 Bits 0 - 3 = Dir 0
NPD2 Bin Matrix Reduction Tables	2	0 => 0x0FFF	Bits 12-15 = PAD Bits 8 – 11 = Dir 2 Bits 4 - 7 = Dir 1 Bits 0 - 3 = Dir 0
Response			
Immediate response			
Related effect		NPD information changes in the HK packet and the NPD Science telemetry packet	

3.5.4 TC(192,12) Set MU HK Packet Generation Frequency

Generic description			
Acronym		AspmHKDelay	
Type	192	**PID**	61
Subtype	12	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Set HK Generation Frequency	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	2	0 => 0xffff	Delay in seconds
Response			
Immediate response			
Related effect			

3.5.5 TC(192,13) Set Scanner mode

Generic description			
Acronym		AspmSCANmode	
Type	192	**PID**	61
Subtype	13	**Packet Category**	12
16 bit parameters	2	**Hazardous**	No
General description			
Description		Set Scanner mode	
Note		In scanning mode (mode = 1), second parameter must be sent but doesn't affect anything. Mu unit will accept scanner mode commands leading the scanner to rotate into b-positions (ie.positions from 0xB0 to 0xBF). If command is for standing mode scanner is simply no moving. In stepping mode next step not in b-positions is commanded instead.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	7 bits	0	0 = Standing (scanner on) 1 = Scanning 2 = Stepping 3 = Not in use (Scanner off)
Scanner mode	1 bits	0 => 3	
Scanner speed	1	0 => 3	0 = Shutdown 1 = 32 sec per scan 2 = 64 sec per scan 3 = 128 sec per scan
Scanner cycle duration	1	0 => 0xFF	Length of measurement cycle (n) so that cycle lasts for 31.25ms * (2^n).
Scanner step angle or Scanner position (based upon Mode Setting)	1	0 => 0xFF	Standing mode => Position Stepping mode => Step Angle
Response			
Immediate response			
Related effect		Scanner information changes in the HK packet and the Scanner Information telemetry packet	

3.5.6 TC(192,14) Initialize Scanner

Generic description			
Acronym		AspmSCANinit	
Type	192	**PID**	61
Subtype	14	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Initialize Scanner	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	7 bits	0	0 = test communication
Scanner init	1 bit	0 => 1	and initialization 1 = test communication only
Communication test value	1	0 => 0xFF	test value
Response			
Immediate response			
Related effect			

3.5.7 TC(192,16) Set High Voltage Shutter Reduced Voltages

Generic description			
Acronym		AspmHVShutVolts	
Type	192	**PID**	61
Subtype	16	**Packet Category**	12
16 bit parameters	3	**Hazardous**	No
General description			
Description		Set HV shutter reduced voltages	
Note		Set HV shutter reduced voltages	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	0	
NPI Bias	1	0 => 0xFF	
NPD1 Stop Bias	1	0 => 0xFF	
NPD1 Start Bias	1	0 => 0xFF	
NPD2 Stop Bias	1	0 => 0xFF	
NPD2 Start Bias	1	0 => 0xFF	
Response			
Immediate response			
Related effect		Bias reference fields values change in the HK packet	

3.5.8 TC(192,15) Set High Voltage Shutter Mode

Generic description			
Acronym		aspmHVShut	
Type	192	**PID**	61
Subtype	15	**Packet Category**	12
16 bit parameters	varies	**Hazardous**	No
General description			
Description		Set HV shutter mode	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Test mode	1 bit	0 off 1 on	In solar sensor mode only
Mode	3 bits	0 off 1 Solar sensor with init 2 Test scan only 3 NPD Countrate 4 External	
Others, varies with mode	12 bits		
Others, varies with mode	8		
Command interpretation in	solar sensor mode:		
Test mode	1 bit	0 off 1 on	
Mode	3 bits	1 Solar sensor with init	
Re-init period	8 bits	Number of measurement cycles	
PAD	2 bits		
Scanner speed	2 bits	0 default (32s) 1 32s 2 64s 3 128s	
Solarsensor 1 CW limit	1		Valid if test mode specified
Solarsensor 1 CCW limit	1		Valid if test mode specified
Solarsensor 2 CW limit	1		Valid if test mode specified
Solarsensor 2 CCW limit	1		Valid if test mode specified
PAD	4		
Command interpretation in	NPD countrate mode:		
Test mode	1 bit	N/A	
Mode	3 bits	3 NPD Countrate	
Duration	12bits	Duration (n) so that reduced voltages are used for 31.25 * (n+1) ms	
Countrate criteria for NPD1	2		
Countrate criteria for NPD2	2		
PAD	4		
Command interpretation in	Ext mode:		
Test mode	1 bit	0 off	
Mode	3 bits	4 Ext Countrate	
Duration for NPI shutter	12 bits	Duration (n) so that reduced voltages are used for 31.25 * (n+1) ms	
CW position for NPI shutter	1		
CCW pos for NPI shutter	1		

Generic description		
PAD	4 bits	
Duration for NPD1 and NPD2 shutter	12 bits	Duration (n) so that reduced voltages are used for 31.25 * (n+1) ms
CW position for NPD1 shutter	1	
CCW position for NPD1 shutter	1	
CW position for NPD2 shutter	1	
CCW position for NPD2 shutter	1	
Response		
Immediate response		
Related effect		Values in coresponding fields change in the HK packet

3.5.9 TC(192,20) Run Macro

Generic description			
Acronym		aspmMacroRun	
Type	192	**PID**	61
Subtype	20	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Run macro	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
PAD	1	= 0	
Macro Number	1	0 =>0xFF	0 – 191 range of values
Response			
Immediate response			
Related effect		Corresponding macro is loaded from EEPROM and executed	

3.5.10 TC(192,21) Terminate Current Macro

Generic description			
Acronym		aspmMacroTerminate	
Type	192	**PID**	61
Subtype	21	**Packet Category**	12
16 bit parameters	0	**Hazardous**	No
General description			
Description		Terminate current macro	
Note		This command cannot be used in a macro.	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	-	-	-
Response			
Immediate response			
Related effect			

3.5.11 TC(192,22) Run Single Macro Command

Generic description			
Acronym		aspmMacroRunCmd	
Type	192	**PID**	61
Subtype	22	**Packet Category**	12
16 bit parameters	varies	**Hazardous**	No
General description			
Description		Run single macro command	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	2	= 0x2704	
Confirm Word	2		type+subtype as in aspmLaunch
Type	1	0=>0xFF	
SubType	1	0=>0xFF	
None	2	= 0x0	
Number of Parameters	1	0=>0xFF	
None	1	= 0x0	
Parameters	varies		as many as specified above
Response			
Immediate response			
Related effect			

