XMM OPTICAL MONITOR

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XMM-OM USER MANUAL
TELECOMMAND AND TELEMETRY SPECIFICATION

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CHANGE RECORD

Issue	Date	Comments
Draft	17 Mar '95	Draft Version for Comment
1	'95	Issued Internally only
1.draft	29 Mar '96	Red detector references deleted. Tables updated to PSD version 4 and above format. Major revisions to layout Include TMPSU and HK.
2	29 April '96	Comments Incorporated
2onc	31 Jan '97	Draft copy issued for comment, to include Post DPU EOB modifications. Post ICU-DPU Integration modifications Post OM Commanding discussion
3	26-Feb-97	Issued - changed to letter size for US printing
3onc		Revisions to Filter Wheel commands. Revisions to Memory Management Commands Addition of READ ICB commands Typographic Corrections
4	7 Aug '97	'Snapshot' for EM Delivery
4onc	Aug '97	Corrected Allowed Heater Configs Fixed SSI/RBI Numbering Confusion Clarified format of DPU Events/Exceptions Distinquished between 16 and 24 bit DPU Global Memory Added additional errors to non-DPU exceptions Modified HK to show ICB last error instead Added additional Unsuccessful Execution error code Added details for direct writing to MACSbus ports Added details for direct reading from MACSbus ports
5	22-Sep-97	Update Released for consistency with EM User Manual
5onc		Updated f/w details Introduced bootstrap reports Corrected and enhanced exception error numbers Enhanced key definitions to direct ICB read/write tables Introduced camera halt/running command Clarified nature of ICB direct command. Corrected Format of Read ICB Directly command. Corrected ICB Direct Write contents table Added support for Detector Electronics Table Dumping Only 1 SID enabled or disabled at a time. Implemented change to BPE port numbers Only 1 flood LED now commanded DEMPSU off added. Removed various DPU commands Clarified Prime-Redundant flag in HK Added DPU Heartbeat Watchdog Updated Mode change command Added additional user command execution failure codes. Finalised control of HV and Temperatures.
6	6 Mar '98	Formal Release Tracking Flag Added

CHANGE RECORD (CONTINUED)

Issue	Date	Comments
6onc	21 Apr '98	Removed incorrect reference to 2 LED's in HK. Corrected incorrect reference to address 0x1000 to 0x10000 in memory management packets. Corrected offsets in f/w speed command. Corrected spelling of IC_SYNCH_CLK. RAM error messages corrected. CLK_SYNCH error/alerts clarified Added Invalid for this mode command acceptance error. Added Parameters not Loaded execution failure error.
Draft	9 June '98	Re-Titled as Part 3 of the User Manual.
1	3-July 1998	Issued as Part 3 User Manual
2	Oct '98	Table formatting tidied. Some PREF's corrected. Prime/Redundant Flag in HK corrected. Mode change command corrected - NCR 106. Removed autonomous safing as per ECR-69/NCR 124. Miscellaneous spelling corrections. Clarified whether commands are valid for both basic and operational mode. Clarified Heater Control Algorithm defaults.
3	23 May 99	Corrected Header at page top. Restored 'Notes' numbering to the DPU commands and events and exceptions tables. Made references to the ICU-DPU protocol document consistent. Corrected PREF H1040 reference to H140 (section 2.2.4.1.6). Corrected number of bits used by dichroic position counter in HK. Removed incorrect TBD's. Clarified and removed TBD's from DPU related exceptions table. Re-introduced autonomous safing. Included Spare 4 byte field present at end of HK. Added previously undocumented DPU alerts - ECR 81. Only White local ram dump/load supported - NCR 144. Re-labelled REF-A in HK as spare (not connected). Noted which science SID's are enabled by default. Documented difference of mode change command in Basic - NCR 106. Corrected 24 bit drift information format in HK. Clarified action in event of transition to current state. Noted need to patch basic code to fix NCR 155 (CRC calculation incorrectly applied). Expanded description of Add Time Code command. Added further explanation of the IC_SYNC_CLK command. Added note to HK regarding the -5.3 V TMPSU line. Dichroic position in HK now 6 bits. H9000 (Go to Initial) command removed.

CHANGE RECORD (CONTINUED)

Issue	Date	Comments
4	31-Aug-99	Expanded description of MACSbus error exception packet. Corrected 'type' column description for science data. Added reference to DD_RAW data as 'placeholder'. Alias corrected for frame tag enabled in HK. Added further explanation for : a) Reset Camera Head Electronics, b) Start/Stop Science data acquisition c) On/Off Switched secondary voltages d) Enable/Disable HK e) Start/Stop Autonomous Safing f) Start/Stop DPU Heartbeat Watchdog g) Reset DEMPSU h) DPU Off. Corrected length of Exposure ID in HK. Clarified Units of 'length' for memory dump commands. Clarified format of memory dumps. Added reference to NCR 178 in the 'start task' summary section. Documented contingency version of DPU code containing a IC_DUMP_PROG_RAM that can dump ROM. Clarified consequences of using 'Direct' DPU commands to dump memory.
5	12 May 00	Corrected statement that H6800 is available in Basic Mode ECR 087 – Many ICU generated Exceptions converted into Major Anomalies in release 10 of the software – see sections 3.4. ECR 088 - Additional "F./W not at blocked" message for command execution failure added for release 10 – see section 3.3. NCR 192 – Additional notes added to the heater control task describing the release 10 onwards modifications that enable automatic focus heater control – see section 2.2.4.4.3.2. ECR 089 – Auto safing task on telemetry queue full, description changed to indicate that it now triggers after 1 minute – see section 2.2.2.

TABLE OF CONTENTS

1. Introduction

1.1 Purpose and Scope

The purpose of this document is to specify the telecommand and telemetry packets that will be used to command, and downlink data from, the XMM Optical Monitor (OM). This document, together with the APP-3, is intended to satisfy the requirements for the Satellite Users Manual, section 5.X.10, “Summary of Experiment Telemetry and Telecommand Data”. This is, in turn, specified in Annex A1 of the XMM Operations Interface Requirements Document (PX-RS-0028).

1.2 Applicable Documents

APP - 1. Packet Structure Definition	RS-PX-0032
APP - 2. XMM Operations Interface Requirements	RS-PX-0028
APP - 3. ICU-DPU Protocol Definitions	XMM-OM/MSSL/ML/0011
APP - 4. The MIC Detector	XMM-OM/MSSL/RV/0003
APP - 5. Document Reference removed	
APP - 6. Overview of the XMM-OM DPU	XMM-OM/PENN/TC/0026
APP - 7. Bootstrap Specification and Design	XMM-OM/MSSL/ML/0008
APP - 8. OM Heater Control	XMM-OM/MSSL/SP/165
APP - 9. Experiment On-Board Software -ICU	XMM-OM/MSSL/ML/0008.2

1.3 Terms and Abbreviations

APID	Application Identifier
CRC	Cyclic Redundancy Code
DEM	Digital Electronics Module - this contains the DPU, ICU and power supply.
DEMPSU	Digital Electroncis Module Power Supply.
DMA	Direct Memory Access
DPU	Digital Processing Unit
FID	Function Identifier
F/W	Filter Wheel
ICB	Instrument Control Bus
LED	Light Emitting Diode
LSB	Least Significant Bit
MACSbus	Modular Attitude Control System bus
MFN	Master Function Number
MID	Memory Identifier
MSB	Most Significant Bit
N/A	Not Applicable
OM	Optical Monitor
PREF	Parameter Reference
PSD	Packet Structure Document
RBI	Remote Bus Interface
SCI	Serial Communications Interface - a serial interface connecting the DPU processors
SID	Structure Identifier
SSI	Serial Synchronous Interface
TBC	To Be Confirmed
TBD	To Be Defined
TPN	Telemetry Packet Number
TC	Telecommand Packet
TID	Task Identifier
TM	Telemetry Packet
TMPSU	Telescope Module Power Supply Unit
VBWL	Variable Block Word Length
XMM	X-ray Multi Mirror

1.4 Bit Numbering Conventions

The following conventions are used in describing an N-bit field.
The first bit in the field (starting on the left) is Bit 0 and is the left most justified bit in a diagram. 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 diagram.
If the N-Bit field represents an “Unsigned Integer” value, Bit 0 is the Most Significant Bit (MSB) and Bit N-1 and the Least Significant Bit (LSB).
If the N-Bit field represents a “Signed Integer” value, Bit 0 indicates the sign. Bit 0 = 0 indicates a positive number, and Bit 0 = 1 a negative number.
Adjacent groups of bits are described in terms of octets and words, where 1 octet = 1 byte = 8 bits and 1 word = 2 octets = 16 bits.

1.5 Word and Byte Alignment

For ease of coding, and to conform to APP-1, items in a packet representing a 16 bit word are word aligned, i.e. the offset from the start of the packet data field is an even number of octets. Similarly, octet long items will be at an offset from the start of the packet data field that is a multiple of 8 bits.

1.6 Packet Numbering Conventions.

Packet class and function is provided by packet type and packet subtype, included in the data field header of each packet which is described elsewhere in this document.

A telecommand packet type and subtype combination are represented by the letters TC followed, in brackets, by their numerical values separated by a comma e.g. TC(5,1) refers to Telecommand Packet Type 5, subtype 1.

A telemetry packet type and subtype combination are represented by the letters TM followed, in brackets, by their numerical values separated by a comma e.g. TM(5,1) refers to Telemetry Packet Type 5, subtype 1.

2. Telecommands

2.1 Overview

All telecommand packets will conform to the structure defined in APP-1. The template structure is repeated here for convenience.

PACKET HEADER (48 bits)							PACKET DATA FIELD		
Packet ID				Packet Sequence Control		Packet Length	Data Field Header	Application Data	Packet Error Control
Version Number	Type	Data Field Header Flag	Application Process ID	Sequence Flags	Sequence Count				
3	1	1	11	2	14				
16				16		16	16	N*16	16

2.1.1 Packet Header

2.1.1.1 Packet ID

Version Number set to zero (as per APP-1)
Type set to 1, indicating it is a telecommand packet
Data Field Header set to 1, indicating the data field header is always present
Application Process ID (APID) This identifies the source-sink path for this packet. TheAPID for OM will have the value 1024.

2.1.1.2 Packet Sequence Control

Sequence Flags (bits 0 through 1) These 2 bits are set to “11” (binary), which means “stand-alone” packet.

The following field is provided to identify a particular telecommand packet.

Sequence Count (bits 2 through 15) Bit 2 : 0/1 if source = ground/on-board application respectively

Bits 3 through 15 the actual sequence count. The counter will increment by 1 for each new command and may be reset to zero whenever the source ‘wraps-around’ from full-scale to zero.

2.1.1.3 Packet Length

The Packet Length Field contains an unsigned integer “C”, where C = (Number of octets in Packet Data Field) - 1.

The maximum length of a Telecommand Packet Data Field is 242 octets. Therefore C <= 241.

2.1.2 Packet Data Field

The bulk of this section consists of detailed descriptions of the Packet Data Field for every OM supported packet type and subtype. It consists of up to 3 sub-fields

- Data Field Header (always present)
- Application Data (which may be zero in length)
- Packet Error Control (present only if so indicated by a flag in the Data Field Header)

A summary of the sub-fields is repeated here from APP-1 for convenience.

2.1.2.1 Data Field Header

The Data Field Header is defined as follows:

Spare	Checksum Type	Ack	Packet Type	Packet SubType
2 Bits	2 Bits	4 Bits	4 Bits	4 Bits

The components are as follows:

Spare : Set to '00' (binary).

Checksum Type : Indicates the presence or absence of a Packet Error Control Field at the end of the Packet Data Field.

Value = 0 = No Checksum present.
Value = 3 = Checksum field is present

Ack : Indicates the required acknowledgements from the OM for the command. These will take the form of up to two verification packets.

Bit 4 = 1 = Acknowledge acceptance of packet
Bit 5 = 0 = Not Used
Bit 6 = 0 = Not Used
Bit 7 = 1 = Acknowledge *failed* completion of execution

Packet Type : This identifies the class of the packet. The telecommand packet types supported by OM are given in the table below.

Packet Type	TC Packet Function
5	Task Management
6	Memory Maintenance
9	Telemetry Management
10	Time Management
13	Test Commands

Packet SubType : This, together with the Packet Type, indicates the function of the packet.

The complete list of TC Packets supported by OM is given by the following table.

NOTES
Reception of an unsupported packet type/subtype combination will generate an 'Unsuccessful Command Acceptance packet (see section 3.3.2)

General Category	Type, SubType	Function
TASK MANAGEMENT	5,1	Start Task
	5,2	Stop Task
	5,3	Load Task Functional Parameters
	5,4	Report Task Parameters
	5,5	Mode Transition
MEMORY MAINTENANCE	6,1	Load Memory
	6,2	Dump Memory
	6,3	Calculate Memory Checksum
TELEMETRY MANAGEMENT	9,1	Report TM Packet Generation Status
	9,2	Enable Generation of all TM Packets
	9,3	Disable Generation of all TM Packets
	9,4	Enable Generation of Specific Packets
	9,5	Disable Generation of Specific Packets
ON-BOARD TIME MANAGEMENT	10,2	Enable Time Synchronisation
	10,3	Add Time Code
	10,5	Enable Time Verification
TEST COMMANDS	13,1	Test Command

2.1.2.2 Application Data

This constitutes the data element of the telecommand. The precise format depends on the values of type and subtype. The table in section 2.1.3 provides a summary. The meaning of the terms used is explained elsewhere in the document.

2.1.2.3 Packet Error Control

This field, if present, contains an error detection code (checksum) for the packet. This allows the OM to verify the integrity of the telecommand packet data. It is calculated over the complete packet *less* the final 16 bits of the Packet Error Control Field. Appendix 3 of APP-1 specifies the checksum method used.

NOTE : NCR 155. The OM basic (ROM) code always checks incoming telecommands for a valid CRC, even when the packet header indicates that it is not present. A patch (OM-BASIC-1-CRC) is available to correct this.

2.1.3 2.1.3 Packet Structure Summary

The Telecommand Packet Structure is summarised in the following tables.

Packet	consists of	which consists of	which consists of	which consists of	Size (bits)
TC Packet	Packet Header	Packet ID	Version Number		3
			Type		1
			Data Field Header Flag		1
			APID		11
		Packet Sequence Control	Sequence Flags		2
			Sequence Count	Command Source	1
				Actual Sequence Count	13
		Packet Length			16
	Packet Data Field	Data Field Header	Spare		2
			Checksum Type		2
			Ack		4
			Packet Type		4
			Packet SubType		4
		Application Data	as summarised in next table.		N*16
		Packet Error Control(Optional)			16

TC Packet Summary

Cate-gory	Type, SubType	Application Data (Byte Offsets) 0	1	2	3	4	5	6	7	8 ⇒ end
Task Mgmt.	5,1	TID	Spare							
	5,2	TID	Spare							
	5,3	TID	FID	Parameters						
	5,4	TID	FID							
	5,5	MODE	Spare	Parameters						
Mem. Maint.	6,1	MID		Start Address				Data		
	6,2	MID		Start Address				Length		
	6,3	MID		Start Address				Length		
Tlm. Mgmt.	9,1									
	9,2									
	9,3									
	9,4	SID 1	Spare	SID 2	Spare	Repeat as required				
	9,5	SID 1	Spare	SID 2	Spare	Repeat as required				
Time Mgmt	10,2									
	10,3	Coarse Time				Fine Time				
	10,5									
Test	13,1									

TC Application Data Summary

2.2 Task Commands

This section defines the contents of the packet data field for the task management telecommand packets.

2.2.1 Overview

These commands initiate, stop or load parameters into a task, where a task is “a definite amount of actions to bring about a result for a user” (APP-1). Additionally, they are used to initiate a report of the last parameters loaded and initiate mode changes.

Each command type - dependent on applicability - may be further subdivided into the following sub-systems:

- Detector
- Digital Processing Unit (DPU)
- Spacecraft Interface
- Instrument Control Bus (ICB)
- Serial Synchronous Interface (SSI)
- Telescope Module Power Supply Unit (TMPSU)
- DEM Power Supply

To understand the telecommand packet descriptions in this section, a brief description of key points of the above sub-systems follows.

2.2.1.1 Detector

A full description of this detector can be found in APP-4.

Load Detector Centroid Table Task - using counts from 3 adjacent pixels in both X and Y, each photon event detected is centroided to 1/8 of a pixel, thus providing a 2048*2048 resolution from the 256*256 pixel read out. This is achieved by the detector electronics feeding sum and difference signals into a look-up table (64K by 4 bits) for each axis that returns the required result. This task runs an on-board algorithm that generates the table. It requires 9 parameters, known as Centroid Table Boundaries, for each axis.

Load Detector Window Table Task - the detector electronics contains a window look-up table that is 64K by 4 bits. Each 4 bit location is associated with a 2 by 2 array of CCD pixels and defines whether that group of pixels is active and, if so, to which window they belong. This task runs an on-board algorithm that generates and loads the required table from the windows specified

Load DPU Deduced Windows into Detector Window Table Task - during the course of an exposure, the DPU will deduce the optimum detector windows required for the current observation. Parameters describing those windows are forwarded to, and stored by, the ICU. This task loads the window look-up table consistent with those stored parameters.

Detector Integration - this task controls the detector integration.

High Voltage Tasks - these control the detector high voltages.

2.2.1.2 Digital Processing Unit (DPU)

An overview of the DPU operation is given in APP-6 and some aspects are summarised below for convenience

Due to bandwidth limitations, it is not possible to telemeter every photon detected. Therefore the DPU is used to perform first level data reduction, primarily summing of the image. It must also correct for spacecraft drift to prevent blurring of the resulting image.

ACQUIRE FIELD Task - at the start of each new pointing, the DPU acquires a full format snapshot lasting one *frame* time (10-20 secs) behind a V filter. The co-ordinates of up to 16 *reference* stars of known positions are uplinked and compared with the co-ordinates of brightest stars detected in the field of view. This gives a correction to the commanded position.

CHOOSE GUIDE STARS Task - at the start of each exposure the DPU again acquires a full format snapshot lasting one frame time (10-20 secs) but this time using an observer selected filter. From this *reference* frame, the 10 brightest stars which meet acceptance criteria are selected as *guide* stars. Windows to surround these guide stars, as well as the science windows, are deduced and passed to the ICU so that the detectors can be set up.

WINDOWS - A set of non-overlapping data collection areas, known as memory windows, are set up in the DPU to contain the *science windows.* A memory window corresponds to a fixed sample of detector pixels. A science window may therefore move around within a memory window as the satellite drifts. Each memory window corresponds to one or more *detector windows.*

TRACK GUIDE STARS Task - the remainder of an exposure then consists of an integral number of *tracking* frames. During each of these frames, the guide stars are used to deduce the drift. This deduced drift is passed on to the ICU.

