XMM Optical Monitor

MULLARD SPACE SCIENCE LABORATORY
UNIVERSITY COLLEGE LONDON

Authors: Philip J. Smith, Matthew C. R. Whillock, Howard E. Huckle, Jeonghee Rho, Rudi Much, Kate G. Adamson

---

XMM-OM USER MANUAL (FM) - PART 2
Experiment Operations Procedures

DOCUMENT: XMM-OM/MSSL/ML/0009.01 December 23, 1998

CHANGE RECORD

Issue	Date	Changes
0	30-Oct-98	Draft version
1	23-Dec-98	Added wait for Fred. Added ICU mode information at beginning and end of procedures. Added ICU mode change diagram. Corrected window table. Added missing mem window and sci window load tables. Added prime hvon sequence. Added idle before intermediate safe on time-tagged command. Changed timings. Changed the LUT update. Added stop integration commands. Added BPE binning commands. Added flood LED commands to flat-field. Changed frame_time units.

Contents

List of Tables

List of Figures

1 Introduction

This is the Experiment Operations Procedures Manual for ^{XMM}OM . It specifies the telecommands to send and telemetry to watch for when performing routine and other ^{XMM}OM procedures.

2 Reference Documents

- **XMM-OM/MSSL/ML/0010** ^{XMM}OM User Manual Part 3: Telecomand and Telemetry Specification
- **XMM-OM/MSSL/SP/0194** ^{XMM}OM (FM) Integrated Functional Test Procedure
- **XMM-OM/MSSL/ML/0011** ^{XMM}OM User Manual Part 4: ICU-DPU protocol definitions
- **XMM-SOC/TN-0010-SMD** ^{XMM}OM Operational Procedures Handbook

3 Overview

This document describes the procedures for nominal science and engineering, configuration for orbit phases, maintenance, contingency and commissioning. For each step the database telecommands and params are given, if necessary, the time to wait before the next telecomand, telemetry to expect and for the benefit of ^{XMM}OM consortium software authors, the equivalent VxWorks commands.

4 Abbreviations

XMM	X-ray Multi Mirror Mission
OM	Optical Monitor
HK	Housekeeping
KAL	Keep Alive
IFT	Integrated Functional Test
ICU	Instrument Control Unit
DPU	Digital Processing Unit
HV	High Voltage
LUT	Lookup Table
tc	Telecommand
tm	Telemetry
MSSL	Mullard Space Science Lab (University College London)
ESA	European Space Agency
SOC	Science Operations Centre
MCP	Microchannel Plate(s)
FAQ	Field Acquisition
s/c	spacecraft
GS	guide star(s)
RBI	Remote Bus Interface
TMPSU	Telescope module power supply unit
LOS	Loss of Signal

5 Typographical and Other Conventions Used in this Document

5.1 Typographical

- Running text appears in this normal Roman font.
- *Italic font* will indicate a parameter that should not be taken literally.
- A `"typewriter" font` will be used to indicate MSSL EGSE VxWorks commands.
- A **"bold" font** will be used to indicate database entries.

6 Note: Alerts

Please note the following ...

The ground system should always monitor the telemetry stream for exception packets of (type, subtype):

- (3,2): Unsuccessful Command Acceptance
- (3,4): Unsuccessful Command Execution
- (4,2): Exception Report
- (4,3): Major Anomaly Report

as these indicate an error has occured and should only be expected when a intentional bad command is sent as a test.

If the software fails (particularly the ICU software), after taking diagnostics (DMA read of ICU memory addresses fc0$_{hex}$ to fde$_{hex}$ and a21$_{hex}$ to a25$_{hex}$), the ICU should be reset as soon as possible so that it may safe the hardware.

7 Initial Procedures

7.1 Telescope Door

Opening the ^{XMM}OM telescope door is a spacecraft procedure. The OM telescope door should be opened as late as possible to reduce contamination.

7.2 Initial Switch On Procedure (Full Switch On)

7.2.1 Turn on Power

Perform the "Nominal Switch On Procedure" (see Section 8.1). Note however that **the high voltages must not be switched on until 2 days after launch**.

7.2.2 Load Code

Description	tc	tm	params	VxWorks
Upload ICU operational mode software	multi **h4000** **h4001**			`<load_icu`
Mode change to 1 ("full safe")	**h9001**			`tc_mode 1`
Wait up to 20 s for mode change expect event packet		**92100**	**h7000="cathode ok"**	
Wait up to 20 s for mode change expect event packet		**92100**	**h7000="MCP1 ok"**	
Wait up to 20 s for mode change expect event packet		**92100**	**h7000="MCP2,3 ok"**	
Wait up to 20 s for mode change expect event packet		**92600**	**7010="fw at req pos"**	
Check HK		**90000**	**h5405="Operational"**	
Reset DPU	h7201			`tc_reset_dsp`
Wait up to 12 s for alert		92201		Expect "Fred from the Dead"
Upload DPU "Jim" mode memory load packets	multi **h4020** **h4023** **h4023** **h4027**			`<load_dpu`
Switch to the DPU loadable code	**h7202**			`tc_load_dpuos`
Wait up to 10 s for a DPU_DPUOS_READY		**92202**		Expect "Jim from the Rim"
Load centroid table boundaries	**h7100**		***Table 2***	det_equal_bounds ; tc_det_load_bounds

coninued on next page

Description	tc	tm	params	VxWorks
Wait up to 120 s for event		**92100**	**7000=10h**	

The ICU will be in “full safe” mode.

Table 2: Centroid Table Boundaries

Description	Pref	Value
Verification	h10	“enable”
X Centroid Table Boundary 0	h20	-1000
X Centroid Table Boundary 1	h21	-750
X Centroid Table Boundary 2	h22	-500
X Centroid Table Boundary 3	h23	-250
X Centroid Table Boundary 4	h24	0
X Centroid Table Boundary 5	h25	250
X Centroid Table Boundary 6	h26	500
X Centroid Table Boundary 7	h27	750
X Centroid Table Boundary 8	h28	1000
Y Centroid Table Boundary 0	h30	-1000
Y Centroid Table Boundary 1	h31	-750
Y Centroid Table Boundary 2	h32	-500
Y Centroid Table Boundary 3	h33	-250
Y Centroid Table Boundary 4	h34	0
Y Centroid Table Boundary 5	h35	250
Y Centroid Table Boundary 6	h36	500
Y Centroid Table Boundary 7	h37	750
Y Centroid Table Boundary 8	h38	1000

8 Nominal Procedures

8.1 Nominal Switch On

Description	**tc**	**tm**	**params**	**VxWorks**
Spacecraft procedure: Switch off substitution heater				
Spacecraft procedure: Switch on 28V.				
Wait up to 20 s for a bootstrap report		**92703**	"bootstrap report event packet"	
Check the HK: expect a HK packet every 10 s		**90000**		
In the HK packets, look for mode and heater status		**90000**	**h5395="Initial"** **h5240="OnOnOffOff"** **h5255="Disabled"**	

The ICU will be in "initial" mode.

8.2 Nominal Switch Off

N.B. High voltages must be ramped down slowly and safely before switching off main power

The ICU will be in "idle", "science", "engineering" or "intermediate safe" mode.

Description	tc	tm	params	VxWorks
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode", h160=0, h175="off"**	`tc_det_load_hv_ramp_params 1,0,25,0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="cathode ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1", h160=0, h175="off"**	`tc_det_load_hv_ramp_params 2,0,25,0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="mcp1 ok"**	
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23, h160=0, h175="off"**	`tc_det_load_hv_ramp_params 3,0,25,0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="mcp23 ok"**	
Spacecraft command: Send an RBI suspend				`suspend`
Spacecraft procedure: switch off +28 V				

8.3 Transition to Safe Mode

Before this procedure, the ICU will be in “initial”, “idle” or “intermediate safe” mode.

This is a initiated by a **tc h9001** either autonomously from the spacecraft or as a telecommand from the ground.

8.4 Example Observation

The example observation shown in Table 5 consists of an acquisition phase followed by 2 exposures. In turn, each exposure consists of a choose guide star phase followed by an accumulation and tracking phase. Science data is not available for downlinking until the end of the first exposure. The status of science data, filter wheel and detector during the course of the observation is summarized Table 5. This example can be generalized to a n-exposure sequence by repeating the "between exposures" and "Exposure 2" (with suitable changes in the uplinked configuration) phases as often as required.

