EUROPEAN SPACE AGENCY

DIRECTORATE OF TECHNICAL AND OPERATIONS SUPPORT

XMM Science Operations Centre

# Optical Monitor

# Operational Procedures

# Handbook.

**XMM-SOC-TN-0010-SMD**

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# DOCUMENT APPROVAL

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# 1. INTRODUCTION

## 1.1. Purpose

This Technical note collates the Optical Monitor Operational procedure information known to date. This data will be used as the basis for generation of the IFOP. The note includes an outline of the Instrument Operating modes, the SOC Selectable Fixed configurations as selectable from the Proposal Handling system, and the maintenance requirements.

The note aims to outline the procedure details including the title, procedure objective and instrument pre-requisites for execution. Default set ups, and known Engineering/Calibration type tasks are documented.

## 1.2. Scope

The Technical note covers Nominal Operations: switch on, switch off, science observations and exposures, calibration observations and exposures, engineering tasks, orbit related configurations, Maintenance Operations, Contingency Operations, Commissioning and Performance Verification Operations.

The Technical note includes definition of Activities and Event Designators covering grouping, structure and links to the PHS defined Instrument modes. Annex A contains the command level procedures as output from the ESOC procedure writing tool.

## 1.3. Documentation

Applicable documents are as follows:

Reference document:

[1] User Requirement Specification XMM/OM/MSSL/SP/0030.02 22 Mar 95

[2] XMM-OM User Manual (EM)– XMM-OM/MSSL/SP/0005.1 22 Sep 97

[3] Integrated System Test procedure – XMM –OM XM-TP-DOR-0092 20 Jan 98

[4] OM EID Part B – RS-PX-0018 30 Oct 96

[5] Constraints on the OM Window Config. and Definition of the Default configurations: XMM-SP-TN-26 Iss 2.0 Apr 22 98

## 1.4. Acronyms

To be written

# 2. OPTICAL MONITOR OPERATING MODES

## 2.1. Instrument Operating Modes

This section provides an overview of the Instrument operating modes available from a mode transition point of view. The Instrument Operating Modes are as follows:

### 2.1.1. Initial

After Switch ON, OM autonomously enters the Initial state. This is the first point at which Telecommand and Telemetry are possible. ICU and DPU are in basic mode.

On exiting Initial mode, the remainder of the code for the ICU and DPU is loaded and the Thermal control system will switch to closed loop operation.

### 2.1.2. Safe

Two safe modes are commandable, Full Safe and Intermediate Safe Mode.

On entry to Full Safe Mode, the Blue Detector high voltage supply is switched OFF, no science data is acquired and the Filter wheels are rotated to the reference blocked position. Any backlog science data may be transmitted.

On entry to Intermediate Safe mode the Blue Detector high voltage supply is switched to 80%, no science data is acquired and the Filter wheels are rotated to the reference blocked position. Any backlog science data may be transmitted.

### 2.1.3. Idle

On entry into the Idle state the Blue Detector high voltage supply is activated. ICU commands the DPU to enter the Standby mode. In the Idle state OM will be configured as for the Science State. Filter wheels are now commandable. Full instrument capability is available, no science data is taken.

### 2.1.4. Science

Two Science Modes are available:

- Image Mode: Data is integrated for a time period known as the tracking frame time (<=20sec) into a tracking frame image. These tracking frame images are shifted to compensate for spacecraft pointing (in yaw and pitch) and summed into an accumulating image to produce a single integrated image covering the entire exposure.
- Fast Mode: Successive time slices of the image are not accumulated but stacked. Drift compensation is not carried out but is calculated and telemetered with the data.

### 2.1.5. Engineering and Calibration

The following Engineering and Calibration Modes exist:

- Raw Data
- Centroiding Data
- Full Frame, High Resolution
- Centroiding Confirmation Data
- Intensifier Characteristics data. (event height information)

**Raw Data Mode**: The Blue Detector transmits raw 24 bit event data from the detector as received by one or both of the blue DSPs. The DPU performs no address calculations. Data is limited by available memory and exposure duration. Data is padded at 32 bits and is not compressed

- Raw Data Blue DSP 1&2 -storage of each raw event as photon event list using both DSPs.
- Raw Data Blue DSP 1 - storage of each raw event as photon event list using DSP 1.
- Raw Data Blue DSP 2 - storage of each raw event as photon event list using DSP 2.

**Centroid Calculation (Channel Boundary + M,N Images)** : This mode is used to generate M, N arrays and derive the X and Y centroid Look Up Table (consisting of Channel/Centroid Table boundaries). Two sets of engineering data are generated from this mode:

- the m/n array which consists of two compressed 256x256 pseudo images.
- the Channel boundaries as derived from the m,n array data. Data consists of the channel boundaries scaled by a thousand. Boundaries are originally in the range –1.0 to +1.0, data supplied is in the range –1000 to 1000. Data set consists of 9, 16 bit, values for X channel boundaries and 9, 16 bit, values for the Y channel boundaries. Data is not compressed.

**Full Frame High Resolution:** This data consists of the compressed 2048x2048 pixels of a full frame high resolution image. The data is in column (y axis) order.

**Centroiding Confirmation:** This data consists of the compressed centroiding confirmation data. The full 2048 x 2048 field is divided (8x8) into 64 sub-images, each of 256x256 centroided pixels. Each sub image is modulo 8 binned (every 8 pixels summed in X and Y) to produce a set of 8x8 pixel pseudo images. The images and pixels within are column (y) ordered.

**Intensifier Characteristics:** This mode characterises the intensifier as seen by the CCD. This data consists of the compressed Event Height histogram generated as a 1x256 pseudo image.

### 2.1.6. OFF

OM Main power is OFF in this mode, KAL line is on. OM can only access the OFF Mode from the SAFE Mode.

## 2.2. SOC Selectable Fixed Configurations

This section describes the specific fixed configurations of the modes described above, selectable by Guest Observers and/or SOC from the Proposal Handling interface. These are the fixed configurations in which the instrument will nominally be operated in flight to execute OM Science exposure.

