INTEGRAL

Science Operations Centre

Announcement of Opportunity for Observing Proposals
(AO-5)

Mission Overview, Policies and Procedures

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Issue 5.0

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1 Introduction

1.1 Purpose of this document

This document fulfils two purposes. Firstly it introduces the INTEGRAL satellite with brief descriptions of its orbit, instruments, observation modes and ground system. Secondly, it describes the procedures to be followed by observers preparing INTEGRAL observation proposals, and the policies followed by ESA in handling proposals, from their submission to their evaluation. Failure to abide by these will lead the rejection of the proposal.

1.2 Schedule and scope for AO-5

The schedule for INTEGRAL AO-5 is as follows:

- **12 March 2007: release of INTEGRAL AO-5**
- **20 April 2007, 14.00 CET (13.00 GMT): deadline for proposal submission**
- **29 May - 01 June 2007: INTEGRAL Time Allocation Committee (TAC) meetings**
- **16 August 2007 (revolution 579): Formal start of AO-5 programme.**

This AO primarily intended for scientists of the ESA Member States and countries participating in INTEGRAL (Russia, USA, Czech Republic and Poland), but proposals from other countries will also be considered by the Time Allocation Committee.

Scientists from institutions in the United States are welcome to respond to this AO either as Principal Investigators or as co-Investigators on non-US proposals. Accepted US investigators should request funding from NASA via a separate solicitation.

1.3 Overview of the call for proposals

This call for INTEGRAL proposals consists of all the relevant documentation, a proposal generation and submission tool, and other software to help assess the visibility of a target and estimate the observation time required to meet specific scientific goals.

Here is the list of the available supporting documents:

- *"Mission Overview, Policies and Procedures"* (this document)
- *"IBIS Observer's Manual"*
- *"SPI Observer's Manual"*
- *"JEM-X Observer's Manual"*
- *"OMC Observer's Manual"*
- *"AO-5 Guaranteed time"*
- *"AO-5 Key Programmes and Associated Observations"*
- *"AO-5 Observation Tools Software User Manual"* (describes the use of PGT, OTE, TVP)

All these documents are available from ESA's INTEGRAL Science Operations Centre (ISOC) web page: http://integral.esac.esa.int/, where observers can also find links to download the Proposal Generation Tools (PGT), and access the Observing Time Estimator (OTE) and the

Target Visibility Predictor (TVP). Note that OTE and TVP run remotely over the web, whereas PGT needs to be installed locally.

1.4 Extended mission and future AOs

The nominal operational mission had a duration of 24 months and began on December 17 2002, two months after the launch. Therefore, the nominal mission ended on December 16, 2004. The extended mission is currently approved by the Science Programme Committee (SPC) until December 2010; subject to a further scientific review in 2008. AO-6 is planned to be opened six months after the start of AO-5 observations.

1.5 Available observing time

AO-5 will last 12 months: from August 16, 2007 until August 15, 2008. About 24 Ms of observation time are available for this fifth cycle of INTEGRAL operations. This time is divided between the **Guaranteed Time (5.2 Ms)** and **Open Time (18.8 Ms)**. The Guaranteed Time is used for Core Programme observations (see document "*AO-5 Guaranteed Time*" for details), and the Open Time is used for General Observer Programme and Key Programme observations, the latter of which are described in *"AO-5 Key Programmes and Associated Observations"*.

This implies that a total of 18.8 Ms is available to the scientific community for Open Time proposals. Of this, 6 Ms have been reserved for the AO-5 Key Programmes. Note that this estimate of the available observing time does not include instrument calibrations, performed regularly during the operational phase. Moreover, some unfinished AO-4 observations will be carried forward into the AO-5 cycle. Therefore the numbers given above give the maximum time available for scientific observations, keeping in mind that the main instruments, IBIS and SPI, have large fields of view and can thus observe several targets simultaneously, thereby increasing the observatory's scientific returns. This is done by officially amalgamating observations of different sources.

1.6 AO-5 Key Programme

The INTEGRAL Key Programme was introduced for the first time in AO-4. It is intented as a means to carry out scientific investigations requiring a significant fraction of the total observing time of an AO cycle. A Key Progamme can be presented as a "multi-year" proposal and extend over sevaral AO cycles.

INTEGRAL's large field of view allows for the study and monitoring of multiple targets at once, accomodating various scientific requirements.

2 The INTEGRAL Mission

2.1 Overview of the mission

The **INTE**rnational **G**amma-**R**ay **A**strophysics **L**aboratory was successfully launched with a PROTON rocket from Baikonour in Kazachstan on October 17, 2002 at 04:41 UTC. INTEGRAL is a 15 keV–10 MeV gamma-ray mission whose payload consists of two main gamma-ray instruments, the imager IBIS and the spectrometer SPI, and two monitors, JEM-X (4–35 keV) and OMC (V, 500–600 nm). The IBIS and SPI instruments both have large fields of view (~30°× 30°), simultaneously cover a broad energy range (15 keV–8 MeV), and their design and function are complimentary. In addition, a particle radiation monitor measures charged particle fluxes on the spacecraft.

The scientific goals of INTEGRAL are reached by means of its high resolution spectroscopy allowing spectral line studies, combined with fine imaging and accurate positioning of celestial gamma-ray sources allowing their identification with counterparts at other wavelengths. Moreover, these characteristics can be used to distinguish extended emission from point sources and thus provide considerable power for serendipitous science: a very important feature for an observatory-class mission. Here is a list of scientific topics addressed by INTEGRAL:

i) **Compact Objects:** *white dwarfs, neutron stars, black-hole candidates, high-energy transients and GRB's*.

ii) **Extragalactic Astronomy:** *AGN, Seyferts, blazars, galaxies and clusters, cosmic diffuse background*.

iii) **Stellar Nucleosynthesis:** *hydrostatic nucleosynthesis (AGB and WR stars), explosive nucleosynthesis (supernovae and novae)*.

iv) **Galactic Structure:** *mapping of continuum and line emission, ISM, cosmic-ray distribution*.

v) **Galactic Centre:** *cloud-complex regions, mapping of continuum and line emission, ISM, cosmic-ray distribution*.

vi) **Particle Processes and Acceleration:** *trans-relativistic pair plasmas, beams, jets*.

vii) **Identification of High Energy Sources:** *unidentified gamma-ray objects as a class*.

viii) **Unexpected Discoveries**.

