XMM OPTICAL MONITOR

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XMM-OM USER MANUAL

EXPERIMENT ON-BOARD SOFTWARE - INSTRUMENT CONTROL UNIT

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8.4	31-Aug-99	Corrected f/w position in mode table for safe mode. Clarified operation of coarse and fine sensors on filter wheel. Added sections on the TMPSU, DEMPSU and Image Intensifier. Renumbered sections to reflect DEM / Telescope Module Subdivision. Added section on flood LED’s. Added note to the RBI section about NCR 177.
8.5	12 May 00	NCR192 – Additional section added describing the release 10 onwards modifications that enable automatic focus heater control – see section 2.2.4.6. ECR088 – Description of modes stating additional safing constraints regarding filter wheel position. ECR088 – Description of Modes states that the f/w must be in blocked position for any HV ramp-up. ECR 086 – It is now possible to command a transition to one of Full Safe, Intermediate Safe, Idle, Science or Engineering even if that is already the current mode.

TABLE OF CONTENTS

1. Introduction

1.1 Purpose and Scope

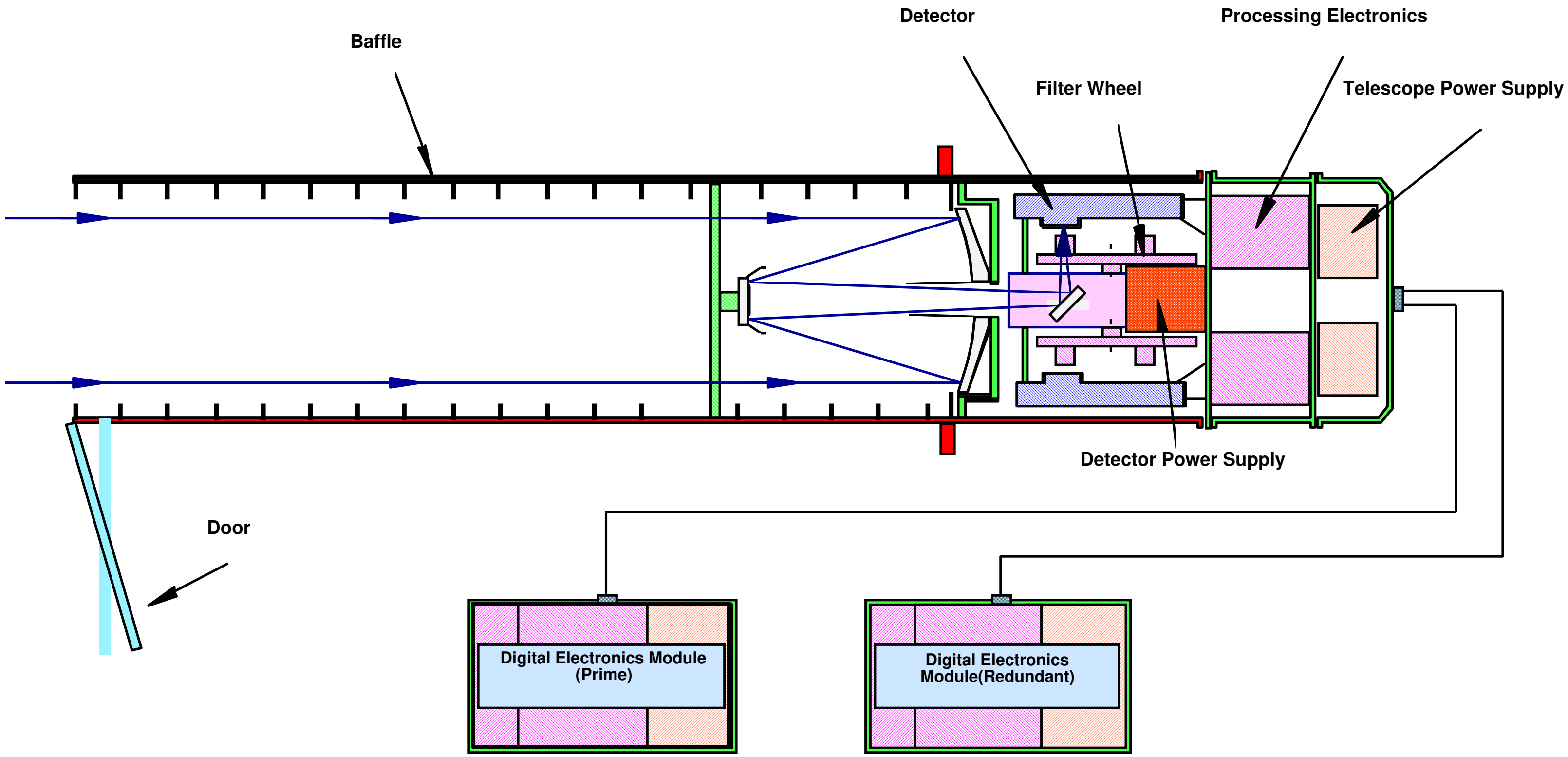
This manual gives an overview of the XMM Optical Monitor (OM) hardware so as to give a context to the OM software. It then gives an overview of the ICU and DPU software, with emphasis on the ICU. Further details regarding the commands and telemetry can be found in APP-3 and APP-4 (see below). A detailed design description of the ICU software can be found in XMM-OM/MSSL/SP/0205 (APP-8). The User Manual for the DPU can be found in APP-9. A detailed design description of the DPU software can be found in XMM-OM/UCSB/ML/0013. Where relevant, additional document references are given.

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	Telecommand & Telemetry Specification	XMM-OM/MSSL/ML/0010
APP-5	User Requirements Specification	XMM-OM/MSSL/SP/0030
APP-6	XMM-OM Bootstrap Specification	XMM-OM/MSSL/SP/0153
APP-7	Instrument Controller Design Description	RGS-MSSL-IC-0002
APP-8	ICU Detailed Design Document	XMM-OM/MSSL/SP/0205
APP-9	User Manual Digital Processing Unit	XMM-OM/UCSB/ML/0012
APP-10	DPU Detailed Design Document	XMM-OM/UCSB/ML/0013
APP-11	Software Setup of the Blue Detector Electronics	XMM-OM/MSSL/SP/0077.02

1.3 Terms and Abbreviations

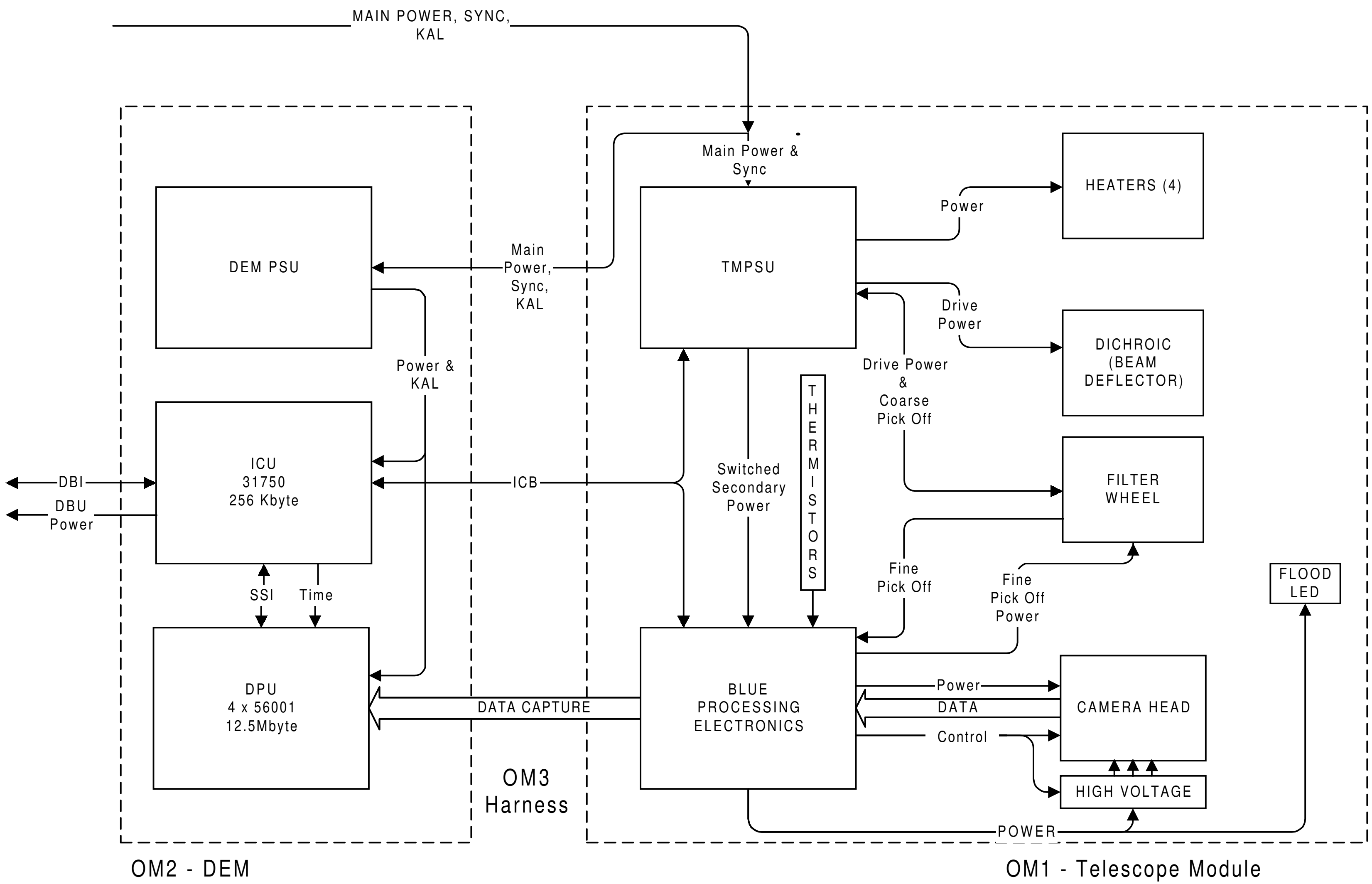
ADC	Analogue to Digital Conversion
APID	Application Identifier
BCH	Blue Camera Head (synonym for Detector Camera Head)
BPE	Blue Processing Electronics (synonym for Detector Processing Electronics)
CCA	Communications Area
CCD	Charge Coupled Device
CRC	Cyclic Redundancy Code
DEM	Digital Electronics Module.
DEMPSU	Digital Electronics Module Power Supply.
DBI	Digital Bus Interface
DBU	Digital Bus Unit.
DMA	Direct Memory Access
DMAE	DMA Enable
DPU	Digital Processing Unit
DSP	Digital Signal Processor
EM	Engineering Model
ESA	European Space Agency
FID	Function Identifier
FM	Flight Model
ICB	Instrument Control Bus
ICU	Instrument Control Unit
IO	Input Output
ISR	Interrupt Service Routine
KAL	Keep Alive Power
LSB	Least Significant Bit
MACSbus	Modular Attitude Control System bus
MFN	Master Function Number
MID	Memory Identifier
MSB	Most Significant Bit
MSSL	Mullard Space Science Lab
N/A	Not Applicable
OBDH	On Board Data Handling
OM	Optical Monitor
OM1	Synonym for the Telescope Module
OM2	Synonym for the Digital Electronics Module
OMIF	OM Interface card
PREF	Parameter Reference
PROM	Programmable Read Only Memory
PSD	Packet Structure Document
RAM	Random Access Memory
RBI	Remote Bus Interface
ROM	Read Only Memory
S/C	Spacecraft
SCET	Spacecraft Elapsed Time
SCI	Serial Communications Interface
SIBA	Spacecraft Interface Bus Adapter
SID	Structure Identifier
SSI	Serial Synchronous Interface
TBA	To Be Added
TBC	To Be Confirmed
TBD	To Be Defined/Determined
TBI	To Be Implemented
TC	Telecommand Packet
TID	Task Identifier
TM	Telemetry Packet
TM	Telescope Module
TMPSU	Telescope Module Power Supply Unit
TPN	Telemetry Packet Number
VBWL	Variable Block Word Length
XMM	X-ray Multi Mirror



XMM Optical Monitor

XMM-OM : Electronic Architecture

(showing Prime only for clarity)



2. Overview

2.1 XMM Mission

The X-ray Multi-Mirror Mission (XMM) is an ESA spacecraft mission aimed at performing detailed imaging spectro-photometry of a wide variety of x-ray sources.

It is designed to be a long duration (~10 years) observatory type mission, open to the astronomical community.

It is planned be launched at the end of the century (~1999), placed into a 48 hour highly eccentric inclined orbit and have continuous ground station contact.

The payload is designed to be a mutually complementary package composed of 3 instruments as follows :-

EPIC - **E**uropean **P**hoton **I**maging **C**amera
RGS - **R**eflection **G**rating **S**pectrometer
OM - **O**ptical **M**onitor

2.2 OM Experiment

2.2.1 Science

The OM (Optical Monitor) experiment is designed to provide optical coverage of astronomical sources simultaneously with the x-ray coverage provided by the EPIC and RGS instruments.

Onboard optical observations remove the need for simultaneous ground based observations which are difficult to organise, expensive and frequently fail due to bad observing conditions. There is also the added difficulty of correlating ground event times with those from the spacecraft. Furthermore, a spaceborn optical monitor allows extension of the wavelength range into the UV.
Such simultaneous optical and x-ray information about astronomical x-ray sources is very important to understanding these objects and in particular provides :-

- Optical variability measurements simultaneously with x-ray measurements.
- Astrometry. (e.g. Identification of optical counterparts)
- Broad band colours/ low resolution spectroscopy.
- Improved spacecraft attitude reconstruction for the x-ray observations.
- Simultaneous correlation of optical & x-ray events/periods.
- Optical measurements extending into the UV. (The Hubble telescope is the only other way to provide this information but will be too heavily subscribed to perform this function for the XMM mission routinely.)
- Ratio of optical to x-ray flux. (Important for cosmological studies of quasars and galaxies).
- Studies of optical objects which may have no x-ray counterparts. (Serendipitous data which may be used for e.g. astro-seismology and micro-variability which may provide insight into the internal structure of such objects.)

2.2.2 Architecture Overview

The OM Instrument is composed of 3 units as follows:

TELESCOPE MODULE (TM)- OM1 - containing

- An optical/UV Ritchey-Chretian telescope
- A beam deflector and prime and redundant filter wheel, each with 10 filter positions and 1 blocked position.
- Heaters to control the temperature of the telescope tube and modify the focal length (if required).
- Prime and redundant detector processing electronics and camera head, including high voltage control and monitoring.
- Prime and redundant TM Power Supplies - the TMPSU's - see OM3 description for more information.