### 2.2.1. OM Science User Defined

The GO has the option to define at exposure level, exposure time, filter selection, science windows (up to five) sizes and window mode, binning factors and time slice duration.

### 2.2.2. GO OFF

GO may opt to specify OM OFF for part/all of an observation.

### 2.2.3. *Instrument* specific Image, Image/Fast

These modes allow the user to select a default configuration with a specific window focus (depending on the prime instrument RGS1,2, EMOS1,2, Epn, OM) and a choice of Image or Image plus Fast window. Each default configuration provides a suite of five exposures covering most of the FOV (92%). In all exposures a second small science window is located at the boresight of the prime instrument to ensure continuous coverage of the prime target The Image/Fast option provides an additional small Fast mode window at the boresight position of the selected prime instrument.

Note: As a result of boresight offsets, the central position of the small central window in the Image option and, the small central window plus small fast mode window in the Image/Fast option need to be defined in RA and DEC. On entry of OM exposures the user will need to define the Science Window centre in RA and DEC for window 2 in Image option and Windows 2 and 3 in Image/Fast option for each exposure.

The Image, Image/Fast options cover: EPIC M1 Image, Image/Fast, EPIC M2 Image, Image Fast, EPIC pn Image, Image Fast, RGS1 Image, Image Fast, RGS2 Image, Image Fast, OM Image, Image Fast.

### 2.2.4. Raw Data Blue DSP1, 2, 1&2

This mode is purely for science diagnostic data collection As defined in section 2.1.5 page 2.

### 2.2.5. Centroiding Data

As defined in section 2.1.5 page 2.

### 2.2.6. Full Frame

As defined in section 2.1.5 page 2.

### 2.2.7. Centroiding Confirmation

As defined in section 2.1.5 page 2.

### 2.2.8. Intensifier Characteristics

As defined in section 2.1.5 page 2.

### 2.2.9. Flatfielding

The Flatfielding mode covers the complete process to collect the OM Flatfield data. This mode will nominally be executed during slews greater than a predefined duration (currently TBD.) This mode may also be planned to be executed at other points in the orbit as an engineering exercise or during observations if no other OM exposures are being executed.

# 3. OM MAINTENANCE REQUIREMENTS - DESCRIPTION

## 3.1. Clock Re-Synchronisation

For the OM instrument the science data time stamps will always use the local copy of the Central On Board Time contained in the time register in the RBI within the Instrument Controller.

A copy of the most significant byte of the CDMU on-board time overwrites the corresponding byte of the instrument transmitted on board time. The RBI chip time (3 bytes + 1 byte fixed in memory) will therefore wrap around every approx. 6 months.

To overcome this a periodic Clock reset and Resynchronisation of the OM clock to the CDMU on-board time is required approx. every 6 months to reset the byte value fixed in RBI memory.

## 3.2. Dichroic Reconfiguration

Reconfiguration of the Dichroic allows the redundant detector to be put in position for use.

NOTE: USE OF THE DICHROIC IS RESTRICTED. RECONFIGRUATION OF THE DICHROIC ONLY TO BE EXECUTED UNDER INSTRUCTION/SUPPORT FROM PI, OM TEAM.

## 3.3. Individual Heater Setting

It is possible to specify the heater control parameters for the Main Interface, Forward Tube and Focusing Heaters (HTR1, HTR2, HT3, HTR4). HTR 1 and 2 will be used in flight to maintain the interface temperature, while HTR 3 and 4 will be used in flight to compensate for any focus shift that may occur after launch.

The parameter settings allow specification of heater control algorithm type i.e. Closed Loop/Open Loop, Free running/Synched, negative or positive focussing. Temperature Min/Max values may be set, On time, Cycle Time, Thermistor selection and Sample Time.

Positive focussing powers the HTR3 Metering Rod heater, negative focussing powers the HTR4 secondary mirror heater and for no focussing both HTR3 and HTR4 are OFF. This is the default.

The Individual Setting Heater Control, and the Heater Control (contingency) task cannot run in parallel. The Heater Control task is started automatically with default settings on switching to IC operational mode.

Note:
- Min Max values are set in "raw" thermistor units. (TBC what units these actually are.)
- On Time is the duration the heater spends powered in the Cycle Time – times are in units of Sample Time.
- Sample Time is in units of seconds in the range 1 through 20. 10 secs is the default.
- A thermistor value of 0 indicates the prime thermistor , a 1 indicates redundant.
- Focus direction may be set as Positive (>0), negative (<0) or no focussing (=0).

## 3.4. Heater Control

It is possible to specify the On/Off configuration of the Temperature control and Focusing heaters. This on/off configuration is used by the Heater Control Task. It allows direct setting of all allowable heater configurations for the Main Interface, Forward Tube, Metering Rods and Secondary Mirror

Use of this TC is restricted to Contingency scenarios only and will be detailed within a CRP. (Section 6.1). The Individual Setting Heater Control, and the Heater Control (contingency) task cannot run in parallel.

## 3.5. Software Maintenance

Software maintenance activities are foreseen to be executed on the IC and DPU code. IC is split into Operand/data space and ICU Instruction space. The DPU has eight DPU Program RAM banks numbered 0 to 7. Memory Checksums may be executed on the IC Operand Data space and on the ICU Instruction Space.

# 4. OM NOMINAL PROCEDURES

## 4.1. Switch On/Off

### 4.1.1. OM Full Switch On

**Objective**

This procedure covers the complete switch on of the OM instrument including all software loading. (DPU and ICU). The OM Full Switch on procedure covers the complete Switch On and software loads assuming state of KAL is unknown.

At Instrument switch ON the Electrical Substitution Heater are switched OFF.

Initial State: OM OFF, KAL unknown.
Final State: OM ON in IDLE mode

**Pre-Requisites**

OM Off . Instrument on-board software state unknown. KAL line lost, interrupted or status not known. Complete software loads required for ICU and DPU.

