EUROPEAN SPACE AGENCY
DIRECTORATE OF TECHNICAL & OPERATIONAL SUPPORT
MISSION OPERATIONS DEPARTMENT

INTEGRAL
Mission Report

INT-MOC-SYS-RP-1001-TOS-OF

No. 007
Week 45

11.11.02

Commissioning Phase

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1 General

It is foreseen to produce weekly reports during the Commissioning Phase. These reports comprise inputs from various teams involved in the Commissioning activities:

- Flight Control Team,
- PI Support Team
- ISOC,
- ISDC.

This report addresses the activities from 01.11, which was the last day of the official LEOP, until including 08.11. This period comprised parts of revolution 6, revolution 7 and most of revolution 8.

2 Summary of Activities

The operations were performed according to the Commissioning Timeline that was produced by the Flight Control Team. The Timeline could be followed for all operations except some activities related to the on-board Imager (IBIS).

The operations concentrated on the one side on the completion of the commissioning of the platform, i.e. calibration of the on-board characteristics such as the satellite inertia and the verification of on-board functions such as the Autonomous Momentum Dump (AMD). The other main area concerned the calibration of the instruments. The functional calibration and electrical check-out of the Optical Monitoring Camera (OMC) and of the X-ray Monitor (JEM-X) has been completed. The other two payload instruments, i.e. the Imager (IBIS) and the Spectrometer (SPI) have been activated and the main functions have been verified. The main outstanding activities of the Commissioning concern the tuning of the on-board parameter settings.

The following table provides an overview of the performed operations:

Date	Revolution	Activity
01.11	6	Thruster Calibration
01.11	6	End of LEOP Move operations from Main Control Room to Dedicated Control Room
01.11 – 03.11	6	Start of automatic commanding for Star Tracker (STR) / Fine Sun Sensor (FSS) misalignment and disturbance torque calibration
	6	OMC imaging operations
03.11 – 06.11	7	Start to perform routine operations such as Perigee Passage activities, wheel biasing, Rate Measurement Unit (RMU) calibration and slews from the automatic Timeline Timeline generated directly from planning inputs provided by Flight Dynamics
03.11	7	Satellite Inertia calibration
03.11 – 06.11	7	Start IBIS activation SPI activation including SPI camera switch-on OMC imaging operations JEM-X electronic calibration
06.11 – 09.11	8	Routine operations executed from automatic Timeline
06.11 – 09.11	8	Continuation of IBIS activation JEM-X put into Data Taking Mode OMC imaging operations
06.11	8	Commissioning of Autonomous Momentum Dump (AMD) function
07.11	8	STR Bright Object Test using Canopus as source

The operations that are listed in the above table have been successfully performed according to the operational Timelines and flight procedures. In addition change requests generated by the S/C and Payload Support Teams have been incorporated. So far 109 change requests have been processed.

In parallel to the real-time operations some effort has been allocated to perform an analysis of the data to identify the performance of the satellite. One important issue was the investigation of the temporary problem related to IBIS.

3 Satellite Status

3.1 Platform

All functions of the platform are nominal. So far redundant units have not been switched on if they are not required for the operations. The performance of the various subsystem is as expected.

3.1.1 AOCS

The performance of the AOCS subsystem is good. All functions of the AOCS have been verified.

A few observations have been made during the LEOP that are still under investigation. They are not critical at the current stage and do not impact the operations for the time being.

- The Guide Star has been lost a few times also outside the Perigee Belt.
- The temperature in one of the fuel lines is showing a non-expected behaviour. A workaround solution using time tagged commands has been put in place. A final solution has been prepared and is currently tested.
- The star position is occasionally oscillating with the thermal cycle.

The fuel mass at Launch was: 541.9 Kg propellant + 4.24 Kg pressurant. The remaining fuel (incl. the pressurant) was on 04 Nov, i.e. after all major manoeuvres 185.4 Kg.

Note: A detailed report concerning the AOCS operations and the fuel budget is provided in the Appendix.

3.1.2 Power

The power subsystem is working properly. The power consumption of the various units is as expected and the power margin is adequate. The available power from the solar arrays is in the order of 2380 W.

