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

INTEGRAL
FLIGHT OPERATIONS PLAN

Volume 3
MOC – SGS Interfaces

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Volume 3
MOC – SGS Interfaces

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Book 1
MOC – ISOC Interface

INT-MOC-FOP-FOP-1001-TOS-OGI

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3.1 Book 1: MOC – ISOC Interface

3.1.1 Introduction

The interactions between the Operational and the Science Ground Segment concern the MOC, ISOC and ISDC. This chapter addresses the MOC – ISOC interactions

The main tasks of the MOC that are relevant to the MOC – ISOC interface are:

- The preparation of planning inputs (PSF),
- The reception and check of the POS,
- The conversion of the POS into the Timeline / Command Schedule,
- The execution of the mission operations incl. instrument health and safety operations,
- The maintenance of the instrument parameters and OBS,
- The execution of instrument contingency recovery operations,
- The generation of reports.

The main tasks of the ISOC that are relevant to the MOC – ISOC interface are:

- The reception of the PSF,
- The processing of the proposals and the subsequent generation of the POS,
- The coordination of updates of the instrument related OBS,
- The maintenance of the instrument on-board configuration parameters,
  Note: Maintenance means in this context that ISOC is to keep track of the instrument settings because ISOC is to give advise to MOC concerning the setting of the instrument parameters after an anomaly or calibration. It is assumed that this is based on recommendation that are provided by the instrument teams.
- The generation of reports.

Since the ISOC is not involved in the real-time operations the MOC – ISOC interface concerns in principle the following areas:

- Exchange of planning information,
- Operational reporting,
- Offline interactions for parameter and OBS maintenance,
- Anomaly related activities.

Note:
It is emphasized that the FOP Vol. 2 Book 1 is also to be considered as an applicable document regarding the MOC – ISOC interface because it specifies the constraints to be considered in the mission planning process.

3.1.2 Interface Set-Up

3.1.2.1 Technical Set-Up

3.1.2.1.1 Communications

The MOC/ISOC communication I/F, defined in relation to the different products to be exchanged, is composed basically of:

- ESACOM (B/U via ISDN)
- Normal E-mail, FAX, Phone
- Normal mail to transfer particular product stored on CD ROM
- WEB I/F to access the stored TM (HK) data using the TM Data Retrieval System (TDRS).

Each one of the previous communication mechanisms has been chosen depending on:

- Particular product to be sent/received
- Frequency of the exchange.

The ESACOM line characteristics are:

- No guaranteed bandwidth
- Time to establish the line: 2-3 seconds
- Double way line (the line can be dialled up from both MOC and ISOC)
- The maximum time the line stays up, from the last transfer of data, is typically 10 seconds. This is one configurable parameter to be set within the router.

The INTEGRAL File Transfer System (IFTS), installed at the MOC and ISOC premises, provides a standard mechanism for file transfer between these systems.

The IP and FTP protocols will be used between the various nodes in order to support the IFTS.

FTP will be the basic mechanism used in the transferring of files and in addition the IP protocol will be used for task to task communication between IFTS instances.

The basic set-up is illustrated in Figure 1 IFTS Set-Up.

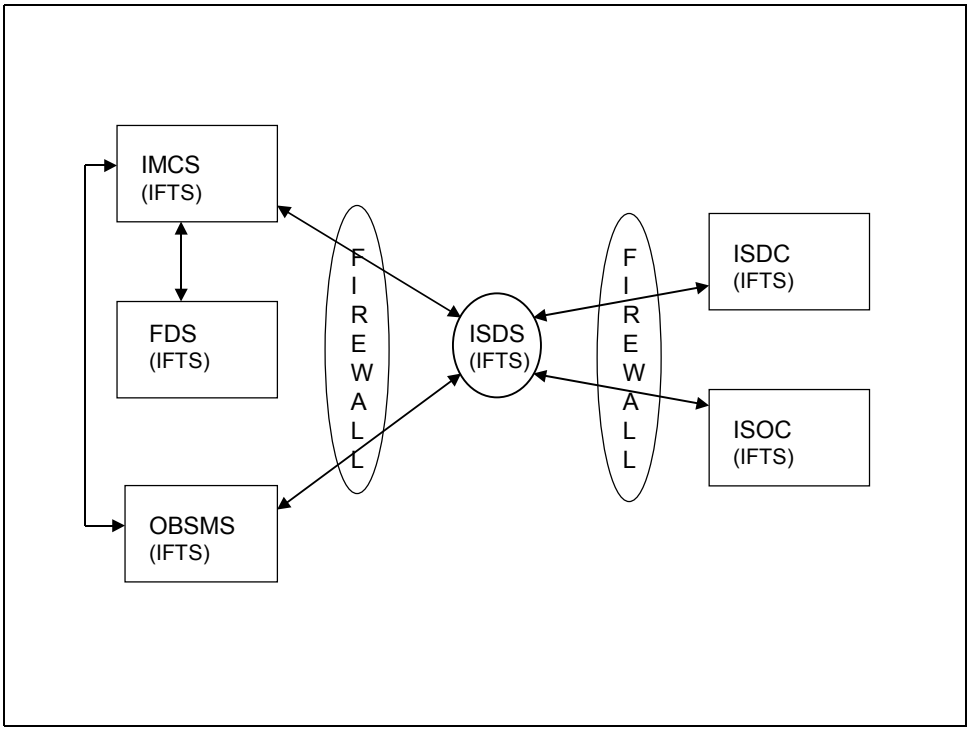

Figure 1 IFTS Set-Up

In order for the IMCS to transfer files through the firewall, the IFTS on the IMCS is notified that a file is to be sent. The IFTS sends this notification to the “Intermediate node” ISDS and “pushes” the file to this node.

When the file has arrived on the intermediate node ISDS a notification is then sent to the IFTS component resident on the ISOC system, which then “pulls” the file from the intermediate node.

Similarly, for the ISDC to transfer a file to the IMCS it is necessary to send a notification to the intermediate node, which “pulls” the file across.

Notification is then sent to the IMCS and then this will, in turn, “pull” the file from the intermediate node.

The FTP connection can be established via the Public Network (Internet).

On arrival at the destination node “action procedures” can be automatically triggered which can be used to instigate further processing of the file. These action procedures take the form of shell scripts (UNIX) or DCL command files (VMS) and they in practice constitute the interface between the IFTS software and the Application Software running on the receiving node. Provision of these action procedures is the responsibility of the receiving node.

Additional information about IFTS is available in the OGS – SGS ICD.

3.1.2.1.2 Tools

3.1.2.1.2.1 MOC Tools

The MOC elements included in the transfer & reception of products through the MOC-ISOC interface are:

- FDS for generation and processing of planning products
- IMCS for Timeline Summary Generation
- OBSMS for receiving instruments memory images files
- Integral Operational Database
- FOP Generation Tool used for the generation of EDs.

The mission planning data, needed by MOC to convert the Preferred Observation Sequences (POS) into the Timeline / Command Schedules, is part of the Operational Database and is under configuration control.

The database contains the following:

- Definitions of all Event Designators (ED’s) in form of command sequences used by the system in the planning cycle
- Data used to translate all the parameters present in the ICP’s.

The data are to be maintained by MOC and the ODB will be provided to ISOC.

3.1.2.1.2.2 ISOC Tools

ISOC related tools will cover the following functions:

- Proposal Handling System
  Note: The PHS is not directly relevant to the I/F to MOC but is important in the context of the scheduling process.

- Observation Scheduling System
- Slew Time Prediction Software
- Attitude Constraint Checker
- Database of Observable Bins
- Visibility Tools
- OMC Catalogue & OMC Pointing S/W.

3.1.2.2 Management Set-Up

3.1.2.2.1 Responsibilities

The MOC responsibilities related to the exchange of products are:

- Generation of the Planning Skeleton File (PSF) identifying the windows available for scientific observations to be sent to ISOC
- Enhancement of the Preferred Observation Sequence (POS) received from ISOC
- Generation of the Timeline Summary File to be sent to ISOC
- Maintenance of CSSW
- Conversion of Instrument “Images” into telecommands.

The ISOC responsibilities are:

- Generation of the Planned Observation Sequence (POS) and the corresponding Instrument Command Parameter (ICP) files to be sent to MOC
- Definition of relevant instrument configurations after anomalies and calibration activities.

Note:
It is assumed that the PI Teams will be consulted and provide recommendations for the appropriate instrument configurations. They are to be approved by ISOC.

3.1.2.2.2 Contact Points

The MOC – ISOC contact points are:

MOC:

- SOM: co-ordination, operational issues, anomalies, etc.