*It is currently foreseen to utilise the EM integrated Test procedure as a basis for the switch ON procedure. (High Voltage switch On details are required)*

### 4.1.2. OM Routine Switch On

**Objective**

Routine switch on of the OM instrument. The ICU flight software is held in RAM and made non-volatile by the KAL. DPU software will need to be loaded.

At Instrument switch ON the Electrical Substitution Heater are switched OFF.

Initially, in-orbit operations will execute a Memory Dump and compare (no load) of all memory areas maintained by KAL.

Initial State: OM OFF, KAL ON.
Final State: OM ON in IDLE mode

Pre-Requisites

OM Off. Instrument Controller Unit (ICU) Flight Software has been maintained by KAL.

*It is currently foreseen to utilise the EM integrated Test procedure as a basis for the switch ON procedure. (High Voltage switch On details are required)*

### 4.1.3. OM Switch Off

**Objective :**

Controlled switch OFF of the OM instrument. This procedure will be used to switch OM instrument OFF and switch the OM2 Prime and OM1 Electrical Substitution Heaters ON. Note: The spacecraft generated Eclipse signal also switches the OM2 Prime and OM1 Electrical Sub heaters ON, and OM2 Redundant DEM Electrical Sub heaters OFF

Initial State: OM ON in IDLE, Science or Eng/Cal Mode.
Final State: OM OFF, Substitution heaters ON.

**Pre-Requisites**

OM ON in IDLE, Science or Eng/Cal Mode.

*It is currently foreseen to utilise the EM integrated Test procedure as a basis for the switch OFF procedure.*

## 4.2. Instrument Science Observation and Exposure Operations

### 4.2.1. Start of Observation

**Objective**

OM Start Observation: Field Acquisition.

Execute the Start of observation activities, generate the Priority Field Acquisition data. This includes: definition of full coverage image in low resolution using the V-filter, loading of 16 reference stars, acquisition of field using the Acquire Field task.

An unsuccessful field acquisition will result in four iterations where less than 12 guide stars were found. In this event the offsets dx, dy and sin(theta) are set to zero.

Initial State: OM ON in IDLE.

Final State: OM ON in SCIENCE.

**Pre-Requisites**

Provided from PHS/SGS - Definition of up to 32 reference stars positions for relevant pointing in units of CCD Pixels, exposure ID. (Note: IC_LOAD REF Stars can take up to 32 stars, the DPU supports up to 32 guide stars, FAQ Priority Data report only handles 16 Guide Stars)

To be predefined in Commanding database (ED/TC Sequence/TCs) - definition of DPU Frame Time, duration of acquire field task to Stop Detector integration.

*It is currently foreseen to utilise the XMM-OM Example Command Sequences XMM-OM/MSSL/TC/0040.01 as a basis for this procedure.*

### 4.2.2. End of Observation

**Objective**

OM End Observation: Move Filter Wheel to Blocked

Execute the End of Observation tasks which includes setting the filter wheel to blocked and configuring OM DPU to IDLE.

Initial State: OM ON in SCIENCE.

Final State: OM ON in IDLE.

**Pre-Requisites**

n/a

*It is currently foreseen to utilise the XMM-OM Example Command Sequences XMM-OM/MSSL/TC/0040.01 as a basis for this procedure.*

### 4.2.3. Science Exposures User Defined

**Objective**

Complete operations to execute one exposure covering: Set up exposure, Choose Guide Stars and receive priority window data, Accumulate and Track, End Exposure.

Initial State: OM ON in SCIENCE.

Final State: OM ON in SCIENCE.

**Pre-Requisites**

Provided from PHS/SGS – Desired Filter wheel position, Exposure duration, Number of DPU Cycles, Number of frames, Science Window definitions, Memory window definitions, binning factors, fast mode science window sampling time and Memory area, exposure ID.

To be predefined in Commanding database (ED/TC Sequence/TCs) - duration of Choose Guide Star task to Stop Detector integration for the Choose guide stars

*It is currently foreseen to utilise the XMM-OM Example Command Sequences XMM-OM/MSSL/TC/0040.01 as a basis for this procedure.*

### 4.2.4. Science Exposures *Instrument* Image

**Objective**

Complete procedure to execute default exposures with a selected Prime instrument.

Each default configuration provides a suite of five exposures covering most of the FOV (92%). In all exposures a second small science window is located at the boresight of the prime instrument to ensure continuous coverage of the prime target.

Five consecutive exposures - Choose Guide Stars, Set up exposure, Accumulate and Track, End Exposure.

Initial State: OM ON in SCIENCE.

Final State: OM ON in SCIENCE.

**Pre-Requisites**

Provided from PHS/SGS – Desired Filter wheel position, Exposure time, exposure duration(frames), exposure ID, window centre in RA and DEC for Science window ( if boresight offset is to be accounted for) for each exposure (1 to 5.)

To be predefined in Commanding database (Activities/ED/TC Sequence/TCs) - duration of Choose Guide Star task to Stop Detector integration for the Choose guide stars, Number of DPU Cycles, Number of frames, Science Window definitions, Memory window definitions, binning factors, fast mode science window sampling time and Memory area.

*It is currently foreseen to utilise the XMM-OM Example Command Sequences XMM-OM/MSSL/TC/0040.01 and the Tech note Constraints on the OM window configuration …. XMM-PS-TN-28 Iss 2.0 dated April 22 98, as a basis for this procedure.*

### 4.2.5. Science Exposures *Instrument* Image/Fast

**Objective**

Complete procedure to execute default exposures with a selected Prime instrument.

Each default configuration provides a suite of five exposures covering most of the FOV (92%). In all exposures a second small science window is located at the boresight of the prime instrument to ensure continuous coverage of the prime target. The Image/Fast option provides an additional small Fast mode window at the boresight position of the selected prime instrument.

Five consecutive exposures - Choose Guide Stars, Set up exposure, Accumulate and Track, End Exposure.

Initial State: OM ON in SCIENCE.

Final State: OM ON in SCIENCE.

**Pre-Requisites**

Provided from PHS/SGS – Desired Filter wheel position, Exposure time, exposure duration(frames), exposure ID, window centre in RA and DEC for Science window 2 and 3 ( if boresight offset is to be accounted for) for each exposure (1 to 5).