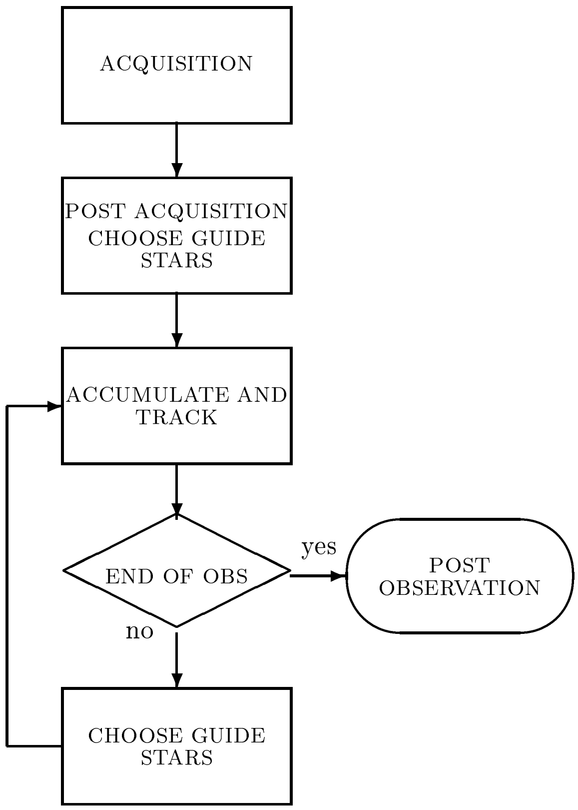
Table 5: Example Observation

Observation Phase	**Associated Command Sequences**	**Detector Status**		**Filter Wheel Position**	**Science Data Status**	
		Windows	**Resolution**		**Priority**	**Regular**
Acquisition	Acquisition	Four abutting windows covering the whole detector	Low	V Filter	–	–
Exposure 1	Post Acquisition Choose Guide Stars			Observer Requested	Exposure 1 Downloading	–
	Accumulate and Track	Observer requested + guiding	High			
Between Exposures	–	HV on Data not sent to DPU		Last Observer Request	–	
Exposure2	Choose Guide Stars	Four abutting windows covering the whole detector	Low	Observer Requested	Exposure2 Downloading	Exposure 1 Downloading
	Accumulate and Track	Observer requested + guiding	High			
Post Observation	Post Observation	HV On Data not sent to DPU			–	Exposure2 Downloading
				Blocked		

8.5 Overall Flow Diagram

The overall flow diagram is shown in Figure 1.

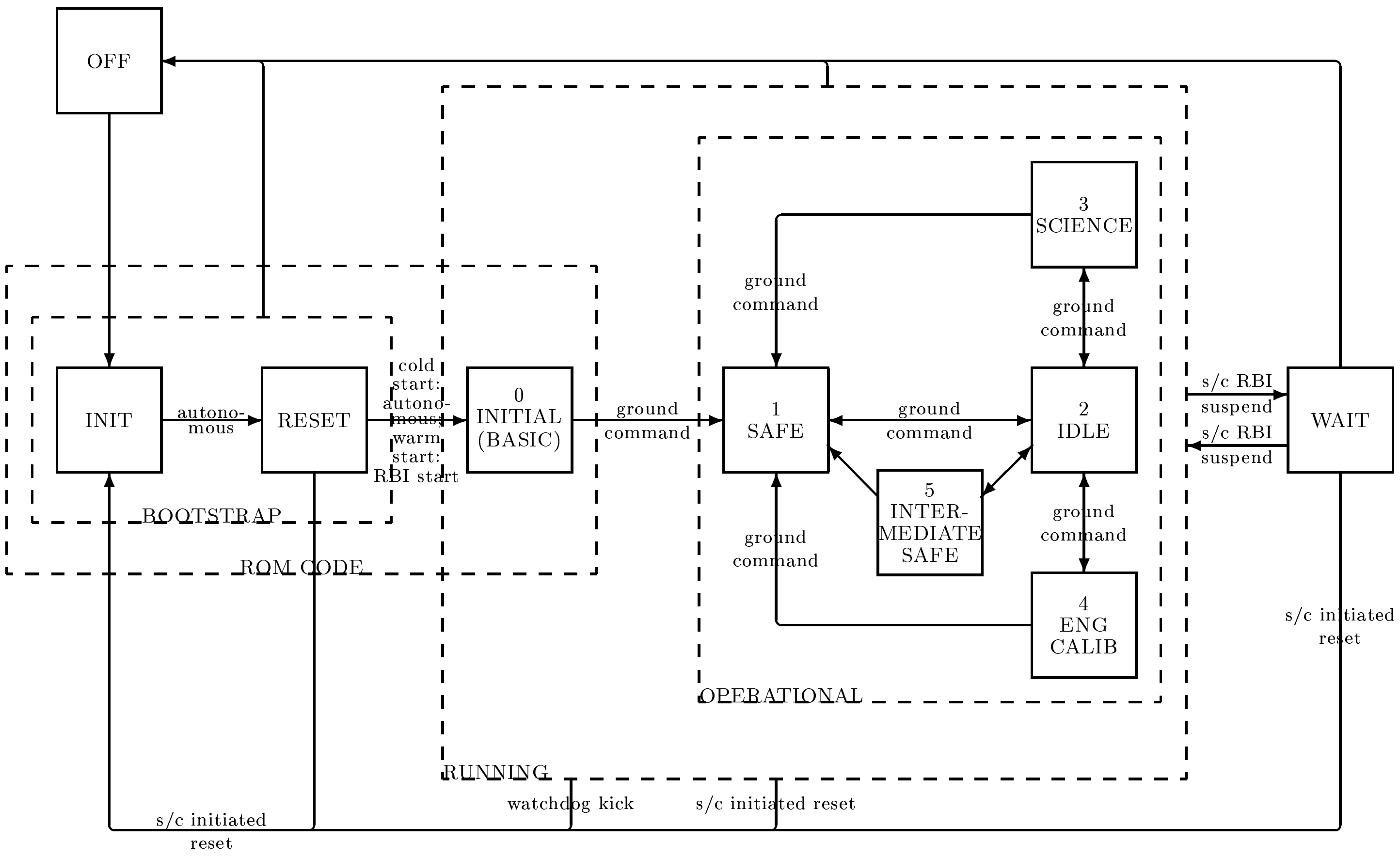
Figure 1: Overall Flow Diagram



8.6 OM FM Mode Transitions

The OM FM mode transitions are shown in Figure 2.

Figure 2: OM FM Mode Transitions



8.7 Acquisition

Description	tc	tm	params	VxWorks
Set acquisition mode	**h7130**		**"low res win"**	`tc_det_acq_mode 0`
Load window table parameters	**h7110**		***Table 7***	`det_reset_wind ; det_wind` *`arg, arg, arg, arg ...`*
Start load window table task	**h5110**			`tc_det_load_windows 4`
Wait up to 30 s for detector event		**92100**	**"win tab load"**	
Set filter wheel number for the V filter	**h7604**		**h280="V"**	`tc_fw_filter 1`
Move the filter wheel	**h5600**			`tc_fw_move`
Wait up to 20 s for TMPSU event		**92600**	**h7010="FW @ req pos"**	
Set the exposure id	**h7238**		**h530=*exposure_number***	`tc_set_exp_no` *`exposure_id`*
Ensure frame tags are enabled	**h7135**		**h16="enabled"**	`tc_det_enbl_frame_tag 1`
Prepare BPE for image acquisition	**h7131**		**h120=threshold**	`tc_det_event_threshold` *`threshold`*
Load the reference stars	**h7240**		***Table 8***	`tc_prog_ref_stars` *`file`*
Set the DPU frame time (in units of 1/1024 s)	**h7236**		**h710=*frame_time***	`tc_set_frame_time` *`frame_time`*
Prepare the DPU for acquiring low resolution data	**h7249**			`tc_send_command IC_INIT_EXP`
Change to ICU mode 3 ("science")	**h9003**			`tc_mode 3`
Start the detector integration	**h5130**			`tc_det_start_int`
Initiate acquire field	**h7250**			`tc_send_command IC_ACQUIRE_FLD` or `tc_acquire_field`
Wait (frame time) for the end of integration		**92211**		
Stop integration		**h6130**		`tc_det_stop_int`
Wait (25 s) for DA_EOT_ACQUIRE_FLD		**92211**		`tm_wait_for_alert DA_EOT_ACQUIRE_FLD`
Set filter wheel number (filter for exposure 1)	**h7604**		**h280=*filter***	`tc_fw_filter` *`filter`*
Move the filter wheel	**h5600**			`tc_fw_move`
Wait up to 20 s for TMPSU event		**92600**	**h7010="FW @ req pos"**	
Receive priority science data (acquisition data)		**97402**		

Table 7: Flatfield Window Table

Description	Pref	Value	
		Prime	Redundant
Verification	h10	"enable"	"enable"
Number of windows	h40	4	4
Window 1 Xlow	h50	52	64
Window 1 Ylow	h51	27	15
Window 1 Xsize	h52	128	128
Window 1 Ysize	h53	128	128
Window 2 Xlow	h50	52	64
Window 2 Ylow	h51	155	143
Window 2 Xsize	h52	128	128
Window 2 Ysize	h53	128	128
Window 3 Xlow	h50	180	192
Window 3 Ylow	h51	27	15
Window 3 Xsize	h52	128	128
Window 3 Ysize	h53	128	128
Window 4 Xlow	h50	180	192
Window 4 Ylow	h51	155	143
Window 4 Xsize	h52	128	128
Window 4 Ysize	h53	128	128