3.6 Telecommand set Part IV - commands of type 193

3.6.1 TC(193,1) Pipe Telecommand

Generic description			
Acronym		aspmPipe	
Type	193	**PID**	61
Subtype	1	**Packet Category**	12
16 bit parameters	Varies	**Hazardous**	No
General description			
Description		Pipe TC to TM Send parameters back to telemetry	
Note			
Parameter description			
Response			
Immediate response			
Related effect		Piped TC report packet TM (193, 128)	

3.6.2 TC(193,2) Relax (do nothing)

Generic description			
Acronym		aspmRelax	
Type	193	**PID**	61
Subtype	2	**Packet Category**	12
16 bit parameters	0	**Hazardous**	No
General description			
Description		Relax i e do nothing	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
None	-	-	-
Response			
Immediate response			
Related effect			

3.6.3 TC(193,3) Generate simulated data

Generic description			
Acronym		AspmSim	
Type	193	**PID**	61
Subtype	3	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Generate simulated data	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Simulation enabled	2	0 => 1	0: simulation disabled 1: simulation enabled
Response			
Immediate response			
Related effect			

3.6.4 TC(193,4) Write word to address

Generic description			
Acronym		aspmWrite	
Type	193	**PID**	61
Subtype	4	**Packet Category**	12
16 bit parameters	2	**Hazardous**	Yes
General description			
Description		Write word to address	
Note		Command must be verified with TC(191, 255)	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Address	2	0 => 0xFFFF	
Data word	2	0 => 0xFFFF	
Response			
Immediate response			
Related effect			

3.6.5 TC(193,5): Read word from address

Generic description			
Acronym		aspmRead	
Type	193	**PID**	61
Subtype	5	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Read word from address	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Address	2	0 => 0xFFFF	
Response			
Immediate response		Read word report packet TM(193,6)	
Related effect			

3.6.6 TC(193,10) Patch EEPROM

Generic description			
Acronym		aspmPatch	
Type	193	**PID**	61
Subtype	10	**Packet Category**	12
16 bit parameters	6	**Hazardous**	No
General description			
Description		Patch EEPROM (starting from absolute address) using specified number of words found from massmemory at specified absolute address.	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Massmemory address	4	0 => 0x0007 FFFF	
Eeprom address	4	0 => 0x0003 FFFF	
Patch Mode	1 bit	0 => 1	0 = Patch without using paging mode 1 = Patch using paging mode
Patch length	15 bits	1 => 0x7FFF	Length of patch in 16bit words

Generic description			
Patch CRC checksum	2	0 => 0xFFFF	CRC checksum calculated over whole patch
Response			
Immediate response		EVENT: - EEPROM programmed or - EEPROM programming not successful or - EEPROM programming CRC error	
Related effect			

3.6.7 TC(193,11): Load Module

Generic description			
Acronym		aspmModule	
Type	193	**PID**	61
Subtype	11	**Packet Category**	12
16 bit parameters	3	**Hazardous**	No
General description			
Description		Load Module	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Address	4	0 => 0x0007 FFFF	
PAD	6 bits	= 0	
Execution Flag	1 bit	0 => 1	0 = Load and run module 1 = Load but don't run module
CRC Verify	1 bit	0 => 1	0 = Verify crc 1 = Don't verify crc
Memory ID	1	= 0x82	(EEPROM)
Response			
Immediate response		EVENT: - Module loaded or - Module load failed	
Related effect			

3.6.8 TC(193,12) Select Boot Mode

Generic description			
Acronym		aspmBootMode	
Type	193	**PID**	61
Subtype	12	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Select boot mode	
Note		No use after boot process	
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Boot Mode	1	1 => 2	1 = Safe Mode 2 = Normal Mode
Response			
Immediate response			
Related effect			

3.6.9 TC(193,16) Watchdog reset

Generic description			

Generic description			
Acronym		aspmWDReset	
Type	193	**PID**	61
Subtype	16	**Packet Category**	12
16 bit parameters	1	**Hazardous**	No
General description			
Description		Force watchdog reset	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Security code	2	=0x2704	
Response			
Immediate response		EVENTS: - I'm alive and - Watchdog reset	
Related effect			