To be predefined in Commanding database (Activities/ED/TC Sequence/TCs) - duration of Choose Guide Star task to Stop Detector integration for the Choose guide stars, Number of DPU Cycles, Number of frames, Science Window definitions, Memory window definitions, binning factors, fast mode science window sampling time and Memory area.

*It is currently foreseen to utilise the XMM-OM Example Command Sequences XMM-OM/MSSL/TC/0040.01 and the Tech note Constraints on the OM window configuration …. XMM-PS-TN-28 Iss 2.0 dated April 22 98, as a basis for this procedure.*

## 4.3. Instrument Engineering/Calibration Exposure Operations

### 4.3.1. Raw Data Mode (Blue DSP 1 & 2)

**Objective**

Execute a complete Raw data Mode exposure using both Blue DSPs. Engineering operation is executed by using the DPU Task 'IC_ENBL_ENG' Mode 0.

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

*Detailed Procedure to be defined.*

### 4.3.2. Raw Data Mode (Blue DSP 1)

**Objective**

Execute a complete Raw data Mode exposure using Blue DSP 1. Engineering operation is executed by using the DPU Task 'IC_ENBL_ENG' Mode 1.

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

*Detailed Procedure to be defined.*

### 4.3.3. Raw Data Mode (Blue DSP 2)

**Objective**

Execute a complete Raw data Mode exposure using Blue DSPs 2. Engineering operation is executed by using the DPU Task 'IC_ENBL_ENG' Mode 2.

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

*Detailed Procedure to be defined.*

### 4.3.4. Centroiding Data

**Objective**

This procedure calculates the centroiding table channel boundaries by enabling the centroiding data engineering task. Engineering operation is executed by using the DPU Task 'IC_ENBL_ENG' Mode 3. The following TM will be generated M/N Images, Channel Boundary Data.

This procedure needs to be executed at least once per orbit. The Centroiding LUT is calculated on board and loaded internally from the DPU to the Detector, as well as being telemetered to ground.

Note: The Centroid table boundaries may also be uplinked by Telecommand.

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

*Detailed Procedure to be defined.*

### 4.3.5. Full Frame.

**Objective**

This procedure generates engineering Full frame data by enabling the Full Frame, High Resolution engineering task. Engineering operation is executed by using the DPU Task 'IC_ENBL_ENG' Mode 4. The following data is generated in this mode: Full frame, high resolution image (8 detector pixels per CCD pixel, yielding a 2048x2048 image).

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

*Detailed Procedure to be defined.*

### 4.3.6. Centroiding Confirmation

**Objective**

This procedure generates engineering Centroiding Confirmation data by enabling the Centroiding confirmation data engineering task. Engineering operation is executed by using the DPU Task 'IC_ENBL_ENG' Mode 5. The following data is generated in this mode: Compressed centroiding confirmation data – pixel counts for 8x8 modulo 8 folded image.

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

*Detailed Procedure to be defined.*

### 4.3.7. Intensifier Characteristics

**Objective**

Procedure objective is to characterise the intensifier as seen by the CCD. This is executed by illuminating the detector with an even source of illumination i.e. flat fielding. An image is taken and DPU processing searches for event peaks. Data consists of the compressed Event Height histogram generated as a 1x256 pseudo image.

This data is used for optimising the performance of the detector. The intensifier gain is adjusted based on these figures to ensure the peak of the pulse height distribution is at an optimum level i.e. that the photon events are still above the detector detection threshold. This is done by changing the EHT voltages applied to the detector. If the MCP voltage has to be adjusted, and is set to a higher voltage, this will change the relevant parameter in the post perigee/eclipse (TBC) procedure.

This procedure generates engineering Intensifier characteristic data by enabling the Intensifier Characteristic data engineering task. Engineering operation is executed by using the DPU Task 'IC_ENBL_ENG' Mode 6.

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

*Detailed Procedure to be defined.*

### 4.3.8. Flatfielding

**Objective**

This procedure defines the flatfielding operations during slews.

Low resolution Flatfielding Data Acquisition will be the default operating mode during slews. This configuration will only be invoked by the planning system if the slew exceeds a predefined duration. If the slew duration does not exceed the allocated time for the flatfielding procedure, no activities are invoked by the planning system and the OM DPU will remain in the IDLE mode for the duration of the slew. If the slew duration exceeds the allocated time for the flatfielding procedure, the flatfielding activities are executed. For longer duration slews, more than one flatfielding may be scheduled depending on time available.

As a working baseline the OM slew ED will consist of 30 minute data acquisition with subsequent 10 minute data downlinking. Note downlinking figures are only applicable if a higher TM rate is allocated to OM.

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

**Pre-Requisites**

Flatfielding task duration and Event Designator ID to be set in the SGS planning system to allow automated scheduling of slew activities.

*Procedure outline covers :*
*30 minutes of data acquisition.*
*10 minutes of data downlink (TBC if this is during the following observation or part of slew time?)*
*The flush DPU data compression queue for the data from the last exposure is triggered implicitly by start of the data acquisition for the flatfielding exposure. It is desirable to allocate a higher TM rate to OM during the slews i.e. 8 bps. Selection of the ideal BRAT from the existing set is limited as: the EPIC RM is foreseen to be operated in Fast mode during slews, RGS wishes to execute flatfielding and the EPICs may execute a TBD operating mode. The programmable BRAT may have to be utilised to allow optimum bit rate allocation for all instruments.*

*Detailed Procedure to be defined.*

## 4.4. Configure for Orbit Phases

### 4.4.1. Concept for Executing Flush Compress

OM's process of taking exposures and downlinking the exposure data is unique in that the current exposure (Exp n) is executed while the data taken from the previous exposure (Exp n-1) is being downlinked. The triggering of this downlinking of data for Exp n-1 is automatically executed within the DPU on start of Exp n. This implies that at the end of an observation, the last exposure will not be downlinked until the first exposure of the following observation (or slew flatfielding) is executed.

The following is proposed to cover executing of the Flush compress and downlinking of the last exposure of the last observation in an orbit.