More details about the INTEGRAL spacecraft, instruments and scientific aims can be found in A&A Vol. 411 (2003). This is a special issue dedicated to INTEGRAL.

2.2 The INTEGRAL spacecraft and its orbit

The INTEGRAL spacecraft has two main components: the *payload module* and the *service module*. The payload module comprises the instruments with which the observations are performed. The service module provides the necessary infrastructure for the payload module.

This includes functions such as attitude control and communication with the ground stations. Below is a detailed description of these.

2.2.1 The service module

The service module of the INTEGRAL spacecraft is a re-build of that developed for the XMM-Newton project and is composed of the following key sub-systems:

- **Mechanical Structure:** Consists of the primary structure (central cone and shear panels) supporting the launch loads, and one carrying the sub-system units and the tanks.
- **Thermal Control System:** Consist of active (heaters) and passive (MLI) thermal controls.
- **Attitude and Orbital Control Subsystem (AOCS):** Provides control, stabilisation, and measurements about the three satellite axes. This is done using star and sun sensors for primary attitude measurements and Reaction Wheels for torque actuation and momentum storage. The AOCS also controls the Reaction Control System; its thrusters provide the ability to dump momentum from the reaction wheels for orbit maintenance. A hard-wired Emergency Sun Acquisition Mode is implemented to acquire a safe Sun-pointing attitude in case that an AOCS failure results in uncontrolled attitude conditions.
- **Electrical Power System:** Regulates the function of power generation (solar arrays), storage (batteries), control and conditioning, distribution of the required power on a regulated 28 V main and redundant power bus.
- **Radio Frequency Function:** Ensures permanent up- and down-link of telecommands and telemetry using a quasi omni-directional antenna and two redundant S-band transponder.
- **Data Handling System:** Provides the ability to acquire, process and format data for the down-link. It consists of a single failure tolerant Command and Data Management Unit (CDMU – the central on-board computer) and two Remote Terminal Units: one on the service and the other on the payload module. These are used for data acquisition from peripheral units. Spacecraft telemetry is down-linked in real-time; there is no on-board data storage. Early in the mission after it was confirmed that the link RF margin was sufficiently large, it was decided to increase the telemetry clocking frequency and thus to increase the bit rate by ~25%. The rate for science data was increased from 86 to 108 kbps.
- **Launcher Adapter:** A special adapter including the separation system that provided the connection of the service module with the Russian PROTON launcher.

2.2.2 The payload module

The INTEGRAL payload module consists of an equipment platform accommodating the detector assemblies and an empty box supporting the "upper floor" at a height of about 3.2 m on which the coded masks are fixed. The detector bench provides the interface to the service module cone upper flange and carries SPI, IBIS and the relevant electronics and data processing units. System units (Payload module power distribution unit and remote terminal unit) are accommodated on the lower side. The vertical panels carry the OMC, the IBIS calibration unit and lead shields, as well as the star trackers, while providing support for the IBIS mask and the JEM-X mask support panel. Sun acquisition sensors (part of AOCS) are accommodated on dedicated brackets. The detailed instrument descriptions can be found in the intruments' observer's manuals.

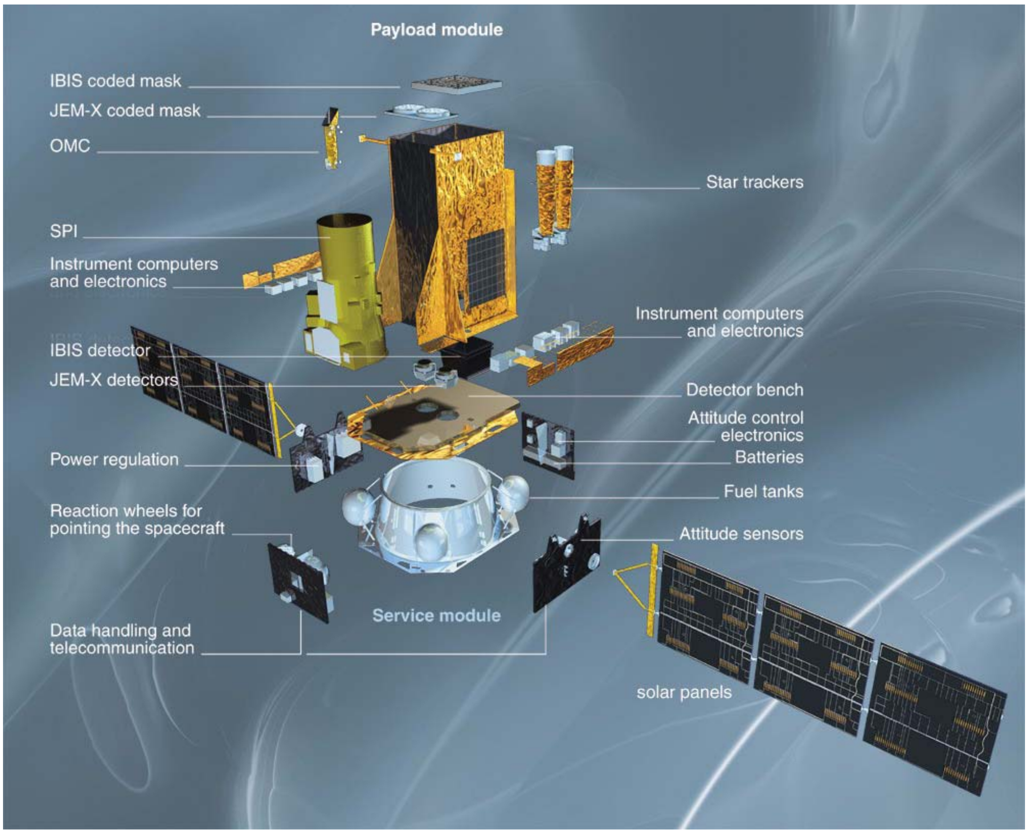

Figure 1: Exploded view of INTEGRAL service and payload modules

2.2.3 The orbit

INTEGRAL follows a highly elliptical 72-hour orbit with an apogee of 150200 km and a perigee of 12460 km, although there is a slight drift of the orbital parameters in time. For example, the perigee of 9050 km in November 2002, increased to 12400 km over the course of four years, and the apogee evolved from 153600 km to 150300 km in the same period. The inclination has increased continuously from 52^o in November 2002 to 85^o in December 2007. Still, 65 hrs of the 72-hour orbit are spent above 40000 km.

