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

INTEGRAL
FLIGHT OPERATIONS PLAN

Volume 1
Mission Management

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Mission Management

EUROPEAN SPACE AGENCY
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INTEGRAL
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Volume 1
Mission Management

Book 1
Mission Summary

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1.1 Book 1: Mission Summary

1.1.1 Mission Characteristics

INTEGRAL is dedicated to the fine spectroscopy and fine imaging of celestial gamma-ray sources with concurrent monitoring in the x-ray and optical energy ranges.

INTEGRAL was launched by a Russian PROTON rocket (baseline) on 17 October 2002 into a highly eccentric orbit. The initial operational orbit is shown in the following table.

Orbit Parameter	PROTON (Initial orbit)	
Apogee	153,600 Km	
Perigee	9,000 Km	
Inclination	51.6 °	
Right Ascension	104.9 °	
Argument of Perigee	300 °	
Orbital Period	72 h	
Max. Eclipse Duration	1.13 h	
Ground Stations	Redu, Goldstone, Villafranca (B/U)	

Table 1 Orbit Parameters

The nominal lifetime of the satellite will be 2 years with a potential extension of up to 5 years after a period of 2 months used for Commissioning.

The following mission phases are relevant to the INTEGRAL mission:

- Launch and Early Orbit Phase (LEOP)

  This phase comprises the period from separation until the achievement of the orbital configuration for the Routine Phase. It includes the initial acquisition, the satellite configuration establishment and the required Perigee Raise Burns.

- Commissioning Phase

  This phase includes the activities needed to verify the correct performance of the S/C and instruments and to calibrate the on-board equipment. In order to limit the time until the start of the Scientific Mission Phase the Commissioning Phase will commence in parallel to the LEOP and will last 2 months.

- Scientific Mission / Routine Phase

  This phase covers the routine tasks of conducting observations of selected targets and of the generation of the requested scientific products.
  The Routine Phase will last nominally 2 years and can be extended by 3 additional years.

- Post Operational Phase

  This phase will commence at the termination of the mission operations and will comprise the run down of the operational facilities and the maintenance of the Mission Archive.

1.1.2 Mission Constraints

The mission constraints to be considered are defined in the INTEGRAL Users Manual (see AD 1). Chapter 4.4.5 of the IUM defines the constraints for the Routine Mission.

As far as necessary the constraints are considered already at planning level. This concerns mainly the AOCS related constraints. Other constraints such as timing of commands are considered for the generation of the flight procedures. The Vol. 2 Book 1 of the FOP identifies the constraints to be considered at planning.

1.1.3 Space Segment Set-Up

The "*Satellite*" includes the Spacecraft (S/C) and the Payload (PL).

The S/C consists of two modules, the Service Module (SVM) and the Payload Module (PLM).

The SVM comprises the functions needed to control the S/C, such as power generation, thermal control and data handling.

The PLM houses the INTEGRAL instruments and the facilities that are needed for the I/F between the S/C and the PL, such as the Data Processing Electronics (DPE) and the PL Power Distribution Unit (PDU). In addition it comprises the Star Trackers (STR) that have to be co-aligned with the instruments' Field Of View (FOV).

The Payload consists of two gamma-ray instruments

- Spectrometer (SPI)
- Imager (IBIS.

Each of them has both spectral and angular resolution, but they are differently optimised in order to complement each other and to achieve overall excellent performance. These instruments are supported by two monitor instruments, which will provide complementary observations at x-ray and optical energy bands:

- X-ray Monitor (JEM-X)
- Optical Monitoring Camera (OMC).

The Spectrometer, Imager and JEM-X share a common principle of operation: they are all coded-mask telescopes. The coded-mask technique is the key, which allows imaging that is all-important in separating and locating sources. It also provided near-perfect background subtraction because, for any particular source direction, the detector pixels can be considered to be split into two intermingled subsets, those capable of viewing the source and those for which the flux is blocked by opaque mask elements. Effectively the latter subset provides an exactly contemporaneous background measurement for the former, made under identical conditions.

The S/C can be in one of the operational modes that are shown in the following diagram.

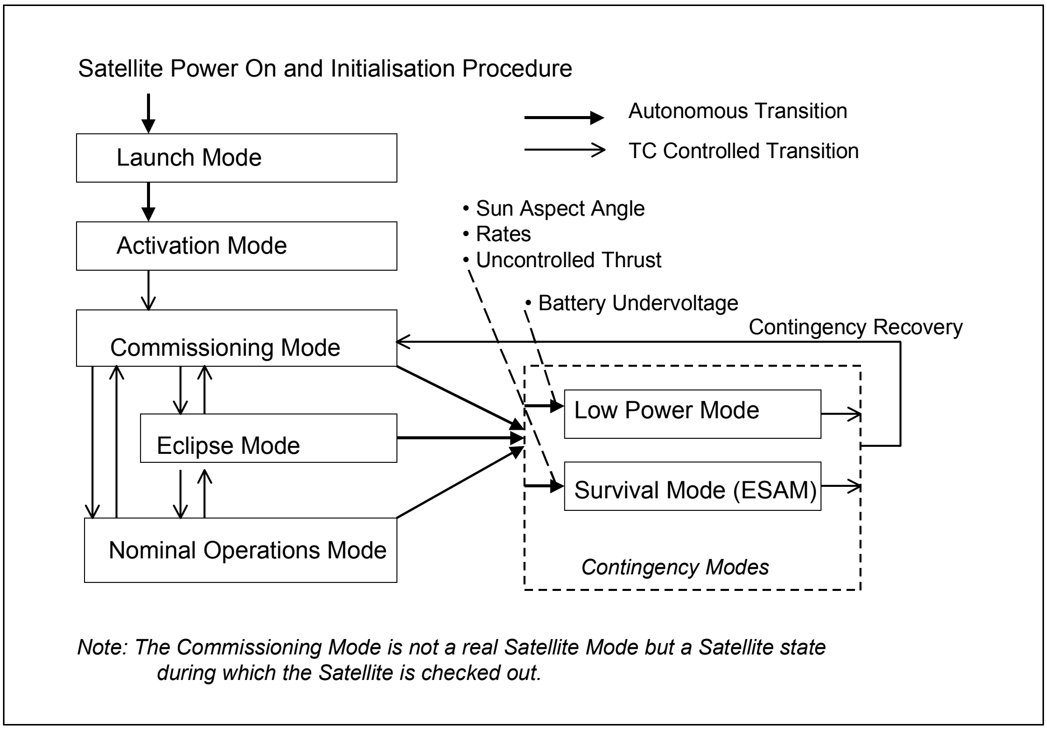

Figure 1 Operations Modes and Transitions

The instruments can be in various modes, which are dependent on the mission phase or the observation to be performed.