3.1.3 Thermal

The thermal control of the satellite is working satisfactory. The number of temperatures outside limits has been significantly reduced. This was achieved by adjusting the operational limits to the actual satellite behaviour. In addition the satellite has reached almost its operational configuration, i.e. all of the operational units have been switched on and are dissipating power.

As mentioned above the thermal control of the fuel lines shows a non-expected behaviour. A special operation has bee put in place to avoid impacts on the satellite health.

3.1.4 OBDH

The functions of the On-board data handling subsystem is as expected. All Data Processing units have been switched on and the on-board communications flow is working properly.

The On-board monitoring table has been updated to improve the thermal control of the fuel lines.

3.1.5 RF

The RF subsystem is working properly. The link margin is sufficient to ensure proper TM reception and execution of commands with the ranging channel enabled.

3.2 Payload

3.2.1 SPI

The instrument is currently working in nominal science mode. The detector temperature is now nominal (90 K). The cryo-cooler is working well with a stroke setting of 5 mm A&B and 5.15 mm C&D). The detector High Voltages (HV) have been set to 4000 V. The energy resolution of the detectors is good with a slight degradation on detector 15. The parameter optimisation will start in revolution 9 (09 Nov).

3.2.2 IBIS

After some difficulties due to the configuration settings the IBIS is now fully switched on and is working well in nominal scientific mode (VETO HV switched on, PICSIT and ISGRI in nominal configuration).

The first complete histogram of IBIS with VETO active has been produced indicating a good health status of the detectors. The main ongoing activities concern the parameter optimisation.

The anomaly on the VETO strobe distribution to PICSIT could be fixed on 07.11 by simply forcing the transition of the strobe ports from main to redundant channels and back to main. The investigation to identify the cause of the anomaly is still ongoing.

3.2.3 JEM-X

Both JEM-X's were running in Data Taking Mode for some days. During the analysis performed by the JEM-X PI of the data recorded during a test with low discriminator settings an anomaly was seen in the distribution of event counts along the cathode direction. Due to a hypothesis of a possible erosion of anodes caused by heavy ions, it was decided to put both JEM-X's in a Save Mode, i.e. no high voltage applied, for the upcoming revolution.

3.2.4 OMC

The OMC is working well in nominal mode taking regularly images (once per day). Outside these periods OMC is in stand-by mode. Further image acquisitions are planned in the upcoming week.

On 02 November (between 0700 and 1600 Z) one several image acquisitions were performed at different pointings. The focus was on the verification of the Centring Algorithm. The results were good.

3.2.5 IREM

The INTEGRAL Radiation Monitor (IREM) is working nominally.

Initial measurements indicating the start of the electron belts at 60000 km have been confirmed by the count rates of the other instruments. As a consequence the radiation belt entry limit (stop of any instrument activity and transition to the safe configuration) is now considered at 60000 km, since revolution 7.

The Radiation thresholds for some of the instruments have been fine tuned on order to have a better response at radiation belt entry. An update of the settings for the remaining instruments is foreseen in the next days.

4 Ground Facilities

4.1 Mission Operations Centre

The performance of the MOC was good. There were a few minor problems that did not significantly impact the execution of the operations.

The INTEGRAL Mission Control System worked flawlessly including the automatic Timeline. There were only a few interruptions due to a known S/W bug in the INTEGRAL Mission Control System (IMCS), see section 5.

The Timelines and procedures that were produced by the MOC are good. The operations could be performed following the timelines and procedures. Change requests issued by the Project Support Teams have been implemented to take into account the actual status of the satellite.

4.2 Ground Stations & Network

The performance of the operational network was good. There was no problem that impacted the operations.

The performance of the ground stations was in general good. There were two station passes, during which major problems occurred that impacted the operations, see section 5.

4.3 Science Ground Segment

4.3.1 ISOC

The INTEGRAL Science Operations Centre (ISOC) was not yet actively involved in the operations. However since the planning process involving ISOC will start in revolution 11 ISOC is currently preparing the activities.