Table 8: Reference Stars

Description	PREF
Verification	h10
Number of reference stars	h1160
X co-ordinate of reference star 1	h1095
Y co-ordinate of reference star 1	h1096
X co-ordinate of reference star 2	h1097
Y co-ordinate of reference star 2	h1098
X co-ordinate of reference star 3	h1099
Y co-ordinate of reference star 3	h1100
X co-ordinate of reference star 4	h1101
Y co-ordinate of reference star 4	h1102
X co-ordinate of reference star 5	h1103
Y co-ordinate of reference star 5	h1104
X co-ordinate of reference star 6	h1105
Y co-ordinate of reference star 6	h1106
X co-ordinate of reference star 7	h1107
Y co-ordinate of reference star 7	h1108
X co-ordinate of reference star 8	h1109
Y co-ordinate of reference star 8	h1110
X co-ordinate of reference star 9	h1111
Y co-ordinate of reference star 9	h1112
X co-ordinate of reference star 10	h1113
Y co-ordinate of reference star 10	h1114
X co-ordinate of reference star 11	h1115
Y co-ordinate of reference star 11	h1116
X co-ordinate of reference star 12	h1117
Y co-ordinate of reference star 12	h1118
X co-ordinate of reference star 13	h1119
Y co-ordinate of reference star 13	h1120
X co-ordinate of reference star 14	h1121
Y co-ordinate of reference star 14	h1122
X co-ordinate of reference star 15	h1123
Y co-ordinate of reference star 15	h1124
X co-ordinate of reference star 16	h1125
Y co-ordinate of reference star 16	h1126
X co-ordinate of reference star 17	h1127
Y co-ordinate of reference star 17	h1128
X co-ordinate of reference star 18	h1129
Y co-ordinate of reference star 18	h1130
X co-ordinate of reference star 19	h1131
Y co-ordinate of reference star 19	h1132
X co-ordinate of reference star 20	h1133

coninued on next page

(continued)

Description	PREF
Y co-ordinate of reference star 20	h1134
X co-ordinate of reference star 21	h1135
Y co-ordinate of reference star 21	h1136
X co-ordinate of reference star 22	h1137
Y co-ordinate of reference star 22	h1138
X co-ordinate of reference star 23	h1139
Y co-ordinate of reference star 23	h1140
X co-ordinate of reference star 24	h1141
Y co-ordinate of reference star 24	h1142
X co-ordinate of reference star 25	h1143
Y co-ordinate of reference star 25	h1144
X co-ordinate of reference star 26	h1145
Y co-ordinate of reference star 26	h1146
X co-ordinate of reference star 27	h1147
Y co-ordinate of reference star 27	h1148
X co-ordinate of reference star 28	h1149
Y co-ordinate of reference star 28	h1150
X co-ordinate of reference star 29	h1151
Y co-ordinate of reference star 29	h1152
X co-ordinate of reference star 30	h1153
Y co-ordinate of reference star 30	h1154
X co-ordinate of reference star 31	h1155
Y co-ordinate of reference star 31	h1156
X co-ordinate of reference star 32	h1157
Y co-ordinate of reference star 32	h1158

8.8 Post Acquisition Choose Guide Stars

The ICU is in "science" mode.

Description	tc	tm	params	VxWorks
Set the DPU frame time (in units of 1/1024 s)	**h7236**		**h710=*frame_time***	`tc_set_frame_time` *`frame_time`*
Set the exposure id	**h7238**		**h530=*exposure_number***	`tc_set_exp_no` *`exposure_id`*
Load the memory windows	**h7242**		***Table 10***	`tc_prog_mem_wind` ``` ``file'' ```
Load the science windows	**h7243**		***Table 11***	`tc_prog_sci_wind` ``` ``file'' ```
Set the exposure duration (units = frames)	**h7237**		**h720=*number_of_frames***	`tc_set_exposure_time`
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Set BPE binning 0	**h7257**		**h540="No binning"**	`tc_set_bpe 0`
Start the detector integration task	**h5130**			`tc_det_start_int`
Enable choose guide stars task	**h7251**			`tc_send_command IC_CHOOSE_GS`
Wait up to 60 s for DPU event report DA_EOT_CHOOSE_GS		**92212**		`tm_wait_for_alert DA_EOT_CHOOSE_GS`
Wait for priority science data (window data)		**97401**		
Wait for window table loaded event		**92100**	**h7000="win tab load"**	
Stop integration		**h6130**		`tc_det_stop_int`

The ICU is in "science" mode.

Table 11: Load Science Windows

Description	Pref
Number of science windows (max 5)	h1161
Window 1 bottom left x coord	h1050
Window 1 bottom left y coord	h1051
Window 1 x size (centroided pixels)	h1052
Window 1 y size (centroided pixels)	h1053
Window 1 operation mode	h1070
Window 1 mode-dependent parameter	h1071
Window 1 mode-dependent parameter	h1072
Window 1 mode-dependent parameter	h1073
Window 1 mode-dependent parameter	h1074
Window 1 address in DPU RAM	
Window 1 memory window ID	
coninued on next page	

(continued)

Description	PREF
Window 2 bottom left x coord	h1054
Window 2 bottom left y coord	h1055
Window 2 x size (centroided pixels)	h1056
Window 2 y size (centroided pixels)	h1057
Window 2 operation mode	h1075
Window 2 mode-dependent parameter	h1076
Window 2 mode-dependent parameter	h1077
Window 2 mode-dependent parameter	h1078
Window 2 mode-dependent parameter	h1079
Window 2 address in DPU RAM	
Window 2 memory window ID	
Window 3 bottom left x coord	h1058
Window 3 bottom left y coord	h1059
Window 3 x size (centroided pixels)	h1060
Window 3 y size (centroided pixels)	h1061
Window 3 operation mode	h1080
Window 3 mode-dependent parameter	h1081
Window 3 mode-dependent parameter	h1082
Window 3 mode-dependent parameter	h1083
Window 3 mode-dependent parameter	h1084
Window 3 address in DPU RAM	
Window 3 memory window ID	
Window 4 bottom left x coord	h1062
Window 4 bottom left y coord	h1063
Window 4 x size (centroided pixels)	h1064
Window 4 y size (centroided pixels)	h1065
Window 4 operation mode	h1085
Window 4 mode-dependent parameter	h1086
Window 4 mode-dependent parameter	h1087
Window 4 mode-dependent parameter	h1088
Window 4 mode-dependent parameter	h1089
Window 4 address in DPU RAM	
Window 4 memory window ID	
Window 5 bottom left x coord	h1066
Window 5 bottom left y coord	h1067
Window 5 x size (centroided pixels)	h1068
Window 5 y size (centroided pixels)	h1069
Window 5 operation mode	h1090
Window 5 mode-dependent parameter	h1091
Window 5 mode-dependent parameter	h1092
Window 5 mode-dependent parameter	h1093

coninued on next page

(continued)

Description	**PREF**
Window 5 mode-dependent parameter Window 5 address in DPU RAM Window 5 memory window ID	h1094

Table 10: Load Memory Windows

Description	Pref
Number of memory windows (max 5)	h1159
Window 1 bottom left x coord	h1050
Window 1 bottom left y coord	h1051
Window 1 x size (centroided pixels)	h1052
Window 1 y size (centroided pixels)	h1053
Window 1 address in DPU RAM	
Window 2 bottom left x coord	h1054
Window 2 bottom left y coord	h1055
Window 2 x size (centroided pixels)	h1056
Window 2 y size (centroided pixels)	h1057
Window 2 address in DPU RAM	
Window 3 bottom left x coord	h1058
Window 3 bottom left y coord	h1059
Window 3 x size (centroided pixels)	h1060
Window 3 y size (centroided pixels)	h1061
Window 3 address in DPU RAM	
Window 4 bottom left x coord	h1062
Window 4 bottom left y coord	h1063
Window 4 x size (centroided pixels)	h1064
Window 4 y size (centroided pixels)	h1065
Window 4 address in DPU RAM	
Window 5 bottom left x coord	h1066
Window 5 bottom left y coord	h1067
Window 5 x size (centroided pixels)	h1068
Window 5 y size (centroided pixels)	h1069
Window 5 address in DPU RAM	

8.9 Accumulate and Track

The ICU is in "science" mode.

Description	tc	tm	params	VxWorks
Set the acquisition mode to high resolution windowed	**h7130**		**h110="Hi Res Win"**	`tc_det_acq_mode 2`
Set BPE binning 0	**h7257**		**h540="No binning"**	`tc_set_bpe 0`
Start the detector integration task	**h5130**			`tc_det_start_int`
Enable track guide stars task	**h7252**			`tc_send_command IC_TRACK_GS`
Wait up to (exp_time $\times$ frames + 60) s for DPU event report end of exposure		**92205**		`tm_wait_for_alert DA_COMPLETE_EXP`

The ICU is in "science" mode.

8.10 Post Perigee Procedure

8.10.1 Switch On

The "Nominal Switch On" procedure should already have been performed (see Section 8.1) if not, do it now.

The ICU is in "initial" mode.

8.10.2 Memory Dump of ICU's Loadable Code

Send dump memory packets to dump out the ICU's operational mode (loadable) code. Compare the memory dump report tm packets with the memory load packets. Reload full code if a difference is found (see Section 10.0.2).

8.10.3 Filter Wheel to Datum

Description	tc	tm	params	VxWorks
Specify next move of the filter wheel to the datum position	**h7608**			`tc_fw_to_datum`
Command the filter wheel to move	**h5600**			`tc_fw_move`
Wait up to 20 s for a TMPSU event		**92600**	**h7010="fw @ req pos"**	

8.10.4 HV

The following HV ramp-up is for the Prime Channel only.