ACCUMULATE IMAGE Task - for those windows in which an Image mode exposure is to be obtained, the individual tracking frames are shifted to compensate for the drift and summed into an accumulating image for the duration of an exposure. This is achieved by the DPU alternating automatically between TRACK GUIDE STARS and ACCUMULATE IMAGE.

2.2.1.3 Spacecraft Interface

This takes the form of a Remote Bus Interface (RBI) which DMA's packets to and from memory areas in the ICU. These memory areas contain the telecommand and telemetry queues.

2.2.1.4 Instrument Control Bus (ICB)

The Instrument Control Bus is implemented using the MACSbus standard. All commands to the detectors and mechanisms in the OM Telescope Module are implemented via this bus. Each unit and internal register is visible to the ICU as an address and sub-address combination. The ICU is the master, all other units are slaves.

2.2.1.5 Serial Synchronous Interface (SSI)

This provides the ICU with the command path to, and data path from, the DPU.

2.2.1.6 Telescope Module Power Supply Unit (TMPSU)

This converts power from the spacecraft 28V power bus to provide the OM Telescope Module regulated power rails used to power the mechanisms, heaters and detector. It also powers the filter wheel coarse position sensor system (the fine sensor system is powered via the detector electronics).

2.2.1.7 Filter Wheel Mechanism Control Tasks

The eleven optical elements are equally-spaced around the filter wheel. The wheel is driven by a pinion on a 4-phase stepper motor shaft, with a gear ratio of 11 to 1. Thus one revolution of the motor, which requires 200 steps, moves the wheel from one optical element to another, and 2200 steps will completely rotate the filter wheel.

The wheel position will normally be determined in open loop mode by step counting from a known datum position. A system of position sensors is provided to relocate the datum position, should it be lost, and to verify the wheel position during and after every traverse. This system also confirms that the centre of any optical element has been found, although the element is not identified. A reflective infra-red *coarse* position sensor is fitted to the wheel which gives a true output when the blank is within about ± 15° of its correct operational position. A further infra-red *fine* position sensor, this time used in transmissive mode, is fitted to the rear end of the motor. An occulting disk with a small aperture, through which the sensor looks, is fitted to the rear extension of the motor shaft. This is used to determine the motor position to a single step.

Should either sensor fail, contingency tasks are provided to move the filter wheel using only the coarse or fine sensor, or to move the filter wheel by direct pulsing of the motor.

2.2.1.8 Dichoic Mechanism Control Task

The dichroic mechanism contains a mirror placed at 45° in the path of the incoming beam. The purpose of the mechanism is to steer the reflected light beam from one of two redundant detector systems. It will be traversed from one position to the other by pulse counting. The final step will drive the rotor to its stop where it will be held by a magnetic detent. The dichroic mechanism has to rotate 180° between the stops and is driven by a 4 step per revolution motor geared at 14.5:1. Therefore the motor needs to be driven 29 steps from one position to the other. One further stop in each direction means that the rotor is driven hard onto its stop. Thus the total number of steps required is 31. As there is no harm in overdriving the system against this stop, the dichroic mechanism task always drives the motor the maximum number of steps required in the specified direction. The drive frequency is 2 Hz.

2.2.1.9 DEM Power Supply

This provides the conditioned power for the ICU and DPU in the DEM. It provides latchup protection. A digital control to reset the DEM-PSU latchup circuits will come from the ICU.

2.2.2 Start Tasks

When a Start Task telecommand is received, the ICU will start the task specified by the Task ID (TID).

If a Load Task Parameters telecommand has already been received (see section 2.2.4), the task shall be started with the loaded parameters.

If a task is already running, it shall immediately use the parameters on receipt of the Load Task Parameters telecommand.

Some tasks are deemed to be always running. These, therefore, do not have an associated Start Task Telecommand and are indicated below with 'N/A' in the Master Function Number (MFN) column.

The following table lists the valid TID's, the associated MFN and whether they are valid in both basic and operational modes - see overleaf for associated notes.

Sub-System	TID (Hex)	Task Function	MFN	Basic	Oper
Detector	10	Load Centroid Table	H5100	No	Yes
	11	Load Window Table	H5110		
	12	Load DPU Deduced Window Table (always running)	N/A		
	13	Start Detector Integration	H5130		
	14	High Voltage Ramp-up/down	H5140		
	18	Reset Camera Head Electronics (Contingency only) [1]	H5180		
DPU	A4	Direct DPU Control (always running)	N/A	No	Yes
	A5	Start Science Data Acquisition (contingency) [2]	H5250		
	A6	Start DPU Heartbeat Watchdog (contingency) [6]	H5760		
ICB	41	Enable ICB Load Port	H5410	Yes	Yes
RBI Watchdog	50	Watchdog Enable	H5510	Yes	Yes
TMPSU	60	Move Filter Wheel	H5600	No	Yes
	65	Move Dichroic Mechanism	H5650		
	66	Heater Control (Contingency)	H5660		
	67	Heater Control	H5670	Yes	
	69	Turn on Switchable Secondary Voltages (contingency) [3]	H5690		
DEMPSU	80	Reset of DEM-PSU Latchup Protection Circuits/ DPU On [7]	H5800	Yes	Yes
Housekeeping and Safing	D0	Enable Housekeeping (contingency) [4]	H5700	Yes	Yes
	D1	Enable Autonomous Safing (contingency) [5]	H5710	No	Yes

Start Task ID Summary

The format of all Start Task Telecommand Packet Data Fields is as follows:

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Type and Ack	Data Field Header
1	1	-	Packet Type /SubType = 5,1	
2	1	Unsigned Integer	Task ID (TID)	Application Data
3	1		Spare	
4	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

Notes.

1. Reset Camera Head Electronics. This contingency command performs a hardware reset of the blue camera head electronics.
2. Start Science Data Acquisition. This contingency command (re)enables the following ‘handshake’ sequence, which is enabled by default.
   a) When science data has been prepared by the DPU for downloading to the ground, the alert DA_DATA_ALERT is sent to the ICU.
   b) The ICU then requests 1 block of science data which the DPU then transmits to the ICU.
   c) If there is any more science data, the DPU sends a further DA_DATA_ALERT at which point step b) repeats.
   d) This cycle repeats until there is no more science data, at which point a DA_DATA_END alert is sent.
   e) The ICU then awaits further DA_DATA_ALERT’s.
3. Turn On Switchable Secondary Voltages. This contingency command turns on switched secondary voltages if they are off. They are on by default in operational mode, off by default in basic mode. The HK parameters H5280 through H5315 will increase in value to reflect their new state.
4. Enable Housekeeping. This is on by default. This contingency command (re)enables both HK acquisition and the sending of HK packets to ground.
5. Start Autonomous Safing. This contingency command (re)starts the autonomous safing task, which is on by default. The autonomous safing monitors the status of the telemetry queue. If the queue becomes full and remains so for 1 minute, it assumes the spacecraft has a problem. It then ramps down the high voltages to zero and moves the filter wheel to blocked.
6. Start DPU Heartbeat Watchdog. This contingency (re)starts the DPU heartbeat watchdog task, which is on by default. A software watchdog runs in the ICU and monitors the DPU heartbeat blocks it receives. These heartbeats should be issued every 10 seconds by the DPU. If there is a gap between these heartbeats of greater than 25 seconds, the watchdog assumes that there is a possible DPU problem and issues the 92802 ‘Loss of DPU Heartbeat Exception’.
7. Reset DEMPSU/DPU On. This contingency command:
   a) resets the DEMPSU latchup circuits if required.
   b) powers up the DPU if off. **Note** - NCR 178 : it has been observed on the flight spare model that if the DPU is powered off by a prior H6800 command (see next section), this command causes a reset of the ICU as well. This has only been tested on the flight spare.

2.2.3 Stop Tasks

This command stops the task specified by the Task ID (TID).

However, this command is only supported for the tasks listed below because of one of the following reasons:

1. the task stops itself within a short period of time.
2. the task is deemed to be always running.
3. because it is not meaningful.

The following table lists the valid **TID**s , the associated MFN and whether they are valid in both basic and operational modes - see overleaf for associated notes..

Sub-System	TID (Hex)	Task Function	MFN	Basic	Oper-ational
Detector	10	Load Centroid Table	H6100	No	Yes
	11	Load Window Table	H6110		
	13	Stop Detector Integration	H6130		
	14	High Voltage Ramp-up/down	H6140		
DPU	A5	Stop Science Data Acquisition (contingency) [1]	H6250	No	Yes
	A6	Stop DPU Heartbeat Watchdog (contingency) [5]	H6760		
ICB	41	Disable ICB Load Port	H6410	Yes	Yes
RBI Watchdog	50	Watchdog Disable	H6510	Yes	Yes
TMPSU	60	Move Filter Wheel	H6600	No	Yes
	65	Move Dichroic Mechanism	H6650	No	
	66	Heater Control (Contingency)	H6660	No	
	67	Heater Control	H6670	Yes	
	69	Turn off Switchable secondary voltages (contingency) [2]	H6690	Yes	
DEMPSU	80	DPU Off (contingency) [6]	H6800	No	Yes
Housekeeping & Safing	D0	Disable Housekeeping (contingency) [3]	H6700	Yes	Yes
	D1	Disable Autonomous Safing (contingency) [4]	H6710	No	Yes

Stop Task ID's

The format of a Stop Task Telecommand Packet Data Field is as follows:

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Type/Ack	Data Field Header
1	1	-	Packet Type /SubType = 5,2	
2	1	Unsigned Integer	Task ID (TID)	Application Data
3	1	-	Spare	
4	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

Notes.

1. Stop Science Data Acquisition. This contingency command disables the science data acquisition 'handshake' sequence described in the previous section. It is enabled by default..
2. Turn Off Switchable Secondary Voltages. This contingency command turns off the switched secondary voltages if they are on. They are on by default in operational mode, off by default in basic mode. The HK parameters H5280 through H5315 will decrease in value to reflect their new state.
3. Disable Housekeeping. This is on by default. This contingency command disables both HK acquisition and the sending of HK packets to ground.
4. Stop Autonomous Safing. This contingency command stops the autonomous safing task, on by default, described in the previous section.
5. Stop DPU Heartbeat Watchdog. This contingency stops the DPU heartbeat watchdog task, on by default, described in the previous section.
6. DPU Off. This contingency command powers off the DPU separately from the ICU.

2.2.4 Load Task Parameters

The format of a Load Task Telecommand Packet Data Field is as follows:

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Type/Ack	Data Field
1	1	-	Packet Type /SubType = 5,3	Header
2	1	Unsigned Integer	Task ID (TID)	Application
3	1	Unsigned Integer	Function ID (FID)	Data
4	N*2	Unsigned Integers	N Parameters	
4+N*2	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

Task ID (TID) is as for the Start Task Telecommand Packet.

Function ID (FID) , together with the TID, specifies the structure of the parameters that follow.

Parameters consist of 1 or more (16 bit) words.

N is defined by the TID-FID combination and is the number of (word length) parameters ($0 \le N \le 118$)

The table overleaf summarises the defined Load Task Parameters commands, the associated MFN and whether they are valid in both basic and operational modes.

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Sub System	TID (Hex)	Associated Start Task	FID (Hex)	Load Task Description	MFN	Basic	Operat-ional
Detector	10	Load Centroid Table	00	Load Centroid Table Boundaries	H7100	No	Yes
	11	Load Window Table	00	Load Window Table	H7110		
	12	Load DPU Deduced Window Table	00	Enable/Disable Verification	H7120		
	13	Detector Integration	00	Set Acquisition Mode	H7130		
			01	Set Single Event Threshold	H7131		
			04	Set Flood LED Current	H7134		
			05	Enable Frame Tag	H7135		
			06	Camera Running/Halted	H7136		
	14	High Voltage Ramp	00	Load HV Ramp Parameters	H7140		
DPU	A4	Direct DPU Control	00 ⇒ FF	DPU Commanding	see later	No	Yes
RBI	50	Watchdog Control	00	Reset Watchdog Parameters	H7310	Yes	Yes
TMPSU	60	Move Filter Wheel	00	Set Coarse Position Sensor LED Current	H7600	No	Yes
			01	Set Fine Position Sensor LED Current	H7601		
			02	Set Step Rate of Filter Wheel	H7602		
			03	Reset Filter Wheel Position Counter	H7603		
			04	Set Filter Number	H7604		
			05	Set Absolute Step Position	H7605		
			06	Set Relative Step Position	H7606		
			07	Set Number of Fine Sensor Pulses	H7607		
			08	Set next move to Datum	H7608		
			09	Set next move to Coarse Sensor	H7609		
	65	Move Dichroic Mechanism	00	Set Direction of Dichroic Movement	H7650		
			01	Set Step Rate of Dichroic	H7651		
	66	Heater Control (Contingency)	00	Heater Configuration	H7660		
	67	Heater Control	01 ⇒ 08	Control Parameters	H7671 ⇒ H7678		
ICB	41	ICB Load	00	Load ICB Directly	H7410 ⇒ H7426	Yes	Yes

Load Task Summary

2.2.4.1 *Detector*

2.2.4.1.1 Load Centroid Table Boundaries

MFN = H7100.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 10 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)	-	
4	2	Unsigned Integer	Enable/Disable Verification = 1/0	H10	
6	18	Signed Integers	X Centroid Table Boundaries	H20 $\Rightarrow$ H28	
24	18	Signed Integers	Y Centroid Table Boundaries	H30 $\Rightarrow$ H38	
42	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

Note - the verification process (see H10 parameter) consists of reading back each location of the detector electronics centroid boundaries table to see if it contains the expected value. Any mismatch causes the table load to fail and 92101 ‘Table Load Failure’ exception to be sent instead of a 92100 ‘Table Loaded’ event.

2.2.4.1.2 Load Window Table Parameters

MFN = H7110.

Offset*	Length (Octets)	Type	Description		PREF	Packet Data Field
0	1	-	Checksum Type/Ack		-	Data Field
1	1	-	Packet Type /SubType = 5,3		-	Header
2	1	Unsigned Integer	Task ID (TID) = 11 (hex)		-	
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)		-	
4	2	Unsigned Integer	Enable/Disable Verification = 1/0		H10	
6	2	Unsigned Integer	No of Windows = N_{win} ($1 \le N_{win} \le 15$)		H40	
8	2	Unsigned Integer	X_{low}	Parameters for	H50	
10	2	Unsigned Integer	Y_{low}	Window 1	H51	
12	2	Unsigned Integer	X_{size}	(Units are CCD pixels)	H52	Application
14	2	Unsigned Integer	Y_{size}		H53	Data
16	8	Unsigned Integers	Parameters for Window 2		H54⇒H57	
24	8	Unsigned Integers	Parameters for Window 3		H58⇒H61	
32	8	Unsigned Integers	Parameters for Window 4		H62⇒H65	
40	8	Unsigned Integers	Parameters for Window 5		H66⇒H69	
48	8	Unsigned Integers	Parameters for Window 6		H70⇒H73	
56	8	Unsigned Integers	Parameters for Window 7		H74⇒H77	
64	8	Unsigned Integers	Parameters for Window 8		H78⇒H81	
72	8	Unsigned Integers	Parameters for Window 9		H82⇒H85	
80	8	Unsigned Integers	Parameters for Window 10		H86⇒H89	
88	8	Unsigned Integers	Parameters for Window 11		H90⇒H93	
96	8	Unsigned Integers	Parameters for Window 12		H94⇒H97	
104	8	Unsigned Integers	Parameters for Window 13		H98⇒H101	
112	8	Unsigned Integers	Parameters for Window 14		H102⇒H105	
120	8	Unsigned Integers	Parameters for Window 15		H106⇒H109	
128	2	Unsigned Integer	CRC		-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

Notes :

1. The above packet is always large enough to contain 15 windows, even when N_{win} is less than 15. N_{win} is used to determine how many windows are actually present. Parameters for windows greater than the value of N_{win} are ignored.
2. The verification process (see H10 parameter) consists of reading back each location of the detector electronics window table to see if it contains the expected value. Any mismatch causes the table load to fail and 92101 ‘Table Load Failure’ exception to be sent instead of a 92100 ‘Table Loaded’ event.

2.2.4.1.3 Enable/Disable Verification of DPU Deduced Window Table Parameters

MFN = H7120.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 12 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)	-	
4	2	Unsigned Integer	Enable/Disable Verification = 1/0	H10	
128	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

Note: At the end of the choose guide stars phase, the DPU sends the ICU parameters describing the windows to be set up in the detector electronics. The ICU does this and then normally sends the 92100 ‘Table Loaded’ event packet. This command determines whether a table verification process is performed before the 92100 is sent. The process consists of reading back each location of the detector electronics window table to see if it contains the expected value. Any mismatch causes the window load to fail and a 92101 ‘Table Load Failure’ exception to be sent instead. This command is the equivalent of the H10 parameter for H7110 which loads the tables directly and then optionally verifies them.

2.2.4.1.4 Set Acquisition Mode

MFN = H7130.

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	-	Checksum Type/Ack	-		Data Field Header
1	1	-	Packet Type /SubType = 5,3	-		
2	1	Unsigned Integer	Task ID (TID) = 13 (hex)	-		Application Data
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)	-		
4	2	Unsigned Integer	Acquisition Mode = M_{acq}	H110	9030	
6	2	Unsigned Integer	CRC	-		Error Control

* All offsets measured in octets from the start of the Packet Data Field

M_{acq} (alias 9030) has the following values

M_{acq}	Description
0	Low Resolution, Windowed
1	Low Resolution, Full Frame
2	High Resolution, Windowed
3	High Resolution,. Full Frame
4	Engineering, x m/n data
5	Engineering, y m/n data
6	Engineering, event height
7	Engineering, event energy

Detector Data Acquisition Modes

2.2.4.1.5 Set Single Event Threshold

MFN = 7131.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 13 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 01 (hex)	-	
4	2	Unsigned Integer	Threshold	H120	
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.1.6 Set Flood LED Current

MFN = H7134.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 13 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 04 (hex)	-	
4	2	Unsigned Integer	LED Current	H140	
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.1.7 Enable Frame Tag

MFN = H7135

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	-	Checksum Type/Ack	-		Data Field Header
1	1	-	Packet Type /SubType = 5,3	-		
2	1	Unsigned Integer	Task ID (TID) = 13 (hex)	-		Application Data
3	1	Unsigned Integer	Function ID (FID) = 05 (hex)	-		
4	2	Unsigned Integer	Enable/Disable = 1/0	H16	9010	
6	2	Unsigned Integer	CRC	-		Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.1.8 Camera Halted/Running

This is a contingency command. Normally the camera is halted whilst the window table is being loaded, otherwise it is running.