PRIME and REDUNDANT DIGITAL ELECTRONICS MODULES (DEM's) - OM2 - each containing a

- Digital Processing Unit (DPU). It performs basic science data reception and processing including image accumulation.
- Instrument Control Unit (ICU). The ICU provides the basic instrument control function, housekeeping monitoring and code up-link for both itself and the DPU. DPU processed data is passed to the Instrument Control Unit (ICU) processor for reformatting into packets prior to being passed to the spacecraft OBDH system.
- SSI Interface. The DPU and ICU communicate via a full duplex Serial Synchronous Interface (SSI).
- DBI. The interface from the ICU to the spacecraft for data downlink and command up-link will be carried by a digital bus interface (DBI). The ICU supports a telemetry rate of up to 8 kbps and a telecommand rate of 2 kbps.
- DEM Power Supply. This provides the conditioned power for the ICU and DPU in the DEM. It provides latchup protection.

INTERCONNECTING HARNESS MODULE - OM3

- This harness carries power, synchronisation information, keep-alive line and an Instrument Control Bus (ICB) between the Telescope Module and the Digital Electronics Modules. The ICB is used by the ICU to control and monitor the detector, mechanisms and heaters via the TMPSU. It is based on the MACS-bus standard.

2.2.3 Digital Electronics Module (DEM)

2.2.3.1 ICU

This consists of 5 cards:-

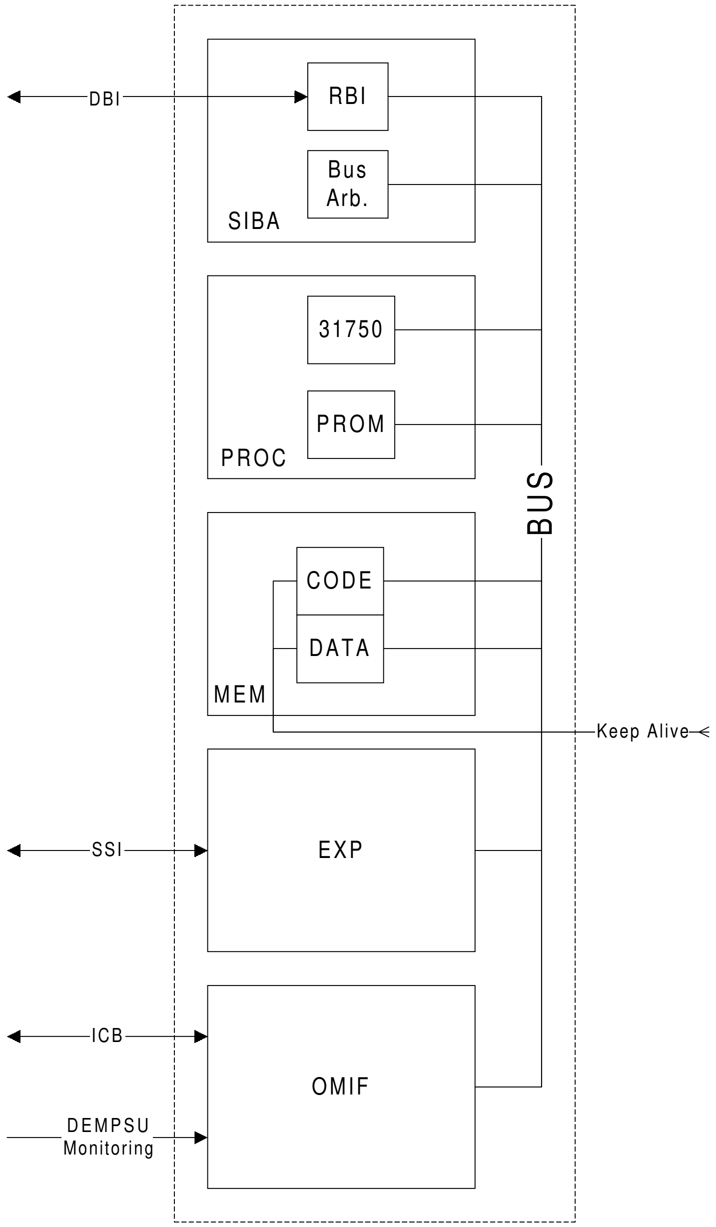
SIBA The Spacecraft Interface Bus Adapter card. Contains the RBI chip and bus arbitrator. The RBI provides
-interfaces to the spacecraft to provide DMA of telemetry and telecommand packets
- input of spacecraft time time signals to be forwarded to the DPU.
- the watchdog

PROC The processor card - contains a 31750 processor running at 8 MHz.
PROMs - 16K 16 bit words - containing the bootstrap and basic mode code.

MEM The memory card
64k 16 bit words of code
64k 16 bit words of data.
The RAM is radiation hardened.

EXP The expansion card - Contains the Synchronous Serial Interface (SSI) control circuitry- the DPU communication path.

OMIF The OM Interface card.- contains
- ICB interface circuitry
- DEMPSU monitoring circuitry



Note - see section 2.2.5.4.2 about structure of, and access to, memory.

2.2.3.2 DPU

The DPU is a hybrid local/shared memory multiple processor computer. It shares the DEM with the ICU and DEMPSU.

Four Digital Signal Processor (DSP) cards access a global memory in series via a global bus, with access to the bus managed by an arbiter card. Each processor is granted access to the bus once per millisecond. Each DSP also has local memory. Each DSP is assigned specific tasks

White	Overall Management of the Other Processors via the Serial Command Interface (SCI) ICU communication Initial field acquisition Spacecraft drift tracking.
Blue 1 and 2	Data collection and initial processing (e.g. tracking frame image accumulation)
Red	Shift and Add Calculation (i.e. summation of image corrected for drift)

The global memory consists of 12.5 Mbytes of memory, divided into:-

Small Word Memory	4 Mwords of 16 bit words RAM. Used to store a tracking frame and full frame applications
Big Word Memory	1 Mwords of 24 bit words RAM. Stores accumulated images.
Program Memory	0.5 Mwords of 24 bit RAM and 8k 24 bit words of PROM.

Each DSP card has its own local memory (32k by 24 bit words) which can only be accessed by that DSP.

A block diagram illustrating the above is given overleaf.

2.2.3.3 DEMPSU

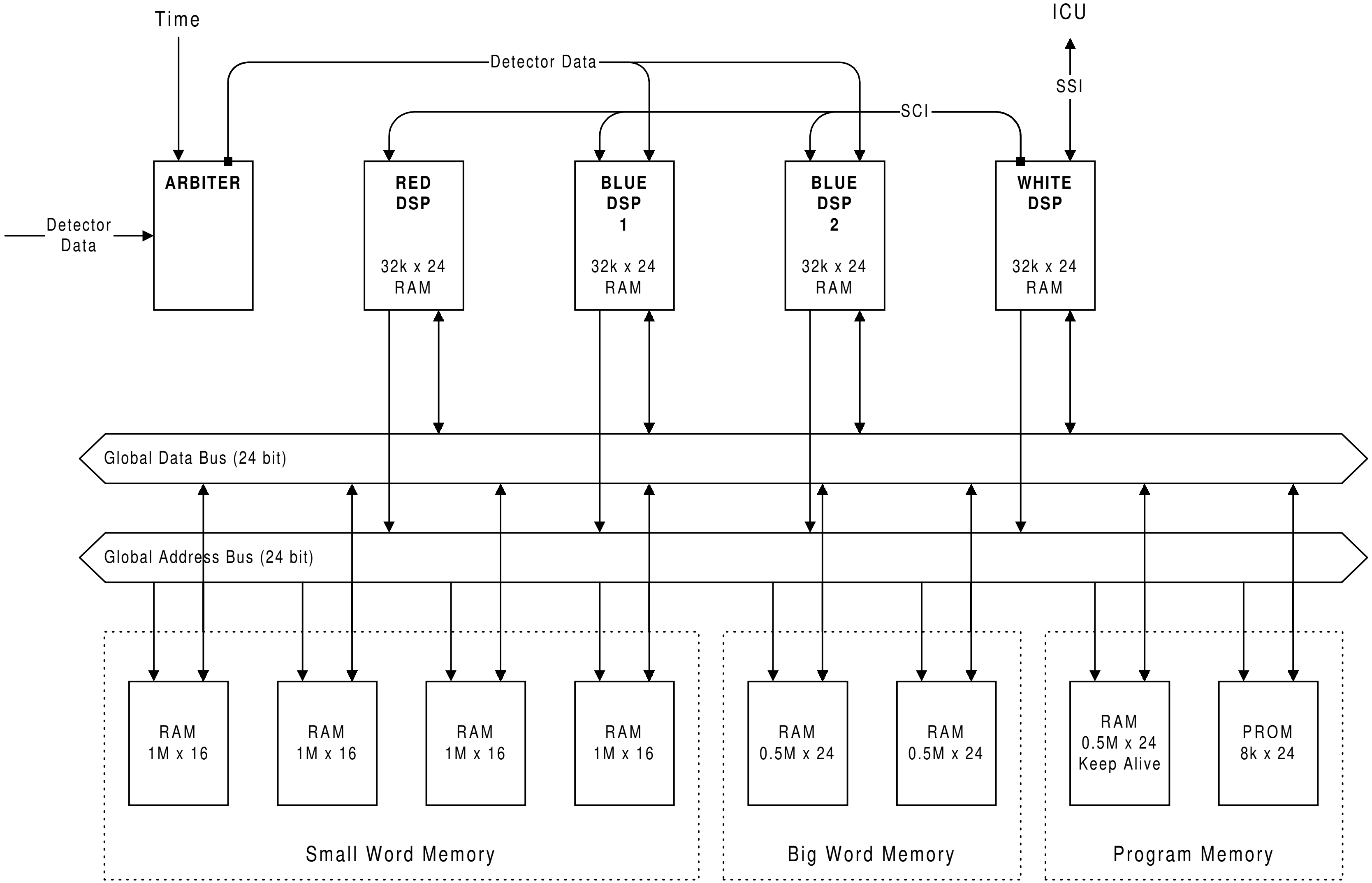
This power supply generates conditioned power for the DEM sub-systems. When the power is applied from the spacecraft, both the DPU and ICU are supplied, but subject to over-current protection on the output. Additionally the PSU receives as an input a signal from each of the DPU sub-system PCB's latchup protection circuits which cause the PSU to switch of the DPU main power when a latchup is detected. In this event, the ICU can command on the DPU power.

Secondary Rail	Destination
+6V	DBU
+5.3V-A	DPU main power
+5.3V-B	ICU main power
+3.3V-A	DPU KAL power
+3.3V-B	ICU KAL power

Key:

DBU	Data Bus Unit
DPU	Data Processing Unit
ICU	Instrument controller Unit

DPU Block Diagram



2.2.3.4 Interfaces

2.2.3.4.1 Serial Synchronous Interface (SSI)

Overview

The SSI is a bi-directional communications interface between the DPU and ICU which is carried on the DEM backplane.

The definition of the SSI is in XMM-OM/MSSL/SP/0007 "Electrical Interfaces Specification".

Hardware

Both the ICU and the DPU can send and receive data on this interface but the ICU is the master.

The interface consists of:

SSI_CLK	a continuous clock signal generated by the ICU
SSI_ENV_TX	active high when data presen
SSI_DATA_TX	16-bit data
SSI_ENV_RX	active high when data present
SSI_DATA_RX:	16-bit data
	Signal return

Commands are sent from the ICU to the DPU. Science data is passed from the DPU to the ICU when demanded by the ICU. Alerts are sent (unrequested) by the DPU to the ICU. There is no direct feedback as part of the protocol and there is no error correction nor checksums. The interface can be thought of as the same irrespective of direction.

The SSI clock frequency is 125 kHz producing a period of 8 us (1 bit-period). The SSI 16-bit data words are separated by at least one bit-period and at most the SSI block gap (defined in software). The SSI data blocks are separated by at least the SSI block gap (defined in software).

Transmitting data

The words that constitute the block are sent not more than the SSI block gap apart and, when finished, the software must wait for at least the SSI block gap before sending more data. The receiving software must wait for a little longer than the transmitting software's block gap to be sure to see the gap. A factor of two is sufficient.

Receiving data

The data being received must be read suitably fast and if the time between any two words is greater than the SSI block gap, the gap will be considered a block gap. All blocks contain a length as their second word so errors caused by an accidentally lengthened word gap may be identified (see data format).

SSI block gaps

Because the SSI block gaps are defined and used only in software they can be set to different values in different versions of the code and they can be different depending on the direction of the data (ICU->DPU or DPU->ICU).

SSI block gaps as defined by the ICU software

	EPROM code	Uploadable code
ICU -> DPU	>4 ms	>4 ms
DPU -> ICU	6 ms	4 ms

SSI block gaps as defined by the DPU software

	EPROM code	Uploadable code
ICU -> DPU	2 +/- 1 ms	2 +/- 1 ms
DPU -> ICU	15 +/- 1 ms	15 +/- 1 ms

The ICU's SSI hardware will give an interrupt (used by the ICU's software) at the end of the first word of each block. The ICU software must then read this first word before the end of the second word. The time for this is 16 bit-periods for the word and a minimum of 1 bit-period for the word gap. So the software must be able to respond to the interrupt and read the word in 136 us.

An overflow (OVF) bit in the hardware SSI status word is made active (low) if a data word is not read before the arrival of another.

SSI errors

If the DPU resets whilst transmitting the first part of a word, that word will be truncated and the envelope will be truncated resulting in an earlier than expected "data receive" flag which will not be able to be processed in time and cause an overflow on the ICU.

If the DPU resets whilst transmitting the last part of a word, that word and the envelope will be truncated but not so much that the ICU's software cannot keep up as in the previous case. This will result in a corrupt last word and, except in the case of a reset during the last word, a truncated SSI block. This will be detected and handled properly by the ICU's software.

Data format

The data format is described in XMM-OM ICU-DPU Protocol Definitions Each SSI data block consists of

1. 16-bit type - the block type
2. 16-bit length - the number of 16-bit words following this word (i.e. total length - 2)
3. the rest of the data

The data types are grouped into categories as follows:

1. Regular DPU to ICU data blocks
   Regular science data.
2. DPU priority data
   These contain science data that is sent out as soon as it is available rather than at the end of an exposure.
3. DPU RAM dumps
   RAM dumps.
4. DPU to ICU alerts
   Alerts from the DPU to signify something is has happened, is ready or an error has occured.
5. ICU to DPU commands
   Commands to the DPU.