Description	tc	tm	params	VxWorks
Transition to ICU mode 2 ("idle mode")	**h9002**			`tc_mode 2`
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23" h160=1400 h175="off"**	`tc_det_load_hv_ramp_params 3, 1400, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="mcp23 ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1" h160=550 h175="off"**	`tc_det_load_hv_ramp_params 2, 550, 25, 0`
Wait up to 120 s for event		**92100**	**h7000="mcp1 ok"**	
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode" h160=2 h175="off"**	`tc_det_load_hv_ramp_params 1,2,25,0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 10 s for event		**92100**	**h7000="cathode ok"**	
coninued on next page				

Description	tc	tm	params	VxWorks
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode" h160=396 h175="off"**	`tc_det_load_hv_ramp_params 1, 396, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="cathode ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1" h160=520 h175="off"**	`tc_det_load_hv_ramp_params 2, 520, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 60 s for event		**92100**	**h7000="mcp1 ok"**	
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23" h160=1700 h175="off"**	`tc_det_load_hv_ramp_params 3, 1700, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 60 s for event		**92100**	**h7000="mcp23 ok"**	

The following HV ramp-up is for the Redundant Channel only.

Description	tc	tm	params	VxWorks
Transition to ICU mode 2 ("idle mode")	**h9002**			`tc_mode 2`
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23" h160=1500 h175="off"**	`tc_det_load_hv_ramp_params 3, 1500, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="mcp23 ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1" h160=500 h175="off"**	`tc_det_load_hv_ramp_params 2, 500, 25, 0`
Wait up to 120 s for event		**92100**	**h7000="mcp1 ok"**	
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode" h160=2 h175="off"**	`tc_det_load_hv_ramp_params 1,2,25,0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 10 s for event		**92100**	**h7000="cathode ok"**	
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode" h160=390 h175="off"**	`tc_det_load_hv_ramp_params 1, 390, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="cathode ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1" h160=550 h175="off"**	`tc_det_load_hv_ramp_params 2, 550, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 60 s for event		**92100**	**h7000="mcp1 ok"**	
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23" h160=1850 h175="off"**	`tc_det_load_hv_ramp_params 3, 1850, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 60 s for event		**92100**	**h7000="mcp23 ok"**	

8.10.5 Memory Dump of DPU's Loadable Code

Send dump memory packets to dump out the DPU's loadable code. Compare the memory dump report tm packets with the memory load packets. Reload full code if a difference is found (see Section 10.0.2).

Description	tc	tm	params	VxWorks
Switch to the DPU loadable code	**h7202**			`tc_load_dpuos`
Wait up to 20 s for DA_DPUOS_READY		**92202**		Expect ``‘‘Jim from the Rim’’``
Enable red dsp	**h7207**		**h522="Red"** **h16="Enabled"**	`tc_enbl_dsp red,1`
Wait 10 s				
Enable blue1 dsp	**h7207**		**h522="Blue1"** **h16="Enabled"**	`tc_enbl_dsp blue1,1`
Wait 10 s				
Enable blue2 dsp	**h7207**		**h522="Blue2"** **h16="Enabled"**	`tc_enbl_dsp blue2,1`
Wait 10 s				
Select blue2 as the klingon	**h7206**		**h523="blue1"**	`tc_sel_klingon 1`
Perform clock synchronization	**h7214**		**h600=20**	`tc_synch_clk 20`
Wait 3 s				
Initialize DPU	**h7248**			`tc_init_dpu`
Wait up to 25 s for event		**92210**		`tm_wait_for_alert DA_EOT_INIT_DPU` ("Dave from the Grave")

8.10.6 LUT Update

(Assuming one iteration only as baseline.)

Description	tc	tm	params	VxWorks
Load centroid table boundaries	**h7100**		***Table 2***	`det_get_bounds < ` *`filename`* ` ; tc_det_load_bounds`
Wait up to 120 s for event		**92100**	**7000=10h**	

Perform "Engineering Mode 3: Channel Boundary Data" procedure (see Section 9.7.

Perform "Engineering Mode 5: Centroiding Confirmation Data" procedure (see Section 9.9.

Check the output on the ground.

(If more than one iteration: repeat Mode 3 and Mode 5 if necessary.)

8.10.7 Time Verification

Perform Clock Resynchronisation (see Section 9.1).

Description	tc	tm	params	VxWorks
Send a tc (10, 5)				`tc_enable_time_verification`
Wait up to 2 s for a tm (10, 5)				
Check that the contents of the time management report packet are as expected				

The ICU is in "idle" mode.

8.11 Choose Guide Stars

The ICU is in "science" mode.

Description	tc	tm	params	VxWorks
Set the filter wheel number for the next exposure	**h7604**		**h280=*filter_number***	`tc_fw_filter` *filter*
Move the filter wheel	**h5600**			`tc_fw_move`
Wait up to 20 s for TMPSU event report		**92600**	**h7010="fw @ req pos"**	
Set the acquisition mode to low resolution windowed	**h7130**		**h110="Lo Res Win"**	`tc_det_acq_mode 0`
Load the window table parameters	**h7110**		***Table 7***	
Start the load window table task	**h5110**			`tc_det_load_windows 1`
Wait up to 30 s for detector event report		**92100**	**h7000="win tab load"**	
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Set the DPU frame time (in units of 1/1024 s)	**h7236**		**h710=*frame_time***	`tc_set_frame_time` *frame_time*
Set the exposure id	**h7238**		**h530=*exposure_number***	`tc_set_exp_no` *exposure_number*
Load the memory windows	**h7242**		***Table 10***	`tc_prog_mem_wind` ``*file*''
Load the science windows	**h7243**		***Table 11***	`tc_prog_sci_wind` ``*file*''
Set the exposure duration (units = frames)	**h7237**		**h720=*number_of_frames***	`tc_set_exposure_time` *exposure_time*
Set BPE binning 0	**h7257**		**h540="No binning"**	`tc_set_bpe 0`
Start the detector integration task	**h5130**			`tc_det_start_int`
Enable choose guide stars task	**h7251**			`tc_send_command IC_CHOOSE_GS`
Wait up to 60 s for DPU event report DA_EOT_CHOOSE_GS		**92212**		
Wait for priority science data (window data)		**97401**		
Wait for window table loaded event		**92100**	**h7000="win tab load"**	
Stop integration		**h6130**		`tc_det_stop_int`

The ICU is in "science" mode.

8.12 Post Observation

The ICU is in "science" mode.

Description	**tc**	**tm**	**params**	**VxWorks**
Set the filter wheel to blocked	**h7604**		**h280="Blocked"**	`tc_fw_filter 0`
Move the filter wheel	**h5600**			`tc_fw_move`
Wait up to 20 s for TMPSU event report		**92600**	**h7010="fw @ req pos"**	

The ICU is in "science" mode.

8.13 Flatfielding

The ICU is in "idle" mode. The filter wheel must be in the "blocked" position.

Description	tc	tm	params	VxWorks
Check HK		**90000**	**h5265=1200 ("blocked")**	
Switch to mode 4 ("engineering")	**h9004**			`tc_mode 4`
Set exposure id	**h7238**		**h530=exposure_id**	`tc_set_exp_no` *exposure_number*
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Enable frame tags	**h7135**		**h16="disabled"**	`tc_det_enbl_frame_tag 1`
Set threshold	**h7131**		**h120=30**	`tc_det_event_threshold 30`
Start sending events from mic	**h5130**			`tc_det_start_int`
Load flatfield window table	**h7110**		***Table 7***	`det_reset_wind ; det_wind` *arg, arg, arg, arg ...*
Load windows	**h5110**			`tc_det_load_windows 4`
Wait up to 60 s for event		**92100**	**h7000="win tab load"**	
Turn off tracking	**h7256**		**h1040="on"**	`tc_set_trk 0`
Set BPE binning	**h7257**		**h540="binning"**	`tc_set_bpe 1`
Set up reporting option	**h7234**		**h16="enable"**	`tc_report_tracking 1`
Set up reporting option	**h7244**		**h760="tracking" h16="enable"**	`tc_enbl_verbose 0,1`
Set up reporting option	**h7244**		**h760="ref frame" h16="enable"**	`tc_enbl_verbose 3,1`
Set the DPU frame time (in units of 1/1024 s)	**h7236**		**h710=250000**	`tc_set_frame_time 25000`
Set exposure time, in units of frames	**h7237**		**h720=40**	`tc_set_exposure_time 40`
Load the memory windows	**h7242**		***Table 10***	`tc_prog_mem_wind` *''file''*
Load the science windows	**h7243**		***Table 11***	`tc_prog_sci_wind` *''file''*
Turn on flood LEDs	**h7134**		**h1040=3**	`tc_det_flood_led_current 3`
Reference frame processing, done by invoking the choose_guide_stars task on the DPU	**h7251**			`tc_send_command IC_CHOOSE_GS`
Wait up to 80 s for alert DA_EOT_CHOOSE_GS		**92212**		`tm_wait_for_alert DA_EOT_CHOOSE_GS`
Set acquisition mode	**h7130**		**h110="hi res win"**	`tc_det_acq_mode 3`
Start the exposure	**h7252**			`tc_send_command IC_TRACK_GS`

coninued on next page

Description	tc	tm	params	VxWorks
Wait for up to 1200 s for alert DA_COMPLETE_EXP. This will take approximately ((frame time in second) × (exposure time in second) + 60) second		**92209**		`tm_wait_for_alert DA_COMPLETE_EXP`
Turn off flood LEDs	**h7134**		**h1040=0**	`tc_det_flood_led_current 0`
Flush the compression queue	**h7255**			`tc_send_command IC_FLUSH_CMPRS`
Wait up to 600 s for alert DA_EOT_FLUSH_CMPRS		**92217**		`tm_wait_for_alert DA_EOT_FLUSH_CMPRS`
Wait up to 120 s for the data to come out				

The ICU is in "science" mode.