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  FAX : 0049.6151.904008
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- FD Coordinator: co-ordination of FD related products

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- Ops Coordinator: co-ordination of routine operational activities

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- Mission Planning : coordination of mission planning activities

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  Telephone : 0049.6151.902438
  FAX : 0049.6151.904008
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ISOC:

- ISOC OM: co-ordination, anomalies, etc.
- Planner: routine mission planning issues

3.1.3 Tools Delivery

MOC will provide ISOC with a couple of tools that are needed by ISOC to perform the mission planning.

3.1.3.1 Database Of Observable Bins

The INTEGRAL Database of Observable Bins provides the INTEGRAL ISOC with a facility to quickly schedule planned observations taking spacecraft pointing constraints into account. To do this the celestial sphere is sub-divided in small areas – the so-called BINS. Each bin is delimited by sections of spherical longitude and latitude circles. The BINS are selected such that they cover approximately the same area (size) of the celestial sphere. BINs are sized between 2 x 2 degrees and 10 x 10 degrees.

For each BIN all periods in a selected revolution are calculated during which:

- the spacecraft altitude is above a certain threshold
- none of the four corner points nor the centre is violating any spacecraft pointing constraints related to Earth, Sun and Moon – fully unconstrained periods
- at least one of the four corner point or the centre is not violating any spacecraft pointing constraints related to Earth, Sun and Moon – partially unconstrained periods

In order to enable the ISOC to accurately assess a selected observation (pointing during a selected period) attitude constraint checker software is also provided.

The delivery of the following products is to be generated by Flight Dynamics:

- the functional interface to access the DataBase of Observable Bins (DBOB) for the Mission Planning part of the ISOC
- the DBOB database.

The functional interface is delivered in two parts:

- a library of subroutines callable from FORTRAN in a linkable form for a SUN/Solaris platform
- a set of data files which can only be accessed via the access subroutines.

This interface software and the DBOB database shall be installed on workstations within the ISOC.

Both software and data are transmitted from the IFDS to the ISOC on a CD ROM. The first operational (i.e. post-launch) DBOB shall be delivered to the ISOC within 4 days after the final orbit acquisition manoeuvre (by courier).

The DBOB data element is generated by the IFDS on ISOC request. Updates are foreseen to be issued once every 3-month to account for accumulative orbit perturbations caused by thruster firings.
Furthermore after each planned orbit maintenance manoeuvre an updated DBOB shall be delivered.
Data file transfers are initiated manually. Transfer to the ISOC is normally via public mail.

The DBOB software and data will be delivered as soon as the operational orbit is available. Updates will be provided on ISOC request.

Both DBOB access software and data are to be used on a SUN/Solaris platform in the ISOC. No other platform is supported.

The total size of software to be installed in the ISOC is approximately 3 MB.

House keeping, i.e. deletion of old versions is done by the ISOC.

The access to the INTEGRAL DBOB will be via a set of FORTRAN callable subroutines. These subroutines are provided by IFDS and are designed to run on a SUN/Solaris platform in the ISOC.

The subroutines will access data files, which are maintained by FD. The structure of these data files is documented internally to FD only, which reserves the right to change the file structure.
On the occasion of a change of the file structure a new version of the subroutines – updated to fit with the new structure – will be delivered.

Additional detailed information is available in the OGS – SGS ICD.

3.1.3.2 Attitude Constraint Checker

The INTEGRAL Attitude Constraint Checker provides the INTEGRAL ISOC with a facility to assess whether the planned observations are in compliance with spacecraft pointing constraints. It includes also the Dither Composition Tool that is to be provided to ISOC.

This is done by calculating all periods in a selected revolution, during which the spacecraft can maintain a desired attitude - given in right ascension, declination and position angle - without violating pointing constraints related to Earth, Sun and Moon.

The delivery of the following products is generated by Flight Dynamics:

- the functional interface to access the constraint checker for the Mission Planning part of the ISOC
- the functional interface to the dither decomposition tool
- the ephemeris and configuration data required by the software.

The functional interface is delivered in two parts:

- a library of subroutines callable from FORTRAN in a linkable form for a SUN/Solaris platform
- a set of data files which can only be accessed via the access subroutines.

The software is transmitted from the IFDS to the ISOC on a CD ROM.

The data, on the contrary, are transmitted from the IFDS to the ISOC via file transfer using the INTEGRAL file transfer method.

The constraint checker data element is generated by the IFDS on ISOC request.

Updates are to be issued when required.

Data file transfers are initiated by the orbit subsystem in the FDS.

Both constraint checker software and data is intended to be used on a SUN/Solaris platform in the ISOC. No other platform is supported.

The amount of data is estimated to be about 7 MB to cover a period of 1 year.
The total size of software to be installed in the ISOC is approximately 1 MB.
House keeping, i.e. deletion of old versions is done by the ISOC.

Transfers of software between the IFDS computers and ISOC workstations are done via CD ROM.
Transfers of data between the IFDS computers and ISOC workstations are done via notification/ftp.

Additional details are available in the OGS – SGS ICD.

3.1.3.3 Slew Time Prediction S/W

The INTEGRAL slew time prediction software provides the ISOC with a facility to check whether or not a closed slew manoeuvre is feasible starting at a given initial attitude and ending at a selected target attitude and to estimate the duration of such a slew manoeuvre. Additionally the software checks whether the specified attitude slew is valid w.r.t. the spacecraft pointing constraints.

The delivery of the following products is foreseen to be generated by Flight Dynamics (FD):

- the functional interface to access the attitude slew time prediction software for the Mission Planning part of the ISOC
- the ephemeris and configuration data required by the software.

The functional interface is delivered in two parts:

- a library of subroutines callable from FORTRAN in a linkable form for a SUN/Solaris platform
- a set of data files which can only be accessed via the access subroutines.

The software is transmitted from the IFDS to the ISOC on a CD ROM.

The data is transmitted from the IFDS to the ISOC via file transfer using the IFTS previously described.

The slew time prediction software data are generated by Flight Dynamics on ISOC request.

Updates are to be issued when required (typically every 2 weeks). Data file transfers are initiated by the orbit subsystem in the IFDS.

Both slew time prediction software and data are to be used on a SUN/Solaris platform in the ISOC. No other platform is supported.

A DAT drive must be available on one of the ISOC SUN workstations to read the tape. Sufficient disk space needs to be provided to store the data files and the software elements.

Additional information is available in the OGS – SGS ICD.

3.1.3.4 Mission Operational Database

ISOC requires some data that are part of the ODB. This concerns mainly the definition of EDs.

ESOC is providing an ED Browser, which provides the relevant ED data. On request ESOC can also provide the complete ODB, which would follow the delivery scheme described in following.

The ODB export file is generated at the MOC on a dedicated technical workstation.

The ODB is maintained in an Access database on the IMCS by means of the IMCS Database System.

The transfer of the ODB to ISOC is performed by the methods described below:

1. Compress the IODB to be exported into a ZIP file

2. Load the ZIP file onto a location of a public server.

3. Send e-mail notification to ISOC that a new Export ODB has been made available at the relevant location of the server.

The access to the server is via the standard FTP anonymous access mechanism or services available onto standard web browser's applications.

The ODB export file sent to the ISOC will be a Microsoft Office 97 Access database file.

The ODB is a single file with an estimated size of 100 MB.

On the IMCS and FDS it is assumed that the exported ODB is the one currently active on the MOC, and referred to as the Reference ODB.

The ODB will be updated when necessary. This will be more frequent during the Commissioning than during the Routine Phase. The MOC will attempt to update the ODB during the non-operational periods, i.e. around Perigee.

During the operational phase, updates are infrequent.

Manual activity is required every time a new Reference ODB is exported to ISOC.

The activities consist of:
- Loading the ODB onto the public server
- E-mail notification to ISOC.

3.1.3.5 In Orbit Access Software

The orbit determination subsystem has to provide the satellite state (position and velocity) for the past and for the future. Data closely related to the satellite motion, such as eclipse times and ground station visibility is also provided by the orbit determination subsystem.

These data are provided to ISOC as an Orbit File (ASCII) containing revolution numbers and retrieval routines.
It is planned that the orbit file is transmitted once a week via the IFTS. The determined orbit will cover the period up to Sunday night (i.e. end of previous calendar week) and the predicted orbit will commence on Monday morning (beginning of current week).

Additional information is available in the OGS – SGS ICD.

3.1.4 Configuration Control & Coordination

3.1.4.1 Configuration Control

All operational products will be subject to configuration control to ensure that the latest and approved version of them is effectively the one used for the operations.