The instruments enter the OFF mode also in case of a Bus Undervoltage situation. During eclipses the peripherals are switched off and the DPE's remain powered to maintain the Instrument specific Application S/W (IASW) including the previous parameter settings.

During periods of high radiation, e.g. during the perigee passages or in case of high count rate detected by the Radiation Monitor, the instruments will either be in High Voltage (HV) Stand-By mode or in a specific Safe Mode.

1.1.4 Ground Segment Set-Up

The Ground Segment consists of the Operational Ground Segment (OGS) and the Science Ground Segment (SGS).

The OGS comprises the

- Ground Stations for the Routine Phase at Redu, Goldstone and Villafranca (B/U) and for the LEOP Perth,
- Mission Operations Centre (MOC) at ESOC, Darmstadt,
- Associated communication facilities.

The SGS comprises the

- INTEGRAL Science Operations Centre (ISOC) at ESTEC, Nordwijk,
- INTEGRAL Science Data Centre (ISDC) at Versoix.

The Science ground element is complemented by the

- Science Community, which interfaces to the SGS to issue proposals and to receive science products,
- Time Allocation Committee (TAC), which vets the general program proposals and recommends to the PS which ones should be selected / approved,
- PI Team, which support instrument activities after launch including the provision of staff to ISDC and maintenance of the instrument S/W,
- INTEGRAL Science Working Team (ISWT), which will discuss potential improvements and modifications of the scientific program.

The satellite operations that are addressed in the FOP are performed by the MOC and comprise the following functions:

- Link maintenance
- Ranging operations
- Orbit maintenance
- Power resources management
- Battery health monitoring
- Mechanisms activation (apart from Solar Array deployment)
- Setting of satellite configurations for specific events
- Thermal control monitoring
- Attitude control monitoring
- Momentum dumping management
- Radiation belt management
- Eclipse management
- Mission planning
- Mission plan execution
- Operational modes management
- System failure management.

The MOC consists of the following elements to perform the above listed functions:

- INTEGRAL Monitoring and Control System (IMCS)
- Timeline Generation System (MPS, part of IMCS)
- Flight Dynamics System (FDS)
- Mission Archive & Data Distribution System (MADDS, part of IMCS)
- Offline Performance Analysis System (PAS)
- On-Board S/W Maintenance System (OBSMS)
- INTEGRAL Overall Simulator (IOS)
- INTEGRAL Security Distribution System (ISDS).

1.1.5 Mission Objectives

Gamma-ray astronomy explores the most energetic phenomena that occur in nature and addresses some of the most fundamental aspects in physics and astrophysics. It embraces a great variety of processes: nuclear excitation, radioactivity, positron annihilation and Compton scattering; and an even greater diversity of astrophysical objects and phenomena: nucleosynthesis, nova and supernova explosions, the interstellar medium, cosmic ray interactions and sources, neutron stars, black holes, gamma-ray bursts, active galactic nuclei and the cosmic gamma-ray background. Not only do gamma-rays allow us to see deeper into these objects, but the bulk of the power radiated by them is often at gamma-ray energies.

The scientific goals of INTEGRAL will be attained by fine spectroscopy with imaging and accurate positioning of celestial sources of gamma-ray emission. Fine spectroscopy over the entire energy range will permit spectral features to be uniquely identified and line profiles to be determined for physical studies of the source region. The fine imaging capability of INTEGRAL within a large field of view will permit the accurate location and hence identification of the gamma-ray emitting objects with counterparts at other wavelengths, enable extended regions to be distinguished from point sources and provide considerable serendipitous science which is very important for an observatory-class mission.

In the 15 KeV – 10 MeV region, line-forming processes become important. Unique astrophysical information is contained in the spectral shift, line width, and line profiles. Detailed studies of these processes require the resolving power (E/∩E = 500) of a germanium spectrometer such as that employed on INTEGRAL.

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1.2 Book 2: Management Set-Up

This book addresses the management set-up relevant to the Routine Phase. The special management set-ups relevant to LEOP and Commissioning Phase are defined in the dedicated books in Vol 10 & 11.

1.2.1 Distribution of Tasks

The tasks to plan and execute the mission operations are split between the OGS and SGS.

The OGS is responsible for the S/C and instrument operations, which in particular comprise:

MOC

- S/C and instrument operations execution
- Satellite (S/C and instruments) safety and health monitoring
- Orbit and attitude determination and control
- S/C maintenance
- S/C performance evaluation
- Satellite On-Board S/W Maintenance (OBSM)
- Execution of instrument maintenance operations
- Provision of planning inputs to ISOC
- Execution of mission operations planning

Ground Stations

- Establishment of the satellite / Ground interface

Communications

- Data routing within OGS and between OGS and SGS
- Transmission of satellite TM and auxiliary data to ISDC.

The SGS is responsible for the science operations, which comprise in particular the

ISOC

- Long and short term planning of instruments utilisation based on the observation proposals issued by the science community
- Preparation of the Announcement of Opportunities (AO)
- Maintenance of a copy of the science archive

ISDC

- Science data processing and archiving
- Provision of the science products to the scientific community
- Identification of Target Of Opportunities (TOO)
- Generation of Gamma Ray Burst (GRB) Alerts
- Identification of the instrument trend and performance.

The PI's remain responsible for the maintenance of the instrument on-board software (OBS) and the definition of the instrument configuration.