In order to allow for undisturbed scientific measurements and guarantee maximum science return, it is required to optimize the time spent outside the Earth's radiation belts. The real-time nature of the INTEGRAL mission requires full ground station coverage of the operational orbit above 40000 km with maximum use of available coverage below.

Generally, scientific observations can be carried out if the spacecraft is at an altitude of at least 40000 km, but the on-board radiation environment monitor can be used to adjust this limit. Scientific observations are currently performed between an altitude of 40000 km (ascending leg of the revolution) and 60000 km (descending leg of revolution). Instrument operation is interrupted in case of a higher radiation environment, e.g., during a strong solar flare.

Ground station coverage of the orbit above 40000 km is achieved by the combined use of the Redu (ESA) and Goldstone stations (NASA DSN) that offer simultaneous coverage during a large part of the orbit. The requirement for maximum visibility from ESA's European ground stations imposes a high inclination angle and an apogee position in the northern hemisphere. For critical operations like orbital manoeuvres, simultaneous coverage from two stations is required.

The satellite requirements on the orbital scenarios are dictated by power consumption, thermal and operational considerations. In order to guarantee sufficient power throughout the mission, the Solar Aspect Angle (SAA) is currently constrained to ± 40^o. This implies that the pointing angle of the spacecraft must be greater than about 50^o away from the Sun and the anti-Sun. The maximum duration of eclipses (umbra plus penumbra) cannot exceed 1.8 hours due to thermal and energetic constraints.

2.3 Overview of scientific instruments

Table 1 is a schematic summary of the complimentary features of the instruments on INTEGRAL, and Tables 2 and 3 list the key performance parameters of the payload. For more details on the instruments including their sensitivities, please refer to the appropriate "*Instrument Observer's Manuals*".

Table 1: INTEGRAL science and payload complementarity.

Instrument	**Energy range**	**Main purpose**
Spectrometer SPI	18 keV - 8 MeV	Fine spectroscopy of narrow lines
		Study diffuse emission on >1^o scale
Imager IBIS	15 keV - 10 MeV	Accurate point source imaging
		Broad line spectroscopy and continuum
X-ray Monitor JEM-X	4 - 35 keV	Source identification
		X-ray monitoring of high energy sources
Optical Monitor OMC	500 - 600 nm (V-band)	Optical monitoring of high energy sources

Table 2: Key parameters for SPI & IBIS

	SPI	**IBIS**
Energy range	18 keV - 8 MeV	15 keV - 10 MeV
Detector	17 Ge detectors ($6\times6\times7$ cm^3), @ 85K	16384 CdTe detectors ($4\times4\times2$ mm^3), 4096 CsI dets ($8.55\times8.55\times30$ mm^3)
Detector area (cm^2)	500	2600 (CdTe), 3000 (CsI)
Spectral resolution (FWHM)	3 keV @ 1.7 MeV	8 keV @ 100 keV
Field of view (fully coded)	16^o (corner to corner)	8.3^o × 8^o
Angular resolution (FWHM)	2.5^o (point source)	12'
Source location (radius)	< 1.3^o (depending on source strength)	30"@100 keV (50 σ source) 3' @100 keV (5 σ source)
Absolute timing accuracy (3σ)	~130 μs	~90 μs
Mass (kg)	1309	746
Power [max/average] (W)	385/110	240/208

Table 3: Key parameters for JEM-X & OMC

	JEM-X	**OMC**
Energy range	3 keV - 35 keV	500 nm - 600 nm
Detector	Microstrip Xe/CH_4-gas(1.5 bar)	CCD + V-filter
Detector area (cm^2)	500 for each of the two JEM-X detectors	CCD: (2055 × 1056) pixels Imaging area: (1024 × 1024)
Spectral resolution (FWHM)	2.0 keV @ 22 keV	--
Field of view (fully coded)	4.8^o	4.979^o × 4.9979^o
Angular resolution (FWHM)	3'	23"
10σ source location (radius)	1' (90% conf., 15 σ source)	2"
Absolute Timing accuracy	~1 ms	> 3 s
Mass (kg)	65	17
Power [max/average] (W)	50/37	26/17

2.4 Overview of INTEGRAL observation modes

Table 4 summarises the observation modes available for each instrument. Those shown in italics are used in exceptional circumstances only. More details are given in the relevant "*Instrument Observer's Manual*" and should be consulted especially in the case of JEM-X, where the operation strategy had to be adjusted for operations with one of the JEM-X cameras.

Table 4: INTEGRAL observing modes

Instrument	Modes
SPI	Photon-by-photon
IBIS-ISGRI	Photon-by-photon
IBIS-PICSIT	Histogram
JEM-X[1] (Modes in italics are for special circumstances only)	Full Imaging *Restricted Imaging* *Spectral Timing* *Timing* *Spectrum*
OMC	Normal *Fast*

[1] Only JEM-X 1 of two JEM-X detectors is currently used.

3 Observing with INTEGRAL

3.1 Overview and observation types

Since the four instruments on-board INTEGRAL are co-aligned (Figures 1 and 2) and operated simultaneously, observers generally receive the data for all instruments together with auxiliary data including that of the particle radiation monitor from the INTEGRAL Science Data Center (ISDC, see §4.4). Typical observations can last from ~1 day to a few weeks, and proposals may contain several observations.

There are four classes of observations that can be applied for in the open time of the General Programme: *Standard*, *Fixed Time*, *Target of Opportunity*, and *Key Programme* observations. Calibrations constitute another kind of observations but cannot be applied for in the open time. Each class has implications for science operations and are described in detail below.

3.1.1 Standard observations

Standard observations are the majority of scientific observations. They do not require any special boundary conditions, e.g., constraints on sky visibility. This type of observation allows for the most efficient scheduling.