3.7 List of telecommands

Telecommand	*Acronym*	*Description*	*Number of Parameters*
TC (3, 5)	aspmHKEnable	Enable HK generation	1
TC (3, 6)	aspmHKDisable	Disable HK generation	1
TC (6, 2)	aspmMEMLoad	Load memory	4
TC (6, 5)	aspmMEMDump	Dump memory	4
TC (9, 1)	aspmTime	Accept Time Update	0
TC (17, 1)	aspmConn	Connection Test	0
TC (20, 1)	aspmSCIRnable	Enable Science on RTU link	0
TC (20, 2)	aspmSCIDisable	Disable Science on RTU link	0
TC (191, 1)	aspmELS30	Switch ELS +30V on/off	1
TC (191, 2)	aspmELSGrid	Set ELS Screen Grid voltage	1
TC (191, 3)	aspmELSDefl	Set ELS Deflection voltage and switch	1
TC (191, 4)	aspmELSHV	Switch ELS high voltage on/off	1
TC (191, 5)	aspmELSMcp	Set ELS MCP bias voltage	1
TC (191, 7)	aspmIMA30	Switch IMA +30V on/off	1
TC (191, 9)	aspmIMAPow	Switch MA ± 5V and ± 12V on/off	1
TC (191, 10)	aspmNPDheaters	Switch NPD heaters on/off	1
TC (191, 11)	aspmNPD130	Switch NPD1 +30V on/off	1
TC (191, 12)	aspmNPD1bias	Set NPD1 bias	1
TC (191, 13)	aspmNPD1defl	Set NPD1 Deflection bias	1
TC (191, 14)	aspmNPD1start	Set NPD1 Start bias	1
TC (191, 15)	aspmNPD1stop	Set NPD1 Stop bias	1
TC (191, 16)	aspmNPD230	Switch NPD2 +30V on/off	1
TC (191, 17)	aspmNPD2bias	Set NPD2 bias	1
TC (191, 18)	aspmNPD2defl	Set NPD2 Deflection bias	1
TC (191, 19)	aspmNPD2start	Set NPD2 Start bias	1
TC (191, 20)	aspmNPD2stop	Set NPD2 Stop bias	1
TC (191, 21)	aspmNPI30	Switch NPI +30V on/off	1
TC (191, 22)	aspmNPIBias	Set NPI Bias	1
TC (191, 23)	aspmNPIDefl	Set NPI Deflection voltage	1
TC (191, 24)	aspmNPISwitch	Set NPI Switch	1
TC (191, 25)	aspmSCANSetup	Set Scanner setup	1
TC (191, 26)	aspmSCANVolts	Set Scanner voltages	3
TC (191, 27)	aspmSCANStrHeat	Switch stringheaters on/off	1
TC (191, 30)	aspmWatchdog	Enable Watchdog	1
TC (191, 32)	aspmNPD1switch	Set NPD1 high voltages	1
TC (191, 33)	aspmNPD2switch	Set NPD2 high voltages	1
TC (191, 34)	aspmNPD1Tresholds	Set NPD1 counter tresholds	2
TC (191, 35)	aspmNPD2Tresholds	Set NPD2 counter tresholds	2
TC (191, 255)	aspmLaunch	Confirm Hazardous Command	1
TC (192, 1)	aspmELSmode	Set ELS mode	2
TC (192, 6)	aspmNPImode	Set NPI mode	3
TC (192, 7)	aspmNPDmode	Set NPD mode	3
TC (192, 12)	aspmHKDelay	Set HK generation frequency	1
TC (192, 13)	aspmSCANmode	Set Scanner mode	2
TC (192, 14)	aspmSCANinit	Initialize Scanner	1
TC (192, 15)	aspmHVShut	Set HV shutter mode	Varies
TC (192, 16)	aspmHVShutVolts	Set HV shutter reduced voltages	3
TC (192, 20)	aspmMacroRun	Run macro	1
TC (192, 21)	aspmMacroTerminate	Terminate current macro	0
TC (192, 22)	aspmMacroRunCmd	Run single macro command	Varies
TC (193, 1)	aspmPipe	Pipe TC to TM	Varies
TC (193, 2)	aspmRelax	Relax, I e do nothing	0
TC (193, 3)	aspmSim	Generate simulated data	1
TC (193, 4)	aspmWrite	Write to address	2

Telecommand	*Acronym*	*Description*	*Number of Parameters*
TC (193, 5)	aspmRead	Read from address	1
TC (193, 10)	aspmPatch	Patch eeprom	6
TC (193, 11)	aspmModule	Load module	3
TC (193, 12)	aspmBootMode	Select boot mode	1
TC (193, 16)	aspmWDReset	Watchdog reset	1

4 TELEMETRY

4.1 General

4.2 Telemetry packages

4.2.1 TM(1,1) Telecommand Acceptance report - Success

Generic description			
Acronym		ASPMTCAck	
Type	1	**PID**	61
Subtype	1	**Packet Category**	1
16 bit parameters	4		
General description			
Description		Telecommand acceptance report	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Telecomand packet ID	2	0 => 0xFFFF	
Telecommand packet sequency control	2	0 => 0xFFFF	
Long description			
In SGICD			

4.2.2 TM(1,2) Telecommand Acceptance report - Failure

Generic description			
Acronym		ASPMTCNack	
Type	1	**PID**	61
Subtype	2	**Packet Category**	1
16 bit parameters	Varies		
General description			
Description		Telecommand acceptance report - failure	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Long description			
In SGICD - No changes or additions to that definition has been made			

4.2.3 TM(1,7) TM Execution acknowledgment report – Success

As specified in SGICD

4.2.4 TM(1,8) TM Execution acknowledgment report – Failure

As specified in SGICD

4.2.5 TM(3,25) Housekeeping report

Generic description			
Acronym		ASPMHKRep / ASPIHKRep	
Type	3	**Subtype**	25
APID		61 => 62	
16 bit parameters		Varies	
General description			
Description		Housekeeping report	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Long description			
Description later in this document			

4.2.6 TM(6,6) Memory dump report packet (as specified in SGICD)

Generic description			
Acronym		aspmMemDump	
Type	6	**Subtype**	6
APID		61	
16 bit parameters		Varies	
General description			
Description		Memory dump report packet.	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Long description			

4.2.7 TM(17,2) Connection test report

Generic description			
Acronym		ASPMConnRep	
Type	17	**Subtype**	2
APID		61	
16 bit parameters			
General description			
Description		Connection test report	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Long description			
In SGICD			

4.2.8 TM(20,3) Science data report

Generic description			
Acronym		ASPMScienceRep	
Type	20	**Subtype**	3
APID		61	
16 bit parameters		Varies	
General description			
Description		Science data report	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Long description			
Definition later in this document			

4.2.9 TM(193,6) Read word report packet

Generic description			
Acronym		ASPMReadRep	
Type	193	**Subtype**	6
APID		61	
16 bit parameters		2	
General description			
Description		Word read from address specified in packet TC(193,5)	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Address	2	Any	Address of word
Data	2	Any	Word read from address
Long description			

4.2.10 TM(193,128) Piped TC report packet

Generic description			
Acronym		ASPMPipeRep	
Type	193	**Subtype**	128
APID		61	
16 bit parameters		Varies	
General description			
Description		Piped Telecommad	
Note			
Parameter description			
Name	***Size (bytes)***	***Value***	***Note***
Long description			
Parameters should be exact copy of source data field (without checksum) of received telecommand aspmPipe			

4.3 Telemetry list

Telecommand	*Acronym*	*Description*	*Note*
TM (1, 1)	aspmTCAck	Telecommand acceptance report – Success	
TM (1, 2)	AspmTCNack	Telecommand acceptance report – Failure	
TM (1, 7)	AspiTCEAck	Telecommand execution report – Success	Only from IMA
TM (1, 8)	aspiTCENAck	Telecommand execution report – Failure	Only from IMA
TM (6,6)	AspmMemDumpRep / aspiMemDumpRep	Memory dump report packet for MU / IMA	
TM (6, X)	AspiMemCheckRep	Memory check report for IMA	Only for iMA
TM (3, 25)	AspmHKRep / AspmHKRep	Housekeeping packet fro MU / IMA	
TM (17, 2)	aspmConnRep	Connection Test response	
TM (20, 3)	AspmScienceRep / aspiScinceRep	Enable Science on RTU link for MU/IMA	
TM (193,6)	ASPMReadRep		
TM (193,128)	aspmSCIDisable	Disable Science on RTU link	

5 EVENT REPORTING

5.1 General

All events from the MU are formatted according to the same scheme. First word (after headers, i e word number 8) is the event number. The following two words are freely chosen extra information about the event, typically just zeros. Events generated by the MU are of type TM(5,1) to TM(5,2), as specified in the SGICD. Subtype 1 corresponds to normal progress and subtype 2 corresponds to a warning.