The configuration control mechanism concerning the Ground Segment is described in the relevant book of the FOP (Vol. 1, Book 4).

The configuration control of the planning products is mainly based on the tracking / verification of their version. This information is normally reported in the header of the products themselves.

Configuration Control is applied on two levels. The first is the working level. At this level configuration control is ensured through the application of proper procedures. The second level concerns the CCB level, which is mainly to be involved in case of conflicts or if it is necessary to agree on system upgrades that might have some implications, e.g. regarding costs.

3.1.4.2 Maintenance of Ops Products

3.1.4.2.1 FOP Maintenance

MOC is fully responsible for the maintenance of the FOP.

Before launch all the new generated FOP versions under the MOC Configuration Control mechanism, have been checked / approved also by Project/ PI.

After launch, the FCT will issue a new release of the FOP, incorporating new or modified procedures necessary to cope with the actual performance / characteristics of the satellite.

The FOP is under configuration control. Each procedure is under configuration control. If a single procedure is updated or introduced it is possible that only the existing procedures will be modified or a new procedures will be added without releasing a complete new FOP.

If necessary, i.e. if changes effect also the other elements of the Ground Segment, the GS CCB will be involved in the approval process.

3.1.4.2.2 Database Maintenance

MOC is fully responsible for the maintenance of the Mission Operational Database. Updates will be implemented when required.

The typical elements, which could be changed during S/C lifetime, are:

- S/C engineering parameters, as resulting from anomalies,
- Instruments engineering parameters, as resulting from in-flight calibrations and also from anomalies,
- LUT/context tables, as resulting from calibrations and on-board automatic actions.

In the first case MOC is fully responsible of the decision/implementation of the required changes. The new version of the ODB will be distributed to ISOC if data are modified that are relevant to ISOC.

In the second and third case, the instrument teams or ISOC will formally request MOC to implement the new specified parameter values. The new version of the ODB, as resulting from the up-date, will be distributed to ISOC.

3.1.4.2.3 ED Maintenance

Event Designators (EDs) are defined in the Operational Database at MOC in form of command sequences and appear in the POS transmitted by ISOC to MOC.

The maintenance of EDs is then an aspect of the whole ODB maintenance activity under MOC responsibility. The revised ODB will be provided to ISOC when an update relevant to ED's has been implemented.

3.1.4.3 Maintenance of Delivered Products

MOC (FD) is fully responsible for the DBOB maintenance. A new issue is foreseen after each planned orbit maintenance manoeuvre, to account for cumulative orbit perturbations.

MOC (FD) is fully responsible for the Attitude Constraint Checker S/W maintenance. Updates will be distributed when required.

MOC (FD) is fully responsible for the Slew Time Prediction S/W maintenance. Updates will be distributed when required.

MOC (FD) is fully responsible for the In Orbit Access S/W maintenance. Updates will be distributed when required.

3.1.4.4 Regular Meetings

Regular meetings will be held in order to discuss/approve:

- Changes in the MOC planning products
- Changes in the MOC off-line products
- Changes in the Instruments default parameters affecting ODB coming from Instruments data processing and Calibrations

- Current Platform Status: this is necessary to highlight the possible impacts on Routine Orbit Planning due to Platform anomalies. Discussion about relevant Database changes could also be necessary.
- Current Instruments Status: this is necessary to analyse / report on possible Instruments anomalies and to describe the necessary modifications affecting Planning, Operational Procedures and impacts on the Instruments' Parameters List and Database.

The meetings will be held alternatively in the ESOC and ISOC (ESTEC) premises.

MOC will be responsible for the generation of the Agenda and of the conduction of the meeting itself when it is held in ESOC.

ISOC will have similar responsibilities when the meeting is held at ESTEC.

3.1.5 Activities relevant to the Interface

The interface related to the exchange of products with ISOC are:

- IFTS, see Section 3.1.2.1.1
- E-Mail
  E-mail is mainly used to provide supplementary non-operational information.
- CD ROMs or DAT disks via public mail.

In addition to the above some interaction is foreseen via Phone and FAX.

3.1.5.1 Planning Activities

3.1.5.1.1 Planning Schedule

- One planning period, will cover a period of 30 days.
  Note: It is the period, which is covered by the set of PSF's that will be sent to ISOC.

- The PSF will be available at least 30 days prior to the relevant planning period.

- A set of PSF's will be provided to cover a period of 30 days (10 revolutions).

- The POS will be available at least 15 days prior to the relevant planning period.

- A set of POS's will be provided to cover a period of at least 15 days (5 revolutions).

- The executable timeline will be available one week in advance to the planning period.

- TOO requests (via POS/REPOS) will be incorporated by the MOC within 8 hours after receipt of the request.

- Instrument Parameters Change Requests will be incorporated for the next revolution under the prerequisite that 8 working hours are available between the request and the start of the concerned revolution.

The schedule of the delivery of the various planning products is defined in the following table.

Originator	Product	Frequency	Remarks
MOC	PSF	Every 4 weeks	A set of 10 PSF is provided
ISOC	POS	Every 2 weeks	A set of 4 to 5 POS is provided
MOC	TSF	Every 3 days	Available one week in advance
MOC	Orbit file	Once a week	Covers a period of TBD weeks, available each Wednesday
MOC	Planning Messages	Ad hoc	Generated when POS processing and Timeline Generation performed

Table 1 Schedule of Planning Products

Note:
There might be deviations with respect to the above schedule depending on the availability of the required planning information, e.g. Goldstone planning inputs.

3.1.5.1.2 Exchange of Planning Products

3.1.5.1.2.1 PSF

- The Planning Skeleton File (PSF) will be generated by MOC and be provided to ISOC 30 days in advance of the concerned planning period via IFTS.
- The produced PSF contains a definition of the orbit dependent Events, and Operations Windows related to one revolution. In order to provide the inputs for a planning period of 30 days several PSF's will be generated and transferred as a batch of 10 PSF's covering 10 revolutions.
- FD staff prepares the PSF on the Flight Dynamics System (FDS). The file is referenced and processed according to Revolution Number and Revision Number.
- Windows define periods of time during which a specific activity is to be performed, e.g. orbit manoeuvre.
- Events concern orbit events, e.g. eclipse start and end times, as well as operational events, such as times of station coverage start/end or instrument activation/deactivation.

The duration of the PSF exchange with ISOC (via IFTS) will typically last from 12 to 15 minutes depending on the PSF size.

3.1.5.1.2.2 POS

The POS will be prepared by ISOC staff and provide all relevant information for one revolution as follows:

- all pointing requests
- the relevant instrument configuration
- the times for required slews
- the times for required station hand-over
- the times for Reaction Wheel Bias Manoeuvres
- the windows for special instrument engineering / calibration activities.

Satellite operations will be broken down into activities, which are identified using Event Designators (ED). The ED's will be defined in the Operational Database at MOC and will refer to predefined command sequences.

The ED's relevant to the scientific related operations are provided in the POS. The associated parameter values will be defined in an ICP file associated with each POS.

The POS and the Instrument Command Parameters (ICP) File will be sent from ISOC to MOC via IFTS (always issued together).

The POS will be validated using the FDS at reception regarding format and FD related information. Further checks will be performed by the IMCS concerning instrument specific information when the EPOS is sent to IMCS.

Requests for instrument setting optimisation will be passed from ISDC to ISOC for re-planning. The Re-planned Preferred Observation Sequence (RPOS) File will be sent from ISOC to MOC (FDS) via IFTS.

It is to be noted that re-planning for instrument setting optimisation is only foreseen to be executed in the next orbit, and normally, not before 8 hours from reception at MOC of the RPOS. Moreover, re-planning is only accepted once per orbit.

3.1.5.1.2.3 Mission Planning Messages

The INTEGRAL mission planning messages provide the INTEGRAL ISOC with feedback from the mission planning process as it is executed inside the INTEGRAL Flight Dynamics System (IFDS) and the INTEGRAL Mission Control System (IMCS).

IFDS provides messages that indicate whether the processing of the POS/ICP was successful.
IMCS provides a dedicated log of the timeline generation indicating all identified problems.

The messages are transmitted from MOC to ISOC using the IFTS.

The amount of data depends on the detected failures but its size will be normally in the order of few Kilobytes.

The INTEGRAL planning messages will be logged and archived by both message sender and receiver.

3.1.5.1.2.4 Timeline Summary

The EPOS and APF that are produced by FD on reception of the POS and ICP are used to generate a Timeline of the satellite operations at MOC. This Timeline identifies the sequence of all activities and their major characteristics. The MOUT's / MOUTP's generated during the planning process are part of the Timeline.