3.1.2 Fixed time observations

Fixed Time observations have special scheduling requirements. For example, phase-dependent observations of a binary system, or coordinated multi-wavelength observations would be part of this category. A sequence of observations separated by a time interval, e.g., three observations separated by two weeks, are also considered as fixed time observations. Such observations reduce scheduling efficiency since the spacecraft must be pointing towards a particular source at a particular time. The exact scheduling requirements for a fixed time observation may not be known at the time of proposal submission, but should be clearly stated in the proposal and flagged as such by setting the *Observation Type* to *Fixed Time* in the *Observation Details Panel* of PGT. Once the proposal is approved, ESA will contact the observer to determine the best time to schedule the observation. Visibility constraints different than the usual biannual observation window for most sources, should be described in the scientific justification.

3.1.3 Targets of opportunity or TOO observations

"Target of Opportunity'' (TOO) observations have very special scheduling requirements and are meant as a fast response to "new" phenomena, like outbursts of X-ray novae, AGN flaring, SNe, and high states of galactic micro-quasars. TOOs can be targeted towards known (e.g., 3C 279, GRS 1915+105, GRO J0422+32) or unknown sources identified by their probable class.

TOOs can have either internal or external triggers. Internal triggers come from the ISDC by screening the incoming science telemetry. External triggers are alerts based on observations with other observatories. All triggers are addressed to ISOC via the INTEGRAL TOO Notification Web page: http://integral.esac.esa.int/isoc/html/too/my_too_alert.html.

The Project Scientist decides on declaring a TOO observation. Implementation of the updated command schedule following ISOC's request will subsequently be performed by the Mission Operations Centre (MOC) in Darmstadt, Germany.

TOO observations require the interruption of the pre-planned schedule, re-pointing of the spacecraft and re-scheduling. They are, therefore, a very heavy load on the scheduling system and, like fixed time observations, reduce the mission's overall observation efficiency significantly. The typical response time from detection to re-pointing of the spacecraft is ~20 hours. Although neither the ISDC nor the ISOC have staff around the clock, the ISDC has an automatic TOO detection system and one on-call scientist outside working hours. Both the ISOC and MOC also provide an on-call service outside working hours including weekends and non-working days. Proposals for TOO observations can be made in response to this AO. [2]

In general, the following **rules and guidelines** are applicable to TOO proposals:

- The Time Allocation Committee (TAC) is advised to accept no more than a few TOO proposals per year, all ranked primarily according to their scientific merit.
- In contrast to previous AO's, the INTEGRAL Science Working Team (ISWT) has not included any TOO events as part of the Core Programme.
- A TOO will displace another observation if the latter can be rescheduled by the ISOC and MOC. In some cases, observations can be pushed back to the next AO round.
- The proposer is responsible for requesting[3] the TOO when the trigger event occurs.
- The request is made by submitting a TOO Notification using the ISOC Target of Opportunity Alert Web page (see above). The Project Scientist or appointed deputy must include this request in the ISOC proposal database, allowing the tracking, documenting and time-line inclusion of TOO requests, in the same manner as for the standard proposals accepted by Time Allocation Committee or TAC during the AO cycle.
- The Project Scientist or an appointed deputy must decide to declare, or not, a TOO, by assessing whether the overall science of the mission will be enhanced by this TOO. It is possible that the TOO observation would conflict with a time-critical observation, another TOO or other high priority observations. In such situations the Project Scientist will define the priorities and inform the scientific community of his decision about the TOO.

Gamma-ray bursts (GRBs) are considered as a subset of TOOs. GRBs occur randomly in time and space, therefore both inside and outside the FOVs of the instruments. Typically, one such event per month is detected by INTEGRAL and is found in the normal science data of the on-going observations. Due to the brevity of GRBs, no dedicated follow-up observations are done with INTEGRAL. Afterglow or counterpart observations with INTEGRAL are possible if : 1) the GRB occurs within the FOV of the on-going observation and will be covered during the on-going nominal dithering manoeuvres, or 2) if the event occurs outside the FOV but the

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[2] A ***proposal*** for a TOO observation can be submitted during the normal AO process, in anticipation of the event.

[3] A ***request*** for TOO observation is understood to be made after a scientific event occurred which may justify an INTEGRAL TOO observation. The occurrence of this event may or may not match an existing proposal.

spacecraft will dither onto that position during the nominal dithering manoeuvre of the observation during which the event occurred[3].

GRB data from events occurring outside the FOV can be obtained from the anti-coincidence shield of the SPI instrument (see the "*SPI Instrument Observer's Manual*" and §4.5.2). The ISDC processes the near real-time science telemetry stream in order to detect and localise these events, and then alerts the scientific community.

3.1.4 Key Programme observations

The concept of Key Programme (KP) was introduced in §1.6. The document entitled "*AO-5 Key Programmes and Associated Observations*" contains all the details of the planned KP observations and data rights. PIs may propose to get the data rights for point or extended sources that will be observed during an AO-5 KP. Such proposals should be flagged as associated with the particular KP in the manner outlined in §A.8. The PI will not have to give observation times and instrument modes for these proposals, but the proposal must still be submitted via the PGT together with a full scientific justification and technical feasibility.

3.1.5 Calibration observations

Dedicated payload calibration observations are occasionally executed during the normal operation phase. Observations of the Crab are usually carried out during every visibility period in order to continually monitor, assess and verify the scientific performance of the instruments. This helps to refine our knowledge of the instruments and thus our ability to characterise their performance. This is particularly important after annealing of the SPI detectors or after strong solar flare events. An initial long Crab calibration observation took place in February 2003. Thereafter, typically up to one revolution per viewing period has been used for Crab calibration observations. OMC flat field calibration sequences are performed about once a month with a duration of ~4.5 hours to characterise its response. Other observations to verify the performance of the spacecraft itself, such as AOCS calibration observations, are also performed regularly. Proposers should take care not to duplicate such calibration observations in preparing open time proposals.

Public observations of the Earth were performed during AO-3. This allowed an accurate estimate of the cosmic X-ray background—an important and long-standing problem in high-energy astronomy—while providing a better estimate of the instrumental background, which lead to improved background modelling.