Considering a single orbit:

- At the end of an observation (within the orbit) the last exposure Flush compress and Flush Queue will be triggered by the start of the Slew Flatfield exposure OR the first Exposure of the following observation.
- For the last exposure of the last Observation within the orbit it is proposed to execute the Flush compress and Flush Queue at the end of the OM Science Window using the PSF event "OM Instrument Science Window End". By using this PSF Event flag the Observation period is completed cleanly for each orbit, ensuring all exposure data is down linked within an orbit.

For the period between End Instrument Science Window and Start Instrument Deactive Window, OM engineering activities may be executed. These activities should be self contained such that if flatfields etc. are taken, the exposure Flush compress and Flush Queue command for the last exposure are included.

Using this as a baseline the Preparation for Perigee/Eclipse will be from a known point i.e. all exposure data stored on-board has already been downlinked.

### 4.4.2. Pre Perigee

**Objective**

This procedure configures OM for Perigee passage. OM will be configured to Intermediate Safe Mode for the duration of the Perigee passage. The Blue Detector high voltage supply is switched to 80%, the Filter wheels are rotated to the reference blocked position and no science data is acquired. The above re-configuration is executed using a single Telecommand.

This procedure is triggered during the PSF defined DEACTIVE window marked by the event "DEACTIVE_OPEN".

A time tagged "Goto Intermediate Safe Mode" is loaded onboard 36 hours prior to perigee to ensure correct configuration of OM for the Perigee pass in the event of unexpected LOS For nominal scenarios the Instrument configuration for Perigee passage is executed under ground control and the time tagged command deleted.

Initial State: OM ON in IDLE.

Final State: OM ON in INTERMEDIATE STANDBY.

*Detailed Procedure to be defined.*

### 4.4.3. Post Perigee

**Objective**

This procedure configures OM for operations Post Perigee passage.

To check for SEU the on board memory images are dumped and compared to ground held images. During the initial phases of the mission the Onboard software for the DPU (250kb) and ICU (64 kwords) will be routinely dumped post perigee and compared with the software images as stored on ground. This process is executed in the MOC using the On Board Software Maintenance system (OBSM). The OBSM has the latest instrument software images held in a library. The dump is commanded manually and a comparison can be automatically executed. Any differences are flagged. The OBSM can uplink patches to the onboard code to correct the flagged delta areas using the library image.

The altitude at which OM High Voltage may be switched to 100% depends on the radiation environment. Height at which switch on may occur is currently under review. The Instrument Active window is currently linked to the AOS post Perigee. The Start of Science operations is linked to altitude however this marks the height at which Science Observations may occur – OM should be fully configured for operations at this point. Depending on the outcome of the review at which height OM HV may be switched to 100%, the trigger to plan OM Post Perigee activities can be selected.

Reconfiguration is timed with the PSF window defined by ACTIVE_OPEN/ACTIVE_CLOSE. (TBC on OM HV issue)

The Centroiding table boundaries LUT are updated at this point using the procedure as defined in paragraph 4.3.4 Centroiding Data, Page 10. The LUT update procedure will consist of a single iteration. Evaluation criteria for the centroid confirmation data are TBD.

Initial State: OM ON in INTERMEDIATE STANDBY.

Final State: OM ON in IDLE.

*Procedure Outline covers:*

- *Memory dump and comparison of DPU program code.*
- *Memory dump and comparison of ICU program code.*
- *Load code deltas if differences were found.*
- *Transition from Intermediate Safe to Idle Mode – ramp up the HV to 100%*
- *Centroiding table boundaries Look up table update (assume one iteration) –*
- *Time verification (TBC)*

*Detailed Procedure to be defined.*

### 4.4.4. Slew Operations

**Objective**

The default operation during slews is to execute Low resolution flatfield data acquisition. This procedure defines these default slew operations.

The Flatfielding procedure is invoked by the planning system if the slew exceeds a predefined duration. Flatfielding will be repeated x times depending on the length of the slew.

Initial State: OM ON in IDLE.

Final State: OM ON in IDLE.

*Procedure Outline covers:*

- *30 minute data acquisition.*
- *Optimise bit rate allocation.*
- *10 minute data dowlinking.*
- *Return to nominal bit rate allocation.*

*Detailed Procedure to be defined.*

### 4.4.5. Pre Eclipse

**Objective**

This procedure defines the pre-eclipse operations.

OM is switched OFF for the eclipses. The switch OFF procedure is as defined in section 4.1.3 OM Switch Off page 7.

The switch OFF procedure switches OM OFF and switches the OM1 and OM2 Prime Electrical Substitution Heaters ON. The Eclipse signal also switches OM1 and OM2 Prime Electrical Sub heaters ON, and OM2 Redundant DEM Electrical Sub heaters OFF

Reconfiguration is timed with the PSF window defined by DEACTIVE_OPEN/DEACTIVE_CLOSE.

Initial State: OM ON in IDLE.

Final State: OM OFF.

*Procedure Outline covers:*

- *Instrument Switch OFF.*

*Detailed Procedure to be defined.*

### 4.4.6. Post Eclipse

**Objective**

This procedure defines the Post- Eclipse operations.

The Blue Detector High Voltage requires a stabilisation period of several hours before observations can be executed. To attempt to optimise the observation efficiency it is desirable to switch ON the OM into Intermediate Safe State as soon as possible post eclipse.

For the orbital configuration with Eclipse before perigee passage, the first stage of the Post Eclipse procedure i.e. Switch On into Intermediate Safe Mode can be executed before entry into Perigee (assuming there is sufficient duration TM/TC contact), the remainder of the procedure is executed Post perigee passage.

For the orbital configuration with Eclipse after perigee passage, the complete Post perigee procedure is executed Post Perigee.

The feasibility of executing this split operation type is being considered by MOC. TBC how many commands to switch into Intermediate state, feasibility of time tagging this type of TC.

Complete reconfiguration will be timed with the PSF window defined by ACTIVE_OPEN / ACTIVE_CLOSE.

Initial State: OM OFF.