5.2 Event List

The following table defines all events produced by the MU. If extra parameters are not specified, these are constant zeros.

Event number	***Event name***	***Parameter 1***	***Parameter 2***	***Description***
40001	I'm Alive			Generated after normal boot process as a first event
40003	Going to reboot			
40004	Watchdog reset	wd mask	wd mask cleared	
40005	Going to safe mode			
40006	Going to normal mode			
40007	Telecommand buffer overflow			
40010	Eeprom programmed			
40011	Eeprom programming - nonsuccess	CRC check sum in patch	CRC checksum in programmed EEPROM area	
40012	CRC error in Eeprom patch	CRC check sum in patch	CRC checksum specified in TC	
40013	Module loaded			
40014	Module load failed	Error code defining exact type of error	Optional extra information	
40015	Default boot module loaded			
40016	Default boot module loading failed	Error code defining exact type of error	Optional extra information	
40020	Command handler error	1: command not confirmed properly 16: other error 0xffff: command not found	Seq count of command raising error	
40021	Invalid confirmation by TC(191,255)	For Command to be confirmed: Bit 8-15: type bit 0-7: Subtype	From the confirmation parameters: Bit 8-15: type bit 0-7: Subtype	
40022	Invalid mode definition	Upmost address for the data storage of invalid mode		
40026	Macro execution succesful	Macro number		
40027	Macro terminated by TC	Macro number	Command index in macro command buffer	
40028	Macro Checksum error in EEPROM	Calculated checksum	Checksum in EEPROM	
40029	Macro Can't start			
40074	IMA command buffer full			

Event number	*Event name*	*Parameter 1*	*Parameter 2*	*Description*
40092	Scanner initialized			
40097	Scanner error	2: Communication test failed before initialization 3: Initialization failed. 4: Can't start scanner properly 5: Scanner not stopped properly 6: Scanner not initialized 7: Can't escape endposition on initialization 8: Science not enabled		

6 HOUSEKEEPING TELEMETRY

6.1 General

The ASPERA-4 Main Unit have one type of housekeeping (HK) packet which contains all HK signals and parameters.

6.2 HK packet source data field

6.2.1 Source data field for Main Unit

6.2.1.1 Generic structure

After headers, there will be the source data field. For the HK report packet, it will be as shown below.

Byte	***Bits***	***Field***	***Note***
Source data field			
16		PAD	for TM(3,25) always 0
17		SID	
18-119		Parameters	Full HK packet

The SID field contains an identifier telling which type of HK packet is being sent. For the Main Unit the full Housekeeping packet is identified by setting SID to 0. For IMA SID=10. They can also be recognised by examining the application id field.

6.2.1.2 Full Housekeeping Packet

The full HK packet will have the following format. Bit number 0 will be the LSB (i e numbering is NOT the same as defined in the SGICD). If not otherwise stated, the fields will contain exactly the value read from hardware.

Byte	***Bits***	***Field***	***Note***
18		els_temp	
19		npd1_temp	
20		npd2_temp	
21		npi_temp	
22		scanner_temp_sensor	
23		PAD	
24-25		sw_version	Software version
26		els_minus_5v_screen_grid_ref	sw monitored
27		els_minus_5v_screen_grid_mon	
28		els_bias_mcp_ref	sw monitored
29		els_bias_mcp_mon	
30-31	13-15	PAD	
	12	els_plus_30v_on_off	
	11	els_enable_hv	sw monitored
	9	PAD	
	8	els_range	sw monitored
	0-7	ELS deflection voltage sweep table number	sw_monitored
32		hk_i_plus_30v	
33		hk_i_plus_5v	

Byte	*Bits*	*Field*	*Note*
34		hk_v_plus_12v	
35		hk_v_plus_30v	
36		hk_v_plus_5v	
37		hk_v_minus_12v	
38		hk_v_minus_5v	
39	7	NPD1_defl_switch	
	6	NPD2_defl_switch	
	5	Sun sensor 2	
	4	Sun sensor 1	
	3	PAD	
	2	npd_heaters_on_off	sw monitored
	1	npd1_plus_30v_on_off	
	0	npd2_plus_30v_on_off	
40		npd1_bias_mon	
41		npd1_bias_ref	sw monitored
42		npd1_defl_mon	
43		npd1_defl_ref	sw monitored
44		npd1_start_bias_mon	
45		npd1_start_bias_ref	sw monitored
46		npd1_stop_bias_mon	
47		npd1_stop_bias_ref	sw monitored
48		npd1_frontctrl	
49		npd1_mainctrl	
50-51		npd1_stat	
52-53		npd1_tdcrd	
54-55		npd1_calib11	
56-57		npd1_calib12	
58-59		npd1_calib21	
60-61		npd1_calib22	
62-63		npd1_sefccnt	
64-65		npd1_defccnt	
66		npd2_bias_mon	
67		npd2_bias_ref	sw monitored
68		npd2_defl_mon	
69		npd2_defl_ref	sw monitored
70		npd2_start_bias_mon	sw monitored
71		npd2_start_bias_ref	
72		npd2_stop_bias_mon	
73		npd2_stop_bias_ref	sw monitored
74		npd2_frontctrl	
75		npd2_mainctrl	
76-77		npd2_stat	
78-79		npd2_tdcrd	
80-81		npd2_calib11	
82-83		npd2_calib12	
84-85		npd2_calib21	
86-87		npd2_calib22	
88-89		npd2_sefccnt	
90-91		npd2_defccnt	
92		npi_bias_ref	sw monitored
93		npi_bias_mon	
94		npi_defl_ref	sw monitored
95		npi_defl_mon	
96	7	npi_plus_30v_on_off	sw monitored
	6	npi_defl_switch	sw monitored
	5	npi_defl_mode	sw monitored
	3-4	SPARE4	