Additional checks are performed concerning instrument parameters, which are not part of the FD processing.

A Timeline Summary will be produced and sent to ISOC via IFTS to allow ISOC to verify and approve the planned sequence of activities.

The Timeline is converted into the Command Schedule (TCS). One TCS contains all the commands for one revolution and is generated about 1 week before execution. This will allow

for re-planning activities should any errors be found in the command validation or sequence generation.

3.1.5.1.3 Re-planning Activities

Reasons for re-planning may range from a ground station outage to the identification of a Target Of Opportunity (TOO).

Short term re-planning by MOC is not anticipated. This means that in case of a schedule interruption, e.g. due to a ground outage, activities / exposures will be skipped and the nominal schedule will be resumed at the next possible defined exposure boundary, marked by a Conditional Configuration Change Flag (CCCF).

The Flight Control Team performs re-planning as far as possible during normal working hours. Only if urgent replanning is required, e.g. in case of a TOO, the responsible S/C operations Engineer (SOE) on call will be informed to perform the replanning

MOC will process the modified POS/RPOS according to the following rules:

- If the modified POS/RPOS concerns instrument anomalies or TOO's, to be declared by ISOC, MOC will process the POS/RPOS within 8 hours.

- If the modified POS concerns the change of instrument parameters or the change of the sequence of exposures, then MOC will implement the modified POS for the next orbit, provided that at least 8 working hours are available between receipt of the POS and the start of the relevant orbit.

Re-planning will normally start at ISDC where a Quick Look Analysis of the observation data is performed. ISDC may identify TOO's or the need for modifying specific instrument parameters and inform ISOC about the required changes. If the changes are approved by ISOC a modified POS or a Re-planned POS (RPOS) will be generated.

A modified POS is generated when a future orbit is concerned and will replace an existing POS identified by the Revision Number.

A RPOS is generated when the POS of the ongoing orbit is to be replaced or when an orbit is concerned, which starts outside working hours. Only one RPOS per revolution will be accepted by MOC.

ISOC is to ensure that the satellite / instrument configurations and the attitudes fit to the preceding and succeeding POS.

The mission planning tools at MOC will be defined in such a way that the modified POS / RPOS can be implemented within 8 hours after reception of the POS if necessary. That includes the time of processing of the POS by FDS (less than 1 hour) and the operational activities needed to generate and validate the new Timeline and to replace an existing Timeline by the new Timeline.

In case the FDS will identify an RPOS it will check that the 8 hours constraint has been considered and a message will be generated and sent to the SPACON to inform him about the time at which the new Timeline is to be activated.

In case that a modified POS is provided the FDS will process this POS on reception. The Ops Team will generate and implement the new Timeline in due time for the preparation of the relevant orbit.

3.1.5.2 Operational Interactions / Reporting

Special operational direct interactions between MOC and ISOC are foreseen in case of:

- Contingency related activities: recovery actions are to be co-ordinated
- Change in the Instruments Parameters default Configuration: the interaction is needed to identify / confirm those changes, which must be implemented in the ODB.

The above activities require contacts with ISOC via faxes, E-Mail technical notes, telephone calls, operational meetings, anomaly notifications and anomaly reports.

For routine operations, no special direct interaction is foreseen but only regular mission reporting by means of operational reports.

For this reason, the reporting activity can be organised in three main categories:

- Routine Reports
- Anomaly Reports/Notifications
- Special Reporting.

The Routine Reports exchanged between MOC and ISDC are:

- Revolution Reports (from MOC to ISOC), to provide an overview of the performed operations and the main interruptions of the operations.

- Weekly Reports (from MOC to ISOC), to provide detailed information about timeline of events, S/C status, ground segment statistics and anomalies occurred during the previous week.

- Annual Reports, providing the trend analysis of the satellite data over the last year and a summary of the overall system status.

The Anomaly reporting, distributed from MOC to ISDC, is constituted by:

- Anomaly Notifications, generated within one hour after the occurrence of the anomaly, providing the description of the anomaly with all related information available at this time and preliminary assessments of possible impacts on the mission.

- Anomaly Reports, providing the complete results of the performed diagnosis / analysis and the assessment of impacts on the mission.

Reports to be distributed by ISOC to MOC are :

- Regular Reports on the Instruments (performance, configuration…)

- Instruments Anomaly Reports containing the diagnosis/analysis of the instrument malfunction and possible impacts on the mission.

Special Reports, as a result of special investigations concerning the Instruments, will be distributed by ISOC to MOC.

In addition to the reports regular teleconferences will be held to exchange information.

3.1.5.3 Offline Activities

3.1.5.3.1 Instrument Parameter Maintenance

Throughout the mission there will be the necessity to modify the instrument default configuration settings/parameters. This will most likely be as a consequence of:

- the result of instrument in-flight calibrations
- long term trend/performance monitoring
- an instrument anomaly.

In all three cases the ISDC will co-ordinate, with the appropriate Instrument Team, the definition of updates needed. Once an agreement has been reached, ISDC are expected to submit the appropriate change request, along with details of the technical/scientific justification, to the GS CCB. It is also possible that the instrument teams directly submit the change request to the CCB.
The MOC will directly interface to the Instrument Teams to co-ordinate operational issues.

ISOC will validate the requested change to ensure that the scientific implications of the requested are fully understood.

If the validation process is successful, the GS CCB will then approve the Change Request.

Once a change request has been approved, ISOC will co-ordinate the implementation of the change with MOC.

The changes to the instruments default parameters can have the following forms:

- A small set of individual parameter changes. In this case ISOC will send the information to MOC via E-mail / Fax. MOC will implement the changes into the database and distribute the new version to ISOC.

- Changes affecting entire instrument parameter tables. In this case the entire table will be sent to MOC in the form of an image ASCII file (i.e. it will be treated as a S/W image file) or as an ASCII file in the database format via IFTS (see Section 3.1.5.3.2 “Instrument On-Board S/W Maintenance”).
  Aome special products, e.g. TPF’s related to the SPI configuration, will be sent directly to the MOC. A change request is to be issued to keep informed all elements of the Ground Segment.

3.1.5.3.2 Instrument On-Board S/W Maintenance

The instrument on-board S/W is split in two parts:

- Common Service Software (CSSW) under MOC responsibility
- Instrument Application Software (IASW) under PI responsibility.

The validation process philosophy is based on the following constraints:

a) MOC has the capability of implementing and validating only CSSW S/W changes without the possibility of merging them together with IASW.
b) Instruments Teams/PIs have the capability of implementing, validating IASW S/W changes and merging them together with CSSW.

As a consequence,

- If only the CSSW is to be changed, then MOC will implement/validate the CSSW new version and will send it to Instruments Teams/PIs premises. Here CSSW will be merged with IASW, so that the whole S/W will be run and validated. If this process is successful, the complete S/W image (CSSW+IASW) will be sent back to MOC for up-link to the S/C.

- If, on the contrary, only IASW requires changes, then the Instruments Teams/PIs will implement the new IASW version which will be merged with the current CSSW. The whole S/W will be tested and validated. If the activity is successful, then the complete image will be sent to MOC for up-link to S/C.

ISOC will not perform any check on validation. Nevertheless ISOC could perform an assessment on the effects to be expected on the science data if the S/W change will effect on-board algorithm or instrument configuration.

The exchange rules of new S/W between MOC and ISOC are:

- The input must correspond to a complete S/W image and not to portions of it.
- The input must consist of files that follow the OBSM ICD.

3.1.5.4 Contingency related Activities

During the Satellite lifetime, anomalies concerning platform or instruments may occur.

Depending on the nature of the anomaly the source of detection can be:

- MOC, if the anomalies can be detected through HK (VC0) data;
- ISDC and PI / instruments teams, if the anomalies are detected through the analysis of the science TM data (VC7).

The MOC is responsible to handle all S/C related anomalies. This includes the execution of relevant Contingency Recovery Procedures (CRP) and the co-ordination of the failure analysis with Industry. In the case that the mission execution is impacted the MOC will keep informed the ISOC. This will be done via an Anomaly Notification that will be provided within one hour after occurrence of the anomaly and via an Anomaly Report that provides further details when the analysis is finished.

The responsibility concerning instrument anomalies is shared between the MOC, ISOC and ISDC.
The MOC is responsible for all near real-time activities, i.e. for the execution of the relevant CRP's and for the safety of the instrument. The MOC will inform ISOC via an Anomaly Notification. In case that the instrument operations are impacted the MOC might contact directly the instrument experts, which can be the contact point for the Instrument teams or the instrument experts at ISDC, to clarify necessary operations.