MFN = H7136

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	-	Checksum Type/Ack	-		Data Field Header
1	1	-	Packet Type /SubType = 5,3	-		
2	1	Unsigned Integer	Task ID (TID) = 13 (hex)	-		Application Data
3	1	Unsigned Integer	Function ID (FID) = 06 (hex)	-		
4	2	Unsigned Integer	Running/Halted = 1/0	H130	9000	
6	2	Unsigned Integer	CRC	-		Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.1.9 Load High Voltage Ramp Parameters

This command packet loads parameters that are used by the High Voltage Ramp-up/down task.

MFN = H7140.

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	-	Checksum Type/Ack	-		Data Field Header
1	1	-	Packet Type /SubType = 5,3	-		
2	1	Unsigned Integer	Task ID (TID) = 14 (hex)	-		Application Data
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)	-		
4	2	Unsigned Integer	Voltage to be adjusted[1]	H150	9005	
6	2	Unsigned Integer	Value to be attained	H160		
8	2	Unsigned Integer	Ramp Rate in Volts/sec			
10	2	Unsigned Integer	Force Ramp	H175	9020	
12	2	Unsigned Integer	CRC	-		Error Control

* All offsets measured in octets from the start of the Packet Data Field

Notes:
(Alias 9005) 1 = $V_{cathode}$, 2 = V_{mcp1}, 3 = V_{mcp23}

2.2.4.2 *Digital Processing Unit*

From APP-3, the form of a 'raw' DPU command (i.e. as sent from the ICU to the DPU) is:

Offset (Bytes)	Length (Octets)	Description
0	2	A4xx (hex) - where xx = Command Identifier
2	2	N = No of 16 bit word command parameters
4	2*N	DPU Command Parameters (see below)

For ease of coding, the DPU is commanded by sending its 'raw' commands 'wrapped-up' in a Load Task Parameters packet to the DPU Direct Task. This task is deemed to be always running. Because the first word of a 'raw' DPU command is always of the form A4xx (hex), it is convenient to set the Task ID to 'A4' and the FID to 'xx'.

Thus, the format of all DPU Direct Load Task Parameter commands are as follows:

Offset*	Length (Octets)	Type	Description		Packet Data Field
0	1	-	Checksum Type/Ack		Data Field
1	1	-	Packet Type /SubType = 5,3		Header
2	1	Unsigned Integer	Task ID (TID) = A4 (hex)	'Raw'	
3	1	Unsigned Integer	Function ID (FID) (see table overleaf)	DPU	Application
4	2	Unsigned Integer	N = No of useful 16 bit word parameters	Command	Data
6	2*N	Unsigned Integer	DPU Command Parameters		
6+2*N	2	Unsigned Integer	CRC		Error Control

* All offsets measured in octets from the start of the Packet Data Field

The details of all DPU commands and parameters are given in APP-3 and therefore will not be repeated here. However, it should be noted that any potentially variable length commands will be padded with zeros up to the maximum length for that command. They are summarised in the table below.

Category	Mnemonic	FID (Hex)	MFN
Basic DPUOS manipulation and IO commands	IC_RESET_DSP	01	H7201
	IC_LOAD_DPUOS	02	H7202
	IC_ENBL_LOAD_CODE[1]	03	H7203
	IC_SEL_RAM_BANK[1]	04	H7204
	IC_LOAD_CODE[1]	05	H7205
	IC_SEL_KLINGON	06	H7206
	IC_ENBL_DSP	07	H7207
	IC_ENBL_EVENTS	08	H7208
	IC_DIRECT_DATA	09	H7209
	IC_POWER_DOWN_DPU[2]	0A	H7210
	IC_SEND_SCI_CMD	0B	H7211
	IC_REQ_DATA	0D	H7213
	IC_SYNCH_CLK[3]	0E	H7214
	IC_FLUSH_QUEUE	0F	H7215
Memory [1] management	IC_DUMP_LOCAL_RAM	10	H7216
	IC_LOAD_LOCAL_RAM	11	H7217
	IC_DUMP_PROG_RAM[4]	14	H7220
	IC_DUMP_RAM	15	H7221
	IC_DUMP_RAM_N_ZERO	16	H7222
	IC_LOAD_GLOBAL_RAM	17	H7223
Exposure configuration commands	IC_SET_TRK	20	H7256
	IC_BPE_BINNING	21	H7257
	IC_REPORT_TRK	22	H7234
	IC_REPORT_DIAGS	23	H7235
	IC_SET_FRAME_TIME	24	H7236
	IC_SET_EXP_TIME	25	H7237
	IC_SET_EXP_ID	26	H7238
	IC_CONF_GS_SEL	27	H7239
	IC_LOAD_REF_STARS	28	H7240
	IC_LOAD_FILT_CONF	29	H7241
	IC_LOAD_MEM_WDW	2A	H7242
	IC_LOAD_SCI_WDW	2B	H7243
	IC_ENBL_VERBOSE	2C	H7244
	IC_LOAD_DET_DTW	2D	H7245
Major task invocation commands	IC_INIT_DPU	30	H7248
	IC_INIT_EXP	31	H7249
	IC_ACQUIRE_FLD	32	H7250
	IC_CHOOSE_GS	33	H7251
	IC_TRACK_GS	34	H7252
	IC_ABORT_DPU	35	H7253
	IC_ENBL_ENG	36	H7254
	IC_FLUSH_CMPRS	37	H7255

DPU Commands

Notes:
1. These will normally be implemented via the Memory Management Packets. Note that therefore any of H7216, H7220, H7221 or H7222 will result in TM(6,2) packets without a corresponding TC(6,2).
2. Normally handled by a DEMPSU task stop command.
3. If Number of parameters N is set to 0, the ICU will intercept this command and modify it so that the DPU is (re)synchronised to the ICU. This is a contingency command. No further DPU commands should be sent for another 2 seconds.
4. A contingency version of DPU code is available so that this command can also be used to dump DPU ROM by requesting dumps in the memory range 0xf00000 to 0xffffff.

2.2.4.3 RBI Watchdog

This command resets the RBI watchdog control parameters. The default values are timout = FFF (hex), Reset Interval = 8 secs.

MFN = H7510.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 50 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)	-	
4	2	Unsigned Integer	Timout (1/256 secs)	H400	
6	2	Unsigned Integer	Reset Interval (secs)	H405	
8	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4 Telescope Module Power Supply (TMPSU).

This section covers those commands that load parameters into TMPSU related tasks. These are the filter wheel and dichroic mechanisms and heater control.

2.2.4.4.1 Filter Wheel Commands

2.2.4.4.1.1 Set Filter Wheel Number

MFN = 7604.

Specifies the filter wheel to be moved to by the Move Filter Wheel Task. The filter wheel numbers are defined as follows (alias 9130):

Filter Number	Filter Wheel Station	Description	Filter Position (steps from datum)
0	0	Blocked	1200
1	1	V	1400
2	2	Magnifier	1600
3	3	U	1800
4	4	B	2000
5	5	White	0
6	6	Grism 2 (Visible)	200
7	7	UVW1	400
8	8	UVM2	600
9	9	UVW2	800
10	10	Grism 1 (UV)	1000
11	3	Bar	2100

Table 2-1 : Filter Positions.

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	-	Checksum Type/Ack	-		Data Field Header
1	1	-	Packet Type /SubType = 5,3	-		
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-		Application Data
3	1	Unsigned Integer	Function ID (FID) = 04 (hex)	-		
4	2	Unsigned Integer	Filter Wheel Number	H280	9130	
6	2	Unsigned Integer	CRC	-		Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.2 Set Absolute Position in Steps of FW Movement

MFN = H7605.

Specifies the position in steps from datum (maximum 2199) the filter wheel is to be moved to by the 'Move Filter Wheel' task. It is anticipated that this will only be used as a 'contingency' command in the event of e.g. sensor failure so that the filter wheel can be moved by 'dead reckoning'.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 05 (hex)	-	
4	2	Unsigned Integer	Number of Steps	H290	
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.3 Set Relative Number of Steps of FW Movement

MFN = H7606.

Specifies the position in steps (maximum 2199) the filter wheel is to be moved relative to its current position by the 'Move Filter Wheel' task. It is anticipated that this will only be used as a 'contingency' command in the event of e.g. sensor failure so that the filter wheel can be moved by 'dead reckoning'.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 06 (hex)	-	
4	2	Unsigned Integer	Number of Steps	H290	
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.4 Set Number of Fine Sensor Pulses for F/W Steps

MFN = H 7607.

Specifies the number of fine sensor pulses the filter wheel is to be moved relative to its current position by the 'Move Filter Wheel' task. It is anticipated that this will only be used as a 'contingency' command in the event of e.g. coarse sensor failure so that the filter wheel can be moved by 'dead reckoning'.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 07 (hex)	-	
4	2	Unsigned Integer	Number of Pulses	H295	
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.5 Set Next F/W Movement to be to the Datum.

MFN = H7608.

Specifies that the next filter movement will be to the datum position.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 08 (hex)	-	
4	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.6 Set Next F/W Movement to be to the Coarse Sensor

MFN = H7609.

Specifies that the next filter movement will be to the coarse sensor position.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Type/Ack	Data Field
1	1	-	Packet Type /SubType = 5,3	Header
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	Application
3	1	Unsigned Integer	Function ID (FID) = 09 (hex)	Data
4	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.7 Set Coarse Position Sensor LED Current

MFN = H 7600.

Because of the long duration of the mission and the radiation environment, it is anticipated that the light emission of the LED used as a light source for the filter wheel coarse position sensor will deteriorate. The LED will therefore have to be driven harder to maintain a sufficient light level. This command supplies the setting for the coarse position sensor LED current to the Move Filter Wheel task.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field
1	1	-	Packet Type /SubType = 5,3	-	Header
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-	
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)	-	Application
4	2	Unsigned Integer	Coarse Position LED Current	H300	Data
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.8 Set Fine Position Sensor LED Current

MFN = H7601.

This command supplies the setting for the fine position sensor LED current to the Move Filter Wheel task.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 01 (hex)	-	
4	2	Unsigned Integer	Fine Position LED Current	H310	
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.9 Set Filter Wheel Step Rates

MFN = H7602.

This command is used to specify the step rates of the filter wheel when in movement.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type/SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 02 (hex)	-	
4	2	Unsigned Integer	Min Step Rate (Hz)	H320	
6	2	Unsigned Integer	Max Step Rate (Hz)	H330	
8	2	Unsigned Integer	Acceleration Rate (Hz/sec)	H340	
10	2	Unsigned Integer	CRC		Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.1.10 Reset Filter Wheel Position Counter.

MFN = H7603.

This command is used to reset to a known value of the (s/w internal) Filter Wheel Position Counter. It is anticipated that this will be used only in contingencies.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 60 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 03 (hex)	-	
4	2	Unsigned Integer	Filter Wheel Position	H350	
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.2 Dichroic Mechanism Commands

2.2.4.4.2.1 *Specify Dichroic Mechanism Movement*

MFN = H7650.

This command specifies the movement the Move Dichroic Mechanism command is to use.

If method is 0, the dichroic mechanism is moved to its *maximum* excursion in the direction indicated by the *sign* of number.

If method is 1, the dichroic mechanism is moved by the *magnitude* of number steps in the direction indicated by the *sign* of number.

In both cases,:

a positive value (including zero) of number indicates movement from Primary to Redundant.
a negative value indicates a movement from Redundant to Primary

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	-	Checksum Type/Ack	-		Data Field Header
1	1	-	Packet Type /SubType = 5,3	-		
2	1	Unsigned Integer	Task ID (TID) = 65 (hex)	-		Application Data
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)	-		
4	2	Signed Integer	Number	H370		
6	2	Unsigned Integer	Method = 0/1	H375	9140	
8	2	Unsigned Integer	CRC	-		Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.2.2 *Set Dichroic Mechanism Step Rate*

MFN = H7651.

This command is used to specify the step rate of the dichroic mechanism when in movement.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Type/Ack	-	Data Field Header
1	1	-	Packet Type /SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 65 (hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 01 (hex)	-	
4	2	Unsigned Integer	Step Rate (Hz)	H360	
6	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.4.4.3 Heater Commands

2.2.4.4.3.1 Heater Control (Contingency)

MFN = H7660.

This command (valid only in Operational Mode) specifies the heater on/off configuration to be implemented by the 'Heater Control' task. It is only used in contingency situations and allows direct setting of all allowable heater configurations.

Note that the task identified by a TID of 67 (hex) must be stopped at this stage.

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	-	Checksum Type/Ack	-		Data Field Header
1	1	-	Packet Type /SubType = 5,3	-		
2	1	Unsigned Integer	Task ID (TID) = 66 (hex)	-		Application Data
3	1	Unsigned Integer	Function ID (FID) = 00 (hex)	-		
4	2	12 Bits	Spare	-		
		4 Bits	Heater Configuration (see below)	H380	9050	
6	2	Unsigned Integer	CRC	-		Error Control

* All offsets measured in octets from the start of the Packet Data Field

The heater configurations are defined as follows (Alias 9050 : a '-' indicates 'Off'):

Heater Configuration (Binary)	HEATER			
	Main Interface	Forward Tube	Metering Rods	Secondary Mirror
	Temperature Control		Focusing	
	HTR 1	HTR 2	HTR 3	HTR 4
0000	-	-	-	-
0001	-	-	-	On
0010	-	-	On	-
0100	-	On	-	-
0101	-	On	-	On
0110	-	On	On	-
1000	On	-	-	-
1001	On	-	-	On
1010	On	-	On	-
1100	On	On	-	-
1101	On	On	-	On
1110	On	On	On	-
all others	No Change of Heater Status			

Table 2-2 : Heater Configurations.

2.2.4.4.3.2 Heater Control

This command (valid *only* in Operational Mode) specifies the parameters to control the heaters. As more than one FID value controls a given heater (see table below), the most recent command uplinked will apply. **Note** that task (TID = 66 (hex)) must be stopped while this is running.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Type/Ack	Data Field Header
1	1	-	Packet Type /SubType = 5,3	
2	1	Unsigned Integer	Task ID (TID) = 67 (hex)	Application Data
3	1	Unsigned Integer	Function ID (FID) (See table below)	
4	2	Integers	N Parameters (see table below)	
4+2*N	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

The FID implies the structure of the data, the heater(s) and the algorithm or function as follows:-

FID	Heater(s)	Algorithm/Function[6]	N	Parameters 1	Parameters 2	Parameters 3	MFN
1[7]	Interface	Closed Loop, Free Running	2	T_{min}[3]	T_{max}[3]	-	H7671
2	Interface	Open Loop, Free Running	2	On Time[1]	Cycle Time[1]	-	H7672
3	Forward	Closed Loop, Synched[6]	3	T_{min}[3]	T_{max}[3]	Thermistor[2]	H7673
4[7]	Forward	Closed Loop, Free Running	3	T_{min}[3]	T_{max}[3]	Thermistor[2]	H7674
5	Forward	Open Loop, Synched[6]	2	On Time[1]	Cycle Time[1]	-	H7675
6	Forward	Open Loop, Free Running	2	On Time[1]	Cycle Time[1]	-	H7676
7	Focusing	Negative, Positive Focusing[10]	3	On Time[1]	Cycle Time[1]	Focus Direction[4]	H7677
8	-	Set Sample Time[10]	1	Sample Time[5,7]	-	-	H7678

Notes:

1. The ‘On Time’ (PREF = H200) is the amount the heater spends powered in the ‘Cycle Time’ (PREF = H210). The times are in multiples of ‘Sample Time’ – see notes 5 and 10.
2. A ‘Thermistor’ value of 0 indicates the prime thermistor, a 1 indicates the redundant. PREF = H230, Alias =9100.
3. T_{min} (Minimum Temperature, PREF= H180) and T_{max} (Maximum Temperature, PREF = H190) are in ‘raw’ thermistor units.
4. The value of ‘Focus Direction’ (PREF = H240) requests focusing direction as follows:
   a) > 0 - positive focusing : only HTR3 (metering rods) powered.
   b) < 0 - negative focusing : only HTR4 (secondary mirror) powered.
   c) - no focusing : both HTR3 and HTR4 are not powered.

   From release 10 onwards, the default for operational mode is that HTR3 is powered on all the time as this gives a preferred focus for the majority of filter settings. For more details see note 10 below.
5. ‘Sample Time’ (PREF = H220) is in units of seconds in the range 1 through 20, default = 10 – also see note 10 below.
6. Algorithms based on document APP-8.
7. By default, for operational mode:
   a) The ‘Sample Time’ is 10 sec.
   b) FID’s 1 and 4 are active on start-up of this task in operational mode.
   c) For FID 1, Tmin = 567, Tmax = 583 (corresponding to a temperature range of **19.5 ± 0.5 °C**)
   d) For FID 4, Tmin = 551, Tmax = 599 (corresponding to a temperature range of **19.5 ± 1.5 °C**) and Thermistor = 0.
8. By default, for basic mode, both HTR1 and HTR2 are always on while this task (TID = 67 hex) is active. The above ‘load parameters’ command is **not** supported in basic mode.
9. All heaters are off while this task is stopped and TID = 66 hex is not yet started.
10. **N.B.** During early operation, it was determined that the instrument point spread function was broader than expected due to a non-optimal focus – NCR-192. Investigation indicated that broadening was a function of which filter was used. As a result, and as from release 10 onwards of the OM software, a look-up table of heater settings as a function of filter number was placed on-board. Whenever a filter wheel move is commanded that has been prefaced by the ‘Set Filter Wheel Number’ command (MFN=7604), this table is consulted. The values obtained for the heater settings and sample times are then set using the on-board equivalents of commands MFN=H7677 and MFN=H7678. Consequently, values set by any earlier use of those two commands will be overridden upon the filter wheel movement. If the user wishes to use an alternative set of heater values to those in the table, they should ‘patch’ the lookup table accordingly. For release 10, the lookup table starts at a base address of 23A4 (hex) in ICU data memory. Its format is described overleaf. Alternatively, if you require the values to be independent of filter wheel position, the commands ‘Set Absolute Positions in Steps’ (MFN=H7605) or ‘Set Relative Number of Steps’ (MFN=7606) could be used instead of ‘Set Filter Wheel Number’ (MFN=7604).