8.14 Flatfielding Addendum

After recent discussions, the flatfielding will be more like the following (see a future release of this document).

```
tc_mode 4

tc_det_enbl_frame_tag 1
tc_det_event_threshold 30

# ref frame exp
tc_set_frame_time 25*1024

tc_prog_mem_wind "/home/xmmom/sim_data/e40016/mmw.cfg"
tc_prog_sci_wind "/home/xmmom/sim_data/e40016/scw.cfg"

tc_set_trk 0
tc_set_bpe 1
tc_report_tracking 1
tc_enbl_verbose 0,1
tc_enbl_verbose 3,1
tc_set_exposure_time 40
tc_set_exp_no 0xe00016
tc_send_command IC_INIT_EXP
taskDelay 5*60

tc_det_flood_led_current 3
# start sending events from mic
tc_det_start_int

# choose_guide_stars
tc_send_command IC_CHOOSE_GS

# time allocated for guide star selection
taskDelay 60*(25)

# time allocated for window setup
taskDelay 60*(20)

# Jon delay: extra time for simulator
taskDelay 40*60

tc_det_acq_mode 3
tc_send_command IC_TRACK_GS
```

```
# tm_wait_for_alert DA_BEGOF_EXP

# data arrives ...

taskDelay((25*40+60)*60)

#tm_wait_for_alert DA_ENDOF_EXP
## tm_wait_for_alert DA_SWITCH_FRAME
## tm_wait_for_alert DA_EOT_FLUSH_CMPRS
#tm_wait_for_alert DA_COMPLETE_EXP

tc_det_flood_led_current 0

# wait for rest of data
taskDelay(120*60)

tc_set_trk 1
tc_set_bpe 0
```

8.15 Procedure for the End of Science Data Acquisition Period

At the end of science data acquisition period of an orbit care has to be taken that the science data of the last exposure of the last observation are compressed and are made available for downlinking. This can be ensured by forcing the flush compression queue.

The ICU is in "science" mode.

Description	**tc**	**tm**	**params**	**VxWorks**
Flush the compression queue	**h7255**			`tc_send_command IC_FLUSH_CMPRS`
Wait up to 600 s for alert DA_EOT_FLUSH_CMPRS		**92217**		`tm_wait_for_alert DA_EOT_FLUSH_CMPRS`
Wait up to 120 s for the data to come out				

The ICU is in "science" mode.

8.16 Procedure for the Preparation for Perigee Passage

The procedure will be invoked at the time: LOS+1h+time needed for OM science data downlink period of remaining science data in compressed data buffer. Initially this will happen at 40 000 km altitude.

Time tagged "goto idle mode" AND "goto intermediate safe mode" commands are needed to ensure HV ramp down for the case that unexpected LOS occurs. This command will be scheduled at the instrument activiation period of an orbit and will be removed as part of the preparation for perigee passage procedure.

The ICU is in "science" mode.

Description	**tc**	**tm**	**params**	**VxWorks**
Change to ICU mode 2 ("intermediate safe mode")	**h9002**			`tc_mode 2`
Change to ICU mode 5 ("intermediate safe mode")	**h9005**			`tc_mode 5`
Wait up to 10 s for a $V_{cathode}$ reached tm packet		**92100**	**h7000=13h "Vcathode reached"**	
Spacecraft procedure: remove time tagged command by MOC				

The ICU is in "intermediate safe" mode.

8.17 Procedure for the Preparation for Eclipse

Before transition into eclipse OM has to be switched off by invoking the Nominal Switch Off procedure (see Section 8.2). The remaining data in the compressed data queue buffer have been already sent down in the buffer interval allocated in the PSF.

The ICU is in "science" mode.

Description	**tc**	**tm**	**params**	**VxWorks**
Perform "Nominal Switch Off Procedure" (see Section 8.2)				

8.18 Procedure for Activation After Eclipse

OM will be switched off during eclipse. The MCP HV requires a stabilization period of several hours. For the sake of observation efficiency it is desirable to switch on OM and command it into intermediate safe state before perigee passage for the case that eclipse occurs before perigee and that there is s/c contact before perigee. This approach would require different post eclipse procedures depending on the orbital phase eclipse occurs, treating the case where there is a s/c contact after eclipse and before perigee differently to all other cases. In the latter cases the full procedure would be invoked after perigee, otherwise only the transition to intermediate safe mode is commanded and normal activation after perigee will occur.

1. Perform "Nominal Switch On" (see Section 8.1). The ICU is in "initial mode".
2. Wait until ready for "Post Perigee Procedure".
3. Perform "Post Perigee Procedure" (see Section 8.10). The ICU is in "idle" mode.

Kate will investigate the possibililty of different OM operation for eclipse with s/c contact before perigee.

8.19 Pre-apogee Gap Procedure

Description	tc	tm	params	VxWorks
Change to ICU mode 2 ("idle mode")	**h9002**			`tc_mode 2`

8.20 Procedure for Activation After the Apogee Gap

Normal operation.

9 Maintenance Procedures

9.1 Clock Resynchronisation

Description	**tc**	**tm**	**params**	**VxWorks**
Check HK for time sync flag		90000	h5330="inactive"	
Check time invalid flag in HK		90000	h5335="invalid"	
Enable time synchronization				`tc_enable_time_synch`
Check HK for time sync flag		**90000**	**h5330="active"**	
Check RBI config register in HK		**90000**	**h5345=1**	
Spacecraft procedure: send bcp3				`bcp3`
Check HK for time sync still enabled		**90000**	**h5330="active"**	
Check RBI config register in HK		**90000**	**h5345=0**	
Add time code				`tc_add_time_code` *time*
Check HK for time sync disabled		**90000**	**h5330="inactive"**	
Check HK for time code as expected		**90000**		
Check HK for time invalid flag		**90000**	**h5335="valid"**	

9.2 Procedure to Change Heater Configuration

The procedure for changing the heater configuration can be used for the heater control test or for contingency. For the heater checkout one would cycle through on/off of all heaters individually. (See XMM-OM/MSSL/ML/0010: User Manual Part 3: Telecommand and Telemetry Specification, Section 2.2.4.4.3, pages 27–28).

The ICU is in mode 1-5 (any of the operational modes).

Description	**tc**	**tm**	**params**	**VxWorks**
Load up heater configuration	One of **h7671** to **h7678**		(see XMM-OM/MSSL/ML/0010: User Manual Part 3: Telecommand and Telemetry Specification, Section 2.2.4.4.3.2)	`tc_heater_function` *`fid, param1, param2, param3`*
Start heater control again	**h5670**			`tc_heater_start`

9.3 Dichroic Reconfiguration

9.3.1 Selecting the Prime Chain

The ICU is in any operational mode.

Description	tc	tm	params	VxWorks
Change to ICU mode 2 ("idle mode")	**h9002**			`tc_mode 2`
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Request dichroic move to the prime position	**h7650**		**h370=-1 h375=0**	`tc_dm_direction -1,0`
Move dichroic	**h5650**			`tc_dm_move`
Wait for TMPSU event		**92600**	**h7010="dich @ req pos"**	
Examine HK		**90000**	**h5275=-31**	
Return to ICU mode 2 ("idle mode")	**h9002**			`tc_mode 2`

The ICU is in "idle" mode.

9.3.2 Selecting the Redundant Chain

The ICU is in any operational mode.

Description	tc	tm	params	VxWorks
Change to ICU mode 2 ("idle mode")	**h9002**			`tc_mode 2`
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Request dichroic move to the redundant position	**h7650**		**h370=1 h375=0**	`tc_dm_direction 1,0`
Move dichroic	**h5650**			`tc_dm_move`
Wait for TMPSU event		**92600**	**h7010="dich @ req pos"**	
Examine HK		**90000**	**h5275=32**	
Return to ICU mode 2 ("idle mode")	**h9002**			`tc_mode 2`

The ICU is in "idle" mode.

9.3.3 Check the Image

Run an Engineering Mode 4 exposure (see Section 9.8) to check there is an image.