Final State: OM ON in IDLE.

*Procedure Outline covers:*

- *Instrument Switch ON into intermediate state.*
- *Wait for TBD time for HV to stabilise*
- *Load and dump DPU and ICU code*
- *Transition from Intermediate Safe to Idle Mode (ramp up the HV)*
- *Centroiding table boundaries Look up table update (assume one iteration) –*

*Detailed Procedure to be defined*

### 4.4.7. Pre Apogee Gap

**Objective**

This procedure defines the Pre Apogee Gap operations.

OM should be configure into Idle mode for the Apogee Gap.

Initial State: OM ON in SCIENCE.

Final State: OM ON in IDLE.

### 4.4.8. Post Apogee Gap

**Objective**

No special operations were identified for Post Apogee gap. Normal operations can restart after the apogee gap.

### 4.4.9. End of Science

**Objective**

This procedure defines the activities to occur at the end of the OM Science Window.

Based on the need to command the FLUSH_Compress for the last exposure of the last observation in an orbit, as highlighted in section 4.4.1, this procedure defines the procedure to execute the Flush Compress.

The Science Window is defined by the PSF event *INSTRUMENT_*START and *INSTRUMENT_*END. The OM_END flag would be used to trigger this activity.

NOTE: it is currently TBD whether the SGS will allow the SOC to tag operations to the OM_END PSF event or if this needs to be done at PSF generation by the Flight Dynamic System in MOC. There is an additional option to trigger the Final Flush Compress command to the LATEST_DATA PSF flag (which actually coincides with DEACTIVE_OPEN). This affects the assumptions made in Section 4.4.1.

*Detailed Procedure to be defined*

# 5. MAINTENANCE PROCEDURES

## 5.1. Clock Re-synchronisation

**Objective**

Re-synchronisation of the instrument clock to the central OBDH clock is required every approx. 6 months.

Initial State: OM ON in IDLE or SAFE.

Final State: OM ON in IDLE or SAFE

**Pre-Requisites**

Observation or exposure completed and OM in IDLE or SAFE mode.

*Procedure Outline covers:*
*Command CDMU to synchronise OM clock.*
*Command CDMU to verify OM time.*
*Compare time packets received on ground.*
*DPU to be synchronised against the ICU.*

*Detailed Procedure to be defined*

## 5.2. Dichroic Reconfiguration

**Objective**

Rotate Dichroic clockwise or anticlockwise.

Initial State: OM ON in IDLE or SAFE.

Final State: OM ON in IDLE or SAFE

**Pre-Requisites**

OM PI and team support for this operation. Dichroic is a limited life time device.

*Detailed Procedure to be defined*

## 5.3. Individual Heater Switching

**Objective**

Procedure to allow specification of the heater control parameters for OM Heaters HTR1, HTR2, HTR3 and HTR4

**Pre-Requisites**

Observation or exposure completed and OM in IDLE mode.

*Procedure Outline covers:*
*Stop heater Control Task.*
*Load Heater parameters.*
*Start Heater Control Task.*

*Detailed Procedure to be defined*

## 5.4. Software Maintenance

**Objective**

To support update of the IC and DPU code. Procedure covers Load, Dump and compare of the appropriate memory areas using the MOC based OBSM system.

**Pre-Requisites**

ISS support is needed to generate the updated IC and/or DPU memory images These images are sent to the MOC On board Software maintenance system where they are prepared for uplink. Complete images of the IC, DPU code areas are transferred to MOC – no patches to code are used.

*Detailed Procedures to be defined*

# 6. CONTINGENCY PROCEDURES

## 6.1. Emergency procedure

These are the emergency procedures concerning Instrument health and safety as executed from the MOC. These emergency procedures will be triggered by Instrument Housekeeping alarms or MOC specific failure events e.g. spacecraft failures.

OM has two different safe modes, namely the Full Safe and the Intermediate Safe mode. The Full Safe mode is triggered by DNEL or ESAM messages issued by the spacecraft. The Intermediate Safe mode is used during routine operations during Perigee passage.

NOTE: As a result of incompatibilities between the spacecraft issued OM goto Safe Mode and the OM Goto Safe Mode as expected by the instrument, a problem may arise in the scenario where OM is in its Basic Mode (i.e. immediately after booting) and a Goto Safe Mode is issued by the spacecraft. The Goto Safe Mode telecommand will be rejected by OM as a result of the incompatible command lengths. As a result of this OM should not be left for extended periods in the Initial Mode.

*Procedure details TBD*

## 6.2. SOC Change Requests

These procedures are triggered by alarms received in the PMS or QLA. These alarms may result in the need to generate SOC change requests e.g. as a result of Count rate alarms a change in filter or instrument threshold settings may be required.

*Procedure details TBD*

# 7. FIRST IN-ORBIT SWITCH ON

The following list defines in outline the activities to be executed in orbit for the First Switch On and the appropriate engineering tests to be executed (no Science images – these are executed in the Commissioning phase.). Full details of these procedures are TBD.

Initial switch on procedure is foreseen to cover:

- Instrument switch on
- Perform Initial checks of instrument
- Upload software – Flight software is held in RAM and will therefore need uploading after initial switch on.
- Perform checks (extent of checks TBD)
- Start thermal control heating, inclusive of heater control test.
- Open Telescope door
- Switch MCP High Voltage On
    - Go to intermediate safe mode
    - Go to Idle Mode
    - Functional check out of detector consisting of a sequence of engineering tests

# 8. COMMISSIONING PROCEDURES

## 8.1. Functional Check Out

Functional check out procedures aim to demonstrate that the instrument and its interfaces are working together as an integral part of the spacecraft by verifying all experiment functions, its performance, and the functional interfaces.

List extracted from IST procedure list as executed at DORNIER, document Integrated System Test Procedure for the XMM Experiment OM - XM-TP-DOR-0092 20 Jan 98

Note: the IST defined Image execution procedures do not exercise the nominal in flight imaging. New procedures will be required for the in-flight Functional tests. Dichroic Control test will not be executed in flight.