<table>
<tr><th>Base Address Offset (decimal)</th><th colspan="2">Description</th></tr>
<tr><td>0</td><td>Position of filter on wheel</td><td rowspan="5">Parameters for filter 0 (Blocked)</td></tr>
<tr><td>1</td><td>On Time (in multiples of ‘Sample Time’, equivalent to PREF H200)</td></tr>
<tr><td>2</td><td>Total Cycle Time (in units of ‘Sample Time’, equivalent to PREF H210)</td></tr>
<tr><td>3</td><td>Sample Time (in units of seconds, equivalent to PREF H220)</td></tr>
<tr><td>4</td><td>Focus Direction (+ve = HTR3, -ve = HTR4 powered; 0 = not powered, equivalent to PREF H240)</td></tr>
<tr><td>5</td><td colspan="2">Parameters for Filter 1 (V)</td></tr>
<tr><td>10</td><td colspan="2">Parameters for Filter 2 (Magnifier)</td></tr>
<tr><td>15</td><td colspan="2">Parameters for Filter 3 (U)</td></tr>
<tr><td>20</td><td colspan="2">Parameters for Filter 4 (B)</td></tr>
<tr><td>25</td><td colspan="2">Parameters for Filter 5 (White)</td></tr>
<tr><td>30</td><td colspan="2">Parameters for Filter 6 (Grism 2- visible)</td></tr>
<tr><td>35</td><td colspan="2">Parameters for Filter 7 (UVW1)</td></tr>
<tr><td>40</td><td colspan="2">Parameters for Filter 8 (UVM2)</td></tr>
<tr><td>45</td><td colspan="2">Parameters for Filter 9 (UVW2)</td></tr>
<tr><td>50</td><td colspan="2">Parameters for Filter 10 (Grism 1 – UV)</td></tr>
<tr><td>55</td><td colspan="2">Parameters for Filter 11 (Bar)</td></tr>
</table>

2.2.4.5 Instrument Control Bus (ICB)

This section describes commands which control directly the OM Instrument Control Bus (ICB). They are provided to give a level of command redundancy for those units. The ICB is implemented using the MACSbus standard. All commands to the detector and TMPSU are sent via this bus. Each unit and internal register is visible to the ICU as an address and sub-address combination. The ICU is the master, all other units are slaves.

Note. For this command to work, the ICB Command task (TID = 41 (hex)) must have been started. ICB commands are sent by loading parameters to this task. This philosophy is adopted due to the potentially dangerous 'back-door' nature of this command.

2.2.4.5.1 Load Task ICB Directly Packet Data

This command sends a direct command to any device on the ICB by loading an appropriate value into the necessary address and sub-address combination.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Flag/Ack	-	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 5,3	-	
2	1	Unsigned Integer	Task ID (TID) = 41(hex)	-	Application Data
3	1	Unsigned Integer	Function ID (FID) = 00(hex)	-	
4	2	Unsigned Integer	MACS Address	see below	
6	2	Unsigned Integer	MACS Sub-Address	see below	
8	2	Unsigned Integer	Value to be loaded	see below	
10	2	Unsigned Integer	CRC	-	Error Control

* All offsets measured in octets from the start of the Packet Data Field
The contents of the MACS address and sub-addresses for the various ICB sub-systems are described overleaf.

See section 2.2.5.2 for commands to read the ICB ports directly.

<table>
<tr><th rowspan="2">Addr. (hex)</th><th rowspan="2">Sub System</th><th rowspan="2">Sub-Addr.</th><th rowspan="2">MFN</th><th rowspan="2">Description</th><th colspan="16">Bits</th></tr>
<tr><th>MSB</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>LSB</th></tr>
<tr><td rowspan="4">7</td><td rowspan="4">TMPSU</td><td>0</td><td>H7410</td><td>MISC</td><td colspan="3">CS</td><td colspan="4">FW_PSC</td><td>SE</td><td colspan="8">Don't Care</td></tr>
<tr><td>1</td><td>H7411</td><td>ADC</td><td colspan="16">Don't Care</td></tr>
<tr><td>2</td><td>H7412</td><td>Filter Wheel & Dichroic</td><td>F1</td><td>F2</td><td>F3</td><td>F4</td><td>D1</td><td>D2</td><td>D3</td><td>D4</td><td colspan="8">Don't Care</td></tr>
<tr><td>4</td><td>H7413</td><td>Heaters</td><td>H1</td><td>H2</td><td>H3</td><td>H4</td><td colspan="12">Don't Care</td></tr>
<tr><td rowspan="13">18</td><td rowspan="13">Detector</td><td>2</td><td>H7414</td><td>Camera Start/Stop</td><td colspan="14">Don't Care</td><td>R</td><td>SC</td></tr>
<tr><td>3</td><td>H7415</td><td>Bitmap Address</td><td colspan="8">Bitmap Y Address</td><td colspan="8">Bitmap X Address</td></tr>
<tr><td>4</td><td>H7416</td><td>Bitmap Datum</td><td colspan="12">Don't Care</td><td colspan="4">Map Data</td></tr>
<tr><td>5</td><td>H7417</td><td>Event Detect Threshold</td><td colspan="8">Don't Care</td><td colspan="8">Event Height Threshold</td></tr>
<tr><td>7</td><td>H7418</td><td>Table Access Mode</td><td colspan="15">Don't Care</td><td>TE</td></tr>
<tr><td>8</td><td>H7419</td><td>Lookup Table Address</td><td colspan="8">Lookup Address (M)</td><td colspan="8">Lookup Address (N)</td></tr>
<tr><td>9</td><td>H7420</td><td>Lookup Table Datum</td><td colspan="9">Don't Care</td><td colspan="3">Y sub-pixel</td><td>X</td><td colspan="3">X sub-pixel</td></tr>
<tr><td>10</td><td>H7421</td><td>Acq Mode, Frame Tag</td><td colspan="12">Don't Care</td><td>FE</td><td colspan="3">Int Mode</td></tr>
<tr><td>11</td><td>H7422</td><td>Integration Enable</td><td colspan="15">Don't Care</td><td>IE</td></tr>
<tr><td>12</td><td>H7423</td><td>MUX Address</td><td colspan="12">Don't Care</td><td colspan="4">MUX Address</td></tr>
<tr><td>13</td><td>H7424</td><td>$V_{cathode}$, V_{mcp23}</td><td>R2</td><td colspan="7">V_{mcp23}</td><td>RV</td><td colspan="7">$V_{cathode}$</td></tr>
<tr><td>14</td><td>H7425</td><td>Biases</td><td colspan="4">X</td><td colspan="4">X</td><td colspan="4">Fine Sensor Current</td><td colspan="4">Flood LED current</td></tr>
<tr><td>15</td><td>H7426</td><td>V_{mcp1}</td><td>EH</td><td colspan="5">Don't Care</td><td>R1</td><td colspan="9">V_{mcp1}</td></tr>
</table>

Key

Abbreviation	Description	PREF
CS	Current Select Secondary Voltages	H890
D1, D2, D3, D4	Phases 1 through 4 of the Dichroic Motor, 1 = energised	H895⇒H898
EH	Enable High Voltages, 1 = Enabled (Alias 9010)	H900
F1, F2, F3, F4	Phase 1 through 4 of the Filter Wheel Motor, 1 = energised	H905⇒H908
FE	Frame Tag enabled if zero (Alias 9280)	H910
FW_PSC	Set current of coarse sensor illuminating LED	H915
IE	Integration Enabled is set to 1 (Alias 9010)	H920
H1, H2	Heaters, 1 = On, H1 = Main Interface, H2 = Forward Tube (Alias 9020)	H925⇒H926
H3, H4	H3 = Metering Rods , H4 = Secondary Mirror (Alias 9020)	H927⇒H928
R	Reset Camera Head (Alias 9290)	H930
R1,R2,RV	Range Bits for V_{mcp1}, V_{mcp23}, $V_{cathode}$ (Alias 9020)	H935⇒H937
SC	1 = Start Frame Readout, 0 = No Frame Readout, bitmap RAM loadable (Alias 9300)	H940
SE	Secondary Voltages, 1 = Enabled (Alias 9010)	H945
TE	Lookup Table access, 0 = Accessed by electronics, table **not** loadable (Alias 9310)	H950
X	Don't Care	-

Description	PREF
Bitmap Y Address	H960
Bitmap X Address	H965
Map Data	H970
Event Height Threshold	H975
Lookup Address (M)	H980
Lookup Address (N)	H985
Y sub-pixel	H990
X sub-pixel	H995
Int Mode (Alias 9030)	H1000
MUX Address (Alias 9440)	H1005
V_{mcp23}	H1010
$V_{cathode}$	H1015
Fine Sensor Current	H1020
Flood LED Current	H1025
V_{mcp1}	H1030

2.2.5 Report Task Parameters

2.2.5.1 Most Recently Uploaded Parameters

This command causes the generation of a Task Parameter Report TM packet TM(5,4) containing the most recently uploaded set of parameters for the combination of TID and FID. TID and FID are as defined for Load Task Parameters.

NOTES
This will not be supported for the DPU Direct Task (TID = A4 hex).
Not yet implemented.

The format of a Report Task Telecommand Packet Data Field is as follows:

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Type/Ack	Data Field Header
1	1	-	Packet Type /SubType = 5,4	
2	1	Unsigned Integer	Task ID (TID)	Application Data
3	1	Unsigned Integer	Function ID (FID)	
4	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.2.5.2 Read ICB Address Directly

This command requests that a value be read back from a specified MACSbus address and sub-address combination. As the TID and FID used do not correspond to any TC(5,3), it is used to downlink the value as an additional parameter (see section 2.3.4 of APP-1). It is a contingency command.

See section 2.2.4.5 for commands to write directly to the MACSbus ports.

Note. For this command to work, the ICB Command task (TID = 41 (hex)) must have been started. This philosophy is adopted due to the potentially dangerous 'back-door' nature of this command.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 5,4	
2	1	Unsigned Integer	Task ID (TID) = ICB Address + 40 (hex)	Application Data
3	1	Unsigned Integer	Function ID (FID) = ICB Subaddress	
4	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

The value of TID and FID for the various ICB sub-systems is described below: A description of the response is given in section 3.5.

TID (hex)	Sub-system	FID	MFN	Description	Basic	Operational
47	TMPSU	0	H7440	TMPSU Currents and F/W Coarse Sensor	Yes	Yes
58	Detector	2	H7452	Digital Electronics Status Word	No Unless Secondaries Enabled	Yes
		3	H7453	Digital Bitmap Datum		
		4	H7454	Digital Centroid Table Datum		
		5	H7455	ADC Housekeeping, HV Status, Fine Sensor		
		6	H7456	Initiate ADC		

2.2.6 Mode Transition

Mode transitions are commanded by a packet with the following data field: (Note, in OM documentation, these are sometimes referred to as 'states'.)

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field
1	1	Unsigned Integer	Packet Type/SubType= 5,5	Header
2	1	Unsigned Integer	Mode	Application
3	1	Unsigned Integer	Spare	Data
4	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

The values allowed to "mode" in basic and operational modes are given in the following table. See APP-9 for a statement of valid transitions. It should be noted that any attempt to perform a mode transition to the current mode will be rejected as an 'invalid parameter'.

MODE	Comment	MFN	Basic	Operational.
0	Initial	-	No	No
1	Safe (Full)	H9001	Yes	Yes
2	Idle	H9002	No	Yes
3	Science mode	H9003	No	Yes
4	Engineering and Calibration	H9004	No	Yes
5	Safe (Intermediate)	H9005	No	Yes

Table 2-3 : OM Modes

NOTE - NCR 106. In Initial Mode, the default format of this command is as follows:

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field
1	1	Unsigned Integer	Packet Type/SubType= 5,5	Header
2	1	Unsigned Integer	Mode	Application
3	1	Unsigned Integer	Spare	Data
4	2	Unsigned Integer	Address	
6	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

In Initial mode, the only allowed value of the 'mode' parameter is 1 (causes a transition to the uplinked code). If 'Address' is not zero, then the ICU code will attempt to start running at that address. If the address supplied is zero, then it will start running at the default address of 3800 (hex). Should the spacecraft send an autonomous safing command (which conforms to the first format given above) then it can be seen that the CRC of that packet would be interpreted as a address. This would usually be an invalid entry point for the code and will cause the code to 'crash'. If the watchdog is enabled, this will cause a watchdog triggered reset.

A patch (OM-BASIC-2-SAFE) is available which makes initial mode conform to the normal functionality.

2.3 Memory Maintenance

This section defines the packet data fields for the memory maintenance packets. This covers loading, dumping and calculating the checksum for a contiguous memory area.

In this section, **MID** identifies the destination memory AND the processor (ICU or DPU) as follows:

MID (Hex)	ICU & Detector Memory Description		
	Addresses	Sub-System	Description
0	0 - FFFF (hex)	ICU	Operand/Data Space
	10000 - 1FFFF (hex)	Detector	Window Bitmap Table
	20000 - 2FFFF (hex)	Electronics	Centroid Look-up Table
1	0 - FFFF (hex)	ICU	Instruction Space

MID (hex)	DPU Local Memory Description	
10	DPU Blue 1 DSP Local Memory	N/A
11	DPU Blue 2 DSP Local Memory	
12	DPU Red DSP Local Memory	
13	DPU White DSP Local Memory	

MID (hex)	DPU Global Memory Description	START ADDRESS	END ADDRESS
14	DPU Big Word Memory (24 bit words)	000000	0FFFFF
15	DPU Small Word Memory (16 bit words)	400000	7FFFFF
20	DPU Program Ram Bank 0	E00000	E0FFFF
21	DPU Program Ram Bank 1	E10000	E1FFFF
22	DPU Program Ram Bank 2	E20000	E2FFFF
23	DPU Program Ram Bank 3	E30000	E3FFFF
24	DPU Program Ram Bank 4	E40000	E4FFFF
25	DPU Program Ram Bank 5	E50000	E5FFFF
26	DPU Program Ram Bank 6	E60000	E6FFFF
27	DPU Program Ram Bank 7	E70000	E7FFFF

2.3.1 Load Memory

When the ICU receives this packet, it writes the data to the memory block indicated by MID at the address specified. It does not support the MID =0, address range 10000 (hex) to 2FFFF (hex) option.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Flag/Ack fields		Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 6,1		
2	2	Unsigned Integer	MID		Application Data
4	4	Unsigned Integer	Start Address	H500	
8	232	Unsigned Integers	Data to be loaded		
240	2	Unsigned Integer	CRC		Error Control

* All offsets measured in octets from the start of the Packet Data Field

MID (Hex)	ICU & Detector Memory Description			MFN	Basic	Oper
	Addresses	Sub-System	Description			
0	0 - FFFF (hex)	ICU	Operand/Data Space	H4000	Yes	No
	10000 - 1FFFF (hex)	Detector	Window Bitmap Table	N/A	No	Yes
	20000 - 2FFFF (hex)	Electronics	Centroid Look-up Table	N/A	No	Yes
1	0 - FFFF (hex)	ICU	Instruction Space	H4001	Yes	No

MID (hex)	DPU Local Memory Description	MFN	Basic	Oper
10	DPU Blue 1 DSP Local Memory	H4010	N/A	N/A
11	DPU Blue 2 DSP Local Memory	H4011		
12	DPU Red DSP Local Memory	H4012		
13	DPU White DSP Local Memory	H4013	No	Yes

MID (hex)	DPU Global Memory Description	START ADDRESS	END ADDRESS	MFN	BASIC	OPER
14	DPU Big Word Memory (24 bit words)	000000	0FFFFF	H4014	NO	YES
15	DPU Small Word Memory (16 bit words)	400000	7FFFFF	H4015		
20	DPU Program Ram Bank 0	E00000	E0FFFF	H4020		
21	DPU Program Ram Bank 1	E10000	E1FFFF	H4021		
22	DPU Program Ram Bank 2	E20000	E2FFFF	H4022		
23	DPU Program Ram Bank 3	E30000	E3FFFF	H4023		
24	DPU Program Ram Bank 4	E40000	E4FFFF	H4024		
25	DPU Program Ram Bank 5	E50000	E5FFFF	H4025		
26	DPU Program Ram Bank 6	E60000	E6FFFF	H4026		
27	DPU Program Ram Bank 7	E70000	E7FFFF	H4027		

2.3.2 Dump Memory

This packet causes a downlink of a *Memory Dump Report* containing the contents of the areas specified.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Flag/Ack		Data Field
1	1	Unsigned Integer	Packet Type/SubType = 6,2		Header
2	2	Unsigned Integer	MID		Application
4	4	Unsigned Integer	Start Address	H500	Data
8	2	Unsigned Integer	Length to be dumped	H510	
10	2	Unsigned Integer	CRC		Error Control

* All offsets measured in octets from the start of the Packet Data Field

MID (Hex)	ICU & Detector Memory Description			MFN	Basic	Oper	Mem Size (bits)
	Addresses	Sub-System	Description				
0	0 - FFFF (hex)	ICU	Operand/Data Space	H4100	Yes	Yes	16
	10000 - 1FFFF (hex)	Detector	Window Bitmap Table	H4100	No		4
	20000 - 2FFFF (hex)	Electronics	Centroid Look-up Table	H4100	No		8
1	0 - FFFF (hex)	ICU	Instruction Space	H4101	Yes		16

MID (hex)	DPU Local Memory Description	MFN	Basic	Oper	Mem Size (bits)
10	DPU Blue 1 DSP Local Memory	H4110	N/A	N/A	24
11	DPU Blue 2 DSP Local Memory	H4111			24
12	DPU Red DSP Local Memory	H4112			24
13	DPU White DSP Local Memory	H4113	No	Yes	24

MID (hex)	DPU Global Memory Description	START ADDRESS	END ADDRESS	MFN	BASIC	OPER	MEM SIZE (BITS)
14	DPU Big Word Memory (24 bit words)	000000	0FFFFF	H4114	NO	YES	24
15	DPU Small Word Memory (16 bit words)	400000	7FFFFF	H4115			16
20	DPU Program Ram Bank 0	E00000	E0FFFF	H4120			24
21	DPU Program Ram Bank 1	E10000	E1FFFF	H4121			24
22	DPU Program Ram Bank 2	E20000	E2FFFF	H4122			24
23	DPU Program Ram Bank 3	E30000	E3FFFF	H4123			24
24	DPU Program Ram Bank 4	E40000	E4FFFF	H4124			24
25	DPU Program Ram Bank 5	E50000	E5FFFF	H4125			24
26	DPU Program Ram Bank 6	E60000	E6FFFF	H4126			24
27	DPU Program Ram Bank 7	E70000	E7FFFF	H4127			24

2.3.3 Calculate Memory Checksum

The packet results in the downlink of a *Memory Checksum Report* for the specified areas.

Note - this command is supported for the ICU memory only.