Further detail on the ICU software:-

The first, fast part of the SSI interrupt handler is written in assembler (the first word of the SSI block is read) and the rest in written in Ada (the reading of the rest of the words in the block and the timeout.)

SSI status register

D_TX	2**4
DATA_FULL	2**3
OVF	2**2
D_RX	2**1
INT	2**0

Sequence of actions

```
SSI INTERRUPT happens
Read first word (from i/o address f241h) into input software fifo in less than 136 us after the interrupt
Remember location where next word will be stored for a later check
Start stopwatch
Set interrupt mask to only allow RBI interrupts
Enable interrupts but don't get interrupted for too long!
loop
        read SSI status (i/o address f240h)
        if the DATA_FULL bit (2**3) is set and there is data to output
                write a data word to output i/o address (7241h)
        if input software fifo is full
                error
        if D_RX bit is reset
                read input word (i/o address f241h) into input software fifo
                re-start stopwatch because there is still data on input
        else
                if stopwatch is after 4 ms
                        break out of loop
        read ssi status word (i/o address f240h)
        if OVF bit (2**2) is 0
                clear overflow (write fffb (hex) to status register i/o address 7240h)
        read a word (from i/o address f241h) and dispose of it
end loop

read the second word (length) of this SSI block from the software input buffer
if it is greater then 1027
        error
if no of words read doesn't equal the value of the second word (see above) minus 2
        error
read ssi status word (i/o address f240h)
if OVF bit (2**2) is 0
        clear overflow (write fffb (hex) to status register i/o address 7240h)
        read a word (from i/o address f241h) and dispose of it
clear SSI interrupt by writing fffe (hex) to the SSI status i/o address 7240h
```

To Reset

```
reset software input and output fifos and error value
write OVR_WR fffb (hex) to status address 7240 (hex)
write INT_WR fffe (hex) to status address 7240 (hex)
```

SSI error codes

Error (Hex°	Comment
C	The SSI input circular buffer has filled so fast or not been emptied fast enough and incoming data is about to overwrite outgoing data.
2	The word count is too large while receiving data in the block. The number of words has exceeded that indicated by the second "block length" word or has exceeded the maximum allowed (1029).
8	An overflow (OVF) has been indicated by the ICU's SSI hardware
7	An overflow occured at the end of the block.
11	The second word of the block indicated a length which exceeds the maximum allowed (1029).
1	The length indicated by the second word is inconsistent with the real length of the block
89	An overflow was found during SSI_DRIVER.PUT
9	The length found in SSI_DRIVER.PUT exceeded the maximum allowed (1029).
b	The output block length in SSI_DRIVER.PUT exceeded the maximum allowed (1029).

2.2.3.4.2 Time to DPU

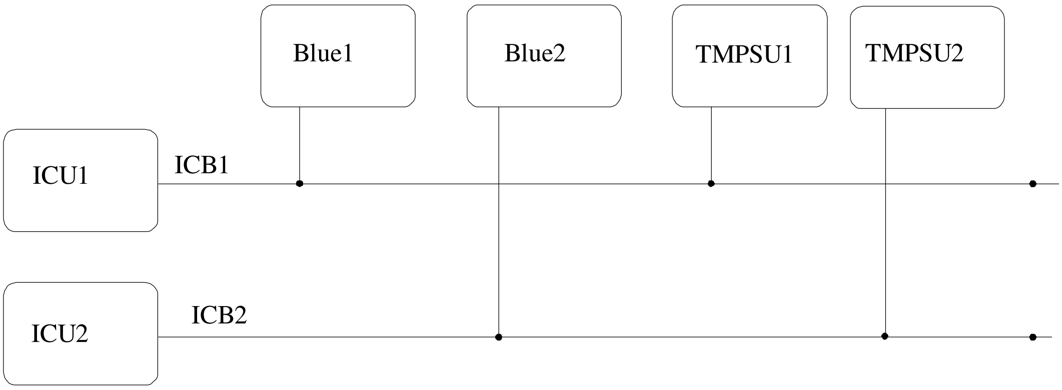
The time used by the DPU is synchronised to the spacecraft clock via a 512*1024 = 524288 Hz clock supplied by the ICU. This clock is divided by 512 in the DPU hardware and used to increment a 24 bit counter. Therefore the time counter is in units of 0.9766 ms (1024 Hz) and rolls over every 4.55 hours. The most significant 14 bits contain the time in seconds. It is used in the time stamping of alerts from the DPU to the ICU.

Note: whenever an ‘Add Time Code’ command is sent to the ICU to adjust the on-board ICU time, the ICU forwards to the DPU (via the SSI) what the value of the least significant 14 bits of the seconds field will be at the next BCP2 pulse (i.e. next whole number of seconds). At that next BCP2 pulse the DPU resets its time counter appropriately (i.e. zeroes its least significant 10 bits and sets its 14 most significant bits to the value supplied).

2.2.3.4.3 Instrument Control Bus (ICB)

2.2.3.4.3.1 Scope

Control and monitoring of the instrument sub-systems are performed by the ICU. The ICB is the digital data highway that the ICU uses to send and receive commands and status. An existing standard has been adopted for the ICB called the MACS bus (Modular Attitude Control Systems bus) detailed in the "MACS Handbook", prepared by MATRA for ESA. It is a prioritised multi-master bus.



2.2.3.4.3.2 Function

Because there are a number of units on the bus the ICB has several functions. The detail of the functions performed on the bus is controlled by software in the ICU and EGSE.

The functions performed via the ICB are:

1. Loading of tables into the detectors.
2. Commanding of the detectors
3. Status monitoring of detectors
4. Reading filter wheel position sensors and temperature sensors.
5. Controlling power switching
6. Controlling heater switching
7. Controlling motor drives
8. Monitoring voltages/currents

The MACS bus specification defines a redundant bus. In the OM, redundancy is provided by two separate detector chains, and therefore only one MACS interface is used per redundant half.

The ICU always drives the clock on its bus.

2.2.3.4.3.3 Interface

The ICB interface consists of 4 signals:

- ICB1 _Clock
- ICB1 _Data
- ICB2 _Clock
- ICB2 _Data

2.2.3.4.3.4 Protocol

The lower layer of protocol is defined in the Section "MACS Protocol" of the MACS Handbook. This sub-section defines the protocol that is required by virtue of the hardware design. Further layers of protocol may be defined as necessary in software.

ICB-commands are defined here as indivisible operations that may be performed on the MACS bus. Possible commands are:

- 16bit transfer of data from the ICU to the sub-system initiated by the ICU - ICBsend
- 16bit transfer of data from the sub-system to the ICU initiated by the ICU - ICBacquire

These ICB-commands are made up pairs[1] of ICB-words. ICB-words are 24 bits long and can be of one of two types ICBinstruction, or ICBdata:

<u>ICBinstruction</u>

0	3	8	13	18	21	22	23
ext	source	dest	subaddr	instr	par	err	ack
3	5	5	5	3	1	1	1

<u>ICBdata</u>

0	3	5	21	22	23
ext	xx	data	par	err	ack
3	2	16	1	1	1

The format of the ICB-commands are as follows:

<u>ICBsend</u>

ICBinstruction								**ICBdata**					
0	3	8	13	18	21	22	23	0	3	5	21	22	23
101	ICUaddr	dest	subaddr	010	par	err	ack	011	00	data	par	err	ack
3	5	5	5	3	1	1	1	3	2	16	1	1	1

Both ICB-words are generated by the ICU.

ICUaddr - the ICB address of the ICU. It will have the value of one of the source address defined below.

dest - the ICB address of the sub-system which should respond to this command

subaddr - if implemented defines one of 32 locations in the sub-system to which the data is to be assigned

par - parity for the word

err - error condition, if true the command should be ignored

ack - acknowledge, generated by the sub-system

data - 16bit value to be used by the sub-system

<u>ICBacquire</u>

ICBinstruction								**ICBdata**					
0	3	8	13	18	21	22	23	0	3	5	21	22	23
101	ICUaddr	dest	subaddr	100	par	err	ack	011	00	data	par	err	ack
3	5	5	5	3	1	1	1	3	2	16	1	1	1

[1]This is the simplest case. Other commands are possible with the MACS protocol, but are not used.

The ICBinstruction word is generated by the ICU and the ICBdata word is generated by the sub-system that is addressed in the instruction.

ICUaddr - the ICB address of the ICU. It will have the value of one of the source address defined below.

dest - the ICB address of the sub-system which should respond to this command

subaddr - if implemented defines one of 32 locations in the sub-system from which the data is to be acquired

par - parity for the word

err - error condition, if true during the instruction the command should be ignored, if true during ICBdata the response will be ignored by the ICU

ack - acknowledge, generated by the sub-system in response to the instruction, generated by the ICU in response to the ICBdata.

data - 16bit value to be used by the sub-system

The ICB addresses are:

Source Addresses
00010 - ICU

Destination Addresses
11000 - Blue Detector
00111 - TMPSU

2.2.3.4.3.5 Timings

The timing of the interface is defined below:

Parameter	Min	Max	Units
Clock Frequency	500	512	kHz

2.2.3.4.4 RBI

2.2.3.4.4.1 Overview.

The standard RBI chip

1. provides the interface (via the DBI) between the ICU and the DBU (OBDH Data Bus Unit), only allowing interrogations if the address matches that of the ICU.
2. allows access to all the ICU memory, including the buffer areas for transfer of TC and TM packets (see below).
3. extracts BCP pulses (Broadcast Pulses) from OBDH interrogations which are used to generate interrupts for use by the software in the timer functions.
4. provides a 43 bit timer incremented by the OBDH clock signal at 524288 Hz.
5. provides a 12 bit programmable watchdog countdown timer, derived from the OBDH clock signal, at 256 Hz (see below).

The chip is fully described in “Standard RBI Chip for OBDH Interface”, MC1031 Technical Information 2.8. All instructions described therein are supported. **NOTE** - NCR 177: during an ESTEC test, the ‘suspend’ instruction followed by a ‘Go’ instruction left the ICU in a non-running state. It has not been possible to reproduce this on the flight spare.

The protocol defining the ‘handshake’ for transfer of TC and TM packets, as well as timing information, is defined in “OBDH Bus Protocol Requirements Specification”, XM-IF-DOR-0002.

2.2.3.4.4.2 Low Level Accesses Of The ICU’s Memory By The Spacecraft.

(The text in this section is adapted from APP-7).

The RBI’s Page address and Start address registers map the processors address lines and address state lines as follows, where AS0-3 are the address state lines, A0-15 the address lines and x are “don’t care”. (Note: the Base Address register will overlay the Page Address register for Immediate Read instructions and Reset Page Address Instructions.)

Page Address

RBI	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Proc	x	x	x	AS0	AS1	AS2	AS3	A0	A1	A2	A3	A4	A5	A6	A7	A8

Start Address

RBI	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Proc	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	note 1

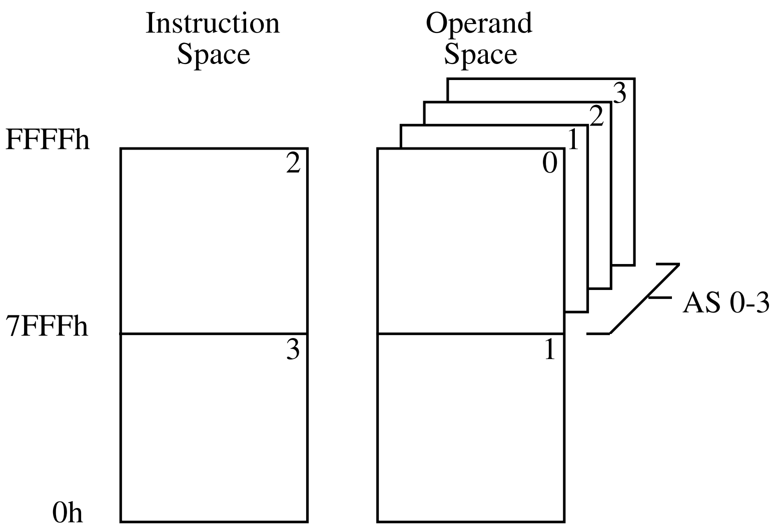
Note 1: For flight this bit is “don’t care”, x.

As shown above the processor address lines are offset by one. This is because the RBI accesses memory one word at a time and increments it’s address by two each time, so RBI bit 15 of the Start Address is not used.

The processor has an address space of 64K words. To give enough area for the application code and working space for data, the processors OIN (operand instruction) control line is used to switch between two 64K words pages. Each page can be seen as two 32K word Areas, two in instruction space and two in operand space, as shown below in figure 2.
The RBI can directly see the whole of the Operand Space, areas 0 and 1, using the RBI register bits that correspond the processors A0 to A15 lines

In addition Area “0” can be switched to any one of the four 32K Word Areas by manipulating the Address State lines indicated as AS0 to AS3 above.
For example An Address State of three (0011bin for AS0-3) would put Area “3” in the top half of the operand space. At the same time A0 would need to be set to a one and then A1 to A15 can be manipulated to address the 32K word block. Table 1 shows the set-up to access all four of the areas.

Area Address State	**Page Address Register (Hex)**	**Start Address Register (Hex)**	
0	0100	0-FFFE	Top half of operand/data space.
1	0300	0-FFFE	Bottom half of operand/data space.
2	0500	0-FFFE	Top half of instruction space.
3	0700	0-FFFE	Bottom half of instruction space.



2.2.3.4.4.3 Watch Dog Operations.

(The text in this section is adapted from APP-7).

The OM will use the RBI’s Watchdog timer, a twelve bit counter clocked by a 256Hz clock derived from the OBDH clock. This timer can give a programmable time out from 3.9mS to 16 seconds. If the timer reaches zero a PWDN (power down) interrupt is generated and 256uS later the IC will be reset. This timer is disabled on power up and is enabled by ICU software. If the ICU is suspended by the S/C this timer is stopped. When the ICU is allowed to continue the watchdog timer will resume from where it was stopped. The timer can be enabled and disabled by ICU software commands to the RBI’s configuration register. The time out period is programmed by writing to the RBI’s Watchdog Register, a value of FFF hex giving the longest time out period. The action of the write loads the value into the timer.

Note: The 31750 processor’s watchdog function is not used.

2.2.3.4.4.4 Time Synchronisation and Verification.

The following is a summary of section 7.2 of APP-7.