If the MOC has no clear guidance how to proceed after the detection of the anomaly it will interrupt the operations to the concerned instrument and will put it into a Save Mode. It is expected that the SGS co-ordinates the anomaly investigation with the instrument experts keeping the MOC informed. At the end of the investigation the SGS is to inform the MOC about the further process. The MOC will then implement all operations that are needed to resume the nominal status. If necessary, MOC will co-ordinate operations related issues directly with the Instrument Teams.

If the anomaly is detected at ISDC, ISDC is to inform MOC and ISOC. In case of critical anomalies, which are to be identified by the instrument teams, the ISDC can contact directly

MOC to co-ordinate the recovery operations. In other cases ISOC is to co-ordinate the further process.

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MISSION OPERATIONS DEPARTMENT

INTEGRAL
FLIGHT OPERATIONS PLAN

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MOC – SGS Interfaces

Book 2
MOC – ISDC Interface

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15/10/2000	Draft / 2	All	Update after discussion with ISDC	
07/11/2000	Draft / 3		Update based on comments from ISDC	
21/12/01	1 / 0	All	Version for Review & Approval	
28/02/02	1 / 1		Update based on the results of the FOP review Page renumbering Various clarification of text Handling of contingencies	
21/02/03	2 / 0	All	General clean-up post Launch	SOM *M. Schmidt*

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3.2.1 Introduction

The FOP defines the interactions between the Operational and the Science Ground Segment, i.e. between the MOC, ISOC and ISDC. This chapter addresses the MOC – ISDC interactions.

The main tasks of the MOC that are relevant to the MOC – ISDC interface are:

- Real Time Telemetry distribution
- The Timeline Summary File generation
- The execution of the mission operations with consequent Observation Log File (OLF) generation and distribution,
- The maintenance of the Mission Archive and the distribution of data,
- The Integral Flight Dynamics System (FDS) related activities and consequent product delivery,
- Check of ISDC inputs concerning “ISGRI Low Threshold Table” and uplink of table,
- Handling of OMC Command Inputs.

The main tasks of the ISDC that are relevant to the MOC – ISDC interface are:

- The reception of the Real Time Telemetry,
- The reception of auxiliary data,
- The reception of the consolidated TM data via CD ROM,
- The maintenance of the ISGRI low threshold table,
- The Integral Burst Alert System (IBAS) task, i.e. monitoring in real time the Integral TM, detecting Gamma Ray Bursts (GRB) and alarming MOC,
- The generation of OMC command inputs.

The MOC – ISDC interface concerns in principle the following areas:

- S/C Real Time Telemetry,
- IMCS products (auxiliary data)
- FDS products (auxiliary data)
- IBIS Tables
- GRB alarms with consequent TC (IM_X) up-link from MOC to OMC instrument (IBAS system).

3.2.2 Interface Set-Up

3.2.2.1 Technical Set-Up

3.2.2.1.1 Communications

The MOC/ISDC communication I/F, defined in relation to the different products to be exchanged, is composed basically of:

- Frame Relay Service of 128 Kbps,

- One line of 64 Kbps for auxiliary data, which comprises voice (up to 10 Kbps) when required and the OMC command input (up to 8 Kbps),
- Two ISDN dial-up lines of 128 Kbps as B/U
- Normal E-mail, FAX, phone
- Normal public mail to transfer CD-ROMs
- WEB I/F (on ISDN line) to access the Performance Analysis Subsystem (PAS).

The transfer mechanisms have been chosen considering:

- Particular product to be sent/received
- Frequency of the exchange

The ISDN line characteristics are:

- Time to establish the line: 2-3 seconds
- Double way line (the line can be dialled up from both MOC and ISDC)
- The maximum time the line stays up, from the last transfer of data, is typically 10 seconds. This is one configurable parameter to be set within the router.

Additional details are provided in the OGS-SGS ICD.

3.2.2.1.1.1 Near Real Time Telemetry Link

MOC receives S/C Telemetry from the ground stations, performs frame level checks, distributes telemetry to the OPSLAN for internal processing and, via Firewall, to the Integral Security Data Server (ISDS), which, in turn, sends the telemetry frames to ISDC.

ISDS is a single node inside the MOC firewall on the ExtServerLAN.

ISDC is located at Versoix (Switzerland) on a remote area network protected from the external world by a Firewall.

The electronic transfer of the S/C Telemetry frames is a point-to-point communication based on the TCP/IP protocol. The maximum available bandwidth is 128 Kbps for real-time TM data.

The link set-up is provoked by ISDC that acts as a client while the ISDS is the server.

No data time / quality checks and time correlation will be performed by ISDS at TM transfer level. In addition there will be neither data replay capability nor archiving functions (in case of link failure) at this level. In order to compensate data gaps CD ROMs will be produced in regular intervals, which will be sent to ISDC via normal mail (see below).

For additional details on this type of link, see OGS-SGS ICD.

3.2.2.1.1.2 Auxiliary data transfer protocol

Auxiliary Data are distributed via file transfer mechanism. The data are provided via a separate line of 64 Kbps.

The INTEGRAL File Transfer System (IFTS), installed at the MOC and ISDC premises, provides a standard mechanism for file transfer between these systems.

The IP and FTP protocols will be used between the various nodes in order to support the IFTS.

FTP will be the basic mechanism used in the transferring of files and in addition the IP protocol will be used for task to task communication between IFTS instances.

The transfer of a file is triggered through a notification to the IFTS. The IFTS sends the notification to the ISDS, which acts as an intermediate node, and pushes the file to the ISDS.

When the file has arrived on the ISDS, a notification is sent to the IFTS component resident on the ISDC system, which then “pulls” the file from the intermediate node.

Similarly, for the ISDC to transfer a file to the IMCS it is necessary to send a notification to the intermediate node which “pulls” the file across.

Notification is then sent to the IMCS and then this will, in turn, “pull” the file from the intermediate node.

A FTP connection between ISDC and ISDS can be established via the Public Network (Internet).

On arrival at the destination node “action procedures” can be automatically triggered which can be used to instigate further processing of the file. These action procedures take the form of shell scripts (UNIX) or DCL command files (VMS) and they in practice constitute the interface between the IFTS software and the Application Software running on the receiving node. Provision of these action procedures is the responsibility of the receiving node.

For additional detailed information about IFTS, see OGS-SGS ICD.

3.2.2.1.2 Tools

3.2.2.1.2.1 MOC Tools

The MOC elements included in the transfer & reception of products through the MOC-ISDC interface are:

- IMCS for Real Time Telemetry and auxiliary products generation
- IFDS for generation and processing of auxiliary products
- On-Board S/W Maintenance System (OBSMS) for handling of OBS images and on-board tables
- Mission Archive and Distribution System
- Integral Operational Database.

The IMCS auxiliary products are:

- Timeline Summary File
- Observation Log File
- Command History File.

The IFDS products are:

- Attitude History File
- Attitude Snapshot File
- Predicted Attitude File.
- Orbit Information

3.2.2.1.2.2 ISDC Tools

ISDC related tools cover the following functions:

- Automatic Operational Processing (AOP), including all real time or near real time processing with stringent timing constraints
- Off-Line Processing, including systematic interactive analyses to complement the AOP
- Archive and Distribution for long term products storage, providing easy assess to the data themselves and distribution to the scientific community
- Alert Management System, giving the capability of monitoring all mission alerts and relevant information. It includes also the real-time Integral Gamma Ray Burst Alert System (IBAS).

3.2.2.2 Management Set-Up

3.2.2.2.1 Responsibilities

The MOC responsibilities related to the exchange of products are:

- Generation / distribution of the Near Real Time Satellite Telemetry (in frames) to ISDC
- Generation of Timeline Summary File (TSF) and distribution to ISDC
- Generation and distribution of the Observation Log and Command History Files to ISDC
- Maintenance of Mission Archive (consolidation of Archive with data retrieved from ground stations) and distribution of data
- Maintenance and distribution of the Operational Database
- Up-link of proper TC to OMC (IM_X TC) after reception of GRB alert from ISDC
- Conversion of IBIS tables into telecommands and their uplink
- FDS products generation and relevant distribution to ISDC.

The ISDC responsibilities are:

- Reception of the data received from MOC
- Generation and distribution of Gamma Ray Bursts Alarms to MOC with related information for successful TC (IM_X) up-link to the OMC instrument
- Maintenance of IBIS tables and provision of relevant data to MOC.