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Flag/Ack		Data Field
1	1	Unsigned Integer	Packet Type/SubType = 6,3		Header
2	2	Unsigned Integer	MID		Application
4	4	Unsigned Integer	Start Address	H500	Data
8	2	Unsigned Integer	Length to be checked	H510	
10	2	Unsigned Integer	CRC		Error Control

* All offsets measured in octets from the start of the Packet Data Field

MID (Hex)	ICU & Detector Memory Description			MFN	Basic	Oper
	Addresses	Sub-System	Description			
0	0 - FFFF (hex)	ICU	Operand/Data Space	H4200	Yes	Yes
	10000 - 1FFFF (hex)	Detector	Window Bitmap Table	N/A	No	
	20000 - 2FFFF (hex)	Electronics	Centroid Look-up Table	N/A	No	
1	0 - FFFF (hex)	ICU	Instruction Space	H4201	Yes	

MID (hex)	DPU Local Memory Description	MFN	Basic	Oper
10	DPU Blue 1 DSP Local Memory	N/A	N/A	N/A
11	DPU Blue 2 DSP Local Memory			
12	DPU Red DSP Local Memory			
13	DPU White DSP Local Memory			

MID (hex)	DPU Global Memory Description	START ADDRESS	END ADDRESS	MFN	BASIC	OPER
14	DPU Big Word Memory (24 bit words)	000000	0FFFFF	N/A	N/A	N/A
15	DPU Small Word Memory (16 bit words)	400000	7FFFFF			
20	DPU Program Ram Bank 0	E00000	E0FFFF			
21	DPU Program Ram Bank 1	E10000	E1FFFF			
22	DPU Program Ram Bank 2	E20000	E2FFFF			
23	DPU Program Ram Bank 3	E30000	E3FFFF			
24	DPU Program Ram Bank 4	E40000	E4FFFF			
25	DPU Program Ram Bank 5	E50000	E5FFFF			
26	DPU Program Ram Bank 6	E60000	E6FFFF			
27	DPU Program Ram Bank 7	E70000	E7FFFF			

2.4 Telemetry Management

This section defines the packet data fields for command packets associated with the telemetry management function. The telecommand type acts on periodic, non-periodic telemetry and science packets. They are supported in both Basic and operational modes.

2.4.1 Report TM Packet Generation Status

This packet causes the generation status of all applicable packets to be downlinked to the ground.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType =9,1	
2	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.4.2 Enable Generation of all TM Packets

As it is illegal to have the high rate housekeeping (SID = 1) enabled at the same time as either science data (SID = Fx hex) or low rate housekeeping (SID = 0), this command is unsupported by the OM.

2.4.3 Disable Generation of all TM Packets

On receipt of this command, generation of all applicable packets is disabled.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 9,3	
2	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.4.4 Enable Generation of Specific Packets

On receipt of this command, generation of the specified housekeeping, science or non-periodic packet is enabled. Note that OM only supports the enabling of one packet type (as specified by the SID) at a time.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType =9,4	
2	1	Unsigned Integer	SID	Application Data
3	1	-	Spare	
4	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.4.5 Disable Generation of Specific Packets

On receipt of this command, generation of the specified housekeeping, science or non-periodic packet is disabled. Note that OM only supports the disabling of one packet type (as specified by the SID) at a time.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType =9,5	
2	1	Unsigned Integer	SID	Application Data
3	1	-	Spare	
4	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.5 Onboard Time Management

This section defines the contents of the packet data field for commands associated with the OBDH time management functions. The commands synchronises selected onboard applications to a common onboard time reference and verify this process. They are supported in both Basic and operational modes.

2.5.1 Enable Time Synchronisation

The CDMU sends this command to the ICU to start the time synchronisation function.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 10,2	
2	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.5.2 Add Time Code

On receipt of this command, the ICU adds the time information delivered in the data field to the local representation of the onboard time. In operational mode only, the ICU then generates and sends to the DPU the appropriate command to synchronise the DPU time to the ICU time that results from the addition.
Note - no further DPU commands should be sent for a period of 2 seconds after this command to ensure the DPU in synchronised. See also note 3 of section 2.2.4.2 about (re)synchronising the DPU clock to the ICU clock.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 10,3	
2	4	Unsigned Integer	Coarse Time	Application Data
6	2	Unsigned Integer	Fine Time	
8	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.5.3 Enable Time Verification

This command enables the generation of a Time Verification Report TM(10,5).

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 10,5	
2	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

2.6 Test Command

MFN = H1.

This section defines the contents of the packet data field for the test telecommand packet. The test command's only function is to confirm that the link to the OM is alive and working - i.e. it is a 'NO-OP' command. It is supported in both Basic and operational modes.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag/Ack fields	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 13,1	
2	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

3. Telemetry

3.1 Overview

All telemetry packets will conform to the structure defined in APP-1. The template structure is repeated here for convenience.

SOURCE PACKET HEADER (48 bits)							PACKET DATA FIELD		
Packet ID				Packet Sequence Control		Packet Length	Data Field Header	Source Data	Packet Error Control
Version Number	Type	Data Field Header Flag	Applic-ation Process ID	Segment-ation Flags	Source Sequence Count				
3	1	1	11	2	14				
16				16		16	16 or 64	N * 16	16

Table 3-1 : Telemetry Packet Template

3.1.1 Source Packet Header

3.1.1.1 Packet ID

Version Number set to 4 (as per APP-1)
Type set to 0, indicating it is a telemetry packet
Data Field Header set to 1, indicating the data field header is always present
Application Process ID (APID) This identifies the source-sink path for this packet. The APID value for OM will be 1024.

3.1.1.2 Packet Sequence Control

Segmentation Flags (bits 0 through 1) :
These 2 bits are normally set to "11" (binary), which means "unsegmented". However, for Science Packets TM(15,x) they are set as follows:

- 01 = First Source Packet of a Group
- 00 = Continuation Source Packet of a Group
- 10 = Last Source Packet of a Group
- 11 = Self Standing Source Packet (not part of a Group)

Sequence Count (bits 2 through 15) :
The sequence count. This counter:

- increments by 1 for each new telemetry packet.
- may be reset to zero by the source
- will 'wrap-around' from full-scale (2^{14}-1) to zero.

3.1.1.3 Packet Length

The Packet Length Field contains an unsigned integer "C", where

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

The maximum length of a Telemetry Packet Data Field is 512 octets. Therefore C <= 511.

3.1.2 Packet Data Field

This consists of 2 or 3 sub-fields

- Data Field Header (always present)
- Source Data (always present)
- Packet Error Control (present only if so indicated by a flag in the Data Field Header)

A summary of the sub-fields is repeated here from APP-1 for convenience.

3.1.2.1 Data Field Header

Data Field Header have the following structure

Spare	Checksum Flag	Packet Type	Packet SubType	Time
6 Bits	2 Bits	4 Bits	4 Bits	48 Bits
Mandatory	Mandatory	Mandatory	Mandatory	*Optional*

Table 3-2 : TM Data Field Header

Its components are as follows.

Spare : Set to all zeros i.e.000000(binary).

Checksum Flag : Indicates the presence or absence of a Packet Error Control Field at the end of the Packet Data Field.

Value = 0 = No checksum present.
Value = 3 = Checksum field is present (always true for OM telemetry).

Packet Type : This identifies the general category to which the telemetry source packet relates and, for OM, defines whether the Time field is present. The packet types applicable to OM are given in the table below.

Packet Type	TM Packet Category	Time Field
1	Periodic Telemetry Reports	✔
3	Telecommands Verification Reports	✔
4	Non-Periodic Telemetry Reports	✔
5	Task Management Reports	✘
6	Memory Maintenance Reports	✘
9	Telemetry Management Reports	✘
10	Time Management Reports	✘
15	Science Data	✘

Table 3-3 : TM Packet Types

Packet SubType : This, together with the Packet Type, uniquely identifies the nature of the telemetry contained in the packet.

The complete list of TM packets supported by OM is given by the following table.

General Category	Type, SubType	Service
PERIODIC TELEMETRY	1,1	Housekeeping Telemetry
TELECOMMAND VERIFICATION	3,1	Successful Command Acceptance
	3,2	Unsuccessful Command Acceptance
	3,4	Unsuccessful Command Execution
NON-PERIODIC TELEMETRY	4,1	Event Report
	4,2	Exception Report
	4,3	Major Anomaly Report
TASK MANAGEMENT	5,4	Task Parameter Report
MEMORY MAINTENANCE	6,2	Memory Dump Report
	6,3	Memory Checksum Report
TELEMETRY MANAGEMENT	9,1	TM Packet Generation Status Report
ON-BOARD TIME MANAGEMENT	10,5	Time Verification Report
SCIENCE DATA	15,x	Science Data

Table 3-4 : TM Packet Functions

Time: This field is optional for packet types 5,6,9,10 and 15. Its format is defined in appendix 5 of APP-1. It consists of 4 octets of coarse time, containing multiples of 1 second, and 2 octets of fine time, containing multiples of 2^{-16} of a second.
The table given under the description of Packet Type in this section indicates its presence or absence as a function of packet type.

Coarse Time				Fine Time	
2^{31}	2^{23}	2^{8}	2^{0}	2^{-1}	2^{-16}

Table 3-5 : TM Time Format

3.1.2.2 Source Data

This constitutes the data element of the telemetry report. The precise format depends on the values of type and subtype. The table in section 3.1.3 provides a summary. The meaning of the terms used is explained in the remainder of the document.

3.1.2.3 Packet Error Control

This field, which is always present in OM telemetry, contains an error detection code (checksum) for the packet. This allows the OM to verify the integrity of the telecommand packet data. It is calculated over the complete packet *less* the final 16 bits of the Packet Error Control Field.

3.1.3 Packet Structure Summary

The Telemetry Packet Structure is summarised in the following tables.

Packet	consists of	which consists of	which consists of	which consists of	Size (bits)
TM Packet	Source Packet Header	Packet ID	Version Number		3
			Type		1
			Data Field Header Flag		1
			APID		11
		Packet Sequence Control	Sequence Flags		2
			Sequence Count		14
		Packet Length			16
	Packet Data Field	Data Field Header	Spare		6
			Checksum Flag		2
			Packet Type		4
			Packet SubType		4
			Time (optional)	Coarse Time	32
				Fine Time	16
		Source Data	as summarised in table overleaf.		N * 16
		Packet Error Control (Optional)			16

Table 3-6 : TM Packet Summary

Category	Data Field Header and Source Data (Byte Offsets from Source Packet Header)															
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15⇒end**
Periodic HK	CRC	1,1	Coarse Time				Fine Time		SID	Parameters						
Verification Reports	CRC	3,1	Coarse Time				Fine Time		TC Seq. Count							
	CRC	3,2	Coarse Time				Fine Time		TC Seq. Count		Err	N	Parameters			
	CRC	3,4	Coarse Time				Fine Time		TC Seq. Count		Err	N	Parameters			
Non-Periodic Telemetry	CRC	4,1	Coarse Time				Fine Time		SID		Parameters					
	CRC	4,2	Coarse Time				Fine Time		SID		Parameters					
	CRC	4,3	Coarse Time				Fine Time		SID		Parameters					
Task Management	CRC	5,4	TID	FID	Parameters											
Memory Maintenance	CRC	6,2	MID		Start Address				Data							
	CRC	6,3	MID		Start Address				Length		CRC Result					
TM Management	CRC	9,1	SID1	Stat 1	SID2	Stat 2	Repeat as required									
Time Management	CRC	10,5	Coarse Time				Fine Time									
Science	CRC	15,x	SID	Offset	Science Data											

Table 3-7 : TM Data Field and Source Data Summary

The terms used in the above table are explained in the text.

NOTE: Table entries with a background like this are part of the Data Field Header

3.2 *Periodic Telemetry Reports*

This section defines the contents of the packet data field for the periodic telemetry report packets.

3.2.1 Housekeeping

TPN = 90000.

This packet type is used to transport periodically sampled housekeeping telemetry every 10 sec.

Off-set*	Length (Octets)	PREF	Alias	Basic (Note 1)	Type	Description			Packet Data Field
0	1				Unsigned Int	Checksum Flag			Data Field Header
1	1				Unsigned Int	Packet Type/SubType = 1,1			
2	6				Time Field	Time			
8	1				Unsigned Int	SID = 00(hex)			Source Data
9	1	H5100		N	Unsigned Int	Wait Resolution (Accuracy of A to D)		Analogue Blue Processing Electronics	
10	2	H5105		N	Unsigned Int	0 BPE	Thermistors		
12	2	H5110		N	Unsigned Int	1 REF B	Thermistors		
14	2	H5115		N	Unsigned Int	2 REF C	Thermistors		
16	2	H5120		N	Unsigned Int	3 MAIN	Thermistors		
18	2	H5125		N	Unsigned Int	4 FORWARD 1	Thermistors		
20	2	H5130		N	Unsigned Int	5 FORWARD 2	Thermistors		
22	2	H5135		N	Unsigned Int	6 CCD	Thermistors		
24	2	H5140		N	Unsigned Int	7 Spare			
26	2				4 bits	Spare			
		H5145	9010	N	1 Bit	High Voltage Enabled/Disabled			
		H5150	9320	N	1 Bit	Fine Pick-Off Sensor			
		H5155		N	10 Bits	V_{mcp1}	High Voltage Monitor		
28	2	H5160		N	Unsigned Int	V_{mcp23}	High Voltage Monitor		
30	2	H5165		N	Unsigned Int	$V_{cathode}$	High Voltage Monitor		
32	2	H5170		N	Unsigned Int	+5 V	Low Voltage Monitor		
34	2	H5175		N	Unsigned Int	+15 V	Low Voltage Monitor		
36	2	H5180		N	Unsigned Int	-15 V	Low Voltage Monitor		
38	2	H5185		N	Unsigned Int	1.23 V Reference	Low Voltage Monitor		
40	2	H5190		N	Unsigned Int	Filter Wheel Pickoff (Analogue)			
42	1	-			4 Bits	Spare			
		H5195		N	4 Bits	Flood LED Bias Current			
43	1	-			4 Bits	Spare			
		H5205		N	4 Bits	Fine Position Sensor LED Drive Current			
44	1	H5210	9010	N	1 Bit	Integration Enabled/Disabled		Digital Blue Processing Electronics	
		H5215	9030	N	3 Bit	Acquisition Mode			
		H5220	9280	N	1 Bit	Frame Tag Enabled/Disabled			
		-			1 Bit	Spare			
		H5225	9410	N	1 Bit	Table Access Mode/Centroid Table Ready			
		H5230	9000	N	1 Bit	Camera Start/Stop - Window Table Ready			
45	1	H5235		N	Unsigned Int	Event Detect Threshold			

continued overleaf

* All offsets measured in octets from the start of the Packet Data Field.

Housekeeping (continued).

Offset*	Length (Octets)	PREF	Alias	Basic (Note 1)	Type	Description				Packet Data Field
46	1	-			4 Bits	Spare			TMPSU	Source Data
		H5240	9050	Y	4 Bits	Commanded Heater Status				
47	1	-			2 bits	Spare				
		H5245		Y	4 Bits	Coarse Position Sensor LED Current				
		H5250	9320	Y	1 Bit	Coarse Position Sensor Status				
		H5255	9010	Y	1 Bit	Secondary Voltage Status				
48	2	H5260		N	4 Bits	Last Commanded Filter Wheel Phase				
		H5265		N	12 Bits	S/W Filter Wheel Position Counter				
50	1	-			4 Bits	Spare				
		H5270		N	4 Bits	Last Commanded Dichroic Phase				
51	1	-			2 Bits	Spare				
		H5275		N	6 Bits	S/W Dichroic Position Counter				
52	1	H5280		Y	Unsigned Integer	Current +25	Switched	Secondary Voltages		
53	1	H5285		Y	Unsigned Integer	Current +15				
54	1	H5290		Y	Unsigned Integer	Current +11				
55	1	H5295		Y	Unsigned Integer	Current +5.3				
56	1	H5300		Y	Unsigned Integer	Current -5.3[2]				
57	1	H5305		Y	Unsigned Integer	Current -15				
58	1	H5310		Y	Unsigned Integer	Current +28	Unswitched			
59	1	H5315		Y	Unsigned Integer	Current +5				
60	1	-			4 Bits	Spare			ICB	
		H5320		Y	4 Bits	ICB Status Register at last error				
61	1	H5325			8 Bits	Spare				
62	2	H5200		Y	14 Bits	S/W Version			S/W	
		H5330	9330	Y	1 Bit	Time Synchronisation Active			S/C Interface	
		H5335	9340	Y	1 Bit	Time Invalid Flag				
64	2	H5340		Y	16 Bits	RBI Status Register				
66	2	H5345		Y	16 Bits	RBI Configuration Register				
68	1	H5350		Y	Unsigned Integer	ICB Error Count modulo 255			Errors	
69	1	H5355		Y	Unsigned Integer	SSI Error Count modulo 255				
70	1	-			Unsigned Integer	Spare				
71	1	H5360		N	Unsigned Integer	SCI Error Count modulo 255				
72	1	-				Spare				
73	1	-				Spare				
74	2	H5385		Y	Unsigned Integer	TC Good Packet Count			Packet Counters	
76	2	H5390		Y	Unsigned Integer	TC Bad Packet Count				

Continued overleaf.

* All offsets measured in octets from the start of the Packet Data Field.

Housekeeping (continued).

Offset	Length (Octets)	PREF	Alias	Basic (Note-1)	Type	Description			Packet Data Field
78	1	-			4 Bits	Spare		General	Source Data
		H5395	9350	Y	3 Bits	OM State			
		H5400	9360	Y	1 Bit	Prime/Redundant Flag (Prime = 1)			
79	1	-			7 Bits-	Spare		ICU	
		H5405	9370	Y	1 Bit	ICU State			
80	2	H5410		Y	Unsigned Integer	Heartbeat Count		DPU	
82	2	H5415	9040	N	Unsigned Integer	Current DPU DD_xxx Data Type			
84	1			N		Spare			
85	3	H5420		N	Signed Integer	Drift x			
88	1			N		Spare			
89	3	H5425		N	Signed Integer	Drift y			
92	1			N		Spare			
93	3	H5430		N	Signed Integer	Drift Roll			
96	2	H5435		N	Unsigned Integer	Number of Frames so far this Exposure			
98	2	H5440		N	Unsigned Integer	Exposure Time (Frames)			
100	1			N		Spare			
101	3	H5445		N	Unsigned Integer	Exposure ID			
104	2	H5450	9120	Y	1 Bit	DPU State (0 /1 = BOOT/DPUOS)			
		H5455	9020	Y	1 Bit	Blue 1 DSP Status	0/1 = Off/On		
		H5460		Y	1 Bit	Blue 2 DSP Status			
		H5465		Y	1 Bit	Red DSP Status			
		H5470		Y	1 Bit	Blue 1 DSP Data Capture			
		H5475		Y	1 Bit	Blue 2 DSP Data Capture			
		H5365	9270	N	1 Bit	Tracking = 0/1 = off/on			
		H5480	9220	N	5 Bits	Current Swap Unit ID			
		H5485	9225	N	4 Bits	Current DPU Task ID			
106	4	-	-	Y	-	Spare			
110	2				Unsigned Integer	CRC			Error Control

* All offsets measured in octets from the start of the Packet Data Field.

Notes :
1. Indicates whether item is valid when ICU is in Basic mode (Y = Yes, N = No).
2. This item on the **prime** unit is subject to overflow. Occasional occurrences of this can be ignored.

3.2.2 Diagnostic Periodic Engineering.

TPN = 90001.

In addition to the normal periodic housekeeping, there is a ‘diagnostic periodic engineering’ packet. Its format is identical in format to the above normal housekeeping, except that it is sent at a rate of 1 packet per 3 seconds and the SID has a value of 1.