2.2.3.4.4.4.1 Synchronisation.

1. TC(10,1) is sent from the ground to the spacecraft telling the CDMU to synchronise time for the instrument.
2. The CDMU sends TC(10,2) to the ICU informing it that its local time is to be synchronised to the SCET.
3. The ICU enables time synchronisation to occur by commanding the RBI appropriately.
4. At least 100 ms later the CDMU generates a BCP3, BCP2 sequence, which resets the RBI time to zero. At the same time the DCMU takes a copy of the SCET. The RBI continues to count from zero.
5. Within a second the CDMU generates TC(10,3), “Add time code packet”, containing a copy of the SCET.
6. The ICU takes a copy of the SCET. It discards the least 8 significant bits. The next 32 bits are written into the RBI. The RBI chip adds the value to the time value it has reached since the BCP3,BCP2 sequence. The remaining 8 bits of the SCET are kept in the ICU memory. **NOTE**: at this point the ICU will synchronise the DPU time to the ICU via the SSI interface - see section 2.2.5.2.
7. The instrument time is now valid.

2.2.3.4.4.4.2 Verification.

1. The ground send a TC(10,4) to the CDMU.
2. The CDMU send a TC(10,5) to the ICU informing it that local time is to be verified.
3. The CDMU generates a BCP2 pulse after a delay of at least 100ms, at the same time taking a copy of the SCET. In the ICU the BCP4 pulse generates an interrupt.
4. The CDMU generates a TM(10,4) packet which contains a copy of the SCET at the BCP4 pulse.
5. The ICU, on reception of the BCP4 pulse, acquires the RBI time. Using this value and the value held in memory, the ICU builds the time field for a TM(10,5) and sends it to the CDMU.

2.2.3.4.5 DBU

See XMM-OM/MSSL/SP/0202 section 6.1 for a description of this interface.

2.2.4 Telescope Module

2.2.4.1 TMPSU

The telescope module power supply (TMPSU) converts the spacecraft 28V power bus to regulated switched and unswitched power rails within the telescope module. These are collectively referred to as the secondary power. The switched rails power the blue digital and analogue electronics and high voltages. The analogue electronics, in turn, controls the high voltages and powers filter wheel fine sensor LED and flood LED's. The unswitched rails power the mechanisms and filter wheel coarse sensor. The integral ICB interface provides the channel for control of the coarse sensor, flood LED's, analogue and digital electronics and also the return of current, high voltage and fine sensor status values. All switched rails are powered simultaneously on command via the ICB.

In addition. the +28V main s/c power, routed via the TMPSU, is used to drive the heaters.

The following table summarises what each secondary rail powers.

Rail	Switched?	BPE	BCH	HVU	FW	DM	TMPSU
+25V	Yes	-	Yes	Yes	-	-	-
+15V		Yes	-	Yes	-	-	-
+11V		-	Yes	-	-	-	-
+5.3V		Yes	Yes	Yes	-	-	-
-5.3V		-	Yes	-	-	-	-
-15V		Yes	-	Yes	-	-	-
+28V	No	-	-	-	Yes	Yes	-
+5V		-	-	-	-	-	Yes

Key:

BPE	Blue Processing Electronics
BCH	Blue Camera Head
HVU	High Voltage Unit
FW	Filter Wheel motor
DM	Dichroic Motor
TMPSU	TMPSU Internal

2.2.4.2 *Detector System*

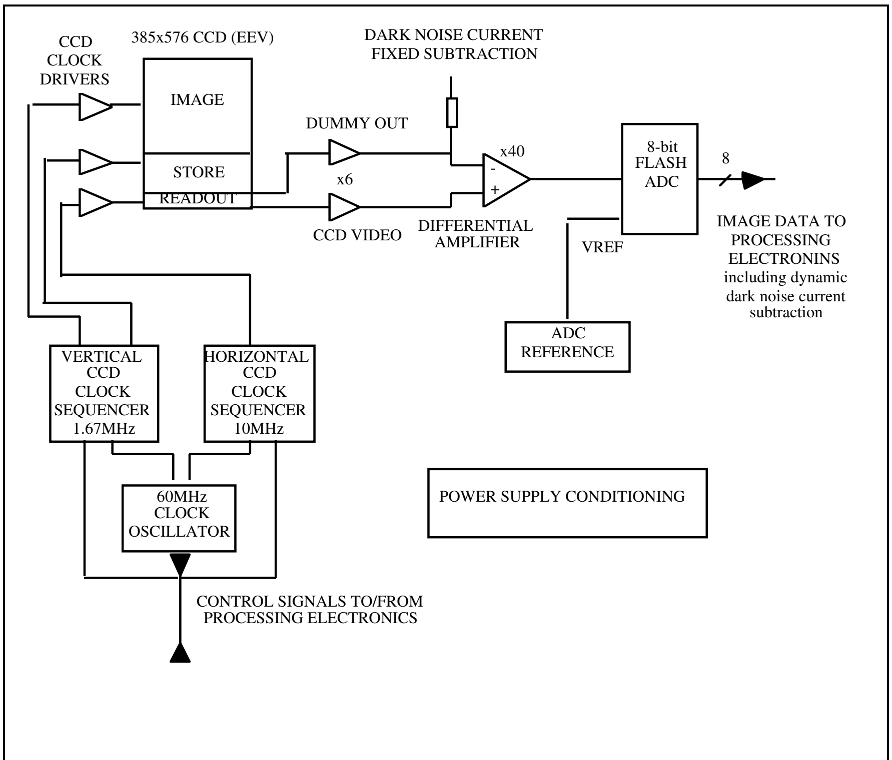
2.2.4.2.1 Camera Head

The sensor in the Camera Head (BCH) is an EEV CCD-02-06 which is a frame transfer device running with a vertical clock rate of 1.67 MHz and a horizontal readout rate of 10 MHz. The CCD is of well proven design and is used in many monochrome commercial and scientific TV applications. The dummy output from the CCD is subtracted from the video signal to reduce the level of saturation of the final video amplifier stage. The main cause of this is clock feed-through in the CCD wiring and the reset spike. The diagram below shows the functional blocks of the camera.

The CCD outputs are directly buffered with wide bandwidth emitter followers. The pre-amps are set at a gain of 4, and the differential amplifier at 10, giving a combined gain of 40. Because of the high read out rate, the video signal has settled to only approximately 75% of its final value at the instant of the ADC sample strobe. The gain is therefore slightly higher than that deduced from the CCD manufacturer's published data.

The horizontal clock sequencers and ADC sample strobe are derived from a highly stable ECL sequencer circuit based around a twisted ring counter. This, together with a fast horizontal driver circuit design, guarantees minimum timing jitter and hence low systematic noise as required for centroiding the image to 1/8th x 1/8th of a pixel.

Under control from the Blue Processing Electronics (BPE), the camera is capable of reading out of a number of windows in the CCD image in rapid succession, or full 256 x 256 pixel frames. The integration time is typically 12 ms.



Block Diagram of Blue Camera Head Electronics

2.2.4.2.2 High Voltage Control Unit

The High Voltage Control Unit (HVU) comprises three converters (see figure 1). Converter 1 and 2 work in parallel to produce the voltage across mcp1 bottom plate and cathode known as cathode voltage or $V_{cathode}$ and the voltage across mcp1 known as V_{mcp1}.

Converter 1 produces a negative voltage so that with the use of resistive division with converter 2 it obtains a zero volt output for $V_{cathode}$ on command. Potential reversal is possible but limited approximately to less than -15 volts by diode protection.

Converter 3 is in series with converter 1 and 2 and produces the bias voltage across mcp23 and the anode gap voltage known as V_{mcp23} and V_{anode} where V_{anode} is produced by extension of the voltage multiplier chain used to create V_{mcp23}.

In order to prevent potential reversal of any intensifier plate the bias voltages must be applied sequentially; this sequence being V_{anode}/V_{mcp23}-Vmcp1 then Vcathode. The HVU hardware will prevent any controlled static potentials from reverse bias conditions even if commanded to do so.

Due to the way the HVU works there are conditions in which rapidly control signals could cause momentary reverse bias conditions. i.e. a possibility of dynamic reverse bias. Because of this it is necessary that software commands for bias potentials be rise time limited.

It is recommended that any mcp rise time be limited to greater than 10 seconds from zero volts to maximum operating voltage and greater than 10 seconds from maximum operating voltage to zero volts.

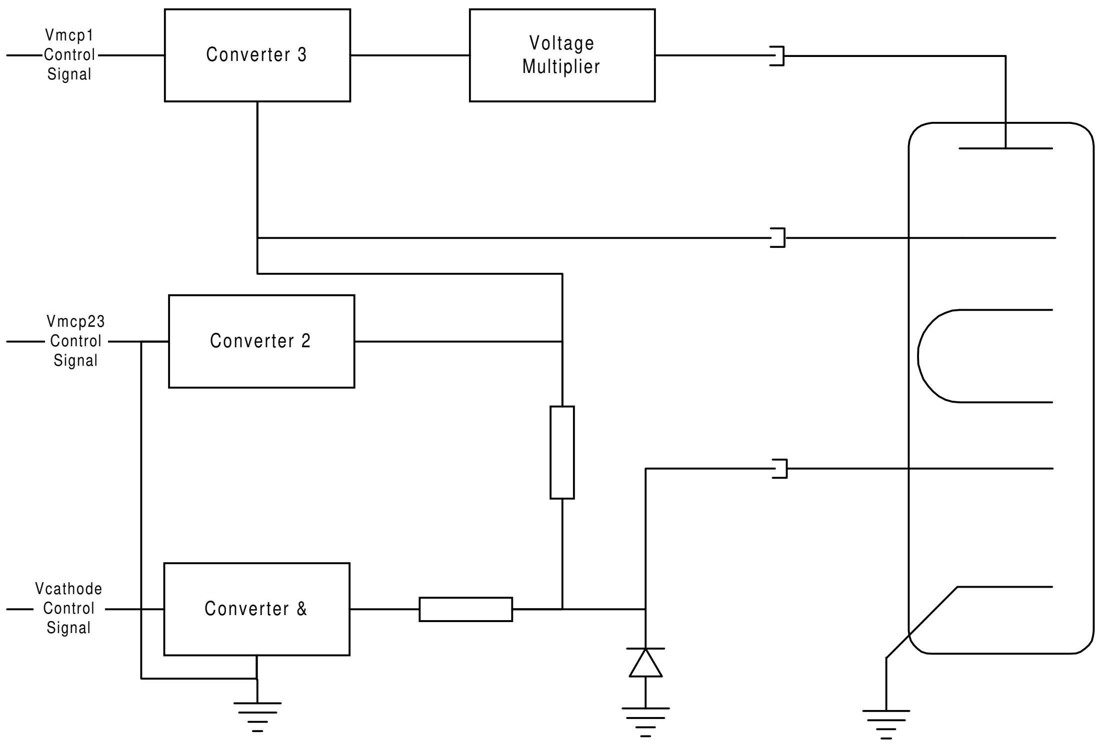
Protection of over voltage on any mcp is also incorporated into the HVU hardware such that any command above maximum operating voltage will remain at maximum voltage as set within the HVU. It should be noted that this condition produces excessive noise on all outputs and so the HVU should not be operated in this condition. If this condition does arise it is necessary to command the voltage below maximum in order to regain control. The amount by which the commanded voltage has to drop depends on the particular mcp limiting and is shown in table 1.

To operate the intensifier mcp23 is first raised to the desired operating voltage over a period defined by the rise time outlined above. V_{anode} will rise simultaneously with V_{mcp23} such that $V_{anode}=1.57*V_{mcp23}$. The voltage Vmcp1 will not be allowed to raise until V_{mcp23} is greater than 1100 volts (both intensifiers). Once V_{mcp23} is above this level V_{mcp1} can be raised to the desired operating voltage and is again rate of rise limited. For redundant intensifier the voltage across mcp1 must be greater than 518 volts before $V_{cathode}$ is allowed to rise and will cause $V_{cathode}$ to collapse if less than 505 volts. For the prime intensifier these restrictions are not incorporated into the hardware. Again the rate of voltage rise and decay for Vmcp1 should be limited as outlined above.

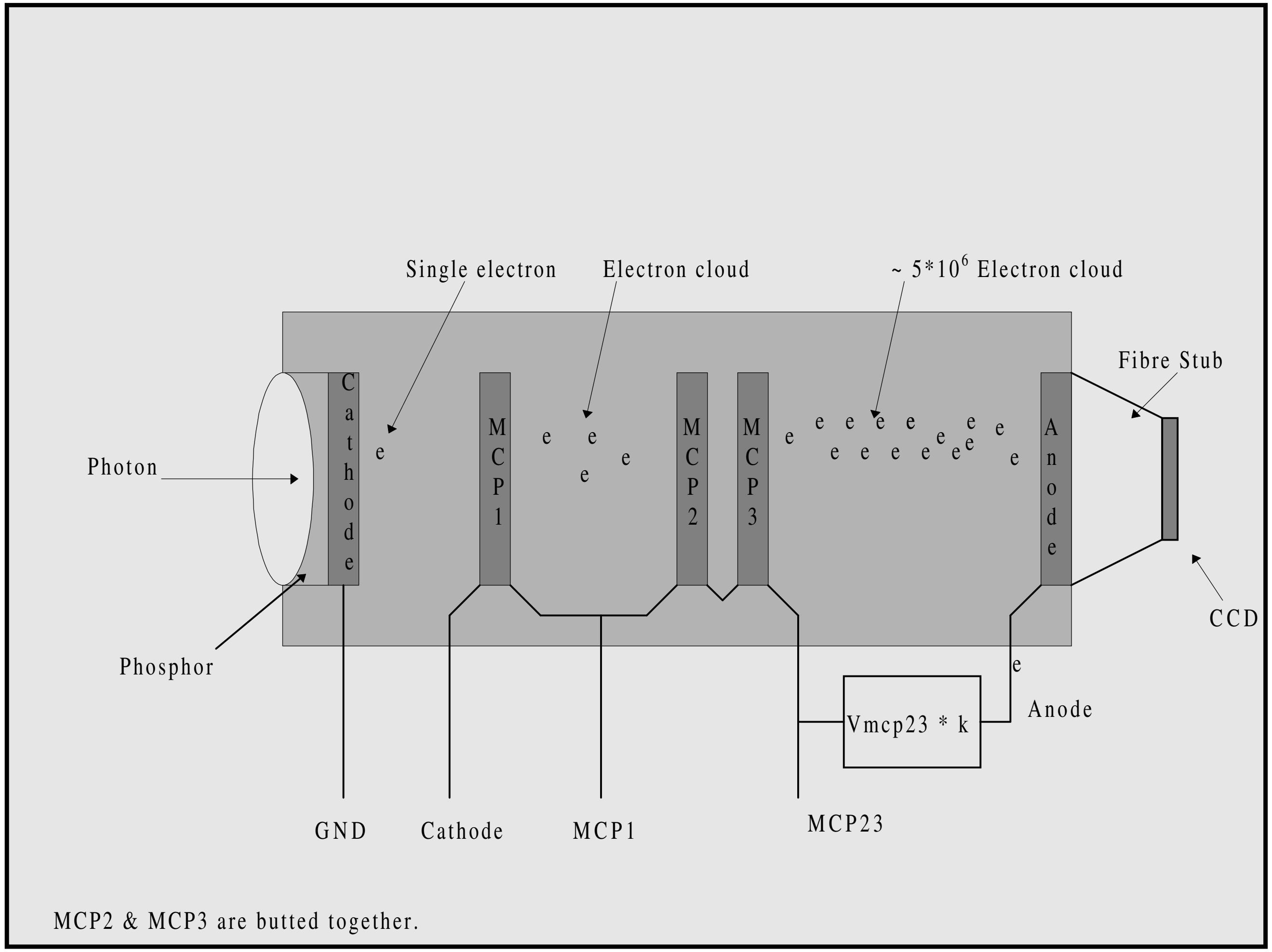
The cathode voltage $V_{cathode}$ is then raised to the desired operating level to effectively switch on the intensifier. To close down the intensifier the above procedure is reversed i.e. $V_{cathode}$ is set to zero volts then Vmcp1 and V_{mcp23}/V_{anode}. Both Vmcp1 and V_{mcp23}/V_{anode} decay rates are limited but $V_{cathode}$ can be commanded to zero instantly if required. Note that for the prime intensifier $V_{cathode}$ is limited to 530 volts and for the redundant intensifier $V_{cathode}$ is limited to 400 volts.