Byte	*Bits*	*Field*	*Note*
	2	ima_plus_minus_12v_on_off	sw monitored
	1	ima_plus_30v_on_off	sw monitored
	0	ima_plus_minus_5v_on_off	sw monitored
97		scanner_vrefmc	
98	7	scanner_status_ccw_end_pos	
	6	scanner_status_cw_end_pos	
	5	scanner_status_pos_clock	
	4	scanner_status_direction	0: 0 - 180 1: 180 - 0
	2-3	scanner_status_state	0: Not busy 1: ramp up 2: Full speed move 3: Ramp down
	1	Lost step	
	0	scanner_initialized	
99	7	scanner_plus_30v_on_off	
	5-6	PAD	
	4	scanner_setup_mode	0: normal 1: manual
	3	scanner_setup_direction	0: 0 - 180 1: 180 - 0 for manual mode speed command only
	2	PAD	
	0-1	scanner_speed	0: STOP 1: 32s scan 2: 64s scan 2: 128s scan
100		scanner_coast_current_ref	
101		scanner_ramp_current_ref	
102		scanner_treshold_cw_ref	
103		scanner_treshold_ccw_ref	
104		scanner_treshold_wheel_ref	
105		scanner_position	
106		sw_mode	sw monitored
107		cpu_load	sw monitored
108-109		ELS sector mask	sw monitored
110-111	8-15	ELS compression scheme (ie. defines mode)	sw monitored
	0-7	ima_link_status	Bitfield is best explained in document called 'Rosetta RPC PIU Interfaces document. Part II - Data handling interfaces'. In short, it contains status register of IEEE 1355 LINK Chip. Bit: 7: ndata0A Bit 6: crdMEM Bit 5: datav Bit 4: resetm Bit 3: ffrx Bit 2: EOP1 Bit 1: ndata0 Bit 0: nm1 In typical nominal operation one should find value 0x41 on the link when link is working properly.
112-115		NPI Sector mask	
116-117	7-15	PAD	
	6	NPI Mode	
	2-5	NPI Accumulation time	$31.25ms*2^{n-1}$
	1	NPI Log compression enabled	
	0	NPI RICE compression enabled	
118	7	PAD	

Byte	*Bits*	*Field*	*Note*
	6	NPD RICE compression enabled	
	5	NPD Log compression enabled	
	0-4	NPD Accumulation time	
119	4-7	NPD2 mode	0: not in use 1: raw data 2: bin matrix (0 0 0) 3: bin matrix (0 0 1), (0 1 0) or (1 0 0) 4: bin matrix (0 0 2), (0 2 0) or (2 0 0) 5: bin matrix (0 1 1), (1 0 1) or (1 1 0) 6: bin matrix (0 1 2), (1 0 2), (0 2 1), (1 2 0), (2 0 1) or (2 1 0) 7: bin matrix (0 2 2), (2 0 2) or (2 2 0) 8: bin matrix (1 1 1) 9: bin matrix (1 1 2), (1 2 1) or (2 1 1) 10: bin matrix (1 2 2), (2 1 2) or (2 2 1) 11: bin matrix (2 2 2) 12: phd mode 13: tof mode NOTE: Although reduction tables for bin matrixc can be defined independendently all default modes in macros are defined so that bin matrix is of type (0 0 0), (1 1 1) or (2 2 2) for both NPDs simultaneosly.
	0-3	NPD1 mode	

There are a few spare bits. They are used to align 8 bit signals to 8 bit fields. Spare bits can be allocated later for some other use.

Software signal fields:

*ref: All values named *ref are monitored by software. They represent values written to some hardware register, typically values commanded by TC.

sw_version: sw_version is one 16-bit number defining the software version. It is included in every private tecommand packet originating in MU and in MU HK packets. S/W mode is constructed as follows:***Bits***	***Name***	***Description***
14-15	Release class	0: N/A 1: D (development) 2: T (Testing version) 3: R (Release, official and stable revision)
9-13	Major	
4-8	Minor	
0-3	Patch number	

For example, Version number 0xC871 means s/w version R-4.7.1 (Release, major=4,minor=7, and patch number =1)

cpu_load: N/A

sw_mode: sw_mode defines software mode

7 INSTRUMENT SOFTWARE MODES

SW Mode	*Mode name*
1	Booting
2	Safe
3	Prom
4	Normal

7.1 Instrument modes

Instrument modes are defined in housekeeping packet just by reporting corresponding settings one by one.

8 IMA TELEMETRY

8.1 Source data field for IMA

After headers, there will be the source data field. For the HK report packet, it will be as shown below:

Byte	*Bits*	*Field*	*Note*
Source data field			
16	8-15	PAD	PAD=0
	0-7	SID	SID=10
18-41		IMA Housekeeping packet data (24 bytes)	

The content of the IMA Housekeeping packet data is defined by the IMA team and can be found in the ICA-IMA TC/TM Data Formats and Related Software Aspects Document issued by Hans Borg at IRF dated 2002-04-07 . The content of the source data field is exactly the same as the data fields of 4 link packets sent by IMA to the MU.

8.2 IMA HK definition

Word offs.	*Bits.*	*Content.*	*Table pos.*	*Parameter.*
0	15-10	Mode. See below.	0	mode
	9-8	Cmd status	9	hk_prm
		0=Ok (Ok)		
		1=Invalid (Inv)		
		2=Out of range (Out)		
		3=Erroneous (Err)		
	7-0	HV switches	10	ad_prm
	7	Deflection HV logical (ref)		
	6	Deflection LV logical (ref)		
	5	Entrance HV logical (ref)		
	4	Grid LV logical (ref)		
	3	Pacc HV logical (ref)		
	2	+28V main		
	1	+28V opto		
	0	+28V mcp		
1	15	Cmd toggle (Numeric 0/1)	12	hk_prm
	14-12	SID no	1	Sid_nr
	0	Minimum (Min)		
	1	Normal (Nrm)		
	2	Burst (Bst)		
	3	Calibration (Cal)		
	4	Special (Spc)		
	5	Test (Tst)		
	11-8	+28V presence	11	ad_prm
	11	HV enable/disable		
	10	Main		
	9	Opto		
	8	Mcp		
	7-0	Fifo filling (F8)	2	fifo_fill
2	15-0	Cmd return (Numeric hex)		direct from tc_decoder
3	15-8	Opto HV monitor	13	ad_prm
	7-0	Mcp HV monitor	14	ad_prm
4	15-8	Deflection HV monitor	15	ad_prm