9.4 Engineering Mode 0: Raw Data of Both DSPs

Description	**tc**	**tm**	**params**	**VxWorks**
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Set frame time to 10 000 ms	**h7236**		**h710=10000**	`tc_set_frame_time 10000`
Set exposure id	**h7238**		**h530=*exposure_id***	`tc_set_exp_no` *exposure_number*
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Load window table	**h7110**		***Table 31***	`det_reset_wind ; det_wind` *0, 0, 255, 255*
Load windows	**h5110**			`tc_det_load_windows 1`
Wait up to 60 s for event		**92100**	**h7000="win tab load"**	
Ensure frame tags are enabled	**h7135**		**h16="enabled"**	`tc_det_enbl_frame_tag 1`
Prepare BPE for image acquisition	**h7131**		**h120=threshold**	`tc_det_event_threshold` *threshold*
Set acquisition mode	**h7130**		**h110="hi res win"**	`tc_det_acq_mode 3`
Start sending events from mic	**h5130**			`tc_det_start_int`
Choose engineering mode 0	**h7254**		**h880="Raw + 2 blue"**	`tc_enbl_eng 1, 0`
Wait up to 12 s for end of exposure		**92205**		`tm_wait_for_alert DA_ENDOF_EXP`
Wait up to *frame_time* + ?? s for end of exposure		**92209**		`tm_wait_for_alert DA_COMPLETE_EXP`
Wait up to ?? s for telemetry to finish				

Table 31: Window Table

Description	**PREF**
Verification	h10
Number of windows	h40
Window 1 Xlow	h50
Window 1 Ylow	h51
Window 1 Xsize	h52
Window 1 Ysize	h53
Window 2 Xlow	h54
Window 2 Ylow	h55
Window 2 Xsize	h56
Window 2 Ysize	h57
.	.
.	.
.	.
Window 14 Xlow	h102
Window 14 Ylow	h103
Window 14 Xsize	h104
Window 14 Ysize	h105
Window 15 Xlow	h106
Window 15 Ylow	h107
Window 15 Xsize	h108
Window 15 Ysize	h109

9.5 Engineering Mode 1: Raw Data of Blue DSP1

Description	**tc**	**tm**	**params**	**VxWorks**
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Set frame time to 10 000 ms	**h7236**		**h710=10000**	`tc_set_frame_time 10000`
Set exposure id	**h7238**		**h530=exposure_id**	`tc_set_exp_no` *exposure_number*
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Load window table	**h7110**		*Table 31*	`det_reset_wind ; det_wind` *0, 0, 255, 255*
Load windows	**h5110**			`tc_det_load_windows 1`
Wait up to 60 s for event		**92100**	**h7000="win tab load"**	
Ensure frame tags are enabled	**h7135**		**h16="enabled"**	`tc_det_enbl_frame_tag 1`
Prepare BPE for image acquisition	**h7131**		**h120=threshold**	`tc_det_event_threshold` *threshold*
Set acquisition mode	**h7130**		**h110="hi res win"**	`tc_det_acq_mode 3`
Start sending events from mic	**h5130**			`tc_det_start_int`
Choose engineering mode 1	**h7254**		**h880="Raw + blue 1"**	`tc_enbl_eng 1, 1`
Wait up to 12 s for end of exposure		**92205**		`tm_wait_for_alert DA_ENDOF_EXP`
Wait up to ?? s for end of exposure		**92209**		`tm_wait_for_alert DA_COMPLETE_EXP`
Wait up to ?? s for telemetry to finish				

9.6 Engineering Mode 2: Raw Data of Blue DSP2

Description	tc	tm	params	VxWorks
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Set frame time to 10 000 ms	**h7236**		**h710=10000**	`tc_set_frame_time 10000`
Set exposure id	**h7238**		**h530=exposure_id**	`tc_set_exp_no` *exposure_number*
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Load window table	**h7110**		*Table 31*	`det_reset_wind ; det_wind` *0, 0, 255, 255*
Load windows	**h5110**			`tc_det_load_windows 1`
Wait up to 60 s for event		**92100**	**h7000="win tab load"**	
Ensure frame tags are enabled	**h7135**		**h16="enabled"**	`tc_det_enbl_frame_tag 1`
Prepare BPE for image acquisition	**h7131**		**h120=threshold**	`tc_det_event_threshold` *threshold*
Set acquisition mode	**h7130**		**h110="hi res win"**	`tc_det_acq_mode 3`
Start sending events from mic	**h5130**			`tc_det_start_int`
Choose engineering mode 2	**h7254**		**h880="Raw + blue 2"**	`tc_enbl_eng 1, 2`
Wait up to 12 s for end of exposure		**92205**		`tm_wait_for_alert DA_ENDOF_EXP`
Wait up to ?? s for end of exposure		**92209**		`tm_wait_for_alert DA_COMPLETE_EXP`
Wait up to ?? s for telemetry to finish				

9.7 Engineering Mode 3: Channel Boundary Data

Description	tc	tm	params	VxWorks
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Set frame time to 10 000 ms	**h7236**		**h710=10000**	`tc_set_frame_time 10000`
Set exposure id	**h7238**		**h530=exposure_id**	`tc_set_exp_no` *exposure_number*
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Enable M,N image dump, if wanted	**h7244**		**h760="eng data" h16="enable"**	tc_enbl_verbose 4,1
Load window table	**h7110**		***Table 31***	`det_reset_wind ; det_wind` *0, 0, 255, 255*
Load windows	**h5110**			`tc_det_load_windows 1`
Wait up to 60 s for event		**92100**	**h7000="win tab load"**	
Ensure frame tags are enabled	**h7135**		**h16="enabled"**	`tc_det_enbl_frame_tag 1`
Prepare BPE for image acquisition	**h7131**		**h120=threshold**	`tc_det_event_threshold` *threshold*
Set acquisition mode	**h7130**		**h110="hi res win"**	`tc_det_acq_mode 3`
Start sending events from mic	**h5130**			`tc_det_start_int`
Choose engineering mode 3	**h7254**		**h880="Centroiding"**	`tc_enbl_eng 1, 3`
Wait up to 12 s for end of exposure		**92205**		`tm_wait_for_alert DA_ENDOF_EXP`
Wait up to 20 s for complete exposure		**92209**		`tm_wait_for_alert DA_COMPLETE_EXP` and end of data tm packets
Wait up to 20 s for telemetry to finish		Multi- **97322** **92207**		

9.8 Engineering Mode 4: Full Frame, High Resolution

Description	**tc**	**tm**	**params**	**VxWorks**
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Set frame time to 10 000 ms	**h7236**		**h710=10000**	`tc_set_frame_time 10000`
Set exposure id	**h7238**		**h530=exposure_id**	`tc_set_exp_no` *exposure_number*
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Load window table	**h7110**		***Table 31***	`det_reset_wind ; det_wind` *0, 0, 255, 255*
Load windows	**h5110**			`tc_det_load_windows 1`
Wait up to 60 s for event		**92100**	**h7000="win tab load"**	
Ensure frame tags are enabled	**h7135**		**h16="enabled"**	`tc_det_enbl_frame_tag 1`
Prepare BPE for image acquisition	**h7131**		**h120=threshold**	`tc_det_event_threshold` *threshold*
Set acquisition mode	**h7130**		**h110="hi res win"**	`tc_det_acq_mode 3`
Start sending events from mic	**h5130**			`tc_det_start_int`
Choose engineering mode 4	**h7254**		**h880="Full Hi Res"**	`tc_enbl_eng 1, 4`
Wait up to 12 s for end of exposure		**92205**		`tm_wait_for_alert DA_ENDOF_EXP`
Wait up to 4800 s for complete exposure		**92209**		`tm_wait_for_alert DA_COMPLETE_EXP`
Wait up to 1000 s for eng data telemetry to finish		Multi-**97322** **92207**		

9.9 Engineering Mode 5: Centroiding Confirmation Data

Description	tc	tm	params	VxWorks
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Set frame time to 10 000 ms	**h7236**		**h710=10000**	`tc_set_frame_time 10000`
Set exposure id	**h7238**		**h530=exposure_id**	`tc_set_exp_no` *exposure_number*
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Load window table	**h7110**		***Table 31***	`det_reset_wind ; det_wind` *0, 0, 255, 255*
Load windows	**h5110**			`tc_det_load_windows 1`
Wait up to 60 s for event		**92100**	**h7000="win tab load"**	
Ensure frame tags are enabled	**h7135**		**h16="enabled"**	`tc_det_enbl_frame_tag 1`
Prepare BPE for image acquisition	**h7131**		**h120=threshold**	`tc_det_event_threshold` *threshold*
Set acquisition mode	**h7130**		**h110="hi res win"**	`tc_det_acq_mode 3`
Start sending events from mic	**h5130**			`tc_det_start_int`
Choose engineering mode 5	**h7254**		**h880="Centr Conf"**	`tc_enbl_eng 1, 5`
Wait up to 12 s for end of exposure		**92205**		`tm_wait_for_alert DA_ENDOF_EXP`
Wait up to 160 s for complete exposure		**92209**		`tm_wait_for_alert DA_COMPLETE_EXP`
Wait up to 20 s for eng data telemetry to finish		Multi- **97322** **92207**		

9.10 Engineering Mode 6: Intensifier Characteristics

Description	tc	tm	params	VxWorks
Change to ICU mode 4 ("engineering mode")	**h9004**			`tc_mode 4`
Set frame time to 10 000 ms	**h7236**		**h710=10000**	`tc_set_frame_time 10000`
Set exposure id	**h7238**		**h530=exposure_id**	`tc_set_exp_no` *exposure_number*
Send IC_INIT_EXP	**h7249**			`tc_send_command IC_INIT_EXP`
Wait 5 s				
Load window table	**h7110**		***Table 31***	`det_reset_wind ; det_wind` *0, 0, 255, 255*
Load windows	**h5110**			`tc_det_load_windows 1`
Wait up to 60 s for event		**92100**	**h7000="win tab load"**	
Ensure frame tags are enabled	**h7135**		**h16="enabled"**	`tc_det_enbl_frame_tag 1`
Prepare BPE for image acquisition	**h7131**		**h120=threshold**	`tc_det_event_threshold` *threshold*
Set acquisition mode	**h7130**		**h110="hi res win"**	`tc_det_acq_mode 3`
Start sending events from mic	**h5130**			`tc_det_start_int`
Choose engineering mode 6	**h7254**		**h880="Intensifier"**	`tc_enbl_eng 1, 6`
Wait up to 12 s for end of exposure		**92205**		`tm_wait_for_alert DA_ENDOF_EXP`
Wait up to 20 s for complete exposure		**92209**		`tm_wait_for_alert DA_COMPLETE_EXP`
Wait up to 20 s for telemetry to finish		Multi- **97322** **92207**		