System status

The ISOC system operationally available fulfils the objectives agreed in the "version 7 review" in September. This includes freezing of handover windows. In addition is implemented a correction to the OMC misalignments. The tests of this function shows very good agreement with data from LEOP measurements. A new release of OMC pointing software (v 3.2) has been received together with OMC catalogue version 2. The software is being checked at the moment before installing it. The catalogue is said to be the same as used in ISDC. Updated data files including DBOB has been received from ESOC. Some sanity checks are being performed before put into operational use.

PV related activities

A new set of schedules for the PV phase revolutions will be generated shortly as soon as the new PSF's are delivered. The observations to be scheduled are all available in the database. Some tuning may be necessary dependant on the contents of the new PSF's. It is expected the system as mentioned above including the updated OMC software and Flight Dynamics data files will be used for this generation.

4.3.2 ISDC

The INTEGRAL Science Data Centre is processing the TM and auxiliary data (as far as produced at this stage) since the Launch.

Here is a short report on the ISDC activities 3 weeks after launch.

- Data processing

  Beautiful IBIS and SPI data have now been processed in addition to the data from the monitors.

  Some minor problems have been discovered. Solutions have been quickly found and fixed software will be installed before revolution 11. Reprocessing with the faulty components disabled was already done on request.

  Auxiliary data are now received mostly as expected excepting for a problem with the planned attitude on revolution 7. Their accuracy seems now very good. The attitude information is not yet fully usable in the software because of some incompatibilities with the content of the broadcast TM packet expected during normal operations. A fix is under study.

- Scientific analysis

  Since last week we detected a first source with JEM-X and several new bursts with the SPI ACS. Some of them are being used to verify the overall timing accuracy using the inter-planetary network for GRBs.

  The analysis software for JEM-X is being tuned as experience is gained with real data. Source light curve production have been added to the standard analysis which is now complete.

  The SPI analysis software was run on the first SPI data and is now being improved (in particular the first steps of the analysis).

  The first ISGRI and PICSIT images using the first data with the complete detector on are being produced just now.

  The INTEGRAL Bursts alert System is being tuned for the SPI ACS and was run today for the first time on the ISGRI data.

- Operations

  Shift operations are running smoothly. The first CD-ROM with consolidated TM should arrive next week.

  There are no more spurious alerts generated by the monitor
  Many spurious alerts are still generated for IBIS and SPI.

  The OMC PV activities at ISDC are now waiting for the beginning of the PV phase when auxiliary information generated by ISOC will become available.

  The JEM-X PV activities have started with software tuning.

  The activation of SPI and IBIS have been followed-up.

  Three instrument anomalies affecting ISDC data processing have been detected:

  - Since the beginning of revolution 7 the IREM science data are no more synchronized with the HK. This is probably caused by an instrument setting that is not compatible with the 5h ground link outage around the perigee. A new instrument configuration is under study. The ISDC processing of IREM data has been put on hold.

  - Two anomalies have been detected concerning the SPI ACS timing. The first one is related to not up to date documentation. The second one is related an unexpected on-board processing which is under study.

  About 10 members of the OMC, JEM-X and IBIS teams are currently at ISDC and the teams work smoothly together.

Next week should see the beginning of the consolidated data processing.

5 Special Events

The satellite passed two eclipses in the first two revolutions. The automatic functions of the satellite worked as expected. The next Eclipse season will start end of December.

The satellite has undergone a small flare, which was registered by the instrument. However, none of the functions of the satellite was impacted.

6 Anomalies

A list of the anomalies that were identified so far is presented in the Appendix. The main anomalies that impacted the operations are as follows:

The main problems of the Ground System that impacted the operations related to the ground stations.

- One equipment failed during one pass at Redu that caused an interruption of the TM / TC services and impacted the operations for about 1.5 hours. The maintenance team at the station implemented a workaround and the nominal operations could be resumed.
- One of the Goldstone passes was impacted by frequent losses of the TM and TC link. Since the operations were mainly performed using manual commands at this stage the impacts on the operations could be limited.

In addition the automatic Timeline was stopped twice due to a known S/W bug of the INTEGRAL Mission Control System (IMCS). The missed operations have been executed using manual commands and the operations were resumed within minutes.