3.2 Observation modes

There are three distinct observation modes: *rectangular dither*, *hexagonal dither* and *staring*. During all observations, the spacecraft provides stable pointings with errors typically lesser than 7.5″ around the pointing direction.

In order to minimize systematic effects due to spatial and temporal background variations in the IBIS and SPI instruments, **a controlled and systematic spacecraft dithering manoeuvre is required**. This manoeuvre consists of several off-pointings of the spacecraft's pointing axis

[3]Note that in case (i) all three high energy instruments and OMC will provide data, while in case (ii) data will be provided by SPI, IBIS, and JEM-X.

from the target in ~2° steps. The integration time for each pointing (all instruments) on the raster is ~30-60 minutes, adjusted so that an integer number of complete dither patterns are executed. Two different dither patterns and the staring mode are commonly used and described below. Note that the hexagonal dither pattern is implemented as it was in AO-4.

3.2.1 Rectangular dithering

Rectangular dithering is used for observations characterised by a FOV containing multiple point sources whose positions are unknown. It is also used for observations of extended or weak sources that can best be studied through accumulation of exposure time through a sum of individual pointings ("mosaic"). This observation mode should be used as the default.

During AO-1 and most of AO-2, this mode consisted simply of a square pattern centred on the nominal target position, as shown in Figure 2. In this implementation, one pointing was with the source on-axis, and 24 other pointings, each separated by 2^{o}, with the source off-axis, in a rectangular pattern. The roll angle between pointings was always 0^{o}, but recent changes to this angle have been considered and users should refer to the ISOC web pages for details of when and how this will be implemented.

Starting in AO-3, the pattern was optimised to reduce systematic effects in the IBIS images. For observations requiring several dither cycles, an offset between the centre of each dither cycle is introduced. This ensures that no pointing attitude is repeated over the course of the observation. Hence, the **C**entre **O**f a dither **P**attern (COP) moves around in a pattern during an observation. The COP pattern is parallel to the original 5x5 dither and consists of 7x7 points centred on the target , and has step size of 0.3^{o} (see Fig. 2). Thus, the whole COP pattern fits within the inner 3x3 points of the original dither. The 49 points in the COP pattern allow for an observation time of 2.2 Msec without repetition of an individual pointing.

In addition to the moving COP, since June 2005 the orientation of the 5×5 pattern is set such that the axis of the dither pattern makes a 11.3^{o} = arctan(1/5) angle with respect to the instrument axes. This value has been optimized to even further minimize systematic structures in the IBIS images. As the instrument axes depend on the relative position of the Sun, the exact dither pattern positions depend on the time of execution of the observation.

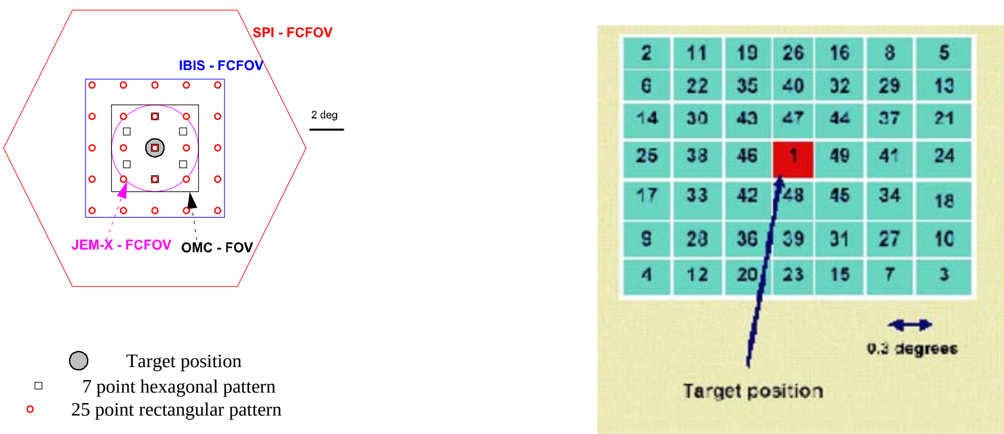

Figure 2: Schematic view of dithering patterns within the fully coded FOVs (left), and associated COP Offset Pattern for 5x5 rectangular dithering (right).

3.2.2 Hexagonal dithering

Hexagonal dithering consists of a hexagonal pattern centred on the nominal target position: one source-on-axis pointing, six source-off-axis pointings, each 2^{o} apart, in a hexagonal pattern. This mode should generally only be used for a single point source whose position is known and where no significant contribution from out-of-view sources is expected. Earlier observations have shown that this is rarely the case because of bright or transient sources, and observers are generally discouraged from using this mode, except if their scientific goals require continuous monitoring of the main target by JEM-X. Such a strategy would however be at the expense of SPI data quality if there is even a few sources in the FOV (see "*SPI Observer's Manual*").

This observation mode was altered in the middle of AO-3 (November 2, 2005) to allow for a wandering COP offset to the hexagonal dither pattern. This COP pattern consists of 2 x 6 points that define two hexagons, (red dots in Figure 3), centred around the original centre point of the (blue) dither pattern.

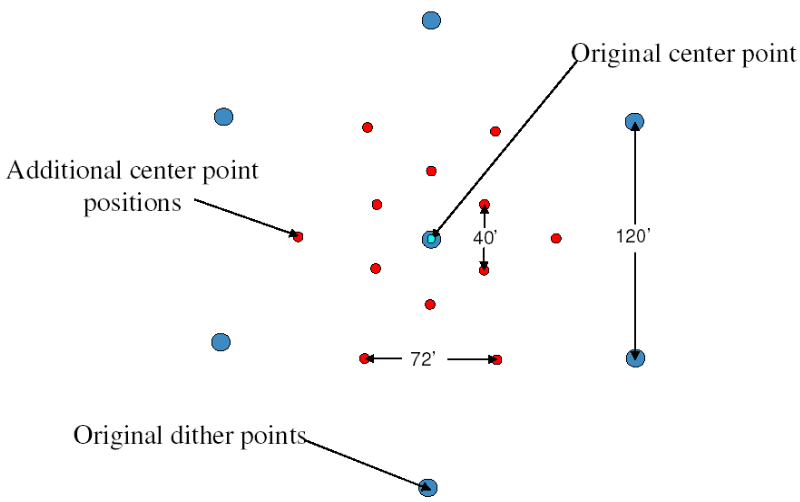

Figure 3: COP Offset Pattern for Hexagonal Dither Pattern.