1.2.2 Operations Management

The operations management is as shown in the following organigram

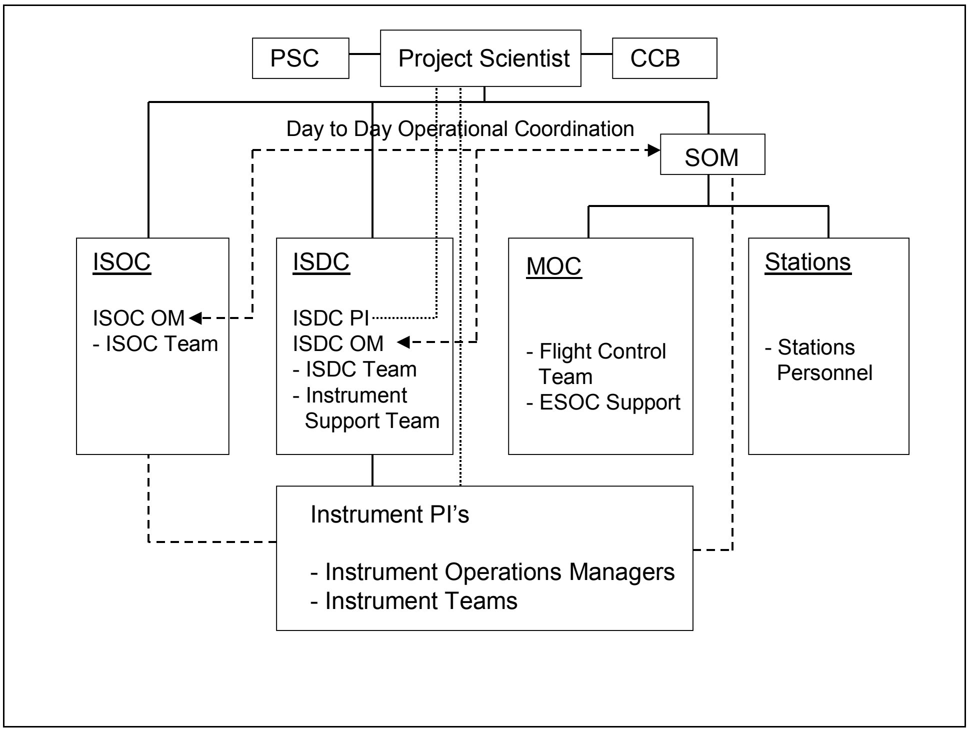

Figure 1 Operations Management Organigram

The responsibilities during the Operational Phase are as follows.

Project Scientist (PS)

The PS holds the overall programmatic, budget and scientific responsibility, which includes with respect to operations:

- The monitoring of the scientific performance of
  - The flight and ground segments
  - The observing program and related science and payload operations
- Interfaces with the science community
- Overall science operations
- Overall configuration control by chairing the Configuration Control Board (CCB) where all ground segment elements are represented.
- Interface liaison between MOC and ISOC and ISDC.

Beside this the PS will have the overall responsibility for the support contracts with the S/C contractors and instrument providers during the Routine Mission Phase. This responsibility, as far as the satellite operations are concerned, is delegated to MOC for the execution of the mission.

A Project Science Coordinator (PSC) will assist the Project Scientist to coordinate science related activities.

ISOC Operations Manager (ISOC OM)

The ISOC OM is responsible for:

- Leading the ISOC team
- Coordinate ISOC operations
- Maintenance of the ISOC system including H/W, S/W, procedures, documentation, etc.
- Providing day to day support to the PS regarding scientific aspects
- Interface liaison with Operations Managers (OM)

Spacecraft Operations Manager (SOM)

The SOM is responsible for:

- Leading the Flight Control team (FCT) at MOC
- Coordinating the engineering support from the ESOC units
- Coordinating the support from the ground stations and for communications
- Providing support to the PS concerning operational aspects regarding the platform and the instruments
- Executing the satellite operations
- Monitoring the safety and health of the satellite
- Maintenance of the OGS system including H/W, S/W, procedures, documentation, etc.
- Interface liaison with other Operations Managers
- Interface liaison to S/C contractor in case of S/C anomalies and to co-ordinate support from S/C contractor
- Interface liaison to Instrument OM's regarding instrument operations in case of instruments' anomalies and for instrument OBS maintenance.

ISDC Operations Manager (ISDC OM)

The ISDC OM is responsible for:

- Leading the ISDC operations team during day to day operations
- Coordinating the support provided by the instruments support teams
- Maintenance of the ISDC system including H/W, S/W, procedures, documentation, etc.
- Interface liaison with other Operations Managers.

PI's (Instrument and ISDC) and Instrument Operations Managers

The PI's interface directly to the Project Scientist regarding programmatic and budgetary aspects.

The Instrument OM's handle the operational matters (as far as the instrument teams are involved) including the instrument OBS maintenance and interface directly with the OM's of the ground segment elements.

Configuration Control Board (CCB)

The CCB assists the PS to perform the configuration control of the overall system. The CCB consists of representatives of the various GS elements and of IT representatives if required.

1.2.3 MOC Team Structure

The MOC Team consists of various entities, the Flight Control Team (FCT), which is dedicated to the INTEGRAL mission, and the ESOC Support that is co-ordinated by the SOM. The ESOC support comprises among others:

- Ground System Control
- Station Equipment & Control
- Communications
- Data Processing
- Flight Dynamics
- Computer Systems.

The organization of the Flight Control Team is as shown in the following diagram. Each member of the FCT has a dedicated role that comprises some primary tasks but also B/U tasks in order to provide cross-support.

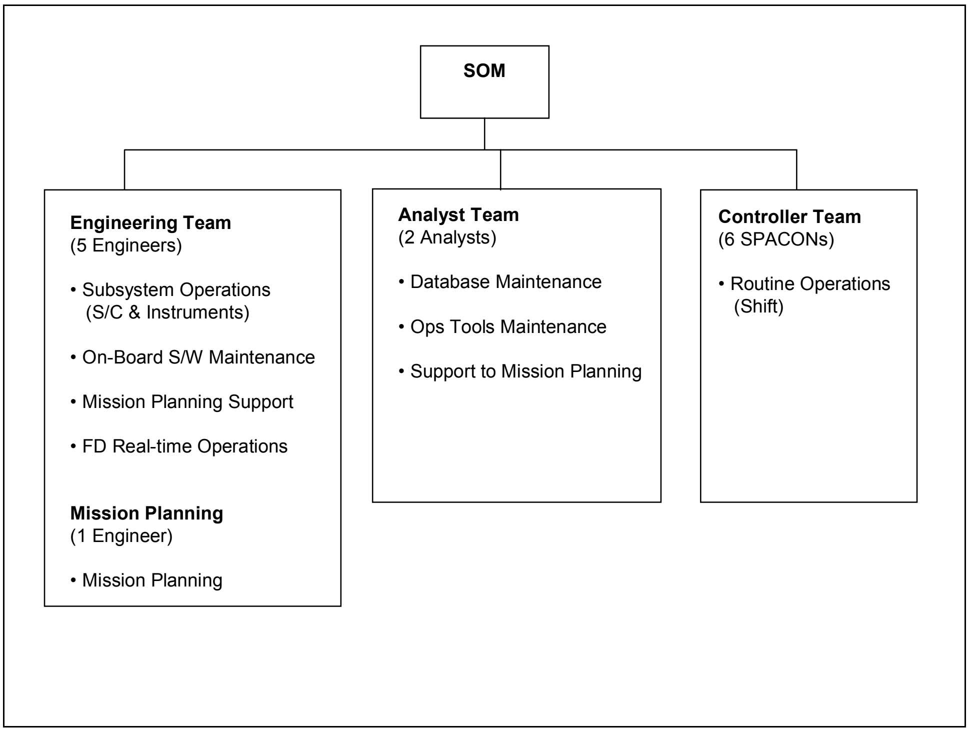

Figure 2 FCT Organisation

The ESOC organisation is as described in the ESOC QM Manual, see RD 27. The D/TOS Organisation as far as ESOC is concerned is illustrated in the following diagram.