The main problems concerning the space segment were as follows:

- The problem related to the VETO Strobe signals could be fixed within two days and does not further impact the instrument operations.
- Both JEM-X's have been put into Save Mode on request of the JEM-X PI due to a non-expected behaviour of the instrument. This behaviour is currently under investigation.
- The temperature of one of the fuel lines has shown a non-expected trend. A procedure has been put in place to avoid the risk of reaching critical temperature. A proper fix is currently in preparation, which is based on the On-board monitoring function.

7 Future Milestones

The schedule for the upcoming revolution 9 is basically as follows:

Date	Revolution	Activity
09.11 – 10.11	9	Routine operations executed from automatic Timeline
09.11 – 10.11	9	Finalisation of IBIS activation JEM-X put into Data Taking Mode OMC imaging operations SPI camera performance verification
09.11	9	Worst case Slew → Verification of slew performance at low altitudes

The upcoming milestones are:

- Finalisation of the instrument calibration activities in revolution 13
- Start of processing planning inputs from the INTEGRAL Science Operations Centre (ISOC) from revolution 11
- Configuring Satellite for Leonides Passage on 19.11.

From revolution 11 to revolution 13 the operations will be performed in a mixed configuration. While IBIS, JEM-X and OMC are mainly driven by the planning inputs from ISOC and will be operated from the automatic Timeline SPI operations will still be performed using the manual stack. After finishing the main commissioning activities in revolution 13 the operations will be mainly performed using the automatic Timeline as foreseen for the Routine Mission Phase.

8 Appendix

The appendix includes various detailed information.

8.1 Detailed Fuel Book-keeping

The fuel-book performed by the Flight Dynamics Team is currently as follows:

```
2002-10-17T04:41:00Z     546.1400      F
Last-minute data: 541.9kg propellant   + 4.24kg pressurant

2002-10-17T09:27:51Z     545.7780      F     LEOP: ISA/SSA
2002-10-18T11:34:33Z     545.7040      F     After RWB 0001_14_M.LRW
2002-10-19T13:31:08Z     545.6830      F     After RWB 0001_17_M.LRW
2002-10-20T07:15:00Z     545.6300      F     After RWB 0002_02_M.LRW
2002-10-22T07:42:59Z     545.6020      F     After RWB 0002_06_M.LRW
2002-10-23T00:27:16Z     545.5700      F     After RWB 0003_06_M.LRW
2002-10-23T03:20:36Z     545.5310      F     After RWB 0003_10_M.LRW
2002-10-23T22:52:38Z     459.2900      F     After PRB1 0003_41_M.DVR
2002-10-24T04:16:30Z     459.2630      F     After RWB 0003_23_M.LRW
2002-10-25T18:58:51Z     459.2280      F     After RWB 0004_02_M.LRW
2002-10-26T20:16:38Z     352.3420      F     After PRB2 0004_51_M.DVR
2002-10-26T22:32:46Z     250.5180      F     After PRB3 0004_52_M.DV2
2002-10-27T01:47:34Z     250.5040      F     After RWB 0004_09_M.LRW
2002-10-28T15:53:06Z     250.4750      F     After RWB 0005_02_M.LRW
2002-10-29T21:20:45Z     189.7180      F     After PRB4 0005_61_M.DVR
2002-10-30T01:15:25Z     189.6740      F     After RWB 0005_14_M.LRW
(NB: inc. TM gap)
2002-10-31T07:32:24Z     185.6690      F     After AAM 0005_65_M.DVR
2002-10-31T10:58:08Z     185.6250      F     After RWB 0006_12_M.LRW
2002-11-01T07:36:18Z     185.5850      F     After RWB 0006_22_M.LRW
2002-11-01T10:00:00Z     185.5640      F     After 1st thr-torque-
                                             cal. sequence
2002-11-01T13:00:00Z     185.5600      F     After 2nd thr-torque-
                                             cal. sequence
2002-11-01T17:06:03Z     185.5350      F     After 0006_03_M.RWB
2002-11-01T18:49:15Z     185.5030      F     Automatic TM processing.
2002-11-01T20:29:39Z     185.5001      F     Automatic TM processing.
2002-11-02T13:12:53Z     185.4910      F     Automatic TM processing.
2002-11-03T01:05:02Z     185.4658      F     Automatic TM processing.
2002-11-03T09:33:59Z     185.4360      F     Automatic TM processing.
2002-11-03T19:37:12Z     185.4010      F     Automatic TM processing.
2002-11-04T20:19:38Z     185.4002      F     Automatic TM processing.
```