10 Calibration and PV

10.0.1 Basic Mode Tests

Description	tc	tm	params	VxWorks
Perform "Nominal Switch On Procedure" (see Section 8.1)				
Send a valid tc packet	**h1**			`tc_test`
Check HK for good tc packet counter		**90000**	**h5385** should increment by 1	
Send a tc packet with an invalid type (15,3)				`packet_test ...`
Check for unsuccessful packet acceptance		**91202**	**h6015=15 h6020=3**	
Send a tc packet with an invalid subtype (5,15)				`packet_test ...`
Check for unsuccessful packet acceptance		**91203**	**h6015=5 h6020=15**	
Send a tc packet with the wrong checksum				`break_crc ; tc_test`
Check for unsuccessful packet acceptance		**91201**	**h6005=*expected_crc*** **h6010=*found_crc***	

10.0.2 Operational Mode Tests

Description	tc	tm	params	VxWorks
Upload ICU operational mode software	multi h4000 h4001			`<load_icu`
Mode change to ICU mode 1 ("full safe")	**h9001**			`tc_mode 1`
Wait up to 20 s for mode change expect event packet		**92100**	**h7000="cathode ok"**	
Wait up to 20 s for mode change expect event packet		**92100**	**h7000="MCP1 ok"**	
Wait up to 20 s for mode change expect event packet		**92100**	**h7000="MCP2,3 ok"**	
Wait up to 20 s for mode change expect event packet		**92600**	**7010="fw at req pos"**	
Check HK		**90000**	**h5405="Operational"**	
Check HK packet arrives approximately every 10 s		**90000**		
(Thermal control starts automatically)				

coninued on next page

Description	**tc**	**tm**	**params**	**VxWorks**
Reset DPU	**h7201**			`tc_reset_dsp`
Wait up to 12 s for alert		92201		Expect "Fred from the Dead"
Upload DPU memory load packets	multi h4020 h4023 h4023 h4027			`<load_dpu`
Switch to the DPU loadable code	**h7202**			`tc_load_dpuos`
Wait up to 20 s for DA_DPUOS_READY		**92202**		Expect `''Jim from the Rim''`
Enable red dsp	**h7207**		**h522="Red" h16="Enabled"**	`tc_enbl_dsp red,1`
Wait 10 s				
Enable blue1 dsp	**h7207**		**h522="Blue1" h16="Enabled"**	`tc_enbl_dsp blue1,1`
Wait 10 s				
Enable blue2 dsp	**h7207**		**h522="Blue2" h16="Enabled"**	`tc_enbl_dsp blue2,1`
Wait 10 s				
Select blue2 as the klingon	**h7206**		**h523="blue1"**	`tc_sel_klingon 1`
Perform clock synchronization	**h7214**		**h600=20**	`tc_synch_clk 20`
Wait 3 s				
Initialize DPU	**h7248**			`tc_init_dpu`
Wait up to 25 s for event		**92210**		`tm_wait_for_alert` `DA_EOT_INIT_DPU` ("Dave from the Grave")
Send a tc packet with an invalid type (15,3)				`packet_test ...`
Check for unsuccessful packet acceptance		**91202**	**h6015=15 h6020=3**	
Send a tc packet with an invalid subtype (5,15)				`packet_test ...`
Check for unsuccessful packet acceptance		**91203**	**h6015=5 h6020=15**	
Send a tc packet with the wrong checksum				`break_crc ; tc_test`
Check for unsuccessful packet acceptance		**91201**	**h6005=*expected_crc* h6010=*found_crc***	
Prepare for heater switching: disable standard control algorithm	**h6670**			`tc_heater_stop`
Examine HK		**90000**	**h5240="offoffoffoff"**	
Measure S/C +28V voltage and current. Compare with Table 40				
Start heater contingency task	**h5660**			`tc_heater_config_start`
Switch on heater 1 (Main I/F)	**h7660**		**h380="onoffoffoff"**	`tc_heater_config 8`

coninued on next page

Description	tc	tm	params	VxWorks
Examine HK		**90000**	**h5240="onoffoffoff"**	
Measure S/C +28V voltage and current. Compare with Table 40				
Switch off heater 1	**h7660**		**h380="offoffoffoff"**	`tc_heater_config 0`
Examine HK		**90000**	**h5240="offoffoffoff"**	
Switch on heater 2 (forward tube)	**h7660**		**h380="offonoffoff"**	`tc_heater_config 4`
Examine HK		**90000**	**h5240="offonoffoff"**	
Measure S/C +28V voltage and current: Compare with Table 40				
Switchoff heater 2	**h7660**		**h380="offoffoffoff"**	`tc_heater_config 0`
Examine HK		**90000**	**h5240="offoffoffoff"**	
Switch on heater 3 (metering rods)	**h7660**		**h380="offoffonoff"**	`tc_heater_config 2`
Examine HK		**90000**	**h5240="offoffonoff"**	
Measure S/C +28V voltage and current: Compare with Table 40				
Switchoff heater 3	**h7660**		**h380="offoffoffoff"**	`tc_heater_config 0`
Examine HK		**90000**	**h5240="offoffoffoff"**	
Switch on heater 4 (secondary mirror)	**h7660**		**h380="offoffoffon"**	`tc_heater_config 1`
Examine HK		**90000**	**h5240="offoffoffon"**	
Measure S/C +28V voltage and current: Compare with Table 40				
Switchoff heater 4	**h7660**		**h380="offoffoffoff"**	`tc_heater_config 0`
Examine HK		**90000**	**h5240="offoffoffoff"**	
Disable heater switching: stop heater contingency task	**h6660**			`tc_heater_config_stop`
Enable standard control algorithm	**h5670**			`tc_heater_start`
Specify next move of the filter wheel to the datum position	**h7608**			`tc_fw_to_datum`
Command the filter wheel to move	**h5600**			`tc_fw_move`
Wait up to 20 s for a TMPSU event		**92600**	**h7010="fw @ req pos"**	
Examine HK		**90000**	**h5150="seen" h5265=0**	
Command the filter wheel away from datum	**h7606**		**h290=1000**	`tc_fw_rel_steps 1000`
Wait up to 20 s for a TMPSU event		**92600**	**h7010="fw @ req pos"**	
Examine HK		**90000**	**h5150="seen" h5250="not seen"**	
Command the filter wheel to move to the coarse sensor position	**h7609**			`tc_fw_to_coarse`
Command the filter wheel to move	**h5600**			`tc_fw_move`
Wait up to 20 s for a TMPSU event		**92600**	**h7010="fw @ req pos"**	
Command the filter wheel to move back to the datum position	**h7608**			`tc_fw_to_datum`
Command the filter wheel to move	**h5600**			`tc_fw_move`
Wait up to 20 s for a TMPSU event		**92600**	**h7010="fw @ req pos"**	
Examine HK		**90000**	**h5150="seen" h5265=0**	

Table 40: Heater Switching Current Profile

Heater	**+28 V Current**
1 (Main Interface)	1440mA ± 100 mA
2 (Forward tube)	1740mA ± 100 mA
3 (Metering Rods)	1060mA ± 100 mA
4 (Secondary Mirror)	950mA ± 100 mA
Disable Heater Algorithm	810mA ± 100 mA

10.0.3 Switch on High Voltages (Prime)

The high voltages can be used 48 hours after launch.

Description	**tc**	**tm**	**params**	**VxWorks**
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23" h160=1400 h175="off"**	`tc_det_load_hv_ramp_params 3, 1400, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="mcp23 ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1" h160=550 h175="off"**	`tc_det_load_hv_ramp_params 2, 550, 25, 0`
Wait up to 120 s for event		**92100**	**h7000="mcp1 ok"**	
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode" h160=2 h175="off"**	`tc_det_load_hv_ramp_params 1,2,25,0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 10 s for event		**92100**	**h7000="cathode ok"**	
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode" h160=396 h175="off"**	`tc_det_load_hv_ramp_params 1, 396, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="cathode ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1" h160=520 h175="off"**	`tc_det_load_hv_ramp_params 2, 520, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 60 s for event		**92100**	**h7000="mcp1 ok"**	
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23" h160=1700 h175="off"**	`tc_det_load_hv_ramp_params 3, 1700, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 60 s for event		**92100**	**h7000="mcp23 ok"**	

10.0.4 Switch on High Voltages (Redundant)

The high volatges can be used 48 hours after launch.