Note: housekeeping packets as defined by a SID of zero MUST be disabled when this packet type is enabled.

It cannot be used in conjunction with Science Data as there is insufficient telemetry capacity.

3.3 Verification

This section defines the contents of the packet data field for the telemetry verification report packets.

Note - in this section, TC Source Sequence Count is structured as follows:

Size (Bits)	Description
2	Spare (set to 00 binary)
1	Command Source = 0/1 = Ground/On-board
13	Actual Sequence Count

3.3.1 Successful Command Acceptance

TPN = 91100.

This packet sub-type is used to transport information concerning successful telecommand acceptance to the ground.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	Unsigned Integer	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 3,1	
2	4	Unsigned Integer	Coarse Time	
6	2	Unsigned Integer	Fine Time	
8	2	Unsigned Integer	TC Source Sequence Count	Source Data
10	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field.

TC Source Sequence Count is the value copied from the Sequence Count field of the uplinked telecommand to which this packet relates. It therefore contains both the command source flag and the actual sequence count.

3.3.2 Unsuccessful Command Acceptance

TPN – see below.

This packet sub-type is used to transport information concerning unsuccessful telecommand acceptance to the ground. They are of the form:

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	Unsigned Integer	Checksum Flag		Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 3,2		
2	4	Unsigned Integer	Coarse Time		
6	2	Unsigned Integer	Fine Time		
8	2	Unsigned Integer	TC Source Sequence Count		Source Data
10	1	Unsigned Integer	Error Code		
11	1	Unsigned Integer	Number of Params N	H9070	
12	2*N	Unsigned Integers	N Parameters		
12+2*N	2	Unsigned Integer	CRC		Error Control

* All offsets measured in octets from the start of the Packet Data Field.

TC Source Sequence Count - the value copied from the Sequence Count field of the uplinked telecommand to which this packet relates. It therefore contains both the command source flag and actual sequence count.

Error Code - the reason for command acceptance failure. Those so far defined, and their associated parameters, are as follows:

TPN	Code	Reason	N	Parameter 1	Parameter 2	PREF 1	PREF 2
91200	0	Illegal APID	1	Illegal APID	-	H6000	
91201	1	Incorrect Checksum	2	Expected CRC	Found CRC	H6005	H6010
91202	2	Illegal Packet Type	2	Detected Packet Type	Detected Packet SubType	H6015	H6020
91203	3	Illegal Packet SubType	2	Detected Packet Type	Detected Packet SubType	H6015	H6020
91204	4	Illegal Parameter Value	0	-	-		
91205	5	Invalid Length	1	Illegal Length	-	H6030	
91208	8	Illegal TID	1	Illegal TID	-	H6035	
91209	9	Illegal FID	2	Associated TID	Illegal FID	H6040	H6045
91210	10	Illegal Mode	1	Illegal Mode	-	H6050	
91211	11	Illegal MID	1	Illegal MID	-	H6055	
91212	12	Illegal Start Address	1	Illegal Start Address		H6060	
91213	13	Non-existent memory	1	MID	-	H6065	
91219	19	Illegal SID	1	Illegal SID	-	H6070	
91292	192	Invalid for this mode	0	-	-		

Table 3-8 : Command Acceptance Failure Summary

3.3.3 Unsuccessful Command Execution

TPN – see below.

This packet sub-type is used to transport information concerning unsuccessful telecommand execution to the ground.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	Unsigned Integer	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 3,4	
2	4	Unsigned Integer	Coarse Time	
6	2	Unsigned Integer	Fine Time	
8	2	Unsigned Integer	TC Source Sequence Count	Source Data
10	1	Unsigned Integer	Error Code	
11	1	Unsigned Integer	0	
12	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

TC Source Sequence Count is the value copied from the Sequence Count field of the uplinked telecommand to which this packet relates. It therefore contains both the command source flag and actual sequence count.

Error Code identifies the reason for command execution failure. Those so far defined, and their associated parameters, are as follows:

TPN	Code	Reason
91400	128	Task Stopped by command early
91401	130	Command too soon
91402	132	Parameters not loaded
91403	133	HV Ramp Failure
91404	134	F/W not yet been set at datum
?????	135	F/W not at blocked

Table 3-9 : Command Execution Failure Summary

3.4 Non-Periodic Housekeeping

This section defines the contents of the packet data field for non-periodic housekeeping telemetry packets.

3.4.1 Event Reports

This packet sub-type is used to transport telemetry that indicates non-critical events.

3.4.1.1 Non-DPU Event Reports

3.4.1.1.1 General Format

The general format for event report packets **NOT** relating to the DPU is:-

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	Unsigned Integer	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,1	
2	4	Unsigned Integer	Coarse Time	
6	2	Unsigned Integer	Fine Time	
8	1	Unsigned Integer	SID (see tables below)	Source Data
9	1	-	Spare	
10	2	Unsigned Integers	Event Code	
12	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field.

The non-DPU Events so far defined are as follows:

TPN	Sub-System	Event Description	SID (Hex)	Event Code	PREF	Alias
92100	DETECTOR	Centroid Table Loaded	10	0010	H7000	9080
		Window Table Loaded		0011		
		Vcathode reached		0013		
		Vmcp1 reached		0014		
		Vmcp23 reached		0015		
92600	TMPSU	Filter Wheel at requested position	60	0060	H7010	9090
		Dichroic Mechanism at requested position		0061		

Table 3-10: Non-DPU Event Summary

3.4.1.1.2 Bootstrap Report

TPN = 92703.

There is an exception to the general format. At the start of the ICU basic / initial mode, the following packet is issued in the event of a nominal boot sequence. It is used to give a record of what happened during the boot process. The full explanation of the items is given in APP-7, together with the criteria for deciding if the operation was nominal. If the boot sequence was non nominal, an identically structured packet, but of the exception report sub-type is issued instead (see below).

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	Unsigned Integer	Checksum Flag			Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,1			
2	4	Unsigned Integer	Coarse Time			
6	2	Unsigned Integer	Fine Time			
8	1	Unsigned Integer	SID = D3 (hex)			Source Data
9	1	Unsigned Integer	Spare			
10	2	Unsigned Integer	Boot Type	H8100	9380	
12	2	Unsigned Integer	Progress Flags	see below		
14	2	Unsigned Integer	ICB Command Counter	H8110		
16	2	Unsigned Integer	ICB Sync Error Counter	H8115		
18	2	Unsigned Integer	ICB Extension Error Counter	H8120		
20	2	Unsigned Integer	ICB Transmit Error Counter	H8125		
22	2	Unsigned Integer	ICB Time Out Error Counter	H8130		
24	2	Unsigned Integer	ICB Dead	H8165	9460	
26	2	Unsigned Integer	Coarse Seen Flag	H8135	9320	
28	2	Unsigned Integer	Steps Remaining Counter	H8140		
30	2	Unsigned Integer	Final Steps Counter	H8145		
32	2	Unsigned Integer	Last Filter Wheel Phase	H8150		
34	2	Unsigned Integer	F/W Safing Error Counter	see below		
36	2	Unsigned Integer	ICB Initialisation	H8160		
38	2	Unsigned Integer	CRC			Error Control

* All offsets measured in octets from the start of the Packet Data Field.

Progress Flags

Description	PREF	Alias
HV Safed	H8101	9390
Heaters Safed	H8102	
Phases Safed	H8103	
DPU Safed	H8104	
Secondaries Safed	H8105	
Filter Wheel Safed	H8106	

Filter Wheel Safing Error Counters

Description	PREF	Alias
Bad Phase	H8155	9430
Bad Sensor Read	H8156	
Bad LED	H8157	

3.4.1.2 DPU Event Reports

The data stream from the DPU to the ICU contain Alerts. Alerts are data blocks informing the ICU of changes in the status of the DPU. The format of these blocks is defined in the ICU-DPU Protocol Document (APP-3, section 7) and are of the general form

1st Word	2nd Word	Remaining Words
Alert Code	Number of Words (N_{words}) to follow	N_{words} of Data

Those DPU alerts of an information nature relevant to ground operations cause an event report packet to be sent to the ground. For ease of coding, the packet is constructed by adding a suitable packet header, SID and checksum around the alert. The format of the resulting packet data field is as follows:

Offset*	Length (Octets)	Type	Description		PREF	Packet Data Field
0	1	Unsigned Integer	Checksum Flag			Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,1			
2	4	Unsigned Integer	Coarse Time			
6	2	Unsigned Integer	Fine Time			
8	1	Unsigned Integer	SID (see Table overleaf)			Source Data
9	1	Unsigned Integer	Spare			
10	2	Unsigned Integer	DPU Alert Code	DPU Alert Block	H9075	
12	2	Unsigned Integer	N_{words}		H9080	
14	2*N_{words}	Unsigned Integers	N_{words} of Data		see APP-3	
14+2*N_{param}	2	Unsigned Integer	CRC			Error Control

* All offsets measured in octets from the start of the Packet Data Field.

As the layout, format and meaning of the parameters associated with each Alert Block are defined in the APP-3, they will not be repeated here. However, the table overleaf defines the associated SID's and TPN's (Telemetry Packet Numbers).

The DPU events so far defined are as follows:

Category	Mnemonic	Alert Code (Hex)	SID (Hex)	TPN	Enabled (Default)
Synchronous	DA_HBEAT	A500	90	92200	-
Asynchronous Health & Status	DA_DPU_BOOT_READY	A510	91	92201	Yes
	DA_DPUOS_READY	A511	92	92202	Yes
	DA_ECHO_ICU_CMD	A512	93	92203	-
	DA_BEGOF_EXP	A513	94	92204	Yes
	DA_ENDOF_EXP	A514	95	92205	Yes
	DA_DATA_ALERT	A515	96	92206	-
	DA_DATA_END	A516	97	92207	-
	DA_DONE_FLD_DATA	A517	98	92208	-
	DA_COMPLETE_EXP	A518	99	92209	Yes
Major Milestones	DA_EOT_INIT_DPU	A520	9A	92210	Yes
	DA_EOT_ACQUIRE_FLD	A521	9B	92211	Yes
	DA_EOT_CHOOSE_GS	A522	9C	92212	Yes
	DA_EOT_INIT_EXP	A523	9E	92213	-
	DA_EOT_ENG	A524	9F	92214	-
	DA_SWITCH_FRAME	A525	A0	92215	-
	DA_TRK	A526	A1	92216	-
	DA_SENT_CMPRSSQ	A527	A2	92217	Yes
	DA_EOT_FLUSH_CMPRS	A528	A3	92218	-
Minor Milestone	DA_EOS_INIT_DPU	A530	A4	92219	-
	DA_EOS_CALBGD	A531	A4	92219	-
	DA_EOS_SCANBS	A532	A4	92219	-
	DA_EOS_RSTR_STARS	A533	A4	92219	-
	DA_EOS_MAKEAGS_ID	A534	A4	92219	-
	DA_EOS_CALDRFT	A535	A4	92219	-
	DA_EOS_SCANGS	A536	A4	92219	-
	DA_EOS_DOWINDOW	A537	A4	92219	-
	DA_EOS_GETREF	A538	A4	92219	-
	DA_EOS_LOCATEGS	A539	A4	92219	-
	DA_EOS_ABORT	A53A	A4	92219	-
	DA_EOS_DLVRDATA	A53B	A4	92219	-
	DA_EOS_ENG	A53C	A4	92219	-
	DA_EOS_COMPRESS	A53D	A4	92219	-
	DA_DONE_SAA	A53E	A4	92219	-
	DA_CLK_SYNCH_ERROR[1]	A580	A5	92220	Yes
	DA_MSTN_SET_ROLL_CTR	A53F	A6	92221	-

Table 3-11 : DPU Event Summary

1. This is a 'downgraded' DA_CLK_SYNCH_ERROR - the DPU issues this during time synchronisation even though it is not an error.

3.4.2 Exception Reports

This packet sub-type is used to transport telemetry that indicates non-fatal anomalies.

3.4.2.1 Non-DPU Exception Reports

3.4.2.1.1 General Format

The general format for the majority of exception report packets **NOT** relating to the DPU is:-

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	Unsigned Integer	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,2	
2	4	Unsigned Integer	Coarse Time	
6	2	Unsigned Integer	Fine Time	
8	1	Unsigned Integer	SID (see tables below)	Source Data
9	1	-	Spare	
10	2	Unsigned Integers	Exception Code	
12	2	Unsigned Integers	Parameter	
14	2	Unsigned Integer	CRC	Error Control

- All offsets measured in octets from the start of the Packet Data Field.

The non-DPU exceptions supported by this format are as follows:

As of release 10 of the ICU OM Software, there are no exceptions supported by this format (ECR 087). They have been converted to Major Anomalies (see relevant section below).

3.4.2.1.2 ICB Errors

TPN = 92404.

There is an exception to the above format in the event of an ICB error. The format is as follows:-

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	Unsigned Integer	Checksum Flag		Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,2		
2	4	Unsigned Integer	Coarse Time		
6	2	Unsigned Integer	Fine Time		
8	1	Unsigned Integer	SID = 44 (hex)		Source Data
9	1	-	Spare		
10	2	Unsigned Integer	Command Word[1]	H8200	
12	2	Unsigned Integer	Datum sent/received	H8205	
14	2	Unsigned Integer	Status at end of operation[2]	H8210	
16	2	Unsigned Integer	CRC		Error Control

- All offsets measured in octets from the start of the Packet Data Field.

N.B. By default, this packet is disabled and requires the appropriate telemetry management command to enable it.

Notes.

1. The format of the command word is as follows:

MSB			LSB
ext	dest	subadr	inst

where:

Name	Value (binary)	Comment
ext	101	
dest	00111	for TMPSU related operations
	11000	for BLUE electronics related operations
subadr	$0 \Rightarrow 11111$	
inst	010	for a MACSbus 'put' (RD) operation
	100	for a MACSbus 'get' (TI) operation

2. The format of the status word is as follows:

							LSB
8	9	10	11	12	13	14	15
Dead Bits			Spare	Trans. Error	Extension Error	Sync Error	End Comm.

a) All 'Dead bits' set indicate a serious problem with the MACSbus interface card. The contents of the remainder of the status word should be considered unreliable.
b) Trans. Error, Sync Error or Extension Error set to 1 indicate that a transmission, synchronisation or extension error respectively has occurred.
c) End Comm. = 0 = timout.

3.4.2.1.3 Bootstrap Report

TPN = 92704.

There is a exception to the general format. At the start of the ICU basic / initial mode, the following packet is issued in the event of a non-nominal boot sequence. It is used to give a record of what happened during the boot process. The full explanation of the items is given in APP-7, together with the criteria for deciding if the operation was nominal. If the boot sequence was nominal, an identically structured packet, but of the event report sub-type is issued instead (see above).

Offset*	Length (Octets)	Type	Description	PREF	Alias	Packet Data Field
0	1	Unsigned Integer	Checksum Flag			Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,2			
2	4	Unsigned Integer	Coarse Time			
6	2	Unsigned Integer	Fine Time			
8	1	Unsigned Integer	SID = D4 (hex)			Source Data
9	1	Unsigned Integer	Spare			
10	2	Unsigned Integer	Boot Type	H8100	9380	
12	2	Unsigned Integer	Progress Flags	see below		
14	2	Unsigned Integer	ICB Command Counter	H8110		
16	2	Unsigned Integer	ICB Sync Error Counter	H8115		
18	2	Unsigned Integer	ICB Extension Error Counter	H8120		
20	2	Unsigned Integer	ICB Transmit Error Counter	H8125		
22	2	Unsigned Integer	ICB Time Out Error Counter	H8130		
24		Unsigned Integer	ICB Dead	H8165	9460	
26	2	Unsigned Integer	Coarse Seen Flag	H8135	9230	
28	2	Unsigned Integer	Steps Remaining Counter	H8140		
30	2	Unsigned Integer	Final Steps Counter	H8145		
32	2	Unsigned Integer	Last Filter Wheel Phase	H8150		
34	2	Unsigned Integer	Filter Wheel Safing Error Counter	see below		
36	2	Unsigned Integer	ICB Initialisation	H8160		
38	2	Unsigned Integer	CRC			Error Control

- All offsets measured in octets from the start of the Packet Data Field.

Progress Flags

Description	PREF	Alias
HV Safed	H8101	9390
Heaters Safed	H8102	
Phases Safed	H8103	
DPU Safed	H8104	
Secondaries Safed	H8105	
Filter Wheel Safed	H8106	

Filter Wheel Safing Error Counter

Description	PREF	Alias
Bad Phase	H8155	9430
Bad Sensor Read	H8156	
Bad LED	H8157	

3.4.2.2 DPU Exception Reports

3.4.2.2.1 DPU Generated Exceptions

The data stream from the DPU to the ICU contains Alerts. Alerts are data blocks informing the ICU of changes in the status of the DPU, **including any exceptions**. The format of these blocks is defined in the ICU-DPU Protocol Document (APP-3, section 7) and are of the form:

1st Word	2nd Word	Remaining Words
Exception Alert Code	Number of Words (N_{words}) to follow	N_{words} of data

Those DPU alerts of an exception nature cause an exception report packet to be sent to the ground. For ease of coding, the packet is constructed by adding a suitable packet header, SID and checksum around the alert. The format of the resulting packet data field is as follows:

Offset*	Length (Octets)	Type	Description		PREF	Packet Data Field
0	1	Unsigned Integer	Checksum Flag			Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,2			
2	4	Unsigned Integer	Coarse Time			
6	2	Unsigned Integer	Fine Time			
8	1	Unsigned Integer	SID (see Table overleaf)			Source Data
9	1	Unsigned Integer	Spare			
10	2	Unsigned Integer	DPU Exception Alert Code	DPU Alert Block	H9076	
12	2	Unsigned Integer	N_{words}		H9080	
14	2*N_{words}	Unsigned Integers	N_{words} of Data		see APP-3	
14+2*N_{param}	2	Unsigned Integer	CRC			Error Control

- All offsets measured in octets from the start of the Packet Data Field.

As the layout, format and meaning of the parameters associated with each Alert Block are defined in App-3, section 7, they will not be repeated here. However, the table overleaf defines the associated SID's.