The pre-launch assumption was (**in-flight assessment in parentheses**);

Before PRB1:	540.221 kg	(**541.291 kg**)
After AAM:	189.327 kg	(**181.429 kg**)
Delta:	350.894 kg	(**359.862 kg**)

Current: (**181.160 kg**)

The differences with respect to the pre-launch assessment are due partly to simplified modelling and partly to the fact that the prediction SW doesn't take the tranquilisation fuel-usage into account ... In addition to which, the pre-launch estimates obviously were based on the pre-flight thruster calibration.

```
Note: fuel-book initial value included 4.24kg pressurant
      which will not be exhausted  -  thus when the fuel
      book reaches a value of 4.24kg this represents the
      ZERO PROPELLANT value.
```

8.2 Detailed Satellite Information

This section contains some detailed information concerning the various subsystems of the satellite and instruments.

8.2.1 AOCS Operations

AOCS SUMMARY OPERATIONS REPORT 01/11/2002-07/11/1002

These are the main AOCS events in the reporting period:

01/11/2002 (Day of Year 305, Revolution 6)

Execution of the Thruster Torque Calibration. This calibration was a pre-requisite for the enabling of the Autonomous Momentum Dump function. The calibration consisted of a series on individual thruster firings, and evaluation of the corresponding effect in the Reaction Wheel speeds. The calibration was performed fist with a firing time of 127 milliseconds, and then applying the minimum firing time, that is 25 ms.

First enabling of the Sun Steering Law. This AOCS function compensates for the apparent motion of the sun, in order to maintain a fixed inertial attitude. The function is only necessary in order to meet the science requirements, and was not used during LEOP.

Reconfiguration of the AOCS from the LEOP to the Operational Mission Phase set up. This was a reconfiguration at subsystem level that, basically, performed the transition from the relatively simple pre-operational onboard autonomy approach to the more sophisticated one required for the routine operations. The reconfiguration involved both the nominal AOCS functions and the Failure Detection and Correction ones. The completion of this operation was considered the end of the LEOP, and operations moved from the ESOC Main Control Room the Integral Dedicated Control Room.

STR/FSS Misalignment and External Torque calibration. This combined calibration basically requires the satellite to be put in all allowed orientations with respect to the sun. The calibration done consisted of more than 50 different slews, and spanned over three days.

Start of AOCS operations from the automatic timeline. Due to the demanding requirements of the calibration above, the operations were performed in automatic way from the Telecommand Autostack. This timeline was, from the AOCS point of view, very similar to the ones required to perform the science observations, and therefore commissioned for the first time the relevant command sequences and Flight Dynamics automatic interfaces in flight. Apart from the slews, the timeline also included the needed Reaction Wheel Bias operations required for momentum maintenance.

02/11/2002 (Day of Year 306, Revolution 6)

Continuation of the automatic timeline execution for the STR/FSS Misalignment and External Torque calibration.

Loss of Guide star. The guide star used for attitude control was lost by the STR. The sequence of events was:

- 14.55.53 The STR reported False Event for 3 cycles in a row, in the position where the guide star was being tracked.
- 14:55:54 Immediately after the False Events, the STR reported Star Lost. The star was a magnitude 7.05 as reported by the STR, and the current height in the orbit was 123000 Km. No special radiation conditions were observed before or after the event.
- Due to the loss of the guide, the ACC commanded a STR mapping to start, and at the same time powered on the IMU. A new guide star was found 14:56:09. 10 minutes later the ACC powered off autonomously the IMU.
- An attitude reconstruction was performed by ground, and since the attitude was unchanged, the timeline was allowed to continue.

03/11/2002 (Day of Year 307, Revolution 6-7)

End of the STR/FSS Misalignment and External Torque calibration. At the end of the calibration, the perigee passage attitude was acquired. This implied an extremely long slew of 174° that performed nominally.