Word offs.	*Bits.*	*Content.*	*Table pos.*	*Parameter.*
	7-0	Deflection LV monitor	16	ad_prm
5	15-8	Pacc HV monitor	17	ad_prm
	7-0	Grid LV monitor	18	ad_prm
6	15-8	Sensor temperature. (Sns)	19	ad_prm
	7-0	DPU temperatur. (Dpu)	20	ad_prm
7	15	Direct command switch	3	switches
	14-12	Pacc low level (ref.)	4	dta_12bit[3]
	11-0	Deflection HV reference	21	dig_dflhv
8	15	Alt. Pacc (Opera=Fix/Alt)	5	switches
	14-12	Pacc high level ref.	6	dta_12bit[4]
	11-0	Deflection LV reference	22	dig_dfllv
9	15	Pacc level (High/Low)	23	ms.flag
	14-12	Grid LV reference	24	dta_12bit[2]
	11-0	Entrance HV reference	25	dig_entr
10	15	Deflection HV (Opera=Stp/Fix)	26	switches
	14-12	Opto default reference	7	dta_12bit[0]
	11-9	Mcpdefault reference	8	dta_12bit[1]
	8-0	Entrance upper HV monitor	27	ad_prm
11	15	Entrance HV (Opera=Stp/Fix)	28	switches
	14-12	Opto current reference	29	Optocur
	11-9	Mcp current reference	30	Mcpcur
	8-0	Entrance lower HV monitor	31	ad_prm

8.3 IMA scientific TM modes

Mode	*Mnemonic*	*Comments*
Minimum		
0	Idle	
1	Mmom	Moments only
2	Mspo	Spectras only
3	Mmsp	Moments and Spectras
4	Msis	Selected Ion Species
5	Mexm	Energy Mass matrix
6	Void	
7	Void	
Normal		
8	Nrm0	Normal 0
9	Nrm1	
10	Nrm2	
11	Nrm3	
12	Nrm4	
13	Nrm5	
14	Nrm6	
15	Nrm7	
Burst		
16	Har0	High angular resolution 0
17	Har1	
18	Har2	
19	Har3	
20	Har4	
21	Har5	
22	Har6	
23	Har7	
24	Exm0	Energy Mass matrix 0
25	Exm1	
26	Exm2	
27	Exm3	
28	Exm4	
29	Exm5	
30	Exm6	
31	Exm7	
Special		
32	Test	
33	Cal1	Calibration 1
34	Cal2	Calibration 2
35	Fake	Faked science data
36	Void	
37	Void	
38	Void	
39	Void	

Fifo filling must be unpacked by int unpack_f8 (int acc)

```
int Astat5a::unpack_f8(int acc)
{
int exp;
        exp=(acc >>4) &0xF;
        if(exp>1) {
                acc=(acc & 0xF) | 0x10;
                acc=acc<< (exp-1);
        }
        return acc;
}
```

9 SCIENCE DATA

9.1 Science data production modes

9.2 Science data packet formats

All packages will have the normal TM header and Data field header in front of the package.

The Lossy compression scheme will be used only if the RICE (lossless) compressed package is larger than the packet size.

If the measurement mode is changed before the data for one packet is completely measured, the packet will be cut on the starting place of invalidity. Hence, the data sent to the ground is valid (in this sense) but the set is not necessarily complete. This can be identified by the packet length (in the uncompressed case it's smaller than normal) or as a smaller amount of decompressed data (in compressed case). Of course, this kind of recovery is not always possible.

9.3 Science data packet types

The Science packets produced in the Main Unit have data types and subtypes. The data Type (4bits) defines mainly an instrument the packet is related to and the subtype (4bits) specifies the packet type within an instrument packet. Packet types and subtypes are allocated as follows.
The Main Unit will also format telemetry packets coming from IMA. These will be formatted to the ESA packet TM format and sent to the s/c. Science data coming from IMA is not analyzed by any means in the Main Unit.

Data Type	***Data subtype***	***Data type name***	***Description***
0	0	Dummy	Doesn't contain anything meaningful
ELS Data Packages			
1	0	ELS Engineering information	First ELS packet within one scan cycle. Contains engineering information needed for analysis of ELS data. No science data included
	1	ELS Complete sweep	Data from one complete sweep included
	2	ELS Sweep step 0-63	Data from first 64 steps in one sweep
	3	ELS Sweep step 64-127	Data from latter 64 steps in one sweep
NPD1 data packages			
2	0	NPD raw data	NPD1 data produced in raw data mode
	1	NPD binning data	NPD1 data produced in bin matrix mode
	2	NPD TOF mode	NPD1 data in Time-of-Flight mode
	3	NPD PHD mode	NPD1 data in Pulse height distribution mode
NPD2 data packages			
3	0	NPD raw data	NPD2 data produced in raw data mode
	1	NPD binning data	NPD2 data produced in bin matrix mode
	2	NPD TOF mode	NPD2 data in Time-of-Flight mode
	3	NPD PHD mode	NPD2 data in Pulse height distribution mode
NPI data packages			
4	0	NPI Normal mode data	NPI data in normal mode
	1	NPI Stepping mode	NPI data in deflection voltage stepping mode
Engineering data packages			
5	0	Solar sensor information	Status of Solar sensor 1&2 in each sample irq during one scan.
	1	Scanner information	Scanner position on each sample irq in one scan.

9.3.1 IMA telemetry packets

IMA telemetry packets will be sent almost as they are received in the Main Unit. The structure of the IMA telemetry packets are as follows. The time tag of the TM packet will be the time of receiving the first link packet from IMA. Time will be the same for all packets built from the same IMA packet.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
16		Error status	0: No errors identified by MU others: first invalid word in IMA data	
17		IMA SID		
18-last		IMA packet		Maximum 2046 words of IMA telemetry packet

9.3.2 ELS telemetry packets

An ELS data packet can contain a maximum of 128 steps*16 sectors = 2048 words of (16-bit) raw data. Based upon whether compression is enabled or not, the data may fit in a single packet or may have to be split into 2 packets, with each packet comprised of 64 steps. The following table represents the ELS packet header that is common to all ELS packets.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
16-17		Science data Header	SW version	
18-19	8-15		Spare	
	4-7		Data type	1 = ELS Packet
	2-3		PAD	
	0-1		ELS packet subtype	0 = ELS engineering information 1 = ELS data steps 0-127 2 = ELS data steps 0-63 3 = ELS data steps 64-127
20-25			SCET Time	On start of first sweep (i e 'engineering' sweep) in this scan
26-27			ELS sector mask	
28	7	ELS compression scheme	Spare	
	6		Rice compression	
	5		Log compression (16 to 8 bit)	Note: If RICE compression is used, values will be 16bits in width, but the range for the value is 0-255. This is to optimize both performance and compression.
	3-4		Energy compression	0= 1 step, 1=2 steps, 2=4 steps , 3= undefined
	0-2		Time compression	0=1 sweep, 1=2 sweeps, 2=4 sweeps, 3=8 sweeps, 4=16 sweeps, 5-7=undefined
29			spare	