3.2.3 Staring observations

There are circumstances that require long, uninterrupted, on-axis observations of a source. This is true for studies of time variability or QPOs, and in such cases, the staring mode is used. Observers must be warned that the staring mode seriously compromises the imaging capabilities of IBIS, SPI and JEM-X, thus affecting all future use of the data. For this reason, staring observations must be very well motivated.

3.3 Amalgamation

INTEGRAL's primary instruments have large FOVs and generally show little off-axis degradation of sensitivity and resolution within the fully coded FOV. This implies that several sources within a ~10° field can be observed simultaneously. ISOC, therefore, sometimes *amalgamates* (combines) several approved observations *into a single observation*, hence increasing operational efficiency, *while respecting the original goals of each observation.*

Amalgamation is the process by which several (independent) observations with similar attributes (sources in the same FOV, instrument configuration, etc.) are linked in the ISOC database, such that they are scheduled as a single observation: the *core* observation.

The following criteria and steps to create a proposed amalgamation are used by ISOC:

- After the TAC process, the proposal database is searched for amalgamation candidates.
- The mode of the core observation is that of the longest candidate observation.
- The duration of the core observation is defined according to the longest observation of the group. It may be lengthened to account for off-axis corrections and ensure that all sources are observed for a time consistent with their requested on-axis duration.
- The TAC's recommended scientific grade for a "core" observation will be as high as or higher than the grades of all observations in the amalgamated group.
- All sources are within the fully coded FOV for the main instruments (SPI, IBIS).
- The observation modes are identical for all four instruments (JEM-X: primary mode only), except when an observer has set "data not required" or deselected "prime" in the proposal.
- The restrictions on the dither patterns that can be amalgamated are listed in Table 5.
- Fixed time observations can not be amalgamated.

ISOC generates a list of possible amalgamations from the database of accepted proposals. It is then submitted to the Project Scientist for endorsement. Proposers are notified if their observations have been amalgamated. ISOC may de-amalgamate observations if necessary.

4 The INTEGRAL science ground segment

4.1 Introduction

The INTEGRAL science ground segment is made up of the ISOC and ISDC, illustrated in the lower part of

Figure 4.

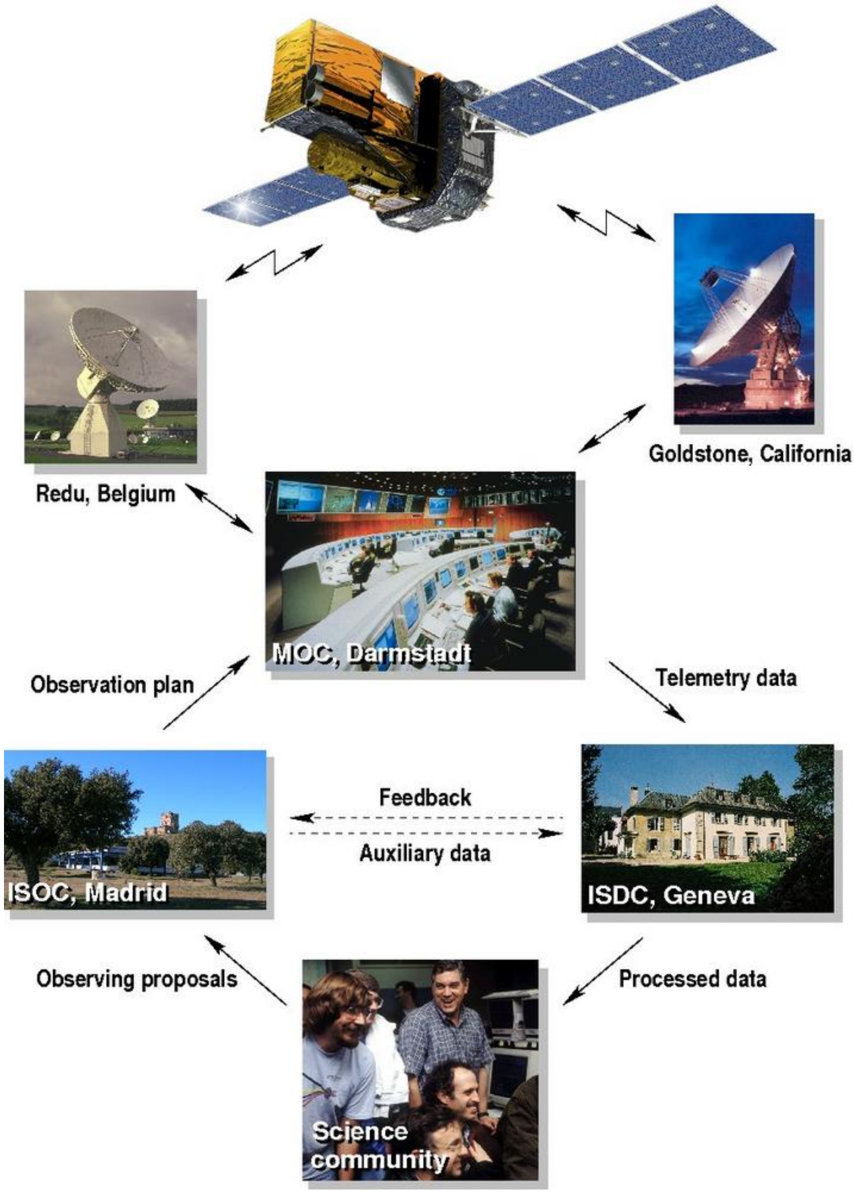

Figure 4: The INTEGRAL ground segment.

ISOC receives observation proposals and processes the accepted ones into an optimised observation plan consisting of a time line of target pointings together with the corresponding instrument configurations. The ISDC receives the science telemetry plus the relevant ancillary spacecraft data from the MOC, responsible for the operations of the spacecraft and payload. The ISDC processes these raw data, and generates standard data products that are distributed and archived. ESA also maintains a copy of this archive at the ISOC.