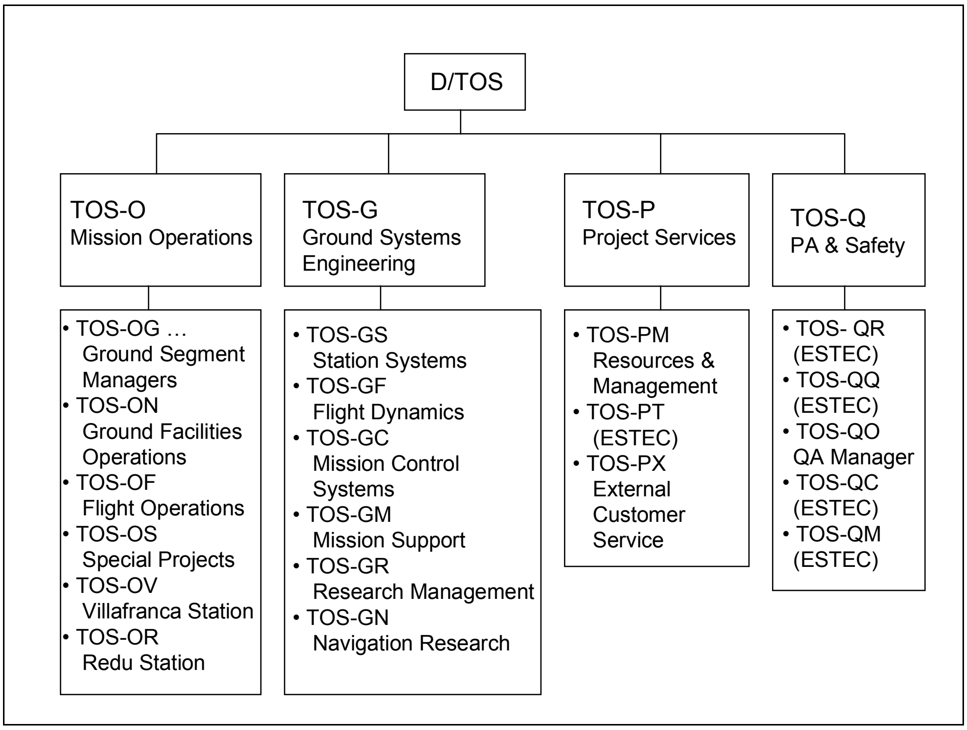

Figure 3 ESOC Organisation

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1 Vol. 1: Mission Management

1.3 Book 3: Mission Rules

The Mission Rules define the high level guidelines to be considered for operational decisions during the various mission phases. They shall enable the Operations Staff to take unambiguously decisions in non nominal situations.

The Mission Rules define:

- the operational responsibilities during the various mission phases,
- the Launch Hold Criteria,
- the criteria to declare a Satellite Emergency,
- the process concerning the redefinition of Mission Goals,
- the process to declare the mission as terminated.

Notes:

- *The mission rules relevant to the Launch are kept for completeness reasons.*
- *The SOM as taken over the responsibility for the mission operations from the Flight Director.*
- *The PS has taken over the responsibility for the mission from the Mroject Manager.*

1.3.1 Operational Responsibility

Mission Rule 1.1: Overall Responsibility

The overall responsibility for the Mission is vested in the Mission Director. The Project Manager takes the role of the Mission Director until the end of the Commissioning Phase when the Satellite is declared operational.
The Project Scientist takes over the responsibility after the Satellite is declared operational.

Mission Rule 1.2: Mission Operations Execution Responsibility

The overall responsibility for the Mission Operations is vested in the Flight Operations Director (OD). The Flight Director, who is in charge during LEOP, will be nominated by the Head of TOS-O.
The S/C Operations Manager (SOM) is responsible for the Mission Operations.
The functions of the GSM and the SOM will be combined into one position after Launch. The SOM will take over the relevant tasks.
The SOM will report to the PS and the Head of TOS-OF.

Mission Rule 1.3: Science Activities Responsibility

The responsibility for the Science related activities is vested in the Project Scientist (PS), who is assisted by a coordinator.

Mission Rule 1.4: Applicable Procedures

The Flight Operations Plan (FOP) provides the timelines and the flight procedures (for nominal and contingency situations) that are to be used for the conduct of the satellite operations post separation.
The FOP procedures override all other derived procedures.

Mission Rule 1.5: Mission Execution

All operations are to be executed according to the FOP. Deviations from the FOP are only allowed when permitted by the Flight Director or SOM (during LEOP) and by the SOM or his nominated representative thereafter.

1.3.2 Launch Hold Criteria

The availability of the Operational Ground Segment at Launch is vital. The Flight Director is to verify before Launch that the Ground Segment is operational.

Mission Rule 2.1: Ground Segment not fully operational

If the following conditions are not fulfilled by the Operational Ground Segment during the countdown the Flight Director is to declare the Ground Segment as not fully operational but the launch preparation countdown will not be stopped:

- Tracking capability is provided at Redu and Villafranca and Goldstone,
- Contact with the Launch site (Voice and Data) is available,
- Voice contact with the Ground Stations (Redu or Villafranca) is available,
- ESOC No-Break Power Supply is operational,
- LCTF at Redu is operational.

Mission Rule 2.2: Ground Segment not operational

If the following conditions are not fulfilled by the Operational Ground Segment during the countdown the Flight Director is to declare the Ground Segment as not operational and the countdown is to be stopped at the next convenient check-point:

- MOC essential functions are available in hot redundancy:
  - IMCS (in particular TM reception & processing and TC generation & release)
  - FDS (in particular attitude determination)
  - Communications (in particular OPSLAN),
- MOC is able to dispatch TC's to Redu or Villafranca,
- MOC is able to receive data from Redu or Villafranca and to process the data,
- Telemetry Reception and Telecommand Transmission are provided at Redu or Villafranca,
- Voice Contact with the Launch site.

1.3.3 Satellite Emergency

Mission Rule 3.1: Spacecraft Emergency

A S/C Emergency will be declared by the Flight Operations Director or his nominated representative (SOM) in case the health and safety of the S/C is jeopardised.