9.3.2.1 ELS engineering information

In the beginning of every scan cycle, some engineering information is sent in a separate ELS science packet. This information is needed for the analysis of the ELS science data that is returned during that scan cycle. This packet is built in the following way, starting from byte 30.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
30	3-7		Spare	
	2		Scanner direction	0 = 0 – 180 1 = 180 – 0
	0-1		Scanner speed	0 = standing 1 = 32s scan 2 = 64s scan 3 = 128s scan
31			Scanner position	On start of scan (or step) period
32		ELS Status	PAD	
33			ELS temperature	
34			ELS MCP reference	
35			ELS MCP monitor	
36			ELS Screen grid reference	
37			ELS Screen grid monitor	
38-39			ELS Deflection reference step1	
40-41			ELS Deflection monitor step 1	
42-43			ELS Deflection ref. step 2	
44-45			ELS Deflection mon. step 2	
Etc				
546-547			ELS Deflection ref. step 128	
548-549			ELS Deflection mon. step 128	

9.3.2.2 ELS data

After the first packet of ELS engineering data is sent, the remaining ELS packets will contain ELS science data. There are three types of packets: (1) one containing data from one complete sweep (128 steps), (2) one containing the first 64 steps from one sweep, and (3) one containing the latter 64 steps from one sweep. All ELS packets will be sent in a row so it's possible to find the order of these packet from the Packet sequence count field. In this case, the packet will be as follows:

Byte	*Bits*	*Field*	*Subfield*	*Remark*
30	3-7		Spare	
	2		Scanner direction	0 = 0 - 180 1 = 180 - 0
	0-1		Scanner speed	0 = standing 1 = 32s scan 2 = 64s scan 3 = 128s scan
31			Scanner position	On start of scan (or step) period
32		Data	Sector 0, step 1, sweep 1	Data from one sweep. If no log, energy nor sectormask type of comresssion is applieed to the data it will be divided to two parts. (ELS data packet subtypes 2 and 3) . In this case both packets will have same time tag on packet bytes 6-11. However, sequence count will differ between these two packets.
			Sector 1, step 1, sweep 1	
			....	
			Sector 0, step 2, sweep 1	
			Sector 1, step 2, sweep 1	

Byte	*Bits*	*Field*	*Subfield*	*Remark*

9.3.3 NPD telemetry packets

Byte	*Bits*	*Field*	*Subfield*	*Remark*
16-17		Science data Header	SW version	
18			spare	
19	4-7		Data type	2 = NPD1 packet 3 = NPD2 packet
	0-3		NPD packet subtype	0 = NPD raw data 1 = NPD binning data 2 = NPD TOF mode 3 = NPD PHD mode

9.3.4 NPD Raw data packet

Because raw data events are 25 bit in width and the compression scheme used is 16 bit RICE, one has to do a trick in order to make the compression as effective as possible. These 25 bit events are divided in the packet into two separate 'data streams', both containing 512 words.

Stream_1 words will have following structure.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
0-1	5-15	Stream_1 word	TOF	
	3-4		Direction	
	0-2		Coincidence	

Stream_2 words will have the following structure.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
0-1	8-15	Stream_2 word	PAD	
	0-7		Stop PH	

The overall structure for the NPD raw data packet will be as follows.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
20-25			Sample start time (SCET)	
26-27	8-15	Scanner information block	Scanner position	In the beginning of sample
	3-7		PAD	
	2		Scanner direction	
	0-1		Scanner speed	
28			PAD	
29	4-7	NPD bit information	Accumulation time	Time = 2^N * 31.25ms
	2-3		PAD	
	1		Log compression enabled	Always 0 for raw data mode (0 = disabled)
	0		RICE Compression enabled	
30		NPD Registers	FRONTCTRL	
31			MAINCTRL	
32-33			STAT	
34-35			TDCRD	
36-37			CALIB11	
38-39			CALIB12	
40-41			CALIB21	
42-43			CALIB22	

Byte	*Bits*	*Field*	*Subfield*	*Remark*
44-45			STARTCNT	
46-47			STOP0CNT	
48-49			STOP1CNT	
50-51			STOP2CNT	
52-53			TOFCNT	
54-55			RAWCNT	
56-		Data	Stream 1: 512 * Stream_1 words Stream 2: 512 * Stream_2 words	If applied, RICE compression is used in 'one-shot' over both streams. If applied, RICE compression is used in 'one-shot' over both streams.

9.3.4.1 NPD Bin matrix data packet

The NPD Bin matrix data packet will contain data from 768 bin counters. The data will be ordered so that bin number 0 is the first one found in the packet.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
20-25			Sample start time (SCET)	
26		Scanner block information	Scanner position	In the beginning of this sample.
27	3-7		PAD	
	2		Scanner direction	
	0-1		Scanner speed	
28			PAD	
29	4-7	NPD Bit information	Accumulation time	Time = 2^N * 31.25ms
	2-3		PAD	
	1		Log compression enabled	0 = disable 1 = enable
	0		RICE Compression enabled	0 = disable 1 = enable
30-31	12-15	Treshold values	PAD	
	8-11		Treshold 3	0 = Matrix 0, 16x16 1-14 = Matrix 1, 2x16 15 = Matrix 2, 1x16
	4-7		Treshold 2	
	0-3		Treshold 1	
32-33		NPD Registers	CALIB11	
34-35			CALIB12	
36-37			CALIB21	
38-39			CALIB22	
40-41			STARTCNT	
42-43			STOP0CNT	
44-45			STOP1CNT	
46-47			STOP2CNT	
48-		Data	Bin number 0x000	Might be RICE compressed Number of bins returned is dependent upon the threshold mode, so the
			Bin number 0x001	
			Etc ...	

Byte	*Bits*	*Field*	*Subfield*	*Remark*
			Bin number 0x2ff	maximum number of bins returned would be 16x16x3 = 300 bins (0x000 to 0x2ff). The 3 represnts the number of directions. In case of 1x16 matrices count for lowest tof value is sent first. In case of 2x16 matrices lowest tof value in hydrogen region is sent frist. 16th element is lowest tof value in oxygen region.