The DPU exceptions so far defined are as follows (**Note** - they are all enabled by default):

Category	Mnemonic	Alert Code (Hex)	SID (Hex)	TPN
Asynchronous Exceptions	DA_CLK_SYNCH_ERROR	A580	B2	92222
	DA_PROG_RAM_ERROR	A581	B3	92223
	DA_BOTTOM_WHITEDSP	A582	B4	92224
	DA_CID_TOO_LARGE	A583	B5	92225
	DA_BAD_CMD	A584	B6	92226
	DA_DPU_ABORTING	A585	B7	92227
	DA_BAD_BLOCK	A586	B8	92228
	DA_ZERO_LENGTH_DQ	A587	B9	92229
Coloured DSP Exceptions	DA_SCI_RCVR_ERROR	A590	BA	92230
	DA_SCI_HBEAT_ERROR	A591	BB	92231
	DA_RED_E_ALERT	A592	BC	92232
	DA_RED_S_ALERT	A593	BD	92233
	DA_BLUE1_E_ALERT	A594	BC	92232
	DA_BLUE1_S_ALERT	A595	BD	92233
	DA_BLUE2_E_ALERT	A596	BC	92232
	DA_BLUE2_S_ALERT	A597	BD	92233
Global Memory Access Exceptions	DA_GADE_RPI	A5A0	BE	92238
	DA_GADE_RPIA_L	A5A1	BF	92239
	DA_GADE_RPIA_H	A5A2	C0	92240
	DA_GADE_WPI	A5A3	BE	92238
	DA_GADE_WPIA_L	A5A4	BF	92239
	DA_GADE_WPIA_H	A5A5	C0	92240
	DA_GADE_RBI	A5A6	BE	92238
	DA_GADE_RBIA_L	A5A7	BF	92239
	DA_GADE_RBIA_H	A5A8	C0	92240
	DA_GADE_WBI	A5A9	BE	92238
	DA_GADE_WBIA_L	A5AA	BF	92239
	DA_GADE_WBIA_H	A5AB	C0	92240
	DA_GADE_RSI	A5AC	BE	92238
	DA_GADE_RSIA_L	A5AD	BF	92239
	DA_GADE_RSIA_H	A5AE	C0	92240
	DA_GADE_WSI	A5AF	BE	92238
	DA_GADE_WSIA_L	A5B0	BF	92239
	DA_GADE_WSIA_H	A5B1	C0	92240
	DA_GADE_RANGE_ERROR	A5B2	C2	92242
Other	DA_NO_GOOD_GS	A5D7	C3	92243
	DA_RSTR_BAD_TASK_ID	A5FC	C4	92244
	DA_ZERO_CNT_CALBGD	A5FF	C5	92245
	Unknown DPU Alert	????	CE	92254

DPU Exception Summary

3.4.2.2.2 DPU Related Exceptions Generated by the ICU

As of release 10 of the OM ICU software, there are no exceptions of this form (ECR 087). They have been converted to Major Anomalies (see relevant section below).

3.4.3 Major Anomaly Reports

This packet sub-type is used to transport telemetry that signifies the occurrence of a serious anomaly.

3.4.3.1 Non-DPU Major Anomaly Reports

The general format for the Major Anomaly Report packets **NOT** relating to the DPU is:-

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	Unsigned Integer	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,3	
2	4	Unsigned Integer	Coarse Time	
6	2	Unsigned Integer	Fine Time	
8	1	Unsigned Integer	SID (see tables below)	Source Data
9	1	-	Spare	
10	2	Unsigned Integers	Exception Code	
12	2	Unsigned Integers	Parameter	
14	2	Unsigned Integer	CRC	Error Control

- All offsets measured in octets from the start of the Packet Data Field.

The non-DPU major anomalies supported by this format are as follows:

Sub-System	Description	TPN	SID (Hex)	Exception Code	PREF	Parameter (hex) and Description	PREF
DETECTOR	Centroid Table Load Failed	92101	12	0010	H8010	0	H8015
	Window Table Load Failed			0011		0	
	ADA Exception[1]			0012		y10x (hex)	
ICB	ADA Exception[1]	92401	42	0041	H8040	yCBx (hex)	H8045
RBI	RBI Watchdog ADA Exception[1]	92501	52	50	H8050	y60x (hex)	H8055
	Telemetry Queue ADA Exception[1]			51		yF0x (hex)	
TMPSU	Loss of Filter Wheel Position	92601	62	0060	H8060	0	H8065
	Loss of Dichroic Mechanism Position			0061		0	
	ADA Exception[1]			0062		Y00x	
	Automatic Safe Transition			0063		0	
	Failed Automatic Safe Transition			0064		0	
SSI	SSI Error	92301	32	0030	H8030	1 = embedded-actual length inconsistent 2 = actual word count > ffff hex 7 = Overflow at end of block 8 = data too soon 9 = embedded put length too long 11 = embedded word count > 1027 (decimal) B = output buffer full C = interrupt input queue full 89 = h/w Overflow detected during put.	H8035
				31		The Invalid DPU Block Type	
	ADA Exception[1]			32		y70x	
HK	HK ADA Exception[1]	92702	02	0002	H8020	y30x (hex)	H8025
General	ICU Memory Manager ADA Exception	92907	D7	00D1	H8070	yC0x (hex)	H8075
	Time Manager ADA Exception[1]			00D2		yC1x (hex)	
	All other ADA exceptions[1]			00D0		y00x (hex)	

Non DPU Exception Summary

Notes:

The parameter is always of the form `yssx`, where:
`y` is odd for ICU basic mode, even for ICU operational mode
`ss` indicates the ADA package
`x` indicates the code block within the package where the exception occurred

3.4.3.2 DPU Major Anomaly Reports

3.4.3.2.1 DPU Generated Anomalies

The data stream from the DPU to the ICU contains Alerts. Alerts are data blocks informing the ICU of changes in the status of the DPU, **including any exceptions or anomalies**. The format of these blocks is defined in the ICU-DPU Protocol Document (APP-3, section 7) and are of the form:

1st Word	2nd Word	Remaining Words
Anomaly Alert Code	Number of Words (N_{words}) to follow	N_{words} of data

Those DPU alerts of an exception nature cause an exception report packet to be sent to the ground. For ease of coding, the packet is constructed by adding a suitable packet header, SID and checksum around the alert. The format of the resulting packet data field is as follows:

Offset*	Length (Octets)	Type	Description		PREF	Packet Data Field
0	1	Unsigned Integer	Checksum Flag			Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,3			
2	4	Unsigned Integer	Coarse Time			
6	2	Unsigned Integer	Fine Time			
8	1	Unsigned Integer	SID (see Table overleaf)			Source Data
9	1	Unsigned Integer	Spare			
10	2	Unsigned Integer	DPU Anomaly Code	DPU Alert Block	H9076	
12	2	Unsigned Integer	N_{words}		H9080	
14	2*N_{words}	Unsigned Integers	N_{words} of Data		see APP-3	
14+2*N_{param}	2	Unsigned Integer	CRC			Error Control

- All offsets measured in octets from the start of the Packet Data Field.

As the layout, format and meaning of the parameters associated with each Alert Block are defined in App-3, section 7, they will not be repeated here. However, the table below defines the associated SID's.

The DPU major anomalies so far defined are as follows (**Note** - they are all enabled by default):

Category	Mnemonic	Alert Code (Hex)	SID (Hex)	TPN
Asynchronous Exceptions	DA_PROG_RAM_MERROR	A588	C1	92241

DPU Major Anomaly Summary

3.4.3.2.2 DPU Related Major Anomalies Generated by the ICU

Certain DPU related major anomalies are detected by the ICU. They are of the following format.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	Unsigned Integer	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 4,3	
2	4	Unsigned Integer	Coarse Time	
6	2	Unsigned Integer	Fine Time	
8	1	Unsigned Integer	SID (see Table below)	Source Data
9	1	Unsigned Integer	Spare	
10	2	Unsigned Integer	Anomaly Code	
12	2	Unsigned Integer	Parameter	
14	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field.

Description	TPN	SID (Hex)	Anomaly Code	PREF	Alias	Params (hex)	PREF
Heartbeat Monitor Task ADA Anomaly[1]	92800	CF	C0	H8080	9460	e00x	H8085
DPU Memory Data Manager Task ADA Anomaly[1]			C1			e1aa	
ADA Exception Anomaly – DPU Data Manager			32			e00y	
Loss of DPU Heartbeat Anomaly	92802	B0	A500	H8090		0	
Unexpected DPU Reset Anomaly[2]	92803	B1	A510	H8095		0	

Notes:

1. ‘x’ or ‘y’ or ‘aa’ in the parameter field indicates the code block within the package where the exception occurred. x is in the range 0-4, y in the range 5-9, aa in the range 00-18hex.
2. This is issued when a DA_DPU_BOOT_READY is issued by the DPU without a preceding IC_RESET_DSP.

3.5 Task Management

3.5.1 Task Parameter Report

This packet subtype is used to report the most recently uploaded task parameters. It is generated as a response to the telecommand Report Task Parameters TC(5,4).

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	Unsigned Integer	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 5,4	
2	1	Unsigned Integer	TID	Source Data
3	1	Unsigned Integer	FID	
4	2*N	Unsigned Integers	N (16 bit word) Parameters	
4+2*N	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field.

TID and FID are as defined for Load Task Parameters TC(5,3), and are not yet Implemented, except in the case when TID and FID values correspond to a read of an ICB port. The contents of the single word that is then read back are detailed overleaf.

Contents of MACSBUS word read back.

<table>
<tr><th rowspan="2">TID (hex)</th><th rowspan="2">MACs Address (hex)</th><th rowspan="2">FID & MACs Sub Address</th><th rowspan="2">Sub-system</th><th rowspan="2">TPN</th><th rowspan="2">Description</th><th colspan="16">Bits</th></tr>
<tr><th>MSB</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>LSB</th></tr>
<tr><td>47</td><td>7</td><td>0</td><td>TMPSU</td><td>93670</td><td>TMPSU Currents and F/W Coarse Sensor</td><td colspan="8">Current Value</td><td colspan="7">Don't Care</td><td>CS</td></tr>
<tr><td rowspan="5">58</td><td rowspan="5">18</td><td>2</td><td rowspan="5">Det-ector</td><td>93182</td><td>Digital Electronics Status Word</td><td colspan="8">Don't Care</td><td>IA</td><td colspan="3">Int Mode</td><td>FE</td><td>X</td><td>TE</td><td>ME</td></tr>
<tr><td>3</td><td>93183</td><td>Digital Bitmap Datum</td><td colspan="12">Don't Care</td><td colspan="4">Datum</td></tr>
<tr><td>4</td><td>93184</td><td>Digital Centroid Table Datum</td><td colspan="8">Don't Care</td><td>0</td><td colspan="3">Y sub-pixel</td><td>0</td><td colspan="3">X sub-pixel</td></tr>
<tr><td>5</td><td>93185</td><td>ADC HK, HV Status, Fine Sensor</td><td colspan="4">ADC Address Echo</td><td>HE</td><td>FP</td><td colspan="10">ADC HK Value</td></tr>
<tr><td>6</td><td>93186</td><td>Initiate ADC</td><td colspan="16">Don't Care</td></tr>
</table>

Key

Abbrev.	Description	PREF	Alias
CS	F/W Coarse Sensor seen = 1	H9005	9320
FE	Frame Tag, 1 = No Frame Tags	H9020	9280
FP	F/W Fine Sensor seen = 1	H9060	9320
HE	High Voltages Enabled = 1	H9055	9010
IA	Integration Active = 1	H9010	9010
ME	0 = CCD clocks halted and access to Bitmap Ram, 1 = clocks running, no access to RAMs	H9030	9400
TE	ICU can write to centroid lookup table = 1	H9025	9410
X	Don't Care	-	-
	Current Value	H9000	-
Int. Mode	Integration Mode	H9015	9030
	Datum	H9035	-
	Y Sub Pixel	H9040	-
	X Sub Pixel	H9045	-
	ADC Address Echo	H9050	-
	ADC HK Value	H9065	-

3.6 Memory Maintenance

This section defines the packet data fields for the memory maintenance report packets.
Note - in this section, **MID** identifies the destination memory AND the processor (ICU or DPU).

3.6.1 Memory Dump Report

1. These packets are generated as a result of a *Dump Memory* command or , in the case of DPU memory, by any of the DPU 'direct' commands H7216, H7220, H7221 or H7222 .

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Flag		Data Field Header
1	1	Unsigned Integer	Packet Type/SubType = 6,2		
2	2	Unsigned Integer	MID		Source Data
4	4	Unsigned Integer	Start Address	H9100	
8	502	Unsigned Integers	Memory to be dumped		
510	2	Unsigned Integer	CRC		Error Control

*All offsets measured in octets from the start of the Packet Data Field

MID (Hex)	ICU & Detector Memory Description			TPN	Format
	Addresses	Sub-System	Description		
0	0 - FFFF (hex)	ICU	Operand/Data Space	94200	16 bit words
	10000 - 1FFFF (hex)	Detector	Window Bitmap Table	94200	lsb 4 bits in 16
	20000 - 2FFFF (hex)	Electronics	Centroid Look-up Table	94200	lsb 8 bits in 16
1	0 - FFFF (hex)	ICU	Instruction Space	94201	16 bit words

MID (hex)	DPU Local Memory Description	TPN	Format
10	DPU Blue 1 DSP Local Memory	N/A	N/A
11	DPU Blue 2 DSP Local Memory		
12	DPU Red DSP Local Memory		
13	DPU White DSP Local Memory	94213	PACKED

MID[2] (hex)	DPU Global Memory Description	START ADDRESS	END ADDRESS	TPN	FORMAT[1]
14	DPU Big Word Memory (24 bit words)	000000	0FFFFF	94214	PACKED
15	DPU Small Word Memory (16 bit words)	400000	7FFFFF	94215	16 BIT WORDS
20	DPU Program Ram Bank 0	E00000	E0FFFF	94220	PACKED
21	DPU Program Ram Bank 1	E10000	E1FFFF	94221	PACKED
22	DPU Program Ram Bank 2	E20000	E2FFFF	94222	PACKED
23	DPU Program Ram Bank 3	E30000	E3FFFF	94223	PACKED
24	DPU Program Ram Bank 4	E40000	E4FFFF	94224	PACKED
25	DPU Program Ram Bank 5	E50000	E5FFFF	94225	PACKED
26	DPU Program Ram Bank 6	E60000	E6FFFF	94226	PACKED
27	DPU Program Ram Bank 7	E70000	E7FFFF	94227	PACKED

NOTES -

1. “PACKED” indicates 2 * 24 bit words are packed into 3 * 16 bit words.
2. A contingency version of DPU code is available such that the command H7220 (IC_DUMP_PROG_RAM) with address parameters in the range F00000 hex through FFFFFF hex will result in memory dump reports of the DPU **ROM** *but* with incorrect MID’s. The MID value that will be assigned is as follows:

MID (hex)	START ADDRESS	END ADDRESS	FORMAT
20	F00000	F0FFFF	PACKED
21	F10000	F1FFFF	PACKED
22	F20000	F2FFFF	PACKED
23	F30000	F3FFFF	PACKED
24	F40000	F4FFFF	PACKED
25	F50000	F5FFFF	PACKED
26	F60000	F6FFFF	PACKED
27	F70000	F7FFFF	PACKED

3.6.2 Memory Checksum Report

These packets are generated as a result of a *Calculate Memory Checksum* command

Offset*	Length (Octets)	Type	Description	PREF	Packet Data Field
0	1	-	Checksum Flag		Data Field
1	1	Unsigned Integer	Packet Type/SubType = 6,3		Header
2	2	Unsigned Integer	MID		
4	4	Unsigned Integer	Start Address	H9100	Source
8	2	Unsigned Integer	Length	H9105	Data
10	2	Unsigned Integer	Checksum Result	H9110	
12	2	Unsigned Integer	CRC		Error Control

* All offsets measured in octets from the start of the Packet Data Field

MID (Hex)	ICU & Detector Memory Description			TPN
	Addresses	Sub-System	Description	
0	0 - FFFF (hex)	ICU	Operand/Data Space	94300
	10000 - 1FFFF (hex)	Detector	Window Bitmap Table	N/A
	20000 - 2FFFF (hex)	Electronics	Centroid Look-up Table	N/A
1	0 - FFFF (hex)	ICU	Instruction Space	94301

MID (hex)	DPU Local Memory Description	TPN
10	DPU Blue 1 DSP Local Memory	N/A
11	DPU Blue 2 DSP Local Memory	
12	DPU Red DSP Local Memory	
13	DPU White DSP Local Memory	

MID (hex)	DPU Global Memory Description	START ADDRESS	END ADDRESS	TPN
14	DPU Big Word Memory (24 bit words)	000000	0FFFFF	N/A
15	DPU Small Word Memory (16 bit words)	400000	7FFFFF	
20	DPU Program Ram Bank 0	E00000	E0FFFF	
21	DPU Program Ram Bank 1	E10000	E1FFFF	
22	DPU Program Ram Bank 2	E20000	E2FFFF	
23	DPU Program Ram Bank 3	E30000	E3FFFF	
24	DPU Program Ram Bank 4	E40000	E4FFFF	
25	DPU Program Ram Bank 5	E50000	E5FFFF	
26	DPU Program Ram Bank 6	E60000	E6FFFF	
27	DPU Program Ram Bank 7	E70000	E7FFFF	

3.7 Telemetry Management Report

This section defines the packet data fields for the telemetry management report packets.

3.7.1 TM Packet Generation Status Report

This packet sub-type is generated in response to a *Report TM Packet Generation Status* command.

For a packet length indicating that n SID's are present:

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type = 9,1	
2	1	Unsigned Integer	SID 1	Source Data
3	1	Unsigned Integer	Status SID 1	
… and so on until…				
2+2*(n-1)	1	Unsigned Integer	SID n	
3+2*(n-1)	1	Unsigned Integer	Status SID n	
4+2*(n-1)	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

N.B. The structure of the SID status octet is as follows:

Spare	Status
7 bit	1 bits

Spare = 0000000(binary);

Status
Status = 1 = Packet Enabled
Status = 0 = Packet Disabled

3.8 Onboard Time Management Reports

After reception of a TC(10,5) command, the ICU shall generate a Time Verification Report containing a copy of the local Spacecraft Elapsed Time.

Offset*	Length (Octets)	Type	Description	Packet Data Field
0	1	-	Checksum Flag	Data Field Header
1	1	Unsigned Integer	Packet Type = 10,5	
2	4	Unsigned Integer	Coarse Time	Source Data
6	2	Unsigned Integer	Fine Time	
8	2	Unsigned Integer	CRC	Error Control

* All offsets measured in octets from the start of the Packet Data Field

3.9 Science

This section defines the packet data fields for science packets.

3.9.1 Science Data Overview

The science data stream, which originates from the DPU, consists of interleaved blocks of Regular Data (mnemonics DD_xxx), Priority Data (mnemonics DP_xxx) and Alerts (Mnemonics DA_xxx). These are sorted on-board into three corresponding classes of science packets, as described below.

3.9.1.1 Regular Data

Regular science data is made available at the end of an exposure. It is stored in the DPU in the form of several large **DPU Production Data Sets** which may be many kilobytes in length. Each production data set consists of a **Standard Data Set Header** which describes and prefixes a **Data Body**. The format of the standard data header is defined in Ref -3, section 4.

The **Data Body** is the data of scientific interest (e.g. an image). It may, or may not, be compressed, using the VBTWL algorithm. Compression will be active by default, its status indicated by a flag in the Standard Data Set Header. If it is compressed, the data body will be a concatenation of compressed *variable* length blocks, each with its own self-describing 128 bit long header. This header, and the Data Body format *prior* to compression, are also defined in App-3, section 4.