These situations include:
- loss of attitude,
- loss of fuel or unexpected fuel consumption,
- critical power situations,
- critical thermal situations,
- loss of on-board TM / TC functions,
- loss of contact to a ground station for more than 24 hours.

Mission Rule 3.2: S/C Recovery

The Operations Team will apply the S/C Recovery Contingency Procedure that corresponds to the relevant contingency case. If such a procedure is not identified the S/C will be put into the appropriate Safe Mode until a recovery procedure has been defined and agreed by the appropriate authorities.

Mission Rule 3.3: Instrument Emergency

An Instrument Emergency will be declared by the Flight Operations Director or his nominated representative (SOM) in case the health and safety of an instrument is jeopardised.

These situations include:
- undefined instrument status
- loss of instrument control by ground
- critical power / thermal situations.

Mission Rule 3.4: Instrument Recovery

The Operations Team will apply the Instrument Recovery Contingency Procedure that corresponds to the relevant contingency case. If such a procedure is not identified the concerned Instrument will be put into the predefined Instrument Safe Mode until a recovery procedure has been defined and agreed by the appropriate authorities.

Mission Rule 3.5: Emergency Declarations

The Flight Operations Director or the SOM will declare the time period of Satellite Emergency. In addition, he decides whether special ground support is required and will initiate the relevant support request.

This will include:
- special ground station coverage,
- special communications,
- special MOC facilities,
- special manpower support.

Mission Rule 3.6: Emergency Reporting

The initiator of the Satellite Emergency (Flight Operations Director or SOM) will inform the responsible Mission Director, the Head of the D/TOS Flight Operations Division, the Project Scientist (if not the Mission Director) and the SGS about the situation.

An appropriate report will be generated that identifies:
- the anomaly,
- the reason for the anomaly,
- the steps that have been taken to recover the situation,
- the potential impacts on the mission,
- the duration of reduced satellite performance.

1.3.4 Redefinition of Mission Goals

Mission Rule 4.1: Non-nominal Orbit

In the event of a non-nominal orbit that can be due to a malfunction of the Launcher or due to uncontrolled thruster firings the prime objective shall be to reachieve the nominal orbit respecting the mission objectives.

Mission Rule 4.2: Orbit Redefinition

If the nominal orbit cannot be achieved at all or only with major impacts on the useful science mission lifetime (e.g. fuel or degradation of components), the Mission Director will decide which orbit to be considered.

Mission Rule 4.3: Reduced Satellite Performance

In the event of a permanent degradation of the satellite performance the Mission Director will redefine the mission objectives to cope with the reduced satellite functionality.
The Mission Director may also decide on relevant upgrades of the ground segment functionality to match the new mission objectives.

Mission Rule 4.4: Mission Operations Redefinition

The Flight Operations Director or the SOM will specify and implement the new Operational Ground Segment facilities and procedures to perform the mission operations according to the new mission objectives.

Mission Rule 4.5: Science Operations Redefinition

The Project Scientist is to redefine the scientific objectives and the ISOC and ISDC Operations Managers are to specify and implement the required functions of the Science Ground Segment.

1.3.5 Mission Termination

Mission Rule 5.1: Mission Termination Criteria

The mission will be declared terminated if the on-board resources do not further allow to achieve the defined mission objectives or if the financial support to perform the mission operations is not granted.

Mission Rule 5.2: Mission Termination Declaration

The responsibility for declaring the mission as terminated resides with the Mission Director.

Mission Rule 5.3: Mission Run Down

The SOM and the Science Operations Manager or ISOC / ISDC Operations Managers will implement the appropriate mission run down procedures.

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1.4 Book 4: Configuration Management & Change Control

1.4.1 Overview

This section defines the configuration control and management of the various INTEGRAL system elements during the operations phase.

Configuration control concerns the Space and Ground Segment. The Space Segment can be split into the Spacecraft and the instruments, for which different configuration control rules are to be applied. The Ground Segment is to be split into the Operational and the Scientific Ground Segment. Though this FOP deals mainly with the OGS it addresses also the important rules of the configuration control relevant to the overall Ground Segment.

The split into the various parts is necessary because the various elements are responsible for different control items.

There is an overall Configuration Control Board (CCB), which consists of representatives of the various ground centers (MOC, ISOC, ISDC).

The chairman of this board is the Project Scientist.

The CCB is in charge if an item is effected, which concerns more than one center or when it concerns a change of the mission set-up, e.g. mission goals. In addition there are local CCBs at each center that handle items that are only of local interest.

1.4.2 Space Segment

1.4.2.1 S/C Configuration Management

The control of the S/C configuration is under the responsibility of the MOC and will be executed by the Flight Control Team (FCT), which is managed by the SOM. The following rules are to be applied:

- Only flight procedures that are provided in the approved FOP are to be applied.
- All changes of the FOP are to be implemented according to the configuration control concept defined in the FOP and are to be approved by the SOM.
- All changes of the Operational Database (ODB) are to be implemented according to the ODB configuration control concept (see RD 26) and are to be approved by the SOM.
- The Timeline to be executed is to be based on the latest version of the EPOS and is to be approved by the SOM or the nominated Mission Planning SOE.

The MOC will keep track of the latest on-board configuration. This comprises among others:

- Configuration control of the on-board S/W (OBS) and related parameters using the On-Board S/W Maintenance System (OBSMS);
- Configuration control of on-board parameters using the ODB.

Here again, all changes are to be approved by the SOM before implementation.

The MOC will inform ISOC and ISDC about changes of the S/C that are relevant to them but the responsibility is with the MOC.

The MOC will also monitor the health and safety of the S/C. It will implement relevant procedures to maintain the health and safety. In case of changes that impact the mission goals they will be co-ordinated between MOC and the Project Scientist and ISOC / ISDC if required.

1.4.2.2 Instrument Configuration Management

The control of the Instruments' configuration is shared between MOC, ISOC and ISDC. While the MOC is responsible for the flight procedures, FOP, ODB and Timeline, the control of the instrument parameter settings is a shared activity.

The ISDC is in charge of evaluating the instrument performance. ISDC will be supported if necessary by the instrument teams provided by the PIs. They recommend changes of the instrument configuration to ISOC.

Another source for changes is the author of an observation proposal, who can be a PI or a Scientist. The recommended changes are to be provided to ISOC.

ISOC is to verify and approve the recommended changes and is to provide the relevant inputs to the MOC. This can be in form of an observation plan, i.e. POS, or in form of a parameter change request. The approved changes will be implemented by the MOC, which will inform ISOC and ISDC when the changes have been implemented.

A few special subjects are to be considered in this context:

- Handling of Instrument Tables,
- Handling of Instrument Parameter Values,
- Handling of Instrument OBS.