### 8.1.1. Switch On prime

Switch on procedure for OM Prime.

Procedure covers: Switch-ON prime and check for Housekeeping data.

Initial State: OM is switched OFF

Final State: OM is switched ON and in Basic Mode.

### 8.1.2. Basic Mode Test

The function of the OM is tested in the basic mode without loading the main application software.

Procedure covers: Dump IC memory and verify the operation of the KAL memory.

Initial State: OM Prime is switched ON and in Basic Mode.

Final State: OM Prime is switched ON and in Basic Mode.

### 8.1.3. Operational Mode Test

The function of the OM is tested.

Procedure covers: Switch on secondary rail of OM-1 and test operation. Test operation of the DPU.

Initial State: OM Prime is switched ON and in Basic Mode.

Final State: OM Prime is switched ON and in Operational Mode. Secondary power ON.

### 8.1.4. Filter Wheel Control Test

The function of the Filter Wheel is tested in operational mode.

Procedure covers: Command search for coarse sensor, command search for datum position.

Initial State: OM Prime is switched ON and in Operational Mode.

Final State: OM Prime is switched ON and in Operational Mode with filter wheel in datum position.

### 8.1.5. Heater Control Test

The function of the heaters is tested in operational mode.

Procedure covers: Each of the four main heaters are cycled On/Off in turn.

Initial State: OM Prime is switched ON and in Operational Mode.

Final State: OM Prime is switched ON and in Operational Mode.

### 8.1.6. Image Acquisition Test – Multiple Window

The function of the Image acquisition is tested in operational mode.

*The IST reference procedure should be updated to reflect in-flight image acquisition method?*

Procedure covers: A multiple window image will be acquired and dumped.

Initial State: OM Prime is switched ON and in Operational Mode.

Final State: OM Prime is switched ON and in Operational Mode.

### 8.1.7. Image Acquisition Test – Full Frame

Function of the Image acquisition Full frame is tested in operational mode.

*The IST reference procedure should be updated to reflect in-flight image acquisition method?*

Procedure covers: A single window full frame image will be acquired and dumped.

Initial State: OM Prime is switched ON and in Operational Mode.

Final State: OM Prime is switched ON and in Operational Mode.

### 8.1.8. Switch Off prime

Procedure covers: Mode and state check and orderly switch off of the OM.

Initial State: OM Prime is switched ON and in Operational Mode. Secondary power ON.

Final State: OM Prime is switched OFF. KAL ON.

## 8.2. Performance Verification and Calibration Procedures

Inputs/procedure definitions needed.

# 9. LIST OF TELECOMMAND SEQUENCES

## 9.1. Introduction

This list aims to cover all the required default Telecommand Sequences. These sequences will be used as building blocks for the Event Designators. Event designators will be grouped to form the Activities. Command Sequence and EDs will be reference in the FCPs and CRPs.

## 9.2. Basics

| | |
|---|---|
| HS 0001 | OM Prime Power ON |
| HS 0501 | OM Redundant Power ON |
| HS 0030 | OM Prime OFF |
| HS 0530 | OM Redundant OFF |

## 9.3. Mechanical

| | |
|---|---|
| HS 6000 | Move Filter to Blocked |
| HS 6001 | Move Filter to Selected Filter. |
| HS 6002 | Move Filter to V Filter |
| HS 6500 | Dichroic ops |

## 9.4. Thermal

| | |
|---|---|
| HS4200 | Heater Control |

## 9.5. S/W Maintenance

## 9.6. Test/Analysis Modes

| | |
|---|---|
| HS 4000 | Load Centroid Table |

## 9.7. TM Management

## 9.8. Mode Transitions

| | |
|---|---|
| HS 1000 | Goto Initial |
| HS 1010 | Goto Safe |
| HS 1020 | Goto Idle |
| HS 1030 | Goto Science |
| HS 1040 | Goto Engineering |

## 9.9. Instrument Configuration

| | |
|---|---|
| HS 1100 | OM Acquire Field |
| HS 1110 | Full Win Low Res. |
| HS 1120 | Setup Exposure |
| HS 1130 | Choose Guide Stars |
| HS 1140 | Accumulate and Track |
| HS 1150 | End Exposure |
| HS 1160 | Load Reference Stars |
| HS 1200 …99 | Load Science Windows |
| HS 1300 …99 | Load Memory Windows |

# 10. LIST OF ACTIVITIES AND EVENT DESIGNATORS

**(note: Activities may be nested to one level, EDs no nesting allowed)**

| INSTRUMENT MODE (as selected in Proposal) | Procedure Number | Comments | ACTIVITIES | | Event Designators | Telecommand Sequences |
|---|---|---|---|---|---|---|
| | FCP-OPM-1000 | Low Res Full Frame – V Filter | START OBS | | OM FIELD ACQUISITION | HS6002<br>HS1110<br>HS1160<br>HS1100 |
| | | | | | | |
| | FCP-OPM-1010 | Filter Wheel to Blocked | END OBS | | GOTO IDLE | HS6000<br>HS1020 |
| | | | | | | |
| GO OFF | FCP_OPM_0003 | | GO OFF | | GOTO IDLE | HS6000<br>HS1020 |
| | | | | | | |
| Science User Defined | FCP_OPM_1020 | **Single Exposure** | SCI USR DEF | | SETUP FILTER WHEEL | HS6001 |
| | | | | | SETUP CHOOSE GUIDE STARS | HS1110 |
| | | | | | SETUP EXPOSURE | HS1120<br>HS1200<br>HS1300 |
| | | | | | EXEC. CHOOSE GUIDE STARS | HS1130 |
| | | | | | ACC AND TRACK | HS1140 |
| | | | | | END EXPOSURE | HS1150 |
| | | | | | | |
| EPIC M1 IMAGE | FCP_OPM_1101 | **Set of five exposures** | EPIC M1 IMAGE | | | |
| | | Start Offset - 0 seconds | | EXP1 | SETUP FILTER WHEEL | HS6001 |
| | | Start Offset – 300 seconds (TBD) | | | SETUP CHOOSE GUIDE STARS | HS1110 |
| | | Start Offset – 300 seconds (TBD)<br>Window ID 1,2 predefined sizes [1] | | | SETUP EXPOSURE 1 | HS1120<br>HS1201<br>HS1301 |
| | | Start Offset – 300 seconds (TBD) | | | EXEC. CHOOSE GUIDE STARS | HS1130 |