Description	**tc**	**tm**	**params**	**VxWorks**
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23" h160=1500 h175="off"**	`tc_det_load_hv_ramp_params 3, 1500, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="mcp23 ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1" h160=500 h175="off"**	`tc_det_load_hv_ramp_params 2, 500, 25, 0`
Wait up to 120 s for event		**92100**	**h7000="mcp1 ok"**	
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode" h160=2 h175="off"**	`tc_det_load_hv_ramp_params 1,2,25,0`

coninued on next page

Description	tc	tm	params	VxWorks
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 10 s for event		**92100**	**h7000="cathode ok"**	
Specify $V_{cathode}$ ramp parameters	**h7140**		**h510="cathode" h160=390 h175="off"**	`tc_det_load_hv_ramp_params 1, 390, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 120 s for event		**92100**	**h7000="cathode ok"**	
Specify V_{mcp1} ramp parameters	**h7140**		**h510="mcp1" h160=550 h175="off"**	`tc_det_load_hv_ramp_params 2, 550, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 60 s for event		**92100**	**h7000="mcp1 ok"**	
Specify V_{mcp23} ramp parameters	**h7140**		**h510="mcp23" h160=1850 h175="off"**	`tc_det_load_hv_ramp_params 3, 1850, 25, 0`
Perform ramp	**h5140**			`tc_det_start_hv_ramp`
Wait up to 60 s for event		**92100**	**h7000="mcp23 ok"**	

10.0.5 Image Acquisition Test

Perform an Engineering mode 4 image test (see Section 9.8).

10.0.6 Other Tests

1. dark current
2. pulse height distribution
3. LUT update
4. flatfield/fullframe
5. flatfield/BPE binned
6. run the other engineering mode tests if there is time

10.0.7 End of Tests

Description	tc	tm	params	VxWorks
Change to ICU mode 2 ("idle")	**h9002**			`tc_mode 2`
Change to ICU mode 5 ("intermediate safe")	**h9005**			`tc_mode 5`
Wait up to 20 s for a $V_{cathode}$ event packet		**92100**	**h7000="Vcathode reached"**	

10.1 Focus

Focussing tests using the magnifier. The heaters will be switched on/off.

Description	tc	tm	params	VxWorks
Focus heater	**h7677**		**h200**=*ontime* **h210**=*cycle_time* **h240**=*focus_direction*	`tc_heater_focussing` *on_time cycle_time* *direction*

Acquisition of a fullframe image to assess the boresight alignment. This observation will be performed without FAQ.

11 Appendix A

Here are the VxWorks scripts used for testing.

11.1 acquire

```
################################################################
#
#   Set up some numbers first
#
################################################################

tc_det_acq_mode 0

det_reset_wind
det_wind 64,15,128,128
det_wind 64,143,128,128
det_wind 192,15,128,128
det_wind 192,143,128,128
tc_det_load_windows 4
taskDelay(30*60)

# Jon delay
taskDelay(40*60)

tc_fw_filter 1
tc_fw_move
taskDelay(20*60)

tc_set_exp_no 0xe00009

tc_det_enbl_frame_tag 1

tc_det_event_threshold 30

tc_prog_ref_stars "/home/xmmom/sim_data/e40009/ref_stars.cfg"

# ref frame exp
tc_set_frame_time 15000

tc_send_command IC_INIT_EXP
#tm_wait_for_alert DA_EOT_INIT_EXP
# ??????????????????????????????????????
taskDelay(5*60)

# change to science mode
tc_mode 3
# start the detector integration
tc_det_start_int
```

```
tc_send_command IC_ACQUIRE_FLD
# tm_wait_for_alert DA_SWITCH_FRAME
# tm_wait_for_alert DA_EOT_ACQUIRE_FLD
#taskDelay((15+25) * 60)
taskDelay(15*60)
tc_det_stop_int
taskDelay(25*60)

tc_fw_filter 4
tc_fw_move
taskDelay(20*60)
```

11.2 pacgs

```
tc_set_frame_time 17000
tc_set_exp_no 2
tc_prog_mem_wind "/home/xmmom/sim_data/e40007/mmw.cfg"
tc_prog_sci_wind "/home/xmmom/sim_data/e40007/scw.cfg"
tc_set_exposure_time 10
tc_send_command IC_INIT_EXP
#tm_wait_for_alert DA_EOT_INIT_EXP
taskDelay(5*60)
tc_set_bpe 0
tc_det_start_int
tc_send_command IC_CHOOSE_GS
taskDelay(120*60)
tc_det_stop_int
# Jon delay
taskDelay(60*60)
```

11.3 exp

```
tc_det_acq_mode 2
tc_set_bpe 0
tc_det_start_int
tc_send_command IC_TRACK_GS
taskDelay(17*10*60 + 60*60)
```

11.4 cgs

```
tc_fw_filter 4
tc_fw_move
taskDelay(20*60)
tc_det_acq_mode 0

det_reset_wind
det_wind 52,27,128,128
det_wind 52,155,128,128
det_wind 180,27,128,128
det_wind 180,155,128,128
tc_det_load_windows 4
taskDelay(30*60)

# Jon delay
taskDelay(20*60)

tc_send_command IC_INIT_EXP
#tm_wait_for_alert DA_EOT_INIT_EXP
taskDelay(5*60)

#tc_send_command IC_INIT_EXP
tc_set_frame_time 17000
tc_set_exp_no 4
tc_prog_mem_wind "/home/xmmom/sim_data/e40007/mmw.cfg"
tc_prog_sci_wind "/home/xmmom/sim_data/e40007/scw.cfg"
tc_set_exposure_time 10
tc_set_bpe 0
tc_det_start_int
tc_send_command IC_CHOOSE_GS
taskDelay(60*60)
tc_det_stop_int
```

11.5 eng4

```
tc_mode 4
tc_set_frame_time 10000
tc_set_exp_no 0xdc00
tc_send_command IC_INIT_EXP
# tm_wait_for_alert DA_EOT_INIT_EXP
taskDelay(5*60)

det_reset_wind
det_wind 64, 15, 256, 256
tc_det_load_windows 1
taskDelay(60*60)

# Jon delay
taskDelay(20*60)

tc_det_enbl_frame_tag 1
tc_det_event_threshold 30
tc_det_acq_mode 3

# start sending events from mic
tc_det_start_int

tc_enbl_eng 1, 4

# wait 10 s for DA_ENDOF_EXP
taskDelay(12*60)
#tm_wait_for_alert DA_COMPLETE_EXP
taskDelay(4800*60)
taskDelay(1000*60)
```

11.6 flatfield_new

```
tc_mode 4

tc_det_enbl_frame_tag 1
tc_det_event_threshold 30

# ref frame exp
tc_set_frame_time 25*1024

tc_prog_mem_wind "/home/xmmom/sim_data/e40016/mmw.cfg"
tc_prog_sci_wind "/home/xmmom/sim_data/e40016/scw.cfg"

tc_set_trk 0
tc_set_bpe 1
tc_report_tracking 1
tc_enbl_verbose 0,1
tc_enbl_verbose 3,1
tc_set_exposure_time 40
tc_set_exp_no 0xe00016
tc_send_command IC_INIT_EXP
taskDelay 5*60

tc_det_flood_led_current 3
# start sending events from mic
tc_det_start_int

# choose_guide_stars
tc_send_command IC_CHOOSE_GS

# time allocated for guide star selection
taskDelay 60*(25)

# time allocated for window setup
taskDelay 60*(20)

# Jon delay: extra time for simulator
taskDelay 40*60

tc_det_acq_mode 3
tc_send_command IC_TRACK_GS

# tm_wait_for_alert DA_BEGOF_EXP

# data arrives ...
```

```
taskDelay((25*40+60)*60)

#tm_wait_for_alert DA_ENDOF_EXP
## tm_wait_for_alert DA_SWITCH_FRAME
## tm_wait_for_alert DA_EOT_FLUSH_CMPRS
#tm_wait_for_alert DA_COMPLETE_EXP

tc_det_flood_led_current 0

# wait for rest of data
taskDelay(120*60)

tc_set_trk 1
tc_set_bpe 0
```

11.7 tc_clean_slate

```
#
#  Reset the ICU to the operational mode
#

set_dump_tm 0

####################################################
#
# This script brings up the DPU in a clean slate
#
####################################################

# clear all GSE semaphores

tm_clear_sem

# < idiot.vsw

#
# slow down red clock rate
#
# no telesim card so don't do this
#wtc 0x11

#
#  First reset the DPU
#

tc_reset_dsp 0
# wait_for_alert 0xa510
taskDelay (60*10)

#
# Next reload the DPUOS
#

tc_load_dpuos
#wait_for_alert 0xa511
taskDelay (60*6)

# tc_enbl_alert_carry_clock 1

# Turn on echo command
```

```
# tc_enbl_command_echo 1

tc_enbl_dsp red,1

taskDelay (60*10)

tc_enbl_dsp blue1,1

taskDelay (60*10)

tc_enbl_dsp blue2,1

taskDelay (60*10)

# Select blue2 as the klingon
tc_sel_klingon 1

tc_synch_clk 20

taskDelay (3*60)

#################################################################
#
# Initialize DPU
#
#################################################################
# Initialize high level DPU

# tc_send_command IC_INIT_DPU
tc_init_dpu

# tm_wait_for_alert DA_EOT_INIT_DPU
taskDelay(60*25)
```