Intensifier protection limits.

Voltage	Limits at	Ideal Control
mcp23	2045 (< 1680V control reset)	< 2000V
mcp1	909V (< 780V control reset)	< 880V
$V_{cathode}$ (Prime intensifier)	530V (< 518V control reset)	< 500V
$V_{cathode}$ (Redundant intensifier)	2045V (< 380V control reset)	< 390V



2.2.4.2.3 Image Intensifier



2.2.4.2.4 Detector Processing Electronics

2.2.4.2.4.1 General

The principal features of the detector processing electronics are:

Generation of the Detector Head clock sequences to operate the CCD in a frame transfer mode
Specification of the area (windows) of CCD to be read out.
Event Detection.
Event Centroiding.
Engineering Data.
Construction and transmission of data to the DPU.
ICB interface for control of the above.

N.B. The detector processing electronics is often referred to as the Blue Processing Electronics (BPE). This refers to an earlier design which included an additional detector more sensitive to the red end of the spectrum. The two detectors were labelled 'blue' and 'red'. A block diagram of the detector electronics is given overleaf.

The remainder of this section is abstracted from APP-11.

2.2.4.2.4.2 Window Bitmap RAM

Before the detector processing electronics may be used, the window bitmap RAM must be loaded. The RAM is 64k by 4 bits. The information loaded will cause only those CCD pixels within the desired windows to be readout i.e. a clocking sequence is generated for the desired camera format.

For every location on the CCD, there is a location in RAM. During a row readout, the corresponding RAM contents are interpreted as a window ID. An ID in the range 1 to 15 is a valid window ID and the corresponding pixel *pair* is readout, whereas a value of 0 means that it is not in any window and will not be readout. By loading up the RAM accordingly, the detector area can be thus divided up into a collection of windows of varying size. **Note** that windows must start on an *even* number in X and an *odd* number in Y.

For each *pair* of CCD rows, there is a location in the RAM that will contain a 'row action code'. This will specify what to do with the row *pair* as a whole. The values and meanings are
0 Perform vertical transfer only, i.e. no horizontal readout. This is used for skipping unwanted rows
2 Readout the row, ignoring window IDs, thus dumping unwanted charge build-up.
3 Readout the row, taking note of window Ids and transmitting the event data to the DPU.
8 Complete horizontal readout and skip to the start of frame transfer i.e. skip to end.

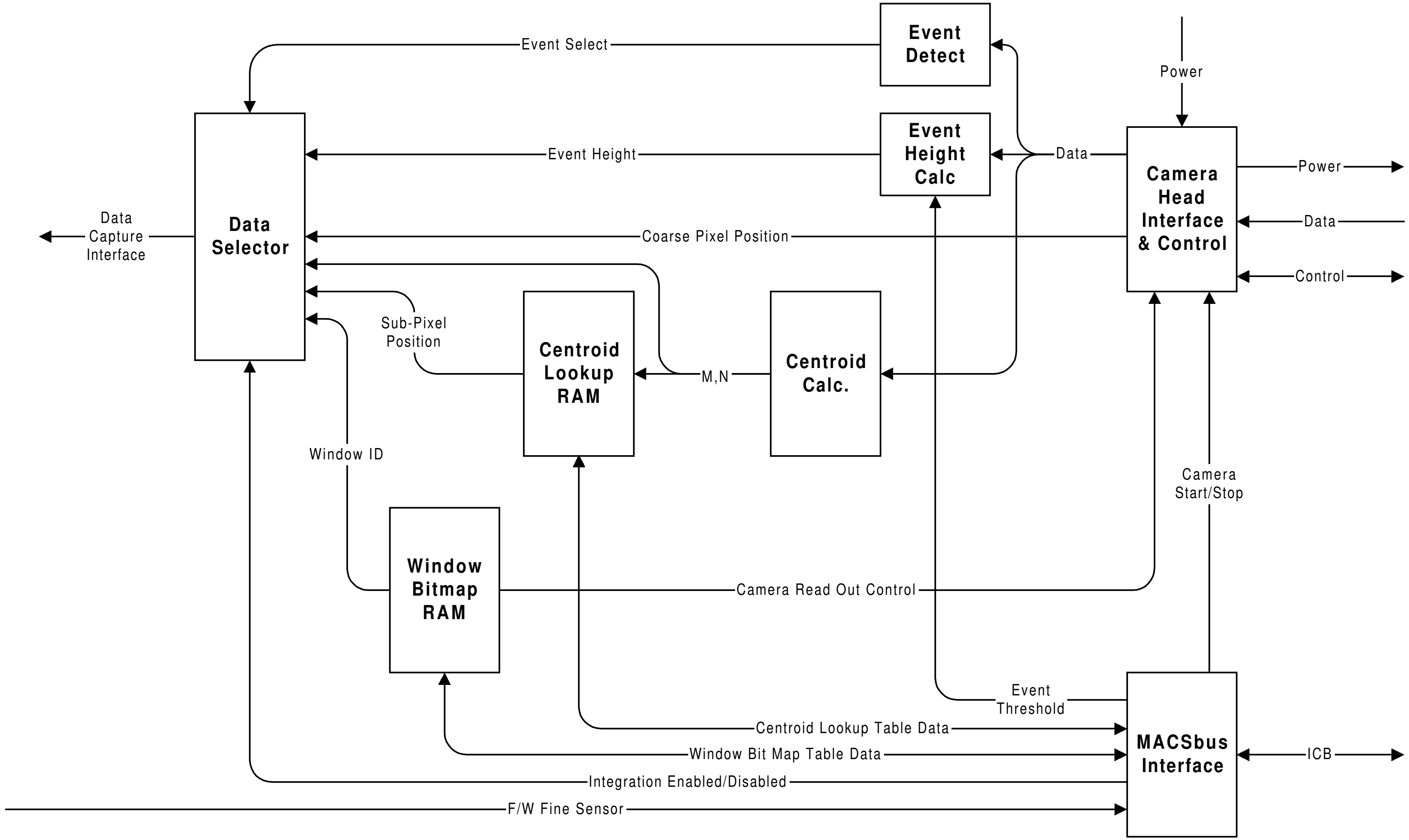
The table is loaded from the ICU via the ICB.

2.2.4.2.4.3 Centroid Lookup RAM

Centroiding is the process of locating the position of an event to an accuracy greater than that of a CCD pixel. For each event and in both the x and y axes, the processing electronics produces two 8 bit numbers, labelled **m** and **n**. The division **m/n** is the fractional position within a CCD pixel of the event. The range is divided into 8 bins, otherwise known as sub-pixels. Rather than performing this calculation, there are two (64k by 4 bit) tables containing all possible results of the division. The **m** and **n** are combined into a single 16 bit address which is used to lookup the result. The result is in the range 0-7.

Preparing the table contents requires two sets of 9 'channel boundary' values giving the edges of the sub-pixels in both x and y. They are in the range -1.00 to 1.00. These values are multiplied by 1000 for up-link purposes. The tables are loaded from the ICU via the ICB.

DETECTOR PROCESSING ELECTRONICS



2.2.4.2.4.4 Output Data Formats

The output of the processing electronics to the DPU is a series of 24 bit words, one per event processed. The format of the word is determined by the data acquisition mode set via the ICB and is detailed in the figure overleaf. There are 4 scientific modes (numbered 0 to 3) and effectively 2 engineering modes (numbered 4 to 7).

The scientific modes provide event positions in the form of the x and y CCD pixel number, the sub-pixel number in x and y and the window ID of the window in which they occurred. There are 2 full frame modes where the window ID is replaced by the most significant bits of the x and y CCD pixel counters, thus giving 16 tiles covering the full detector area.

The engineering modes provide information for setting up and checking the detector. Modes 4 or 5 capture centroiding information in the form of events in which the x and y co-ordinates are replaced with the **m** and **n** values. The two 256 by 256 ‘pseudo images’ thus formed can be used to calculate a new sub-pixel channel boundaries from which the centroid lookup table can be reloaded. Note that a) modes 4 and 5 are equivalent and both formats are transmitted at once b) the first X M/N event for each frame is not transmitted. Modes 6 or 7 gives event height leading to a 1D image i.e. a histogram. They also produce event energy records in which the energy value is set to zero, due to this feature being removed from the design. Therefore, all records of this format should be ignored. Note that mode 6 and 7 are equivalent and both formats are transmitted at once.

In addition, there are two words of all zeros, the ‘frame tags’, transmitted at the start of each frame. These are used for frame counting and timing purposes. This feature is enabled via the ICB. It should be disabled for engineering modes.

For the full frame modes only, windows should be defined so that the full detector area is covered, even though the window ID in bits 4 through 1 does not appear in the data. Instead, the high order bits of the CCD pixel co-ordinates are inserted. Because the DPU will regard these as a window ID, it is thus possible to have an apparent window ID of zero (which is impossible for the windowed modes).

For engineering modes, windows of any ID should be defined to cover the area of the detector from which information is required. The DPU will again regard bits 4 through 1 as a window ID.

A height threshold, set via the ICB, is used to select valid events. This value should be set low (~8) for engineering data so as to obtain a full pulse height distribution. Otherwise a value ~30 should be used.

When, as a result of a command, an integration is enabled, data is sent on to the DPU at the start of the next frame.

Detector Data Transmission Formats

Science or Engineering	Detector Mode	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Science	0	0	YC 6-0							y 2	y 1	XC 6-0							x 2	x 1	ID				P
		Low Resolution, Windowed																							
Science	1	0	0	YC 5-0						y 2	y 1	0	XC 5-0						x 2	x 1	YC 7	YC 6	XC 7	XC 6	P
		Low Resolution, Full Frame																							
Science	2	0	YC 5-0						y 2	y 1	y 0	XC 5-0						x 3	x 2	x 1	ID				P
		High Resolution, Windowed																							
Science	3	0	YC 5-0						y 2	y 1	y 0	XC 5-0						x 3	x 2	x 1	YC 7	YC 6	XC 7	XC 6	P
		High Resolution, Full Frame																							
Engineering	4	0	0	M value								0	N Value								0	0	0	1	P
		Engineering, X M/N Data																							
Engineering	5	0	0	M value								0	N Value								0	0	1	0	P
		Engineering, Y M/N Data																							
Engineering	6	0	0									0	Event Height								0	0	0	1	P
		Engineering, Event Height																							
Engineering	7	0	0									0	0								0	0	1	0	P
		Engineering, Event Energy (contains no meaningful data)																							

P = Parity (Odd)
XC = X CCD Pixel Co-ordinate modulo 64 (high resolution) or modulo 128 (low resolution)
YC = Y CCD Pixel Co-ordinate modulo 64 (high resolution) or modulo 128 (low resolution)
x = X Sub-Pixel Bit
y = Y Sub-Pixel Bit
ID = Window ID

2.2.4.3 Mechanisms

2.2.4.3.1 Filter Wheel

Eleven optical elements are placed at equal angles 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 following table is based on 'Order of the Optical Elements on the Filter Wheel, XMM-OM/MSSL/TC/0047.

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

The wheel position will normally be determined in open loop mode by step counting from a known datum position. Coarse and fine position sensors are provided to relocate the datum position should it be lost, verify the wheel position during and after every rotation and to confirm that the centre of any optical element has been found, although the element is not identified. The reflective infra-red *coarse* position sensor is fitted to the wheel and gives a true output when the wheel is within about ± 15° of the datum position. The infra-red *fine* position sensor, which is 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. It is aligned such that an element will be correctly positioned when the fine sensor gives a true reading *and* the first phase is energised. Thus it is only at the datum position that both the coarse and fine sensors give a true output (see table above).

Tests indicated that the filter wheel should be rotated at a default pull-in speed of 200 Hz, a cruise speed of 420 Hz and an acceleration of 2000 Hz/sec. These rates are applied when moving from filter to filter or from datum to filter. However, in order to ensure success when seeking datum, the filter wheel is rotated at a constant 200 Hz until the coarse sensor is detected and then at 10 Hz until the fine sensor is seen.

The LED that illuminates the *coarse* sensor is powered directly from the TMPSU. However, the *fine* sensor LED is powered and sensed via the detector electronics, which is dependent on the switched secondary power being enabled. This does not normally occur until the OM is in operational mode. Therefore, it is not possible to obtain full control of the filter wheel until that time.
(See 'Filter Wheel Mechanism Design', XMM-OM/MSSL/SP/0039 for more detail).

Note: The filter wheel movement is controlled via the ICB. This is also the main channel for acquiring housekeeping and controlling heaters. It was found during testing that activity on the ICB during a filter wheel movement could introduce erratic motion of the filter wheel and cause occasional failure in locating the fine sensor. Therefore, whilst the filter wheel is being moved, all other ICB activity (such a housekeeping acquisition and heater control) is stopped. As a filter wheel movement takes between 5 - 10 s, this will result in a loss of an HK telemetry packet on its expected 10 or 3 sec boundary.