Complete Inertia calibration. This operation consisted of several offset slews at an attitude with the sun boresighted in the FSS field of view. It was executed from the automatic timeline, in the initial part of revolution 7. The total duration was 8 hours. At the end of the calibration, the attitude for the payload commissioning called Empty Field1 was acquired.

04/11/2002 (Day of Year 308, Revolution 7)

No special AOCS activity, only Momentum Bias operations that were performed from the automatic timeline.

05/11/2002 (Day of Year 309, Revolution 7)

No special AOCS activities.

06/11/2002 (Day of Year 310, Revolution 7-8)

AMD Commissioning Test. The purpose of this test was to provoke the trigger of the Autonomous Momentum Dump function, by predicting the wheel profile evolution and setting the AMD threshold accordingly. The test was executed at the beginning of revolution 8. Both test execution and AOCS behaviour were nominal.

07/11/2002 (Day of Year 311, Revolution 8)

STR Bright Object Test. The purpose of the test was to discard the occurrence on the Integral STR of a recursive problem on the XMM STR, that causes a STR processor fault. The problem seems to be related with very bright and/or extended objects in the STR FoV. The test was performed pointing the satellite to Canopus, taking away the STR from the control loop of the AOCS, and performing a series of increasingly demanding CCD readouts with the STR. The STR behaviour was nominal. Unfortunately the problem was also not reproduced on XMM performing the same test on the same day and object.

8.2.2 IREM

The current configuration is
Electron Count = TC3
Proton Count = TC1
Accumulation time = 60 sec
DTCR = 1 KHz.

8.3 List of Anomalies since Launch

The following table presents the list of all identified anomalies that have been registered since Launch and that are still pending (Status: 07.11.02).

Note: An Anomaly Review Meeting is planned for 08.11, during which some of the anomaly reports will be closed.

ARid	Date Occurrence	Subject	Segment	Element	Status
INT - 002007	22/10/2002	Command sequence TENPE_00 is incorrect.	Space	Procedures	Pending
INT - 002010	22/10/2002	Time correlation not applied correctly to time parameters in TM type 8 reports.	Ground	IMCS	Pending
INT - 002018	22/10/2002	Loss of TM and TC with Goldstone.	Ground	NASA Sta.	Pending
INT - 002021	22/10/2002	JEM-X: Unexpected OEM during HV ramp up.	Space	JEM-X	Pending
INT - 002014	23/10/2002	VETO Context Saving Failed.	Space	IBIS	Pending
INT - 002016	23/10/2002	MCE4 activation anomaly.	Space	IBIS	Pending
INT - 002017	23/10/2002	INCTRB crashed.	Ground	NCTRS	Pending
INT - 002029	23/10/2002	IBIS-ISGRI NPHS switched-off half of MCE4 pixel.	Space	IBIS	Pending
INT - 002029	23/10/2002	IBIS-ISGRI NPHS switched-off half of MCE4 pixel.	Space	IBIS	Pending
INT - 002013	24/10/2002	VETO LSL error.	Space	IBIS	Pending
INT - 002015	24/10/2002	HSL error (loss of SYNCH).	Space	JEM-X	Pending
INT - 002023	27/10/2002	SPI: ACS status error.	Space	SPI	Pending
INT - 002024	28/10/2002	OEM: SPI1 Fixed print overflow	Space	SPI	Pending
INT - 002025	28/10/2002	Telemetry and Telecommand outagesd due to Antenna Mispointing	Ground	NASA Sta.	Pending
INT - 002026	28/10/2002	Sun144 forced logout whilst SPACON was commanding!	Ground	IMCS	Pending

INT - 002031	03/11/2002	VEB does not respond to TCs	Space	IBIS	Pending
INT - 002035	03/11/2002	NCTRS-A went off line	Ground	NCTRS	Pending
INT - 002036	03/11/2002	TM Desktop running very slow	Ground	IMCS	Pending
INT - 002037	03/11/2002	Telemetry loss from REDU	Ground	ESA Sta.	Pending
INT - 002032	04/11/2002	VETO sum counter displayed wrong values in zoning mode	Space	IBIS	Pending