4.2 Science ground segment support for proposers and observers

The INTEGRAL ISOC web site at http://integral.esac.esa.int/ provides access to important information for proposers and observers. This includes:

- INTEGRAL Announcement of Opportunity
  - AO announcement key dates
  - AO documentation
  - Proposal support tools: Proposal Generation Tool (PGT), Observing Time Estimator (OTE), Target Visibility Predictor (TVP)
  - Links to (mainly high-energy) astronomical catalogues.
- INTEGRAL Target and Scheduling Information
  - Scheduling Information
  - Long and short term scheduling
  - Approved Target List
  - ISOC & ISDC data archive.
- INTEGRAL Helpdesk and Frequently Asked Questions.

A helpdesk handles all questions related to the INTEGRAL mission (received via e-mail at inthelp@sciops.esa.int or submitted on the web from http://integral.esac.esa.int/helpdesk/). The helpdesk is organized such that questions relating to proposals, observation modes, scheduling and INTEGRAL in general, are handled by ISOC staff; questions about the data, analysis software, instrument calibration and data delivery are handled by ISDC staff. The sharing of this responsibility is transparent to users. A list of frequently asked questions (FAQ) is maintained on the ISOC and ISDC web pages.

The INTEGRAL science analysis software is available together with documentation and test data for download from the ISDC web page at http://isdc.unige.ch/index.cgi?Soft+download. Further information on ISDC user support is provided in §4.4.

4.3 From proposal to observation: ISOC

4.3.1 ISOC responsibilities

The INTEGRAL Science Operations Centre, ISOC (http://integral.esac.esa.int/), was relocated to the European Space Astronomy Centre (ESAC), Villafranca, Madrid, Spain in early 2005. ISOC is responsible for the definition of scientific operations including instrument configuration for each observation, mission planning and implementation of the observing programme. A newsletter is published as a means to keep the INTEGRAL community informed (http://integral.esac.esa.int/newsletters/).

In summary, ISOC is responsible for:

- Preparing AOs, receives the proposals, assesses their technical feasibility and transmits the assessments to the Time Allocation Committee.
- Scheduling and implementing of the observing programme.
- Defining science related operations and instrument configuration and for each observation.
- Deciding to trigger, or not, a TOO observation upon the receipt of a TOO alert.
- Keeping an archival copy of all scientific data created and maintained by ISDC.

4.3.2 Proposals

Scientists submit proposals in response to an Announcement of Opportunity, issued by ESA/ISOC at regular intervals during routine, in-orbit operations. In general, proposals must reach ISOC before the AO deadline specified in the documentation. Requests to observe newly identified "Targets of Opportunity", however, can be submitted to ISOC at any time (see §3.1.3). Below, we briefly describe what proposals should contain, making a disctinction between standard and Key Programme proposals.

4.3.2.1 Standard proposals

Standard observation proposals must clearly contain: one or several well-defined targets, a description of the preferred instrument modes, the requested observation duration as entered in PGT, and the scientific justification. **All proposals must specify either IBIS or SPI as the main instrument**. The TAC evaluates each proposal primarily on the basis of its scientific merit, but obviously considers its feasibility and related technical issues. Two examples of observations that will normally be rejected are: unrealistically small observation duration where the scientific goal will not be achieved, and survey-type proposals of the kind "*I want the data of all observations with sources from the supplied list/or from all observations with sources of type 'x' in the FOV, but do not request any extra time*".

Each requested observation for each target of a proposal must be entered into the proposal using PGT, otherwise it is not considered by the TAC for evaluation. Hence, targets listed in the scientific justification but not entered in PGT, are not considered by the TAC. The Principle Investigator can request a PGT compatible version of their proposal submitted in response to an earlier AO via the helpdesk. This is very useful in case of long lists with targets and saves re-entering all the observation information. Instructions on downloading and using PGT and other supporting observation tools are given in §5.

4.3.2.2 Key Programme proposals

Proposals that are to be associated with a Key Programme (see §§ 1.6, 3.1.4 and A.8) are treated somewhat differently. Association with the KP within PGT, restricts the options available. This is described in the "*AO-5 Observation Tools Software User Manual*". As is the case for standard observation proposals, all targets for which data rights are claimed, must be entered into PGT, and the science justification is the primary element used by the TAC to evaluate the proposal. It must be demonstrated that the time accumulated during KP observations at the target's location will eventually allow the observer to meet the stated scientific objectives, and that the public archived data are not sufficient.

4.3.3 Proposal handling and Time Allocation Committee

After the deadline for an AO, ISOC will perform a technical feasibility of the submitted proposals using the Target Visibility Predictor and the Observing Time Estimator, and forward the proposals to the TAC for scientific assessment.

The proposals are reviewed by a single international TAC. This committee consists of three panels, covering the range of scientific topics addressed with INTEGRAL:

- Compact objects: black-hole candidates and neutron-star binaries, pulsars, isolated neutron stars and galactic jet sources.
- Active Galactic Nuclei: Seyferts, Blazars, quasars, but also normal galaxies, clusters of galaxies and cosmic background.
- Nucleosynthesis and miscellaneous: including supernovae, supernova remnants, novae, Wolf-Rayet stars, diffuse (line) emission, inter-stellar phenomena, gamma-ray bursts, gamma-ray burst sources and anything not in the two categories given above.

Based on the results of the assessments, the TAC will recommend approval of either an entire proposal (i.e. all requested observations), or part of a proposal (some of the requested observations, possibly with reduced observation time), or rejection of the entire proposal. In addition, all accepted observations (standard, fixed-time and TOO) are graded by the TAC with a letter (A is the highest, C is the lowest), and within a letter grade, with a mark (100 is highest, 10 is lowest). The TAC is advised to allocate time for an oversubscription factor of about 1.5 to increase scheduling efficiency. This means that not all proposals accepted by the TAC can be scheduled within the AO. Where possible, preference will be given to higher graded proposals.

GRB proposals and proposals associated with the AO-5 Key Programme will be evaluated normally by the TAC. However, they only receive a final mark and will not be graded A-C, as they have no scheduling priority of their own.