Similarly, activity on the SSI interface, which channels DPU heartbeats and science data, can cause a problem. Therefore the filter wheel is not moved until after the reception of the next DPU heartbeat. In addition, the normal science data 'handshake' between the DPU and ICU is suspended for the duration of the move.

2.2.4.3.2 Dichroic Mechanism

The dichroic mechanism contains a mirror placed at 45° in the path of the incoming beam. The purpose of the mechanism in the FM is to steer the reflected light beam from one of two redundant detector systems to the other. It will be rotated 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 up to 29 steps from one position to the other. One further step in each direction means that the rotor is driven hard onto its stop. Thus the total number of steps required is 31. The step sequence has to be reversed to return. As there is no harm in overdriving the system against this stop, the motor is always driven the maximum number of steps required in the specified direction. The default drive frequency is 2 Hz.

A pulse train must always finish on a particular phase. It is clear that this phase will be different at the two ends of the traverse. As there are no sensors in the system, the control mechanism is always open loop.

The following algorithm is used. If we label the 4 phases 1,2,3 and 4, a clockwise rotor drive (viewed from the shaft end) towards the redundant detector is achieved by stepping in a positive direction (e.g. the phases are energised in the order 1,2,3,4,1…) until the step count is equal to or greater than 31 and the phase is 1. Similarly a counter-clockwise rotor drive towards the primary detector is achieved by stepping in a negative direction (e.g. the phases are energised in the order 4,3,2,1,4..) until the step count is equal to or greater than 31 and the phase is 2.

2.2.4.4 Flood LED's

In order that the detector may be calibrated in flight, four flood LED's are provided. They are located off-axis close to the detector. They are positioned so that their focused emission falls on the side of the filter facing the detector. The filter used would be the blank which then acts as a defocused 'screen' providing the flat field. They are green LED's but with emission in the UV range.

Their intensity is controlled via ICB commands routed from the Blue Detector analogue control card to a 4 bit port. There are thus 16 possible levels. They are driven in such a way that if one should fail the remaining LED's will remain fully functional.

2.2.4.5 *Heaters and Thermistors*

There are 8 thermistors named and located as follows:

Name	Channel	Location
Ref A	0	Interface Flange - **Not connected- NCR88**
Ref B	1	Interface Flange
Ref C	2	Interface Flange
Main	3	Near Main Interface Heater
Forward 1	4	Near Forward Heater
Forward 2	5	Near Forward Heater
CCD	6	CCD
BPE	7	Blue Processing Electronics

(**Note**: the following is a summary of the document 'OM Heater Control', XMM-OM/MSSL/SP/0165)

The four instrument heaters, and their function, are summarised as follows:

Heater	Purpose
Main Interface Heater (HTR1)	This is located close to the interface flange on the telescope tube, and is intended to control the temperature at the interface bolts to **19.5 ± 0.5 °C** using a closed loop algorithm. It has a control thermistor (Main) located close to it and there are 3 monitoring thermistors (Main, Ref B and Ref C) on the interface flange (**Note:** Ref A was not connected during assembly therefore Main is used as a monitoring point instead - NCR88).
Forward Heater (HTR2)	This is located at the forward of the telescope tube and is intended to control that area and hence the whole telescope tube to about the same temperature as the main interface heater - the default setting are **19.5 ± 1.5 °C** using a closed loop algorithm. This should ensure that all of the telescope optical elements are sensibly isothermal. It is controlled by one of two thermistors (Forward 1 or Forward 2) mounted close to it.
Metering Rod Heaters (HTR3)	These are a set of three parallel heaters, one mounted on each of the metering rods. These are used to *extend* the distance between the primary and secondary mirror by a small amount if necessary. This is done using an open loop algorithm which defines an on-off ratio. It is disabled by default. NCR-192. The settings for this algorithm are, as of release 10 of the OM software, automatically set upon moving the filter wheel to a specified filter – see next section.
Secondary Mirror Mount Heater (HTR4)	This heater is used to *shorten* the separation of the primary and secondary mirror. NOTE that therefore this heater and the metering rod heaters will not be powered at the same time during normal operation**.** This is done using an open loop algorithm which defines an on-off ratio. It is disabled by default. NCR-192. The settings for this algorithm are, as of release 10 of the OM software, automatically set upon moving the filter wheel to a specified filter – see next section.

2.2.4.6 *Automatic Focus Heater Settings*

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 it 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), the table is consulted and appropriate heater settings and sample times automatically set using the on-board equivalent routines of commands MFN=H7677 and MFN=H7678. For release 10, this table starts at a base address of 23A4 (hex) in ICU data memory. Its format is as follows:

<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 units of 'Sample Time')</td></tr>
<tr><td>2</td><td>Total Cycle Time (in units of 'Sample Time')</td></tr>
<tr><td>3</td><td>Sample Time (in units of seconds)</td></tr>
<tr><td>4</td><td>Focus Direction (+ve = HTR3, -ve = HTR4 powered; 0 = unpowered)</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>

2.3 Software

2.3.1 Modes

The OM instrument has several overall modes. An outline of the function of these modes is given below. In addition, both the ICU and DPU have 2 different modes, 1) when they are running code present in the ROM (called 'basic' for the ICU or 'Boot Idle' for the DPU) or 2) they are running uplinked code (called 'Operational' for the ICU and 'DPUOS' for the DPU. The characteristics, inter-relationship and required transitions between the modes, including the individual modes of the ICU and DPU, are given in more detail in the diagram and table overleaf.

2.3.1.1 *Off*

ICU and DPU are not powered. The Bootstrap Init mode is entered autonomously after power on.

2.3.1.2 *Bootstrap Init*

The ICU is powered and

1. performs a reset of interfaces.
2. copies required ROM to RAM.
3. initialises the software.
4. sets high voltage ports to zero.
5. turns off the secondary power.
6. resets the DEMPSU.
7. moves the filter wheel close to the blank position (i.e. such that the coarse sensor is seen).

The software then autonomously enters the Bootstrap Reset mode.

2.3.1.3 *Bootstrap Reset*

The ICU is powered. The configuration is in a known state.

If entry to Bootstrap Init was from being powered on or as a result of a Cold Start Instruction to RBI, the ICU autonomously enters Basic Mode.

Otherwise, the transition to Basic Mode only occurs after receipt of the Start Instruction to RBI.

2.3.1.4 *Initial/Basic*

This is the first point at which telecommanding and telemetry are possible. It is possible to move to operational mode from here provided the ICU code has been uplinked since the last cycling of the Keep Alive Power. It is only possible to uplink ICU code in this mode.

2.3.1.5 Operational

At this point it is now possible to command and receive telemetry from the DPU. The secondary power is now enabled. There are four sub-modes: Full Safe and Intermediate Safe, Idle, Science and Engineering and Calibration. As of release 10 of the software (ECR 086) it is possible to request a transition to any one of these modes even if it is the current mode..

2.3.1.5.1 Safe

This has two sub-modes, Full and Intermediate.

2.3.1.5.1.1 Full Safe

A transition to this mode will cause the High Voltages to be in a safe condition. The filter wheel is moved to the blocked position. Should the latter operation fail for any reason, as from release 10 of the OM software it is not possible to leave this mode unless the filter wheel has been commanded to the blocked position (filter wheel absolute position 1200).

It is only possible to uplink the DPU code in this mode. This must be done before it is possible to move to Idle.

2.3.1.5.1.2 Intermediate Safe

A transition to this mode will cause the High Voltages to be in a condition whereby only the Cathode voltage is ramped down to zero. The filter wheel is moved to the blocked position.

2.3.1.5.2 Idle

In this mode it is possible to control the High Voltages and download previously acquired Science or Engineering Data. However, as from release 10 of the OM software, any attempt to ramp up any high voltage will fail unless the filter wheel is in the blocked position.

2.3.1.5.3 Science

In this mode it is possible to acquire a science image. It is also possible to control the High Voltages and download Science Data. However, as from release 10 of the OM software, any attempt to ramp up any high voltage will fail unless the filter wheel is in the blocked position.

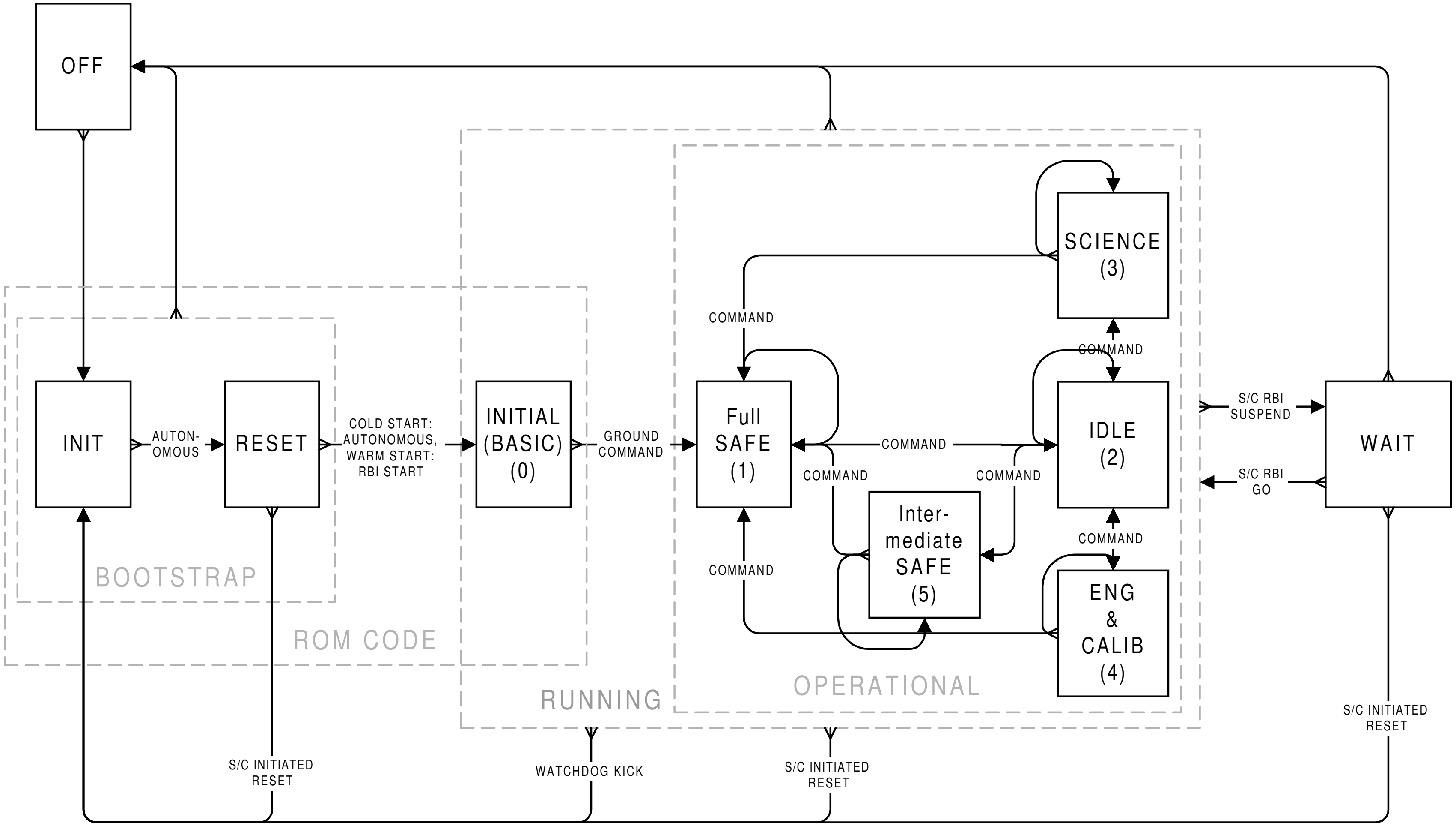
2.3.1.5.4 Engineering and Calibration

This is the only mode in which it is possible to move the Dichroic mechanism. Engineering images can be acquired. It is also possible to control the High Voltages and download Science Data. However, as from release 10 of the OM software, any attempt to ramp up any high voltage will fail unless the filter wheel is in the blocked position.

2.3.1.6 Wait State

The OM is powered but the ICU processor is in a halt state. It is possible to perform low-level memory dumps from and patches to the ICU. TM and TC Packets are not processed.

OM FM MODE TRANSITIONS



FM Model Mode Characteristics

			OFF	BOOTSTRAP		RUNNING						WAIT
				INIT	RESET	BASIC	OPERATIONAL					
							Safe		Idle	Science	Eng.	
						(0)	Full (1)	Inter (5)	(2)	(3)	(4)	
OM2 (DEM)	DEMPSU	Main Power	Off	On	On	On	On		On	O	On	On
		Keep Alive Power	On	On	On	On	On		On	On	ON	On
	ICU	Mode	Off	Init	Reset	Basic	Operational		Operational	Operational	Operational	ICU CPU is halted
		Telecommand	Off	No	No	Yes	Yes		Yes	Yes	Yes	No
		Telemetry	Off	No	No	Yes	Yes		Yes	Yes	Yes	No
	DPU	Mode	Off	From OFF = Boot Idle else unchanged	Boot Idle	Boot Idle	Boot Idle or DPUOS		DPUOS	DPUOS	DPUOS	Unchanged
		Commandable	Off	No	No	No	Partial		Full	Full	Full	No
		Data Acquisition	Off	No	No	No	No		No	Commandable	Commandable	Unchanged
OM2 (TM)	Electro-nics	Main Power	Off	On	On	On	On		On	On	On	On
		Secondary Power	Off	Off	Off	Off	On		On	On	On	Unchanged
		Detector High Voltage	Off	Off	Off	Off	Off	$V_{cathode}$ zero	On	On	On	Unchanged
		Detector Electronics	Off	Unchanged	Off	Off	On		On	On	On	Unchanged
		Thermal	Off	Unchanged	Off	HTR1 + HTR2 on	Closed Loop		Closed Loop	Closed Loop	Closed Loop	Powered Heaters stay on
		Flood LED	Off	Unchanged	Off	Off	Off		Off	Off	Commandable	Unchanged
	Mechan-isms	Filter Wheel Position	Off	Unchanged	Blocked	Blocked	Blocked		Commandable	Commandable	Commandable	Unchanged
		Filter Wheel Coarse Sensor	Off	Unchanged	Available	Available	Available		Available	Available	Available	Unchanged
		Filter Wheel Fine Sensor	Off	Unchanged	Unavailable	Unavailable	Available		Available	Available	Available	Unchanged
		Dichroic mechanism Commandable	Off	No	No	No	No		No	No	Yes	No

2.3.2 ICU

2.3.2.1 Overview

The overall instrument function is provided by the instrument controller. Its main software functions are as follows:-

- Configuring the instrument.
- Monitoring for breakdown/failure conditions (and safing if required).
- Controlling and monitoring status of, the detector, the telescope power supply and the DPU
- Incorporating new or modified code modules for itself or the DPU
- Collecting and telemetering. instrument housekeeping and engineering packets.
- Accepting, reformatting into packets and telemetering science data from the DPU
- Interfacing with the OBDH for data and commands.
- Monitoring and controlling the thermal environment.