3.2.2.2.2 Contact Points

The main MOC – ISDC contact points are:

MOC:

- SOM: co-ordination, operational issues, anomalies, etc.

  Name : Michael Schmidt
  Telephone : 0049.6151.902012
  FAX : 0049.6151.904008
  E-mail : Michael. Schmidt@esa.int

- FD Coordinator: co-ordination of FD related products

  Name : Frank Dreger
  Telephone : 0049.6151.902664
  FAX : TBD
  E-mail : Frank.Dreger@esa.int

- Ops Coordinator: co-ordination of routine operational activities

  Name : R. Southworth
  Telephone : 0049.6151.903827
  FAX : 0049.6151.904008
  E-mail : rsouthwo@esa.int

- GCR Operator: co-ordination of communication related issues

  Name : ESOC-Network
  Telephone : 0049.6151.902496
  FAX : 0049.6151.3934
  E-mail : shiftc@esa.int

- SPACON: coordination of operational activities

  Name : SPACON
  Telephone : 0049.6151.902408
  FAX :
  E-mail :

ISDC:

ISDC Operation Manager

Name : TBD
Telephone : TBD
FAX : TBD
E-mail : TBD

The normal contact ways will be: voice loop, telephone, E-Mail, FAX.

Operational data are to be addressed to the following E-mail and FAX addresses:

E-mail: INTEGRAL@esa.int
FAX : 0049.6151.903899

Either the SOM or the SPACON should be informed if E-mails or FAXes are sent that are of operational interest and require immediate attention.

The SPACON on shift at MOC should only be contacted in exceptional cases via the voice loop, which are:

- Anomalies, detected during day time and neither SOM or the Ops Coordinator can be contacted;
- Anomalies, detected outside working hours.

3.2.3 IMCS Products Delivery

3.2.3.1 Near Real Time Telemetry Data

MOC receives from the ground stations the real-time TM data split into VC 0 and VC 7 virtual channels.
Internally to MOC, these data are put on the ESOC OPSLAN, processed and distributed to all relevant MOC users.

For security reason, the external world cannot access the ESOC OPSLAN. A Firewall prevents external intruders from accessing ESOC internal data.

For this reason the TM data are routed, through the Firewall, to the Integral Security Data Server (ISDS), which, in turn, transfers them, via an X-Router, to ISDC using a point-to-point communication based on the TCP/IP protocol.

These data are provided using a Frame Relay Service. The available bandwidth is 128 Kbps.

ISDC, similarly to MOC, is protected with a Firewall from unauthorised external access.

The data source is the ISDS and ISDC is the data destination. The ISDS includes the transmission task and ISDC the reception task based on TCP/IP transfer mechanism.

No integrity and completeness checks will be performed by the ISDS.

The ISDS will monitor the status of the TCP/IP connection and send an alarm to IMCS in case of disconnection.
It is under the responsibility of ISDC to re-connect to ISDS in order to re-establish the correct data transfer.
The lost data will be transferred from MOC to ISDC via CD-ROM.

These operations do normally not require any manual intervention. Only in case of an interruption of the communications some manual activities are required.
If the MOC detects the malfunction and the problem is at MOC, the MOC (GCR operator) will try to re-establish the communications. The same is in principle valid for the ISDC. If the re-establishment of the communications fails the operators at MOC and ISDC have to co-ordinate the activities.

Further information, see OGS-SGS ICD.

3.2.3.2 IMCS auxiliary products

The IMCS “auxiliary products” are those data that, being an “add on” to the real time telemetry, give information about the planned and actual execution of operations.

These products are:

- Timeline Summary File
- Observation Log File
- Command History File.

They are described in the following sections.

3.2.3.2.1 Timeline Summary File

The Timeline Summary File (TSF) is an IMCS product, generated by the Mission Planning Sub-system (i.e. Timeline Generation function).

Once MOC receives the Preferred Observation Sequence (POS) from ISOC, it processes the POS and generates the Enhanced Preferred Observation Sequence (EPOS). The EPOS is the input for the generation of the Timeline / Command Schedule.

In order to provide visibility to external parties about the planned operations, a Timeline Summary File will be generated containing a copy of the data from the EPOS.

The TSF (ASCII file) will be transferred to ISDC via IFTS mechanism.

Once a TSF, containing data relevant to one 72 hour revolution, is generated, it is sent to ISDC about one week before the execution period.

Considering that re-planning may occur more than one TSF may be generated per orbit. The max. size can be in the order of 2.3 Mbytes.

Several cases have to be considered:

- The nominal case is that one TSF will be created per orbit.
- In case that ISOC performs replanning several days in advance to the concerned period a new POS will be produced, which leads to the generation of a new TSF.
- In case that ISOC performs the replanning on a short term, e.g. concerning the ongoing orbit, a Replanned POS (RPOS) will be created, which leads again to the generation of a new TSF.
- In case that MOC triggers the replanning it is possible that there is no new POS but the existing EPOS is directly modified. This results in a new TSF, which refers to an old POS but might not be in line with it. In this case the difference is most likely that some parts of the old POS will not be executed.
- In case that MOC implement changes at the last moment before the execution it is possible that these changes are performed using manual commands. These changes are not reflected in the TSF. The modified or additional commands are to be derived from the Command History.

Further information, see OGS-SGS ICD.

3.2.3.2.2 Observation Log File

The Observation Log File (OLF) contains information about the execution of the planned operations, and additional information coming from the IMCS TM processing. These data are extracted from the IMCS TM/TC subsystems for external distribution.

Some data of the OLF (MOUTs and MOUTPs) are extracted from the Timeline.

The data sources are the Telemetry Processing Subsystem which generates the time correlation and Out-Of-Limits information, and the Telecommand Subsystem which provides information concerning the MOUTs and MOUTPs.

A dedicated IMCS task will merge information from both sources into the OLF.

The OLF content will cover a period of one hour, so that the execution of planned operations will generate one OLF per hour, which will be sent to ISDC on an hourly basis.

The OLF, in a format of ASCII file, will have a maximum size of 35 Kbytes and will be sent to ISDC via IFTS mechanism.

Further information, see OGS-SGS ICD.

3.2.3.2.3 Command History File

The Command History File (CHF) contains information about the executed telecommands, such as command execution time and command execution status (successful or failed).

The information is derived from the Command History that is generated by the IMCS.

The generation of the CHF is similar to the OLF. This means that the CHF will cover a period of one hour and is generated in intervals of one hour.

The CHF is in a format of an ASCII file. The size depends on the number of executed commands. It will be provided to ISDC using the IFTS.

3.2.4 IFDS Products Delivery

ISDC requires, in addition to Satellite operations information, also orbital and attitude information. These data will be generated by the Integral Flight Dynamics System (FDS).

The produced data are:

- Predicted Attitude File (PAF), containing the predicted (not actual) S/C attitude during one revolution as a function of time
- Attitude History File (AHF), containing the actual S/C attitude as a function of time
- Attitude Snapshot File (ASF), containing S/C actual orientation at the end of each slew
- Orbit Information, containing data for past and future orbits.

Specific details are provided in the following sections.

3.2.4.1 Predicted Attitude File

The Predicted Attitude File (PAF) is generated by the FDS and contains, as a function of time, the calculated (predicted) S/C attitudes for one revolution. Its structure is identical to the Attitude History File.

One PAF will be transferred per revolution from MOC to ISDC via IFTS.

The transfer will be initiated automatically when the corresponding EPOS is produced.

The PAFs will be delivered normally when the corresponding EPOS is produced, i.e. about 2 weeks before the concerned period, but not later than 7 days before the start of a revolution.

For additional detailed information, see OGS-SGS ICD.

3.2.4.2 Attitude History File

The Attitude History File (AHF), generated by IFDS, provides the satellite attitude as a function of time. One AHF will be generated per revolution and will be available a few hours

(typically 5 hours) after a revolution. The file will be transferred automatically to ISDC via IFTS mechanism.

For additional detailed information, see OGS-SGS ICD.

3.2.4.3 Attitude Snapshot File

The Attitude Snapshot File (ASF) provides the S/C attitude reconstituted at the end of a slew. Its structure is the same as the one of the Attitude History File.

The attitude determination will be based either on the STR mapping data available after an Open Loop Slew or on predicted data in case of a Closed Loop Slew. The goal is to achieve an accuracy of better than 1 arcmin.

The file consists of a series of ASCII records containing the time and the associated S/C attitude together with qualifying / quantifying information if necessary.