At the end of an exposure, each production data set is supplied to the ICU, upon request, in the form of a series of **DPU blocks** of data. These blocks are of type DD_xxx. They are obtained by the DPU ‘chopping’ the above **DPU production data set** into **Data Sections** an integer number of 16-bit words in length and prefixing each one with an **‘Extended DPU Header’** Each DPU block is subject to the constraint that the Extended DPU Header plus Data Section must not exceed 1029 16-bit words overall in length. The Extended DPU Header is defined in App-3, section 4.

These DPU blocks are then abutted together in the ICU memory. The resulting data is again ‘chopped’, but by the ICU, into **DPU Block Segments** of up to 504 bytes (252 words) long. Each segment then has a ‘**Science Sub-Header’** and a standard packet header added, a checksum calculated and added to the end. The resulting packets are then transmitted to the ground - see the diagram overleaf illustrating this process and section 3.9.2. The format of the Science Sub-Header is described below.

Note that all packets associated with a given production data set will be sent as a group - e.g. all the image mode data for one window will be sent as one group. The first, continuation and last packet of each group will be indicated by the appropriate segmentation flags in the sequence control field in the packet header - see the introduction to section 3.0 for more details.

Each Science Sub-Header contains:
1) a SID identifying which type of science data is present in the packet.
2) information to assist data recovery in the event of packet loss: This is because, as a result of the above processes, a given DPU block may ‘span’ from one packet to another and thus become de-coupled from its associated Extended DPU Header. The information included is:
a) an offset, in units of 16-bit words, indicating the start of the first valid DPU block with respect to the end of the science sub-header. If the packet contains only part of one DPU block, this offset will be set to zero. If this is the last packet of a group, this offset will be set to all 1’s.
b) a counter (starting from zero) indicating the packet location within the group.

3.9.1.2 Priority Data

These blocks contain science data that is sent out as soon as it is available and without ICU request. Their format is described in App-3, section 5. These blocks are 'chopped' by the ICU into **DPU Block Segments** of up to 504 bytes (252 words) long. Each segment then has the '**Science Sub-Header'** (as defined for Regular Data) and a standard packet header added, a checksum calculated and added to the end. The resulting (one or more) packets are then transmitted to the ground - see the diagram overleaf illustrating this process and section 3.9.2 for format details. If more than one packet is required to transmit a given Priority Data Block, they are sent as one group. The first, continuation and last packet of each group are indicated by the appropriate segmentation flags in the packet sequence control field.

3.9.1.3 Alerts

These are blocks informing the ICU of the status of the DPU and its processing algorithms, and are sent out as soon as they are available and without ICU request. Their format is defined in App-3, section 7. They are normally forwarded as Non-Periodic Housekeeping and play no further role in the science data (see section 3.4).

However, *if* the Science Auxiliary Alert Data telemetry is enabled (SID = FF hex), the alerts are *also* buffered up in the ICU into a **DPU Block Segment** until the next alert would cause the length of the block segment to exceed 252 16-bit words. A 'null' Science Sub-Header (with the offset set to all 1's and the packet counter set to zero), a standard packet header and a calculated checksum are added to the block segment as per the format described in section 3.9.2. The resulting packet is then transmitted to the ground. The process then repeats. See the diagram overleaf illustrating this process.

Note that therefore this packet type is never grouped.

3.9.2 Science Packet Format.

As a result of the processes described above, each packet data field of a science packet is of the following form.

<table>
<tr><th>Offset*</th><th>Length (Octets)</th><th>Type</th><th colspan="2">Description</th><th>PREF</th><th>Packet Data Field</th></tr>
<tr><td>0</td><td>1</td><td>Unsigned Int</td><td colspan="2">Checksum Flag</td><td></td><td rowspan="2">Data Field Header</td></tr>
<tr><td>1</td><td>1</td><td>Unsigned Int</td><td colspan="2">Packet Type/SubType = 15,x</td><td></td></tr>
<tr><td>2</td><td>1</td><td>Unsigned Int</td><td rowspan="3">Science Sub-Header</td><td>SID</td><td></td><td rowspan="4">Source Data</td></tr>
<tr><td>3</td><td>1</td><td>Unsigned Int</td><td>Offset (words)</td><td>H1120</td></tr>
<tr><td>4</td><td>2</td><td>Unsigned Int</td><td>Packet Counter within Group</td><td>H1130</td></tr>
<tr><td>6</td><td>$2*N_{words}$</td><td>see APP-3</td><td colspan="2">DPU Block Segment ($1 \leq N_{words} \leq 252$)</td><td></td></tr>
<tr><td>$6+2*N_{words}$</td><td>2</td><td>Unsigned Int</td><td colspan="2">Checksum</td><td></td><td>Error Control</td></tr>
</table>

* All offsets measured in octets from the start of the Packet Data Field

The value of SID and sub-type are as follows:

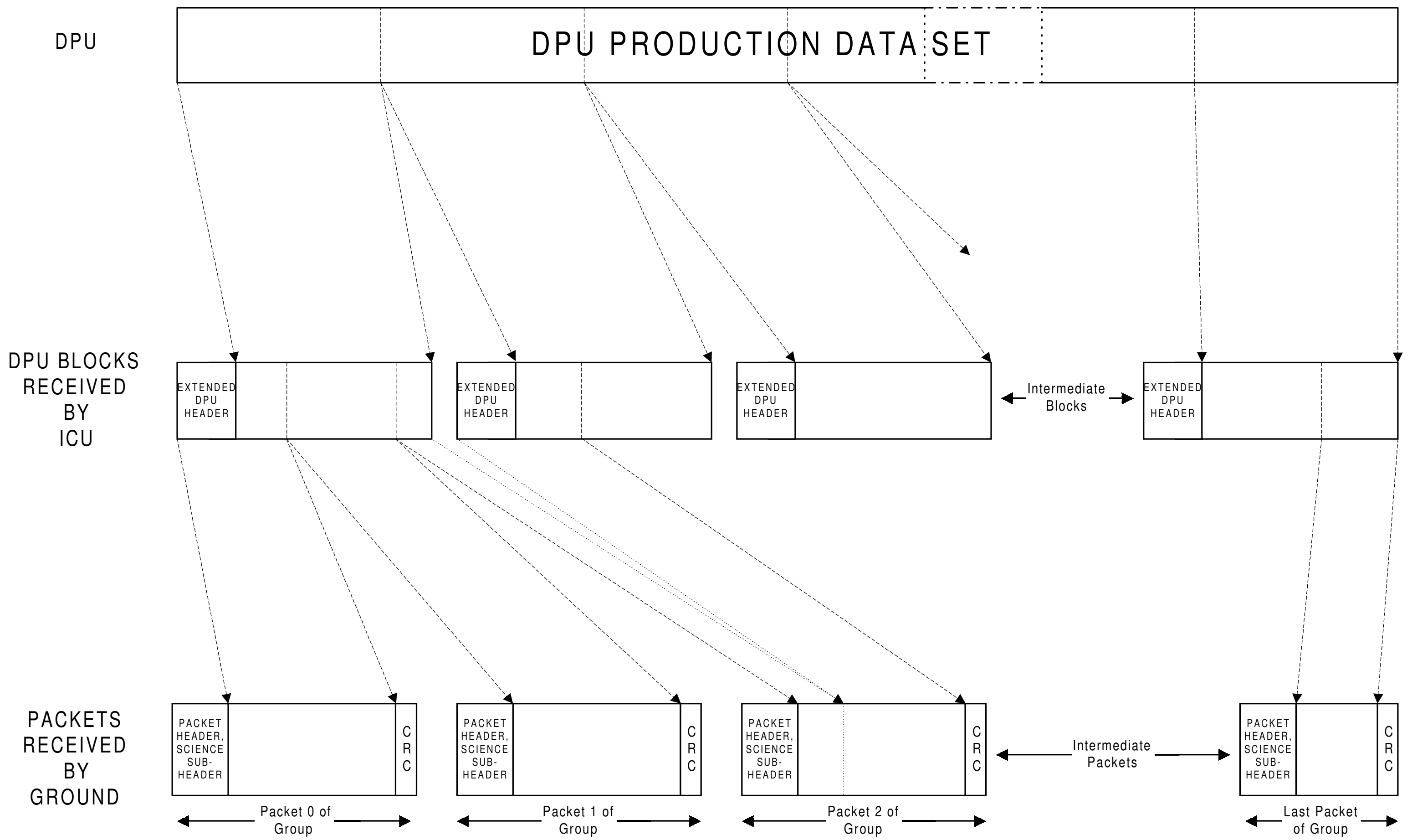
TPN	Class	Data Description	Mnemonic (see App-3)	SID (hex)	Sub Type	Enabled (default)
97401	Priority	Window Data	DP_WDW	E1	4	Yes
97402		Field Acquisition Data	DP_FAQ	E2	4	Yes
97403		Blue Fast Mode Data	DP_BFAST	E3	4	Yes
97417	Regular	Tracking History	DD_TRH	F1	4	Yes
97418		Reference Frame Data	DD_REF	F2	4	Yes
97119		Image Mode Data	DD_IMG	F3	1	Yes
97220		Fast Mode Data	DD_FST	F4	2	Yes
97322		Engineering Data	DD_ENG	F6	3	Yes
TBD		Real Time Raw Data[1]	DD_RAW	F7	2	Yes
97431	Alerts	Auxiliary Alert Data	DA_xxx	FF	4	-

where the sub-type categories are as follows:

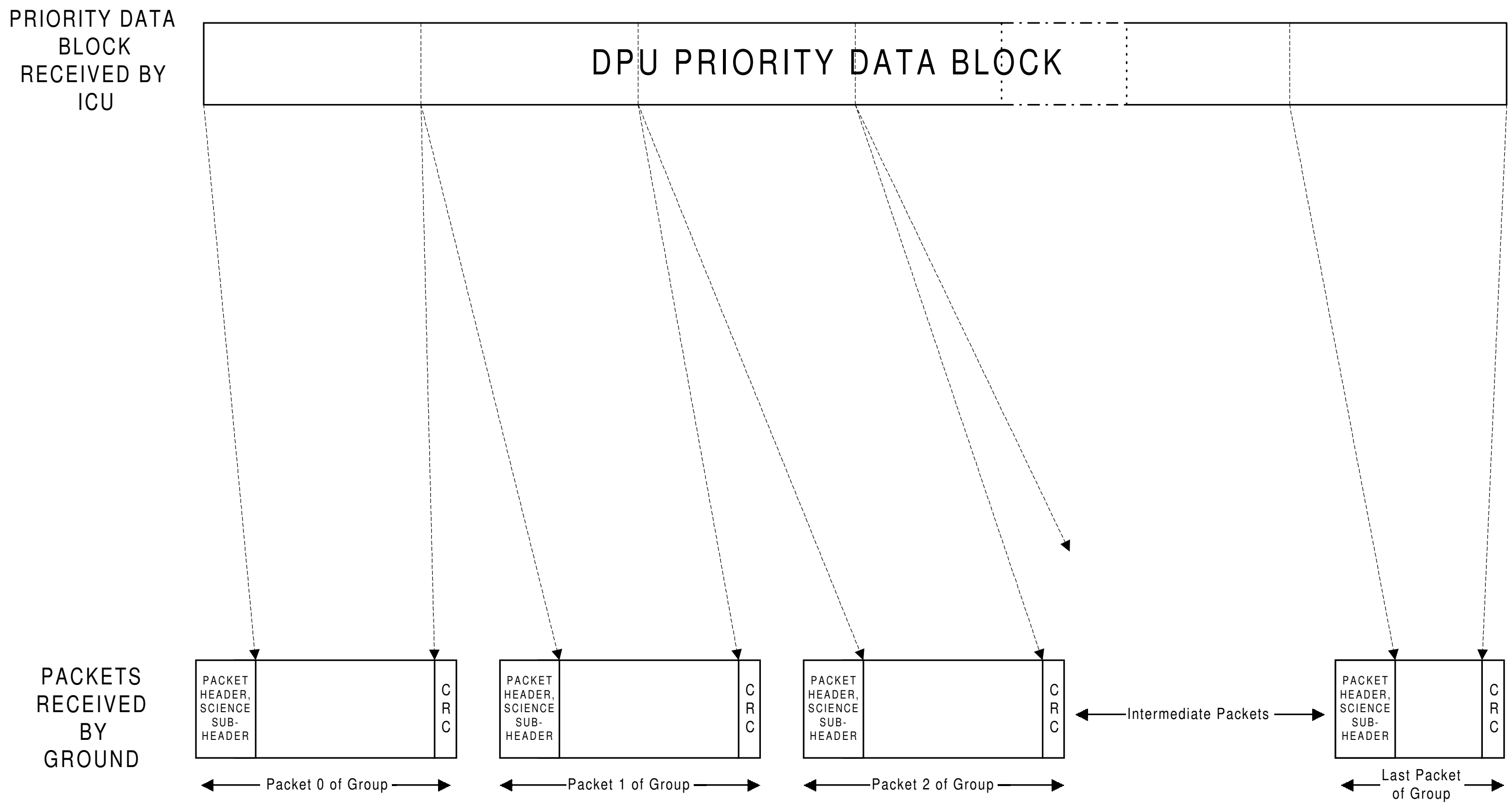
Sub-Type	Category
1	Image Data
2	Timing Data
3	Diagnostic Data
4	Science HK and Auxiliary Data

1. To be implemented post-launch.

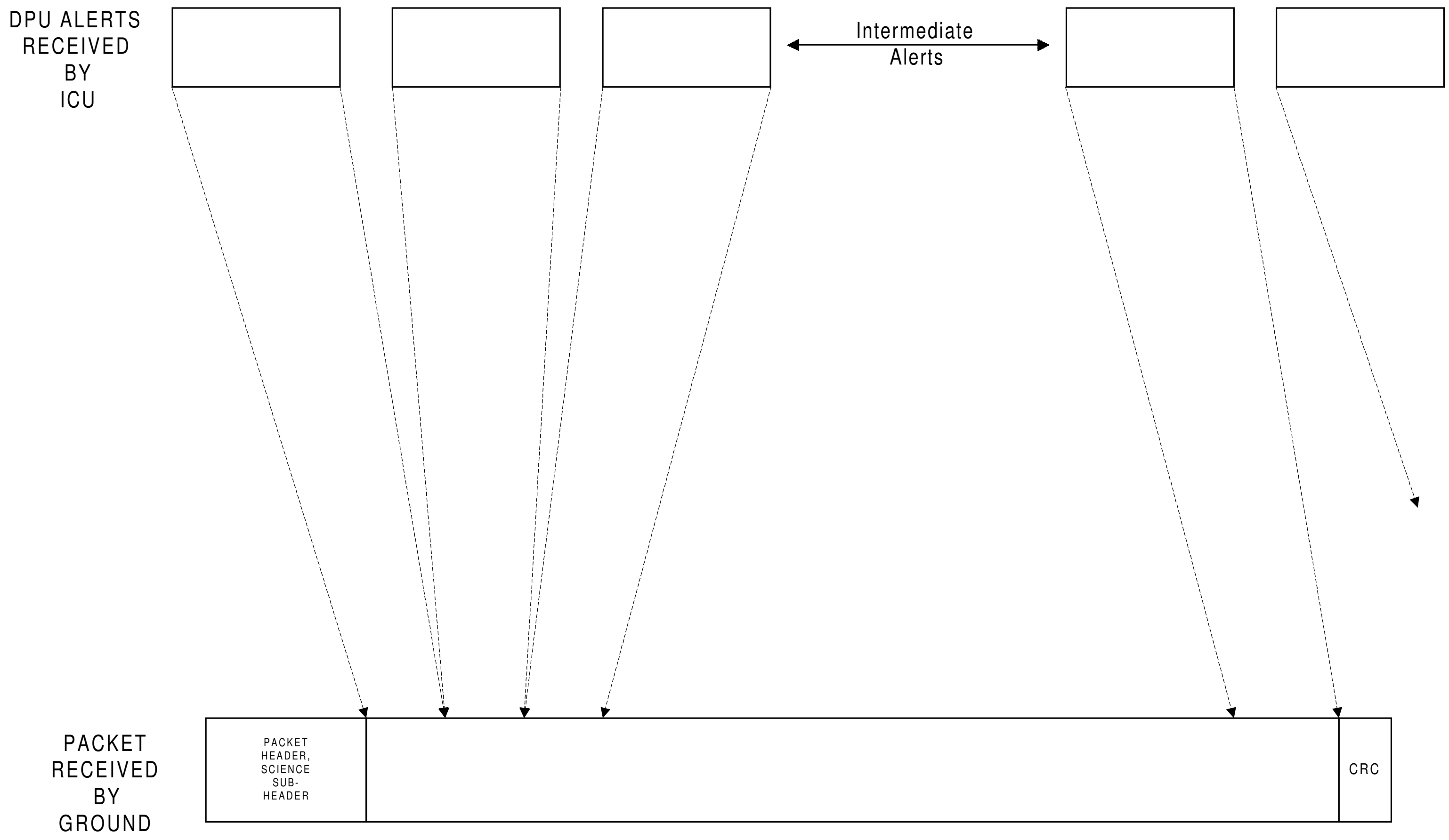
DPU REGULAR DATA TRANSMISSION



DPU PRIORITY DATA TRANSMISSION



DPU AUXILIARY ALERT DATA TRANSMISSION



4. SID Allocation

Note - not all of these may be used.

Class	System	SID (hex)	Description
Periodic HK		00	HK
		01	Diagnostic HK
		02	ADA Exception
Non-Periodic HK	Detector	10	Detector Event
		11	Detector Exception
		12	Detector Major Anomaly
	ICU	20⇒2F	Reserved for OM Internal Diagnostics
	ICB	41	ICB Exception
		42	ICB Major Anomaly
		44	ICB Error
	SSI	31	SSI Exception
		32	SSI Major Anomaly
	RBI	51	RBI Exception
	TMPSU	60	TMPSU Event
		61	TMPSU Exception
		62	TMPSU Major Anomaly
	DEM PSU	80	DEM PSU Event
		81	DEM PSU Exception
		82	DEM PSU Major Anomaly
	DPU	90⇒AF	DPU Event
		B0⇒CF	DPU Exception
		-	DPU Major Anomaly
	OM	D2	Autonomous Transition to Safe State
		D3	Bootstrap Event Report
		D4	Bootstrap Exception Report
		D7	General Exception
Science	Priority	E1	Priority Window Data
		E2	Priority Field Acquisition Data
		E3	Priority Blue Fast Mode Data
	Regular	F1	Tracking History
		F2	Reference Frame Data
		F3	Image Mode Data
		F4	Fast Mode Data
		F6	Engineering Data
	Alerts	FF	Auxiliary Alert Data