The ICU software consists of 3 programs :-

BOOTSTRAP	This resides in ROM and is copied into RAM for execution. It is responsible for bringing up the ICU in a known safe state after turn on or spacecraft initiated reset, from either a cold or warm start. It also copies the basic state software from ROM to RAM.
BASIC	This resides in ROM and is copied into RAM for execution. Basic will be responsible for loading the uplinked ICU operational mode code into RAM, housekeeping and basic thermal control.
OPERATIONAL	This is uplinked and will reside in RAM. Operational provides the full functionality of the ICU. It also allows up-linking of the DPU DPUOS code to provide full OM

2.3.2.2 Bootstrap Code.

The bootstrap code is described in the Detailed Design Document, XMM-OM/MSSL/SP/0205.

2.3.2.3 Basic and Operational Code

2.3.2.3.1 Summary of Telecommands.

A full description of the telecommands is given in Telecommand and Telemetry Specification (XMM-OM/MSSL/ML/0010). In this manual, we will give a overview of the telecommands available to assist in the reading of that document, and indicate whether or not they are supported in basic or operational mode..

2.3.2.3.2 Start Task Management Commands.

<table>
<tr><th>Sub-System</th><th>TID (Hex)</th><th>Task Function</th><th>MFN</th><th>Basic</th><th>Operat -tional</th></tr>
<tr><td rowspan="6">Detector</td><td>10</td><td>Load Centroid Table</td><td>H5100</td><td rowspan="6">No</td><td rowspan="6">Yes</td></tr>
<tr><td>11</td><td>Load Window Table</td><td>H5110</td></tr>
<tr><td>12</td><td>Load DPU Deduced Window Table (always running)</td><td>N/A</td></tr>
<tr><td>13</td><td>Start/(Stop) Detector Integration</td><td>H5130</td></tr>
<tr><td>14</td><td>High Voltage Ramp-up/down</td><td>H5140</td></tr>
<tr><td>18</td><td>Start/Reset Camera Head Electronics (Contingency only)</td><td>H5180</td></tr>
<tr><td rowspan="3">Digital Processing Unit (DPU)</td><td>A4</td><td>Direct DPU Control (always running)</td><td>N/A</td><td rowspan="3">No</td><td rowspan="3">Yes</td></tr>
<tr><td>A5</td><td>(Start/Stop) Science Data Acquisition</td><td>H5250</td></tr>
<tr><td>A6</td><td>(Start/Stop) DPU Heartbeat Watchdog</td><td>H5760</td></tr>
<tr><td>Instrument Control Bus(ICB)</td><td>41</td><td>Enable ICB Load Port</td><td>H5410</td><td>Yes</td><td>Yes</td></tr>
<tr><td>RBI Watchog</td><td>50</td><td>Watchdog Enable</td><td>H5510</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="5">Telescope Module Power Supply (TMPSU)</td><td>60</td><td>Move Filter Wheel</td><td>H5600</td><td>No</td><td rowspan="5">Yes</td></tr>
<tr><td>65</td><td>Move Dichroic mechanism</td><td>H5650</td><td>No</td></tr>
<tr><td>66</td><td>Heater Control (Contingency)</td><td>H5660</td><td>No</td></tr>
<tr><td>67</td><td>Heater Control</td><td>H5670</td><td>Yes</td></tr>
<tr><td>69</td><td>Turn on/off Switchable Secondary Voltages</td><td>H5690</td><td>Yes</td></tr>
<tr><td>DEM Power Supply Unit (DEMPSU)</td><td>80</td><td>Reset of DEM-PSU Latchup Protection Circuits/ DPU On</td><td>H5800</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Housekeeping</td><td>D0</td><td>Enable Housekeeping</td><td>H5700</td><td>Yes</td><td>Yes</td></tr>
</table>

2.3.2.3.3 Stop Task Management Commands.

Sub-System	TID (Hex)	Task Function	MFN	Basic	Operat-ional
Detector	10	Load Centroid Table	H6100	No	Yes
	11	Load Window Table	H6110		
	13	(Start)/Stop Detector Integration	H6130		
	14	High Voltage Ramp-up/down	H6140		
Digital Processing Unit (DPU)	A5	(Start/Stop) Science Data Acquisition	H6250	No	Yes
	A6	(Start/Stop) DPU Heartbeat Watchdog	H6760		
Instrument Control Bus(ICB)	41	Disable ICB Load Port	H6410	Yes	Yes
RBI Watchdog	50	Watchdog Disable	H6510	Yes	Yes
Telescope Module Power Supply (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 on/off Switchable secondary voltages	H6690	Yes	
DEM Power Supply Unit (DEMPSU)	80	DPU Off	H6800	Yes	Yes
Housekeeping	D0	Disable Housekeeping	H6700	Yes	Yes

2.3.2.3.4 Load Task Management Commands.

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
0 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

2.3.2.3.5 Report Task Commands.

Read ICB Address Directly

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		

2.3.2.3.6 Mode Change Commands.

MODE	Comment	MFN	Basic	Oper.
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

2.3.2.3.7 Memory Management.

2.3.2.3.7.1 Load Memory

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 Electronics	Window Bitmap Table	N/A	No	Yes
	20000 - 2FFFF (hex)		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		

2.3.2.3.7.2 Dump Memory

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

MID (hex)	DPU Local Memory Description	MFN	Basic	Oper
10	DPU Blue 1 DSP Local Memory	H4110	N/A	N/A
11	DPU Blue 2 DSP Local Memory	H4111		
12	DPU Red DSP Local Memory	H4112		
13	DPU White DSP Local Memory	H4113	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	H4114	NO	OPER
15	DPU Small Word Memory (16 bit words)	400000	7FFFFF	H4115		
20	DPU Program Ram Bank 0	E00000	E0FFFF	H4120		
21	DPU Program Ram Bank 1	E10000	E1FFFF	H4121		
22	DPU Program Ram Bank 2	E20000	E2FFFF	H4122		
23	DPU Program Ram Bank 3	E30000	E3FFFF	H4123		
24	DPU Program Ram Bank 4	E40000	E4FFFF	H4124		
25	DPU Program Ram Bank 5	E50000	E5FFFF	H4125		
26	DPU Program Ram Bank 6	E60000	E6FFFF	H4126		
27	DPU Program Ram Bank 7	E70000	E7FFFF	H4127		

2.3.2.3.7.3 Calculate Memory Checksum

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 Electronics	Window Bitmap Table	N/A	No	
	20000 - 2FFFF (hex)		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			

2.3.2.3.8 Telemetry Maintenance

Function	Basic	Oper
Report TM Packet Generation Status	Yes	Yes
Disable Generation of All Packets		
Enable Generation of Specific Packets		
Disable Generation of Specific Packets		

2.3.2.3.9 Time Management.

Function	Basic	Oper
Enable Time Synchronisation	Yes	Yes
Add Time Code		
Enable Time Verification		

2.3.2.3.10 Test Commands

Function	MFN	Basic	Oper
Test Command	H1	Yes	Yes

2.3.2.3.11 Summary of Telemetry

A full description of the telemetry is given in Telecommand and Telemetry Specification (XMM-OM/MSSL/ML/0010). In this manual, we will give a summary of the telemetry available to assist in the reading of that document.

Type	**Telemetry Packets Available**		**Comments**
Housekeeping	HK	at 10 secs	Selected by SID value
		at 3 secs	
Telecommand Verification	Successful Command Acceptance		
	Unsuccessful Command Acceptance		
	Unsuccessful Command Execution		
Non Periodic Housekeeping	Event Reports	from Detector System	
		from Mechanisms	
		of Selected DPU Alerts	Selected by SID
		Bootstrap Report	
	Exception Reports	from Detector System	
		of ICB errors	Only when enabled
		if ADA exception	
		loss of mechanism position	
		of SSI errors	Always enabled
		Bootstrap Report	If booting encounters problems
		of all DPU error Alerts	
Task Management	ICB Port read-back		
Memory Maintenance	Memory Dump Reports	of ICU	
		of DPU	
		of Detector Tables	
	Memory Checksum Reports for ICU		
Telemetry Management	TM Packet Generation Status Report		
Time Management	Time Verification Report		
Science	Priority	Window Data	
		Field Acquisition Data	
		Fast Mode Data	
	Regular	Tracking History	
		Reference Frame Data	
		Image Mode Data	
		Fast Mode Data	
		Engineering Data	
	Auxiliary Data		Only when enabled by SID

2.3.2.3.12 Main Software Components for Basic and Operational.

The diagrams overleaf illustrate the control and data flows between the main software components for both basic and operational code. A brief explanation of each component is also given. These two modes share many components. Their similarities and differences are summarised below, together with the type of telecommands (and Task Identifier - TID - if appropriate) they service. This section is abstracted from APP-8, in which a full description of the ICU software can be found..

Component	**Type of TC**	**TID (HEX)**	**Function in Basic**	**Function in Operational**
DEMPSU	5	80	• Resets DEMPSU Latchup • Turns-on DPU if Off	• Resets DEMPSU Latchup • Turns-on DPU if Off • Turns off DPU
DETECTOR	5	10 ⇒ 18	ABSENT	• Control and monitor detector.
DPU MANAGER	5	A4 ⇒ A6	• Monitors DPU heartbeats and sends the count to the HK	• Uses SSI to communicate with the DPU. • Configure and control DPU modes. • Control Science and Engineering data flow from DPU and send to TM QUEUE. • Monitors DPU heartbeats
HK	5	D0	• Collect and pass HK packets to the TM QUEUE that monitor only the TMPSU and DPU heartbeats.	• Collect and pass HK packets to the TM QUEUE for the whole OM.
ICB	5	41	• Controls dataflow to/from the instrument subsystems using the ICB interface	• Controls dataflow to/from the instrument subsystems using the ICB interface.
MECHANISMS	5	60, 65	ABSENT	• Control & monitor mechanisms (filter wheels, dichroic mechanism).
MEMORY MANAGER	6	-	• Supports memory uplink and downlink and memory checksum calculations for the ICU only	• Supports memory uplink and downlink for the DPU only.
MODE MANAGER	5	-	• Implements mode change request to Safe	• Implements mode change requests from spacecraft
RBI	5,10	50	• Provides routines to support the RBI chip • Handle appropriate interrupts to the TC and TM queues and time. • Supply Watchdog Facility	• Provides routines to support the RBI chip • Handle appropriate interrupts to the TC and TM queues and time. • Supply Watchdog Facility
SAFING	5	D1	ABSENT	• Implements command to SAFE mode • Implements Autonomous Safing
SSI	see DPU	-	• Obtains info from the DPU using the SSI interface.	• Passes control and data info to the DPU using the SSI interface. • Obtains info from the DPU using the SSI interface.

Continued on next page…

Component	Type of TC	TID (HEX)	Function in Basic	Function in Operational
TASK MANAGER	5		• Implements the task management packet requests	• Implements the task management packet requests
TC PROCESS	All		• Obtains telecommand packets from the telecommand queue. • Verifies, acknowledges and routes telecommand packets - the 'main' program	• Obtains telecommand packets from the telecommand queue. • Verifies, acknowledges and routes telecommand packets - the 'main' program
THERMAL	5	66,67	• Enables or disables Main and Forward Heaters simultaneously.	• Provide full thermal control
TIME MANAGER	10	-	• Implements the Time management packet requests (verification and synchronisation). • Provide time stamps for packets.	• Implements the Time management packet requests (verification and synchronisation). • Provide time stamps for packets.
TEMEMETRY MANAGER	9	-	• Enables/Disables packets defined by their SID'S	• Enables/Disables packets defined by their SID'S
TM QUEUE	Supplies TM	-	• Provide ability to control and queue telemetry packets for downlink.	• Provide ability to control and queue telemetry packets for downlink.

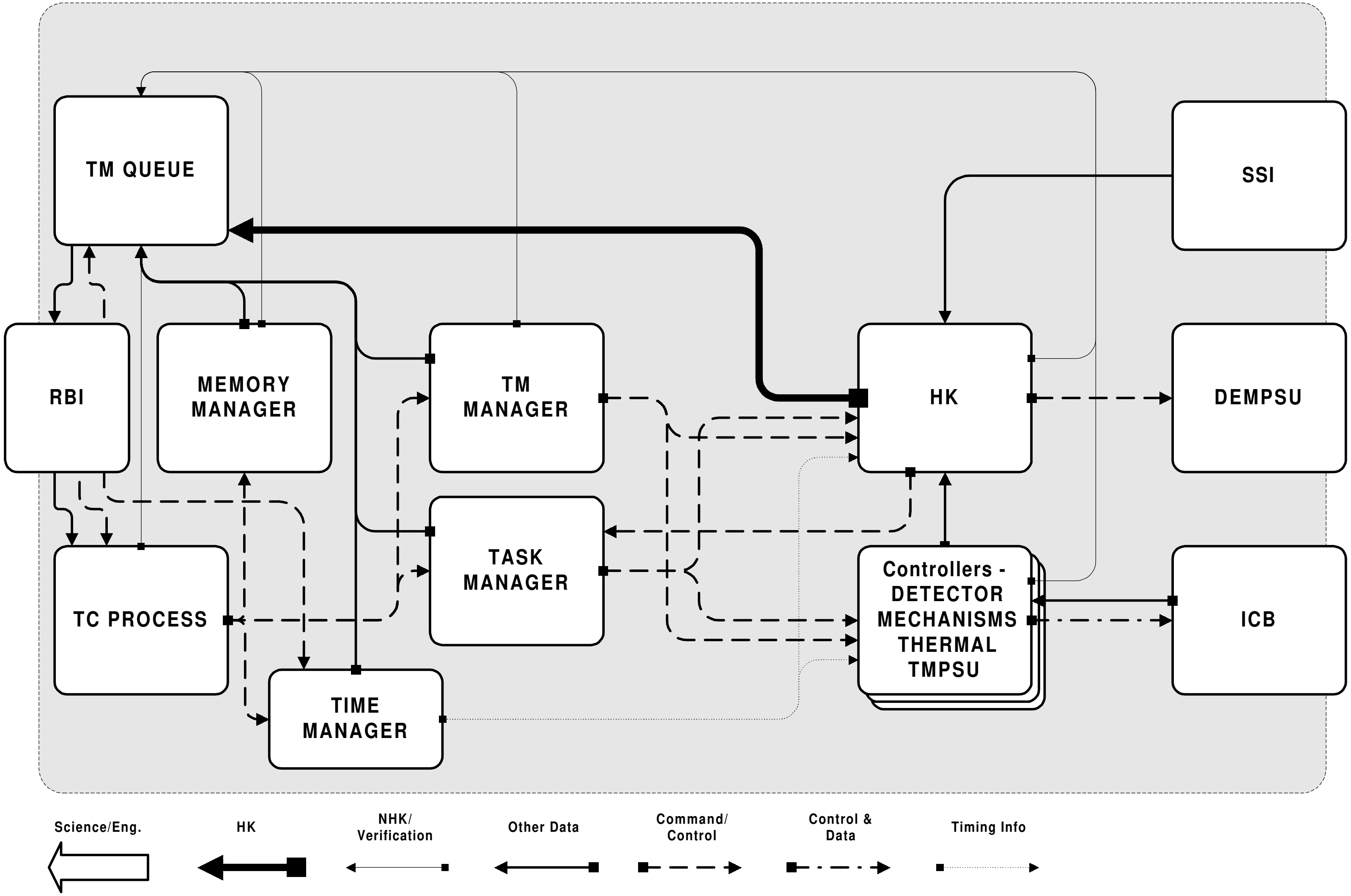
2.3.2.3.13 Overview of Principle Memory Areas

See APP-8 for more detail.