The production of the ASF is triggered automatically. It will be available for transfer to ISDC within 10 minutes after the end of the slew. The transfer of the data file will be initiated automatically. One ASF will be transferred after each S/C slew.

For additional detailed information, see OGS-SGS ICD.

3.2.4.4 Orbit File Information

The Orbit File Information is computed from the various tracking data collected over an orbit. It contains the S/C status vector (Position and Velocity) as a function of time. It presents calculated orbit data of passed orbits and predicted data for future orbits.

It contains auxiliary data to interpret the orbit. The following information is provided:

- Date/time for the start of concerned period
- Date/time for the end of concerned period
- Julian Date
- Revolution Number
- Orbital semi-major axis
- Inverse mean motion
- X-Y-Z components of the position vector of the reference orbit
- X-Y-Z components of the velocity vector of the reference orbit
- Absolute value of the position vector of the reference orbit.

The Orbit File is an ASCII file containing S/C status information for one week, i.e. the start time is Monday morning and the end time is Sunday night.

The Orbit File will be transmitted once a week (typically every Wednesday) via IFTS.

For additional detailed information, see OGS-SGS ICD.

3.2.5 ISDC provided Products

3.2.5.1 Remote OMC Command Request

ISDC has implemented a subsystem called Integral Burst Alert System (IBAS). This system monitors the real time scientific telemetry data coming from the various instruments to detect possible Gamma Ray Burst (GRB) events.

The output of the IBAS is an alert message distributed in real-time to subscribed users of the INTEGRAL data. In addition it is used to trigger the provision of the OMC Command Request to MOC. This command request allows modifying the setting of the OMC subwindows.

When this alert is received at MOC, it is automatically read and converted into a proper Image (IM_X) command which is up-linked to OMC. This TC instructs OMC to create a single sub-window centred on the GRB event.

It is expected that about 20 GRBs per year can be detected. Taking into consideration that also spurious alerts are possibly generated by the system it might be possible that one alert per week is generated.

The interface is based on a socket channel connection. The ISDC acts as the server and the MOC as the client.

For additional details, see OGS-SGS ICD.

3.2.5.2 IBIS Tables

IBIS requires a calibration at the beginning of each orbit, which entails an update of the on-board ISGRI table. The responsibility for the maintenance of the table is shared between MOC and ISDC. The ISDC is to determine the appropriate table content and to provide the relevant data in the appropriate format to MOC. The MOC is responsible for the conversion of the input into the relevant telecommands and for the update of the on-board table via TC.

At the beginning of each orbit the MOC will uplink the latest available table data, which are used on-board for an automatic calibration of IBIS. At the end of the process the MOC will trigger a dump of the calibrated data, which are used by ISDC to determine the content of the next table upload.

ISDC is to determine the table content using a S/W to be provided by the IBIS Team. This S/W is to contain a check of the correctness of the output and is to provide a data file in the Task Paramater File (TPF) format that can be processed by IMCS. The relevant file is to be provided latest 8 hours before the end of the revolution. Thus MOC has sufficient time to perform the relevant processing needed to update the on-board table at the beginning of the following orbit.

The file is received at the INTEGRAL Security Data Server (ISDS) at MOC. The SPACON will pick up the latest file that is available at a predefined time before the end of the revolution. All other files will be discarded. This file will be transferred into the IMCS and put under configuration control. The appropriate telecommands will be derived from the file by commanding it with the default settings of other IBIS parameters that are defined in the ODB.

The MOC will only verify that a suitable file has been used and that the relevant commands have been created. In addition the MOC will ensure the correct upload of the commands. ISDC is to ensure the correctness of the file content before the transmission of the file to MOC.

If sufficient time was available the MOC will uplink the commands at the beginning of the next orbit.

3.2.6 Maintenance of Ops Products

The following products are maintained by MOC and relevant products are provided to ISDC when necessary:

- Operational Database
- Mission Archive
- Instrument Flight Operations Plan.

3.2.6.1 Mission Operational Database

The INTEGRAL Operational Database (ODB) contains all information that is needed to process the TM / TC parameters. It provides in addition operational information, such as command sequences.

The ODB is maintained by the MOC and will be provided to ISOC and ISDC because ISOC and ISDC have to derive operations related information from the ODB.

The ODB will be changed post Launch changes, e.g. regarding:

- Modification of Satellite HK parameters, resulting from in-flight calibration or anomalies;
- Modification of Satellite tables, e.g. Look UP Tables (LUT) or Context Tables, resulting from in-flight calibration or anomalies.

The modification of S/C related data are under the responsibility of the MOC. Inputs for the modification of Instrument related data are normally provided by the PI teams or the SGS and are to be approved by a CCB before implementation. This concerns mainly data that is of relevance for the Science.

As soon as MOC has produced a new ODB, which contains modifications of data relevant to the instrument operations the ODB will be provided to ISDC. The MOC will also inform ISDC when the modified ODB will become operational.

The ODB will be transferred under manual control to ISDC as a Microsoft Access database file. The ODB is maintained on a dedicated PC and transferred to ISDC as follows:

- The ODB will be compressed into a ZIP file.
- The ZIP file will be loaded on a server.
- A notification will be provided to ISDC announcing the availability of the modified ODB.
- ISDC will access the server and download the ODB using standard FTP tools.

The size of a single ODB file will be in the order of 100 MB.

The ODB will be updated when necessary. This will be more frequent during the Commissioning than during the Routine Phase. The MOC will attempt to update the ODB during the non-operational periods, i.e. around Perigee. The MOC will inform ISDC when changes that are of interest to ISDC will be implemented but it is not foreseen to co-ordinate the implementation with ISDC. It is under the responsibility of ISDC to implement the relevant modifications in time.

For additional information, see OGS-SGS ICD.

3.2.6.2 Mission Archive

The MOC maintains a Mission Archive that contains all raw TM data and auxiliary products that have been produced throughout the Mission. The MOC will consolidate this Archive using data retrieved from the ground stations when necessary, e.g. in case of interruptions of the communications between MOC and ground station. This is to ensure that the MOC Mission Archive contains all INTEGRAL TM data that have been received on ground. Data of bad quality, e.g. provided in corrupted TM frames, will be ignored.

In case the MOC-ISDC link connection fails, ISDC will not be able to receive any Satellite and MOC generated information for the whole duration of the line outage.

To overcome this problem the MOC will produce regularly CD ROMs that will contain all TM data received on ground and relevant auxiliary products using the data stored in the Mission Archive.
These CD ROMs are regularly produced latest 10 days after the concerned period and sent to ISDC via normal mail. It is currently envisaged to consolidate the data on an orbit by orbit basis. This means that it is foreseen to provide a collection of 9 CD ROMs every three days. The transfer might be delayed by a few days in case of week-ends.
One CD ROM contains data for 8 hours, i.e. three CD ROMs are produced for one day. The first CD ROM starts at midnight.

Each CD ROM contains the following information:

- Consolidated TM frames
- Observation Log Files
- Command History Files
- Timeline Summary Files
- Predicted Attitude Files
- Attitude History Files
- Attitude Snapshot Files
- Orbit Data Files.

It should be considered that the sequence counter of the telemetry frames retrieved from Ground Stations, being ordered by Earth Reception Time, cannot be correlated with the counter of the real telemetry frames distributed during the real time TM acquisition.

No data integrity checks will be applied to the process of loading/reading the CD-ROMs.

For additional detailed information, see OGS-SGS ICD.

3.2.6.3 Flight Operations Plan

The INTEGRAL Flight Operations Plan (FOP), which is produced and maintained by the MOC, includes the instrument flight procedures. These procedures are the sole reference for all procedures relevant to the space segment.

The MOC will provide the updates of the approved Instrument flight procedures to ISDC.

The FOP will be provided as an Appendix to an E-mail to ISDC.

3.2.7 Configuration Control & Coordination

3.2.7.1 Configuration Control

All operational products will be subject to configuration control to ensure that the latest and approved version of them is effectively the one used for the operations.

This is relevant, for example, to procedures, database, MOC & ISDC control systems.
Each centre will apply its own configuration control rules to the products it is responsible for.

Further details about the configuration control are provided in another book of the FOP.

Concerning products to be exchanged between both centres, proper information on the product version will be supplied.

3.2.7.2 Co-ordination

The co-ordination between MOC and ISDC consists of routine and “ad hoc” interactions.

The routine interactions include:

- Discussion of planned activities, e.g. to allocate special resources if needed
- Exchange of information / experience
- Discussion of recommended system upgrades

It is envisaged to hold regular teleconferences (every few weeks) and regular meeting (every few months).