[1] To account for different Instrument Boresight offsets the Window 2 may be defined with the Target RA and DEC values of the Prime Instrument. The RA and DEC of the Prime instrument must be entered at Proposal entry level as the Science Window Centre for Science Window 2 in each exposure. The RA, DEC values are converted to CCD Pixels by the SGS when the observation is planned.

| INSTRUMENT MODE (as selected in Proposal) | Procedure Number | Comments | ACTIVITIES | | Event Designators | Telecommand Sequences |
|---|---|---|---|---|---|---|
| | | Start Offset – 300 seconds (TBD) | | | ACC AND TRACK | HS1140 |
| | | Start Offset – EXP DUR (from Proposal) | | | END EXPOSURE | HS1150 |
| | | | | | | |
| | | Start Offset - 5 seconds (TBD) | | EXP2 | SETUP CHOOSE GUIDE STARS | HS1110 |
| | | Start Offset – 300 seconds (TBD)<br>Window ID 1,2 predefined sizes | | | SETUP EXPOSURE 2 | HS1120<br>HS1202<br>HS1302 |
| | | Start Offset – 300 seconds (TBD) | | | EXEC. CHOOSE GUIDE STARS | HS1130 |
| | | Start Offset – 300 seconds (TBD) | | | ACC AND TRACK | HS1140 |
| | | Start Offset – EXP DUR (from Proposal) | | | END EXPOSURE | HS1150 |
| | | | | | | |
| | | Start Offset - 5 seconds (TBD) | | EXP3 | SETUP CHOOSE GUIDE STARS | HS1110 |
| | | Start Offset – 300 seconds (TBD)<br>Window ID 1,2 predefined sizes | | | SETUP EXPOSURE 3 | HS1120<br>HS1203<br>HS1303 |
| | | Start Offset – 300 seconds (TBD) | | | EXEC. CHOOSE GUIDE STARS | HS1130 |
| | | Start Offset – 300 seconds (TBD) | | | ACC AND TRACK | HS1140 |
| | | Start Offset – EXP DUR (from Proposal) | | | END EXPOSURE | HS1150 |
| | | | | | | |
| | | Start Offset - 5 seconds (TBD) | | EXP4 | SETUP CHOOSE GUIDE STARS | HS1110 |
| | | Start Offset – 300 seconds (TBD)<br>Window ID 1,2 predefined sizes | | | SETUP EXPOSURE 4 | HS1120<br>HS1204<br>HS1304 |
| | | Start Offset – 300 seconds (TBD) | | | EXEC. CHOOSE GUIDE STARS | HS1130 |
| | | Start Offset – 300 seconds (TBD) | | | ACC AND TRACK | HS1140 |
| | | Start Offset – EXP DUR (from Proposal) | | | END EXPOSURE | HS1150 |
| | | | | | | |
| | | Start Offset – 5 seconds (TBD) | | EXP5 | SETUP CHOOSE GUIDE STARS | HS1110 |
| | | Start Offset – 300 seconds (TBD)<br>Window ID 1,2 predefined sizes | | | SETUP EXPOSURE 5 | HS1120<br>HS1205<br>HS1305 |
| | | Start Offset – 300 seconds (TBD) | | | EXEC. CHOOSE GUIDE STARS | HS1130 |
| | | Start Offset – 300 seconds (TBD) | | | ACC AND TRACK | HS1140 |
| | | Start Offset – EXP DUR (from Proposal) | | | END EXPOSURE | HS1150 |
| | | Start Offset – 10 seconds (TBD)<br>Move Filter Wheel to Blocked | | END OBS | GOTO IDLE | HS6000<br>HS1020 |

| **INSTRUMENT MODE (as selected in Proposal)** | **Procedure Number** | **Comments** | **ACTIVITIES** | | **Event Designators** | **Telecommand Sequences** |
|---|---|---|---|---|---|---|
| | | | | | | |
| EPIC M1 IMAGE/FAST | | *Same set up as for EPIC M1 Image. Windows ID 1,2 and 3 predefined sizes.* [2] | | | | |
| EPIC M2 IMAGE | | *Same set up as for EPIC M1 Image.* | | | | |
| EPIC M2 IMAGE/FAST | | *Same set up as for EPIC M1 Image. Windows ID 1,2 and 3 predefined sizes.* | | | | |
| EPIC pn IMAGE | | *Same set up as for EPIC M1 Image.* | | | | |
| EPIC pn IMAGE/FAST | | *Same set up as for EPIC M1 Image. Windows ID 1,2 and 3 predefined sizes.* | | | | |
| RGS1 IMAGE | | *Same set up as for EPIC M1 Image.* | | | | |
| RGS1 IMAGE/FAST | | *Same set up as for EPIC M1 Image. Windows ID 1,2 and 3 predefined sizes.* | | | | |
| RGS2 IMAGE | | *Same set up as for EPIC M1 Image.* | | | | |
| RGS2 IMAGE/FAST | | *Same set up as for EPIC M1 Image. Windows ID 1,2 and 3 predefined sizes.* | | | | |
| OM IMAGE | | *Same set up as for EPIC M1 Image.* | | | | |
| OM IMAGE/FAST | | *Same set up as for EPIC M1 Image Windows ID 1,2 and 3 predefined sizes.* | | | | |
| | | | | | | |
| | | | | | | |

[2] To account for different Instrument Boresight offsets the Window 2, and 3 may be defined with the Target RA and DEC values of the Prime Instrument. The RA and DEC of the Prime instrument must be entered at Proposal entry level as the Science Window Centre for Science Window 2 and 3 in each exposure. The RA, DEC values are converted to CCD Pixels by the SGS when the observation is planned.

# ANNEX A – PROCEDURE LISTINGS