The instrument tables are maintained by the Instrument Teams. New tables will be provided to MOC in the format defined for the individual data item. The MOC will generate the commands required to uplink the data to the satellite, e.g. images are converted into the uplinkable commands using the OBSM function of the IMCS. The relevant commands will be uplinked according to the Operational Timeline generated by the MOC. The MOC will inform ISOC and ISDC when the tables have been implemented.

The above rules apply to all tables except the ISGRI table that is to be updated regularly each revolution. A special I/F between MOC and ISDC has been set up to handle this table. This I/F is based on the provision of Task Parameter Files that can be directly processed by the IMCS.

The Instrument OBS will be maintained by the Instrument / PI Teams. The PI Teams will provide the OBS images in a predefined format to MOC. In addition a file will be sent to ISDC, which provides the information relevant to ISDC. The MOC will convert the images into uplinkable commands and will load the new OBS according to the schedule provided by ISOC as defined in the POS.

Individual parameter values are controlled via default values as defined in the database. Relevant updates are to be provided by the IBIS Team to the MOC.

The management of the instrument configuration described above will be handled as far as possible on working level keeping all elements of the ground segment informed. If necessary, the CCB will be involved to approve special modifications.

1.4.3 Ground Segment

The Ground Segment is split into two parts, OGS and SGS, each having their own configuration control procedures. Items that are of general interest are dealt with by the common CCB.

1.4.3.1 Operational Ground Segment

1.4.3.1.1 MOC

The MOC comprises H/W and S/W. This includes:

- H/W in the control rooms, such as workstations, displays, printers, etc.;
- H/W in the offices (PCs, etc.);
- IMCS;
- FDS;
- NCTRS.

All items are under configuration control following the standard ESOC rules for configuration control. Staff from the various ESOC units is involved in the configuration control. All modifications have to be approved by the SOM.

1.4.3.1.2 Stations

Since the INTEGRAL station network comprises stations from ESA and NASA different configuration control procedures are to be considered.

1.4.3.1.2.1 ESA Stations

The configuration control of ESA stations is performed by ESOC. Since stations are a common resource shared between several missions a common configuration control mechanism is applied. Though the configuration control is with TOS-G the INTEGRAL SOM is to be involved because he has to approve modifications that could impact the INTEGRAL mission.

1.4.3.1.2.2 DSN Stations

INTEGRAL will utilize Goldstone, which is under configuration control of NASA. It is expected that NASA will consult the INTEGRAL SOM before a modification is implemented that could impact the INTEGRAL mission. Since ESA cannot control the Goldstone configuration it might be necessary that the INTEGRAL system is to be adjusted to changes of the JPL / Goldstone system. The relevant changes will be co-ordinated by the INTEGRAL SOM.

1.4.3.1.3 Communications

The communications within the INTEGRAL network, i.e. between MOC and stations and between MOC and ISOC / ISDC, are under the responsibility of the MOC. The relevant configuration control is performed by TOS-ON. Any modification that could impact the INTEGRAL mission is to be approved by the INTEGRAL SOM.

1.4.3.1.3.1 OGS Communications

The OGS internal communications comprise the communications within MOC and between MOC and stations. The configuration control is handled by ESOC.

It is to be considered that resources are utilized that are shared with other missions. The maintenance is under control of TOS-ON. As mentioned above modifications that could impact the INTEGRAL mission execution and performance are to be approved by the INTEGRAL SOM.

1.4.3.1.3.2 OGS - SGS Communications

The communications between MOC and SGS are under the responsibility of the MOC. This means that the MOC, i.e. TOS-ON, is in charge to set-up and maintain the resources. The set-up is to be agreed with the SGS Managers and should be modified only if agreed by all parties.

Modifications that impact only two centers, i.e. MOC and ISDC or MOC and ISOC, can be handled bilaterally. Modifications that impact the overall mission are to be dealt with at CCB level.

1.4.3.2 Operational Tools

The operational tools that are utilized by the Flight Control Team are maintained and controlled by the FCT under the supervision of the SOM. If necessary, support will be requested from the ESOC support team or the developer of the concerned product.

Note:

The FOP defines only the high level guidelines. Further details are defined in RD 26 and in the general ESOC documentation concerning configuration control.

1.4.3.2.1 Flight Operations Plan

The FOP is prepared and maintained by the FCT under the supervision of the SOM. There are some parts that concern the I/F to the SGS, which are also to be approved by the SGS representatives.

The SOM is solely responsible for the FOP. He has to approve all modifications of the FOP. Modifications that could impact the mission performance are to be coordinated with the PS. The GS CCB will be involved when required.

The most important parts of the FOP are the flight procedures because they are the reference for all flight operations. Operations are only to be executed following the agreed flight procedures. The procedures are to be prepared by the responsible S/C Operations Engineer (SOE) and tested by him and a further SOE or S/C Analyst of the FCT. This is done in most of the cases using the satellite simulator. Before implementing the tested changes they are to be approved by the SOM. When the procedures have been approved they are given to the SPACONs for execution. It is emphasized that the SPACONs are only authorised to execute the approved procedures.

The flight procedures are to be validated before they are applied to the Satellite. The procedure validation is done at various levels.

1. The first validation is to be done by the S/C or instrument manufacturer. They should verify the inputs that they provide in the User Manual.

Note:

The S/C manufacturer is normally not involved anymore during the Routine Mission Phase because the procedures are produced by the FCT. The S/C manufacturer might be consulted in special cases.

2. When the SOE generates a procedure he performs a first check, which is basically a visual inspection of the procedure.

3. Since the procedures are generated using FOPGEN an implicit check of the parameters is performed because FOPGEN accesses the actual database.

4. Before applying a procedure on the satellite, the SOE is testing the procedure using the simulator id necessary. This is not done on a systematic basis.

5. Deleted, not relevant during the Routine Mission Phase.

6. In addition, it is possible that procedures are run by the SPACONs using the control system and the simulator. However, it is to be considered that this is a rather basic check. It includes the execution of the commands, which means that the correctness of the command sequence is verified, and it includes a verification of the TM parameter that is identified in the procedure. This step does not cover a logical verification of the procedure.

7. Deleted, not relevant during the Routine Mission Phase.

8. During the above steps the SOEs have to maintain a verification matrix, i.e. have to keep track which procedures are tested in which context.

1.4.3.2.2 Operational Database

The ODB has been derived from the Satellite Database (SDB), which was provided by the Satellite Manufacturer pre-launch. The SDB is not further maintained. Changes are directly implemented in the ODB during the Routine Mission Phase.