The “ad hoc” interactions include:

- Discussion of problems occurred during operations
- Co-ordination of special operations in case of instrument anomaly

Special meetings will be convened in this case.

In case of special topics of general interest, tripartite (MOC, ISDC, ISOC) meetings / teleconferences will be held.

3.2.7.3 Operational Interactions

The routine operations, do not require direct interaction.
They are mainly limited to the exchange of operational products according to the pre-defined schedule (see following table).

Originator	Product	Frequency	Remarks
MOC	Real Time TM data	continuous	
MOC	TSF	Every 3 days	Available one week in advance
MOC	OLF	Every hour	Covers a period of one hour, i.e. max. delay 2 hours
MOC	CHF	Every hour	Covers a period of one hour, i.e. max. delay 2 hours
MOC	PAF	Every 3 days	Covers a period of one revolution, available one week in advance
MOC	AHF	Every 3 days	Covers a period of one revolution, available about 5 hours after a revolution
MOC	ASF	After each slew	Available within 10 minutes after a slew
MOC	Orbit file	Once a week	Covers a period of several weeks, available each Wednesday
MOC	CD ROMs	Every 3 days	Covers a period of one revolution, available within 10 days
ISDC	OMC Command Request	Ad hoc	Available within a few seconds (typically 3) after a GRB detection
ISDC	IBIS tables	Once per revolution	Available 8 working hours before the end of the revolution

Table 1 Schedule of Product Exchange

3.2.7.4 Reporting

Routine and “ad hoc” reports will be exchanged between MOC and ISDC.

The reporting scheme of the MOC is split into the following categories:

- Routine Reports
- Anomaly Reports/Notifications
- Special Reporting.

The Routine Reports exchanged between MOC and ISDC are:

- Revolution Reports (from MOC to ISOC), to provide an overview of the performed operations and the main interruptions of the operations.

- Weekly Reports (from MOC to ISOC), to provide detailed information about timeline of events, S/C status, ground segment statistics and anomalies occurred during the previous week.

- Annual Reports, providing the trend analysis of the satellite data over the last year and a summary of the overall system status.

The Anomaly reporting, distributed from MOC to ISDC, is constituted by:

- Anomaly Notifications, generated within one hour after the occurrence of the anomaly, providing the description of the anomaly with all related information available at this time and preliminary assessments of possible impacts on the mission.

- Anomaly Reports, providing the complete results of the performed diagnosis / analysis and the assessment of impacts on the mission.

Reports to be distributed by ISDC to MOC are:

- Monthly Regular Reports on the Instruments (performance, special findings, …)
- Instruments Anomaly Reports containing the diagnosis/analysis of the instrument malfunction and possible impacts on the mission.

Special Reports, as a result of special investigations concerning the Instruments, will be distributed by ISDC to MOC.

In addition to the reports regular teleconferences will be held to exchange information. The contacts via the voice link should be minimised.

3.2.8 Contingency related Activities

3.2.8.1 Real Time Operations

During the Satellite lifetime, anomalies concerning platform or instruments may occur.

Depending on the nature of the anomaly the source of detection can be:

- MOC, if the anomalies can be detected through HK (VC0) data;
- ISDC and PI / instruments teams, if the anomalies are detected through the analysis of the science TM data (VC7).

The MOC is responsible to handle all S/C related anomalies. This includes the execution of relevant Contingency Recovery Procedures (CRP) and the co-ordination of the failure analysis with Industry. In the case that the mission execution is impacted the MOC will keep informed the ISDC. This will be done via an Anomaly Notification that will be provided within one hour after occurrence of the anomaly and via an Anomaly Report that provides further details when the analysis is finished.

The responsibility concerning instrument anomalies is shared between the MOC, ISOC and ISDC.
The MOC is responsible for all near real-time activities, i.e. for the execution of the relevant CRP's and for the safety and health of the instrument. The MOC will inform ISDC via an Anomaly Notification. If the MOC has no clear guidance how to proceed after the detection of the anomaly it will interrupt the operations to the concerned instrument and will put it into a Save Mode. In addition, the MOC might contact directly the concerned Instrument Team to coordinate operations in case the safety and health of the instrument is jeopardized.

It is expected that the SGS co-ordinates the anomaly investigation with the instrument experts keeping the MOC informed. At the end of the investigation the SGS is to inform the MOC about the further process. The MOC will then implement all operations that are needed to resume the nominal status. This does not exclude the possibility that MOC will contact directly the Instrument Teams to co-ordinate operations related topics if necessary.

If the anomaly is detected at ISDC, ISDC is to inform MOC and ISOC. In case of critical anomalies, which are to be identified by the instrument teams, the ISDC can contact directly MOC to co-ordinate the recovery operations. In other cases ISOC is to co-ordinate the further process.

The corresponding procedures are basically as follows:

Anomaly Detection at ISDC

An instrument anomaly can be detected at the ISDC by

- either the ShiftTeam during routine operations
- or by the Instrument Representative / Specialist during some performance analysis.

After confirmation of the anomaly through an analysis of the data by the Instrument Representative and the ISDC Instrument Specialist, the ISDC Instrument Specialist triggers the Instrument Anomaly Detection procedure by filling the corresponding Web. An ISDC identification number is automatically assigned to the anomaly by the Web form.

The procedure comprises basically four main steps:

1. The ISDC Instrument Specialist raises a report to the ISDC Operations Manager after the anomaly is confirmed with the Instrument Representative;

2. A formal Anomaly Notification and Analysis Request is sent by the ISDC Operations Manager to the relevant Instrument Operations Manager;

   A copy of the Request is automatically sent by e-mail to the Ground Segment parties and to the Project Scientist for information;

   If the anomaly could impact the satellite operations, the S/C Operations Manager (SOM) at the MOC is contacted during working hours, and the S/C Controller (SPACON) outside working hours. The SPACON will contact the SOM or the Engineer on call as required.

3. The Instrument Operations Manager triggers further analysis involving the Instrument Representative at the ISDC. The Instrument team may get from the ISDC, as appropriate, what they need to diagnose the anomaly;

4. The Instrument Operations Manager sends a formal Anomaly Report to the ISDC ’s Operations Manager summarizing the results of the analysis. A copy of the report is automatically sent to the Ground Segment parties and to the Project Scientist for information.

In most cases, the anomaly detection will lead to the submission of appropriate (software or parameter) change requests by the IT. Those new requests should make reference to the anomaly detection.
The list of anomalies tracked at the ISDC s available on the Web to the INTEGRAL parties.

If an anomaly is detected by an IT, the Instrument Operations Manager fills the ISDC anomaly Webform. The form will automatically assign a number to the anomaly following the ISDC anomaly numbering scheme and send an e-mail notification to the ISDC Operations Manager and to the Ground Segment.

The procedure thereafter resumes at point 3.

If double detections of the same anomaly are recorded through different analysis teams, the ISDC Operations Manager will close the redundant anomaly detections with reference to a unique detection. If the anomaly concerns several instruments, a report must be issued by each instrument team. In that case ’double ’detections will be kept separate, with possible reference to each other.

Anomaly Detection at MOC

When MOC detects an instrument anomaly that might impact the science operations, it informs the ISOC and the ISDC and applies the appropriate recovery procedure.

If the MOC does not have the relevant procedure and sufficient information or in the

case of significant anomalies, the MOC directly contacts the relevant IT and sends an e-mail notification to the ISDC / ISOC within one hour.
The MOC may in this case use the expertise of the Instrument Representatives & Specialists at the ISDC. This expertise may be used to understand the anomaly, but a proper procedure to react to the anomaly can only be provided by the instrument team to the MOC.

Two cases are considered:

- If the anomaly detection can be solved with the IT with minor implication on the instrument, then the MOC applies the procedure provided by the IT and resolves the anomaly.
- If the anomaly detection leads to a procedure, which would impact on the instrument configuration and affects the science data, then the MOC informs ISOC and ISDC.

The anomalies detected by the MOC are maintained by the MOC. Their anomaly reports are available to INTEGRAL parties via the Anomaly Recording & Tracking System (ARTS).

3.2.8.2 Planning Activities

Contingencies concerning the planning activities are less important because there is usually sufficient time available to correct the problem and because ISDC is less involved in the planning exercise. However, two cases have to be considered, which concern the replanning relevant to an ongoing revolution:

- If a replanning has been triggered by ISOC and if ISDC has been informed by ISOC the MOC is to inform ISDC is this replanning has been rejected by MOC.

- If new planning inputs have been received at ISDC from ISOC and if MOC did not provide the relevant inputs in time ISDC will contact MOC to check the status.