9.3.4.2 NPD TOF mode data packet

When NPD is run in the special TOF mode, the data will be packeted into TOF mode packets which contain 3 different 'TOF' tables.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
20-25			Sample start time (SCET)	
26-27	8-15	Scanner information block	Scanner position	In the beginning of sample
	3-7		PAD	
	2		Scanner direction	
	0-1		Scanner speed	
28			PAD	
29	4-7	NPD bit information	Accumulation time	Time = 2^N * 0.5s
	2-3		PAD	
	1		Log compression enabled	0 = disable 1 = enable
	0		RICE Compression enabled	0 = disable 1 = enable
30			Number of (valid) samples integrated to the matrix	Latchups may happen during integration. Affected samples are not integrated to the matrix.
31			PAD	
32-33		NPD Registers	CALIB11	
34-35			CALIB12	
36-37			CALIB21	
38-39			CALIB22	
40-41			STARTCNT	
42-43			STOP0CNT	
44-45			STOP1CNT	
46-47			STOP2CNT	
48-		Data	First data word in TOF mode	768 data words (or bytes), Might be RICE compressed

9.3.4.3 NPD PHD mode data packet

When NPD is run in the special PHD mode, the data will be packeted into PHD mode packets which contain the least significant bytes of the stoparray.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
20-25			Sample start time (SCET)	
26-27	8-15	Scanner information block	Scanner position	In the beginning of sample
	3-7		PAD	
	2		Scanner direction	
	0-1		Scanner speed	
28			PAD	
29	4-7	NPD bit information	Accumulation time	Time = 2^N * 31.25ms
	2-3		PAD	
	1		Log compression enabled	Always 0 for PHD mode (0 = disabled)
	0		RICE Compression enabled	
30-31			PAD	
32-33		NPD Registers	CALIB11	
34-35			CALIB12	
36-37			CALIB21	
38-39			CALIB22	
40-41			STARTCNT	
42-43			STOP0CNT	
44-45			STOP1CNT	
46-47			STOP2CNT	
48-		Data	Least significant byte of STOPARRAY channel 0	48 data bytes (or bytes), Might be RICE compressed
			Least significant byte of STOPARRAY channel 1	
			...	
			Least significant byte of STOPARRAY channel 47	

9.3.5 NPI telemetry packets

One NPI telemetry packet will consist of 32 samples. This leads to 32 samples*32sectors = 1024 words of raw 16 bit data. This data can be compressed. Whether the packet is compressed or uncompressed can be determined using the NPI compression flags that are returned in the MU full housekeeping packet and in byte 28 of the NPI science packet.

Byte	*Bits*	*Field*	*Subfield*	*Remark*
16-17		Science data Header	SW version	
18			PAD	
19	4-7		Data type	4 = NPI packet
	0-3		NPI packet subtype	0 = NPI data (normal mode) 1 = NPI data (defl stepping mode)

9.3.5.1 NPI normal mode data packet

Byte	*Bits*	*Field*	*Subfield*	*Remark*
20-25			Sample start time (SCET)	
26-27	8-15	Scanner information block	Scanner position	In the beginning of sample
	3-7		PAD	
	2		Scanner direction	
	0-1		Scanner speed	
28	4-7	NPI bit information	Accumulation time	Time = 2^N * 31.25ms
	2-3		PAD	
	1		Log compression enabled	0=disabled 1=enabled
	0		RICE Compression enabled	0=disabled 1=enabled
29			Sample Number	Number of samples in packet (max=32)
30-33			NPI Sector mask	
34-		Data	Sample 0, sector 0	Might be RICE compressed
			Sample 0, sector 1	
			...	
			Sample 31, Sector 31	

9.3.5.2 NPI Deflection stepping mode data packet

Byte	*Bits*	*Field*	*Subfield*	*Remark*
20-25			Sample start time (SCET)	
26-27	8-15	Scanner information block	Scanner position	In the beginning of sample
	3-7		PAD	
	2		Scanner direction	
	0-1		Scanner speed	
28	4-7	NPI bit information	Accumulation time	Time = 2^N * 31.25ms
	2-3		PAD	
	1		Log compression enabled	0=disabled 1=enabled
	0		RICE Compression enabled	0=disabled 1=enabled
29			Sample Number	Number of samples in packet (max=32)
30-33			NPI Sector mask	
34-37			NPI deflection status mask	
38-		Data	Sample 0, sector 0	Might be RICE compressed
			Sample 0, sector 1	
			...	
			Sample 31, Sector 31	

9.3.6 Engineering telemetry packets

There are two packets of ‘engineering type' packets; the solar sensor information packet and the scanner information packet. Solar sensor information is a readout of the solar sensors in each sample interrupt during one scan cycle. The Scanner position packet reports on the scanner position on each sample irq during one scan cycle.

Byte	***Bits***	***Field***	***Subfield***	***Remark***
16-17		Science data Header	SW version	
18			PAD	
19	4-7		Data type	5 = Engineering packet
	0-3		Engineering packet subtype	0 = Solar sensor information 1 = Scanner information

9.3.6.1 Solar sensor information packet

Byte	***Bits***	***Field***	***Subfield***	***Remark***
20-25			Sample start time (SCET)	
26			Scanner position	At start
27	7		PAD	
	6		Scanner direction	
	4-5		Scanner speed	
	1-3		PAD	
	0		RICE compression enabled	
28-	7		Solar sensor 1 status pos 0	
	6		Solar sensor 2 status pos 0	
	…			
	1		Solar sensor 1 status pos 3	
	0		Solar sensor 2 status pos 3	
…				
Last	7		Solar sensor 1 status pos last-3	
	6		Solar sensor 2 status pos last-3	
	…			
	1		Solar sensor 1 status pos last	
	0		Solar sensor 2 status pos last	

9.3.6.2 Scanner information packet

Byte	***Bits***	***Field***	***Subfield***	***Remark***
20-25			Sample start time (SCET)	
26			Scanner position	At start
27	7		PAD	
	6		Scanner direction	
	4-5		Scanner speed	
	1-3		PAD	
	0		RICE compression enabled	
28-		Data	Scanner position 0	Up to 2048 positions (each is 1 byte), which corresponds to 64sec. Can be RICE compressed.
			Scanner position 1	
			...	
			Scanner position last	