The S/C Analysts are responsible for the maintenance of the ODB. Any modification of the ODB is to be approved by the SOM. After approval the S/C Analysts are to ensure that the operational system; i.e. IMCS, FOP generation tool and OBSMS; are updated with the approved ODB.

Changes to the ODB might be requested by the FCT but also by the SGS or the Instrument Teams. The changes requested by the SGS / Instrument Teams should also be verified at SGS level before they are implemented by the FCT. This verification will be performed on working level involving the Instrument Teams if required. If necessary, changes are to be approved by the CCB.

Changes concerning operational data within the database will be handled directly by the MOC. The MOC will keep informed ISOC and ISDC.

1.4.3.2.3 On-Board S/W Maintenance System

The OBSMS at MOC is the prime tool to control and verify new or modified OBS images. If necessary other tools available at the premises of the S/C manufacturer or the PI Instrument Teams are involved in the OBSM process if necessary.

The responsibility for the On-Board S/W Maintenance (OBSM) has been handed over to the MOC after the Commissioning Phase. This includes the responsibility for the OBSMS. If necessary, the S/C manufacturer or the PI Instrument Teams will be involved in case of major failures that do not allow utilizing the OBSMS in an efficient manner.

The maintenance and operations of the OBSMS are performed by the dedicated engineers of the FCT under the supervision of the SOM.

1.4.3.2.4 Simulator

The simulator has been developed under the responsibility of TOS-GMS. The simulator was tested and approved before Launch. A maintenance contract has been set up with the simulator developer, which shall ensure that late changes of the satellite or identified malfunctions can be implemented / corrected in the simulator. The SOM is responsible to approve the changes to be implemented.

1.4.3.2.5 Mission Control System

The IMCS has been developed under the responsibility of TOS-GMC. The final acceptance was performed by the FCT. A maintenance contract has been set up with the IMCS developer, which shall ensure that late changes of the satellite or identified malfunctions can be implemented / corrected in the IMCS.

1.4.3.2.6 Flight Dynamics System

The INTEGRAL FDS has been developed by TOS-GFO. TOS-GFO has provided a subset of the FD functions to the FCT according to the requirements of the FCT. This subset is used by the FCT to perform special operations that are allocated to the FCT.

TOS-GFO is responsible for maintaining the FDS. Relevant upgrades of the system are to be coordinated between the SOM and the FD Manager.

1.4.3.3 Overall Ground Segment

1.4.3.3.1 CCB Set-Up

The overall INTEGRAL Ground Segment consists of the OGS and the SGS. Each entity will have its own local configuration control mechanism. The one concerning the OGS is defined in the FOP and the ESOC QA documentation. The one concerning the SGS is defined in the SGS related documentation. This section briefly summarises the set-up of the overall configuration control during the Routine Mission Phase (see also RD29).

The GS CCB consists of representatives of the various ground centers (MOC, ISOC, ISDC):

- Spacecraft Operations Manager from MOC,
- Operations Manager from ISOC,
- Operations Manager from ISDC,
- Project Science Coordinator
- MOC QA Manager.

The chairman of this board is the Project Scientist. He will be assisted by a Project Science Coordinator (PCC).

The routine work of the CCB will be performed by the PCC and the QA Manager of the MOC. He will have mainly an administrative role. They are to keep track of change requests, anomaly reports, producing minutes, organize meetings, etc.

In case of problems affecting the Satellite it will be possible to invite a representative of the S/C manufacturer or of the concerned instrument team to the CCB meeting.

The purpose of the GS CCB is to decide on changes that affect an agreed list of Configuration Items (CI. Any changes affecting one of these CIs shall pass through the CCB. A list of typical CIs is defined in a dedicated document.

To run the approval process it is not necessary to convene the CCB at every change request. The submitted change request will be recorded, to ensure that all CCB members have been informed and to record the agreement of the involved parties.

If necessary any member of the CCB can call for a CCB meeting. This is to be agreed by the chairman of the CCB, i.e. the Project Scientist The arrangement for CCB meeting locations will be decided on a case by case basis.

A common tool supporting the CCB is in place. This will allow common visibility of entries, e.g. change requests, to all GS elements. The mechanism for entering data into the CCB tool is by raising a Change Request on an agreed CI. The loop shall be closed with the implementation of the approved change and with the validation and confirmation of operational readiness. Anomaly Reports are recorded in the relevant tools at MOC, ISOC and ISDC.

It is to be noted that the CCB should not act on time critical issues. These aspects will be handled on operational level involving the local configuration control mechanisms.

It is also to be noted that the CCB has no contractual power. Each board member has to perform the impact assessment as far his responsibility is concerned. In case of conflicts the decision authority on mission level is in principle the Project Scientist. Beyond him the relevant management authorities can be called in case of severe conflicts.

1.4.3.3.2 Configuration Items

It is important to differentiate between items that are under configuration control by the CCB, i.e. an approval is required to implement a modification, and items, which are processed at local level but are relevant to the other elements of the ground segment.

The goal was to set-up a system that ensures the safety and health of the satellite and ensures that the work of the other centres is not impacted but ensuring that the centres have sufficient flexibility to execute their tasks in an efficient manner.

There are basically four areas, which are relevant to configuration control:

- Ground segment set-up relevant to interfaces
- Operational tools
- Operational products

- Documentation.

Ground Segment Set-Up

Each centre is responsible for the set-up of its facilities. Each centre has in principle the right to upgrade its system without asking an approval from the other centres. However, this rule is only applicable as long as the interfaces between centres are not impacted.
Each centre has also the right to modify its H/W set-up. However, this is not valid when the interfaces between centres are concerned.

Hence the following items are to be considered as a configuration control item:

- INTEGRAL File Transfer System (IFTS)

- Communications Interface
  This item comprises typically
  - the allocation of communication lines, e.g. ESACOM or ISDN;
  - the relevant line characteristics, e.g. bandwidth;
  - the I/F ports, e.g. addresses;
  - the Firewall configuration.

- I/F H/W.

Operational Tools

Each centre is responsible for the maintenance of its operational tools. This means that each centre can update its own operational tools. However, there are tools that are provided by one centre but used by another centre. Upgrades of these tools have to be mutually agreed.

Hence the following items are to be considered as configuration control items:

- FD tools provided to ISOC
  This concerns the attitude constraint checker, the dithering composition tool, etc.

- ISGRI table maintenance tool at ISDC.

Operational Products

The actual operational products are under operational control but are not to be considered as configuration control items relevant to the CCB. However, the formats of these products are relevant to configuration control.