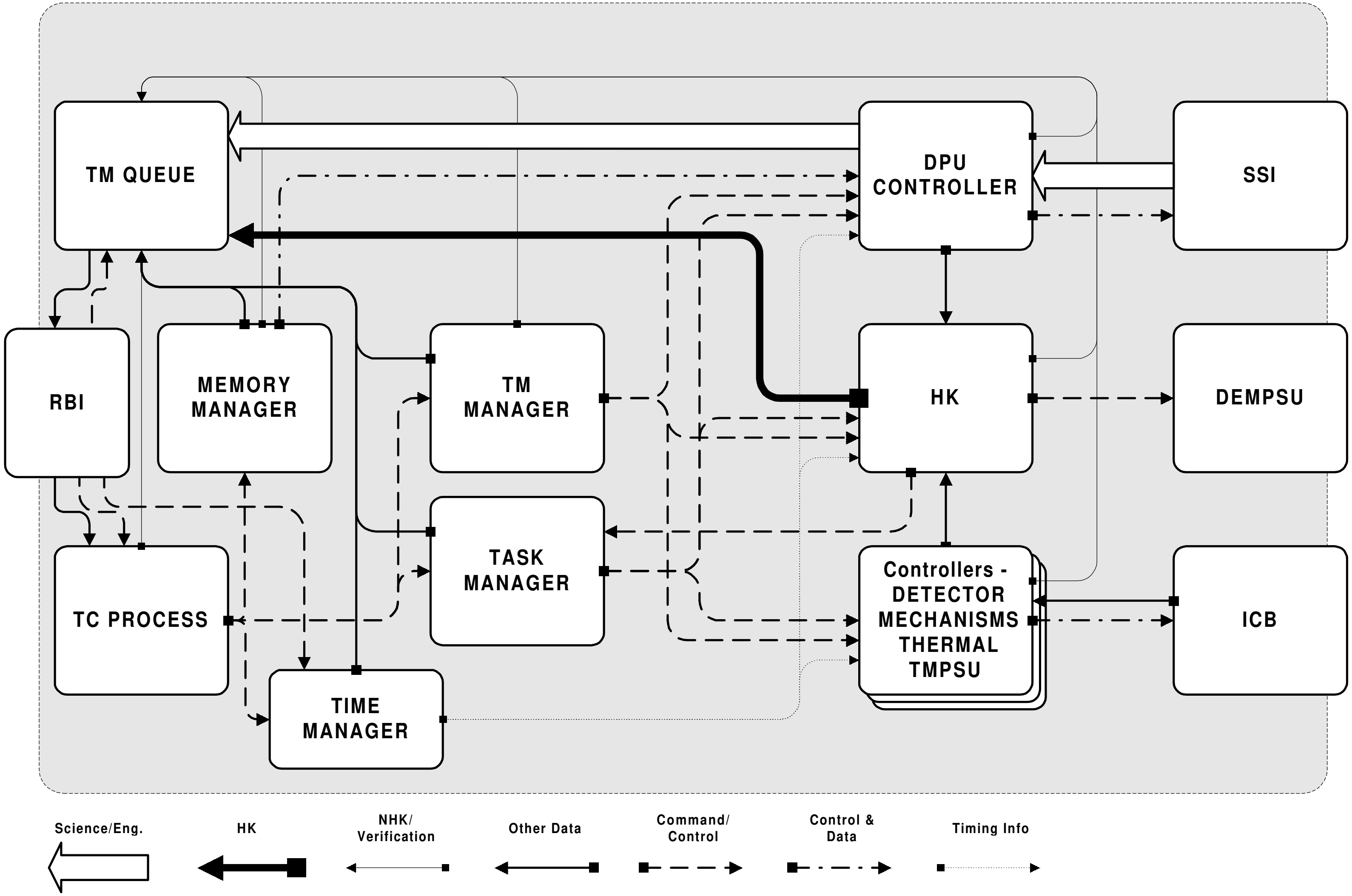
Code Address (hex)		Description
Start	End	
0	3FF	Bootstrap
400	3FFF	Basic Mode
3800	FFFF	Operational Mode

Data Address (hex)		Description
Start	End	
2C7	2D4	Bootstrap Deduced ICU Status
2F1	313	Bootstrap Filter Wheel Acceleration Table
3F2	3FD	Memory Loading Work Area
400	403	RBI Communications Area (CCA)
404	5F3	TC Queue
5F4	9FF	TM Queue
A00	A0A	RBI Code Work Area
A0B	A0B	SSI Code Work Area
FC0	FCF	DEBUG Area
1000	1B55	Basic Mode Operands
1C00	4A10	Operational Mode Operands
23A4	23DB	Focus Heater Settings as function of Filter Wheel
E900	FD00	Main Program Stack
FD01	FFFF	Interrupt Stack

XMM-OM ICU BASIC S/W OVERVIEW



XMM-OM ICU OPERATIONAL S/W OVERVIEW



2.3.3 DPU

2.3.3.1 Overview

APP-9 should be consulted for full details on the DPU operation. This document will confine itself to an overview.

The detector is a photon-counting system. Estimates of the count rate from the field (2e5/sec) imply that for a 1024 x 1024 format image, the bit rate would be 4 Mbit/second. This grossly exceeds the available data rate for XMM as a whole.

To compress this bit rate, the DPU software stores the images in an accumulating memory, for a time compatible with scientific objectives (typically 1000 seconds). However, the spacecraft attitude may drift by more than one imaging pixel on these time scales and produce image blurring. It is the primary goal of the DPU software to compensate for this.

A secondary requirement is to provide high time resolution data of a reduced set of scientific data. For example, some X-ray targets will have interesting intensity variations with time-scale much shorter than an image collection interval. The data is extracted for limited portions of the image on time scales from milliseconds to seconds. It must also provide engineering and housekeeping. In addition, the data is also compressed.

All data types are sent to the ICU for reformatting into packets.

The diagrams overleaf illustrate the main software components in each processor, their functionality in each DPU mode (Boot and DPUOS) and their inter-relationships.

2.3.3.2 Global RAM Map

The global ram is divided as follows:-

start (hex)	end (hex)	description	comment
0	7fff	PROC	
8000	fffff	big word memory	spilt in half for current and previous exposure
100000	3fffff	unused	
400000	5fffff	small word memory	ping-pong area for data acquisition and tracking
600000	6fffff		fast mode data store
700000	7fffff		compressed data store
800000	dfffff	unused	
e00000	~e10000	RAM program code area	white swap unit codes
e30000	~e31000		blue codes
e50000	~e53000		red codes
e70000	~e73000		white dpuos codes
e7ff00	e7ffff		loader lookup table
f00000	ffffff	ROM code area	Addresses at the very high end are reserved by Motorola

XMM-OM DPU FLIGHT S/W OVERVIEW

White DSP:

BOOT
DPUOS-w
White Tasks

Red DSP:

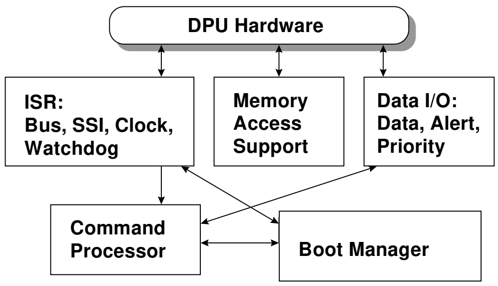
DPUOS-r
Red Tasks

Blue DSP:

ISRs
Blue Tasks

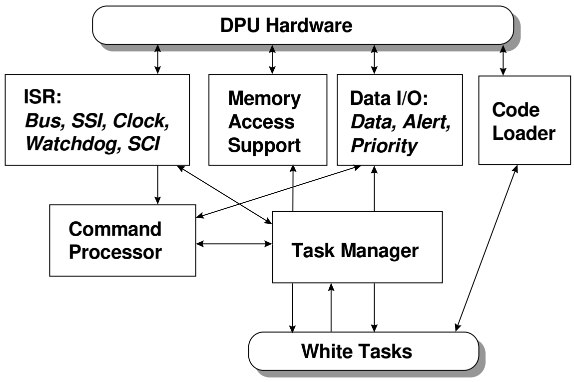
Each of the 4 processors (DSP) in the DPU (white, red, blue 1/2) has different software complement and functionality.

XMM-OM White DSP BOOT

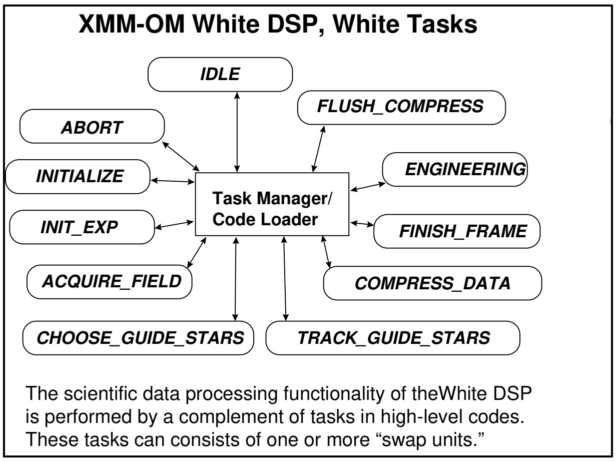


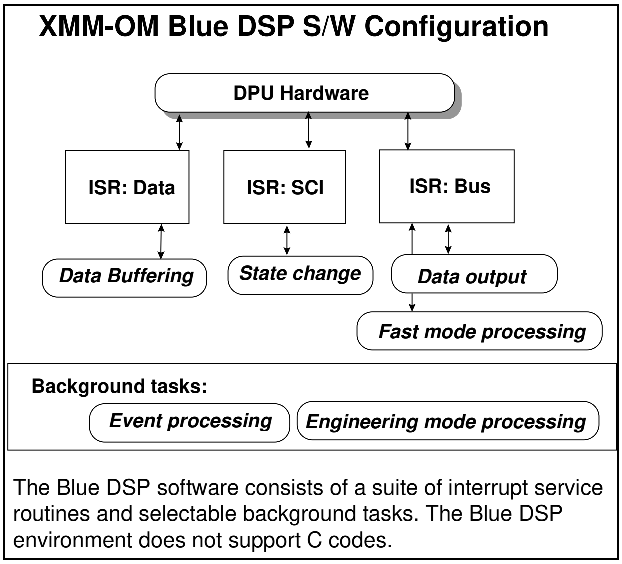
At power-on and reboot, the DPU is in the White DSP Boot state. It supports basic command processing and program upload.

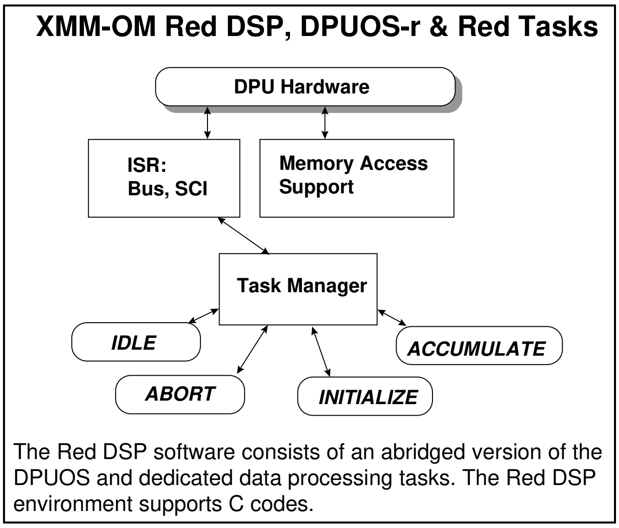
XMM-OM White DSP, DPUOS-w



Under normal operation, the White DSP is in the DPUOS state with full DPUOS functionality. The White DSP environment supports C codes.


XMM-OM White DSP, White Tasks
IDLE
FLUSH_COMPRESS
ABORT
INITIALIZE
ENGINEERING
Task Manager/
Code Loader
INIT_EXP
FINISH_FRAME
ACQUIRE_FIELD
COMPRESS_DATA
CHOOSE_GUIDE_STARS
TRACK_GUIDE_STARS
The scientific data processing functionality of theWhite DSP
is performed by a complement of tasks in high-level codes.
These tasks can consists of one or more “swap units.”


XMM-OM Blue DSP S/W Configuration
DPU Hardware
ISR: Data
ISR: SCI
ISR: Bus
Data Buffering
State change
Data output
Fast mode processing
Background tasks:
Event processing
Engineering mode processing
The Blue DSP software consists of a suite of interrupt service
routines and selectable background tasks. The Blue DSP
environment does not support C codes.


XMM-OM Red DSP, DPUOS-r & Red Tasks
DPU Hardware
ISR:
Bus, SCI
Memory Access
Support
Task Manager
IDLE
ACCUMULATE
ABORT
INITIALIZE
The Red DSP software consists of an abridged version of the
DPUOS and dedicated data processing tasks. The Red DSP
environment supports C codes.