The above is in principle also applicable to other products, such as procedures, database, etc. The maintenance of these products is under the responsibility of the concerned centre and they can be modified without approval. However, this rule is not valid when data items are concerned that are of interest to other centres.

Hence the following items are to be considered as configuration control items:

- Event Designators and related sequences
  The MOC will inform ISOC when EDs are to be updated. The relevant update is to be agreed and the MOC will provide a modified ED Browser.

- Instrument related flight procedures
  Not all instrument flight procedures are concerned. The procedures relevant to the safety and health control of the instrument, e.g. procedures relevant to the Eclipse Passage, are not concerned. Only those procedures that could impact the generation of science products are relevant as a CCB item.

- Instrument TM parameters
  The definition of instrument TM parameters comprises several data fields in the database. Only some data fields are relevant to a CCB approval. These comprise:
  - Definition of calibration curves;
  - Definition of aliases;
  - Definition of Out Of Limits;
  - Definition of Packet Structure;
  - Definition of new parameters.

- Instrument TC parameters
  The definition of instrument TC parameters comprises several data fields in the database. Only some data fields are relevant to a CCB approval. These comprise:
  - Default values;
  - Calibration curves.

- Instrument OBS images.

- DPE CSSW images.

- Instrument Tables.

<u>Documentation</u>

Each centre is responsible for the maintenance of its documentation. This includes also procedures. Each centre can modify its own working procedures without approval from the other centres. Only those procedures that concern the other elements should be agreed.

All documents that specify the external interfaces, such as ICDs, are under configuration control of the CCB.

Hence the following items are to be considered as configuration control items:

- Ground I/F procedures
  This comprises among other mission planning procedures or procedures related to the routing of data to other centres.

- Definition of Ops Products, ICDs
  This comprises the format definition of all products that are exchanged between various centres:
  - Keywords;
  - Window location and length;
  - characteristics of data fields;
  - etc.

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CHANGE RECORD SHEET

DATE	ISSUE / REV. NO.	PAGE / PARA AFFECTED	DESCRIPTION	APPROVAL AUTHORITY
27/11/98	Draft / 0	All		
08/08/99	Draft / 1	All	CDR Revision	
21/12/01	1 / 0	All	Version for Review & Control	
28/02/02	1 / 1	1, 2	Change distribution list of reports	
21/02/03	2 / 0	All	General clean-up post Launch	SOM *M. Schmidt*

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1.5 Book 5: Mission Reporting

Reporting will comprise regular reports and anomaly reports. The Reports will address the characteristics and behaviour of the mission resources.

The operations related reports will be generated by the Flight Control Team under the responsibility of the Flight Operations Director. The science related reports will be generated under the responsibility of the Science Operations Manager.

Note: The FOP addresses only the operations related reports.

1.5.1 Special Reports

1.5.1.1 Mission Phase related Reports

The Flight Director will issue mission reports at the end of the various mission phases covering the mission performance, satellite status, the mission events and relevant anomalies.

Reports will be created at the end of the following mission phases:
- LEOP & Commissioning Phase,
- End of Nominal Mission,
- End of Extended Mission.

1.5.1.2 Study Reports

Special study reports will be produced in case that a special analysis of satellite data has been performed.

1.5.2 Routine Reports

This section defines the nominal reporting scheme of the Flight Control Team. Depending on the mission status it might be decided to reduce the level of reporting, e.g. to drop the Orbit Reports.

The following table provides an overview of the regular reports that will be generated by the Flight Control Team.

Report	Frequency	Originator	Destination
Shift Report	Every shift change	SPACON	S/C Analyst, SOM
Revolution Report	After each revolution	S/C Analyst	ISOC & ISDC OM
Weekly Report	At the end of a week	SOM	PS, ISOC, ISDC, ESOC, ALENIA, PI's, ESA Management
Monthly Report	At the end of a month	SOM	TOS-O Monthly Report to ESA Management
Annual Report	At the end of a year	SOM	PS, ISOC, ISDC, ESOC, ALENIA, PI's, ESA Management

Table 1 Overview of Routine Reports

1.5.2.1 Shift Report

The shift log is primarily for internal use and is a running log of events or information that should be passed on to other shifts, the Spacecraft Analysts and the SOM in case of non-nominal events. The log shall provide an overview of the INTEGRAL operations performed during each shift. Furthermore, the log shall include a record of all ground segment problems and, depending on the event, the actions taken. Most important is the recording of satellite anomalies and the actions (Contingency Procedure) invoked. The log serves as reference book for the executed mission timeline.

1.5.2.2 Revolution Report

The revolution report provides a short summary of the revolution, in particular the observed targets and the coverage from the various ground stations. In addition it identifies the pointings that were lost and the main problems.

1.5.2.3 Weekly Report

The Weekly Report will provide information on the executed operations as follows:

- Timeline of Events,
- Status of the Satellite,
- Special Events and Anomalies,
- Statistics of the Mission Services, Ground Outages, etc.,
- Attachments.

The Weekly Reports form the reference for the evaluation of the mission performance, i.e. the actual with respect to the planned services.

1.5.2.4 Monthly Report

The Monthly Report provides a summary of the mission performance over the past month and is an input to the TOS-O Monthly Report..

1.5.2.5 Annual Report

The Annual Report will provide the results of a trend analysis of the satellite data

Thus the report will contain:
- Satellite status,
- OGS status,
- Mission operations summary,
- Mission statistics, e.g. data recovery,
- Special events and anomalies,
- Subsystem performance data (Trend Reports),
- Attachments.

1.5.3 Anomaly Reporting

The Flight Control Team will generate under the responsibility of the SOM two types of Anomaly Reports:
- Anomaly Notification,
- Anomaly Report.

1.5.3.1 Anomaly Notification

The first level will be an Anomaly Notification that will be generated within one hour of an anomaly and will be distributed to the Project Scientist, ISOC and ISDC. This notification is to be considered as a warning about the non-nominal behaviour.

This Notification will provide the following information:

- Data and time of anomaly occurred
- Description,
- Cause,
- Impacts on the Mission,
- Duration of the impacts.

The notification will be provided via the voice loop to ISDC when ISDC is on-line. Otherwise a short E-mail will be produced.

1.5.3.2 Anomaly Reports

After an assessment of the anomaly the Flight Control Team will generate a proper Anomaly Report under the responsibility of the relevant SOE, which will provide the results of the anomaly analysis. This report will be distributed to the Project Scientist, ISOC, ISDC and the Head of TOS-0F.

This report will provide the following information:
- Data and time of anomaly occurrence,
- Description,
- Cause,
- Impacts on the Mission,
- Duration of the impacts,
- Recovery Operations,
- Relevant Satellite data.