The TAC will be advised to accept only a limited number of proposals for Targets of Opportunity. The reason for this is that the scheduling of TOO observations reduces the overall efficiency of the mission by deviating from the long term scheduling plan.

Following the TAC assessment, and endorsement of the TAC recommended observing programme by the ESA Director of Science, a database of approved observations and associated details is created and maintained by ISOC. This data base contains both Guest Observer and Core Programme observations. A subset of these data is made available to the ISDC. ISOC will communicate to the proposer the ESA endorsed decision of the TAC, and in particular, for the successful proposer, ISOC will communicate the TAC approved observations.

4.3.4 Scientific mission planning

This section describes the scientific mission planning including execution of observations, scheduling and re-scheduling.

During routine observations, ISOC generates and maintains detailed observing schedules based on the approved observations (both from the CP and GO), and delivers these schedules to MOC for uplink and execution. The ISOC scheduling takes into account: celestial viewing constraints, observation efficiency (i.e. observing versus slewing time), scientific value, and any other special requirements such as fixed-time observations. Some observations are too long to be scheduled as a single time block; ISOC must therefore schedules such observations as more than one separate exposures. Both ISOC and MOC provide details of the "live" schedules to ISDC.

Sometimes, the need to reschedule may entail important changes to the pre-planned sequence of observations/operations. Such circumstances are encountered in the case of:

- Instrument or spacecraft anomaly
- TOO trigger
- Unforeseen ground station outages.

Re-planning at MOC can be done at most once per orbit, and can only be justified in the case of a TOO trigger or an anomaly. The reaction time is typically 8 hours from the receipt of the ISOC request. Any other re-planning, related to optimization of instrument configuration, for example, is generally implemented by MOC in the revolution starting at least 8 hours after the request from ISOC.

The rescheduling of an observation is considered by ISOC only if the ISDC deems that it did not yield useful scientific results. An abnormally high background level, due to solar activity for example, is not regarded as a justification for re-scheduling. If the prime instrument is switched off, however, the observation will generally be re-scheduled if the off time amounts to more than 15% of the approved observation.

4.3.5 INTEGRAL archive at ISOC

ISOC offers public access to INTEGRAL data, as does the ISDC. The ISOC Science Data Archive (ISDA) can be accessed through http://integral.esac.esa.int/isda. It uses the same browser technology as that developed for the XMM-Newton Science Archive (XSA) and ISO Data Archive (IDA). It is a highly flexible system for browsing and downloading the data and products, either at the level of observations, individual dither pointings, or so-called observation groups. Interactive tools are available for examining data from the original FITS image files and performing simple analysis tasks. ISOC continues to develop high-level data products and tools to visualize and manipulate these products.

4.4 From observation to data products: ISDC

4.4.1 Introduction

The INTEGRAL Science Data Centre, http://isdc.unige.ch/, is the link between the scientific output of the instruments on the spacecraft and the astronomical community. It is responsible for the receipt, analysis, archiving and worldwide distribution of all INTEGRAL data.

The ISDC was established in Versoix, near Geneva, Switzerland in 1996. The staff consists of about 30 scientists and engineers funded by an international consortium of twelve institutes with support from the European Space Agency (ESA). The ISDC works in close collaboration with the instrument teams to ensure that the software developed and maintained by these is integrated in a coherent data analysis system.

4.4.2 ISDC responsibilities, data flow and data analysis

The ISDC receives all the INTEGRAL telemetry and auxiliary data and converts these raw data to a FITS compliant format. It also monitors the scientific instruments on the spacecraft and works with the instrument teams to solve the problems that may arise. It performs a quick-look analysis of the data, and alerts the astronomical community when unexpected features and events such as gamma-ray bursts are detected.

The data flows in real-time from MOC to ISDC at a rate of ~113 kbits/s. The ISDC performs a *Quick-Look Analysis* (QLA) in *Real-Time*. The data stream is cut into a series of contiguous *Science Windows* (SCWs): a 30-60 minute pointing in a dither mode or a slew of the spacecraft. Every few days, the telemetry is sent again to the ISDC on CD-ROM, in the form of *consolidated data,* where all recoverable telemetry losses (e.g. at station handover) have been corrected. These consolidated data include auxiliary files and the current observing plan, and are used in the standard scientific analysis.

The purpose of the QLA is to rapidly detect bright transient sources, large flux changes in known sources and instrument anomalies. In the case of an unusual event, the QLA results are communicated to the PI of the observation and ISOC is contacted if the event could potentially trigger a TOO or follow-up observation. Once the consolidated data have been received, the ISDC uses the *Offline Science Analysis* (OSA) software to perform a standard analysis that yields reconstructed sky images in several pre-defined energy bands, spectra and light-curves of individual sources. OSA is a pipeline of high-level software components developed primarily by the instrument teams and integrated by the ISDC. The standard analysis is generally completed within three weeks after receipt of the consolidated data. The results are stored in the INTEGRAL archive.

4.4.3 INTEGRAL data

One three-day revolution yields a telemetry volume of 2.7 GBytes. Processing of this telemetry stream yields ~17 Gbytes of uncompressed data products. These data are stored in FITS files and consist of:

- **raw data** (4.5 GBytes): reformatted data of the telemetry,
- **prepared data** (7.2 GBytes): includes additional timing information,
- **corrected data** (2.7 GByte): includes gain corrected event energy, and
- **high-level products** (2.7 GBytes): SA products including images, spectra and light curves.

And are made available to the observer in compressed format (~9 Gbytes per revolution). Raw and prepared data are stored by SCW, whereas corrected data, intermediate results of the analysis and high level data products are stored per observation, usually consisting of 10–100 SCWs. The FITS standards are used throughout and for all data products. All data delivered by the ISDC are calibrated relying on the instrument teams' expertise.

4.4.4 INTEGRAL archive at ISDC

The main archive, located at the ISDC, contains all INTEGRAL data from raw telemetry to SA products, as well as calibration and response files, auxiliary data and source catalogues. As mentioned in see §4.3.5, a second archive located at ISOC contains the same data.

All archived public data can be downloaded from the ISDC via anonymous FTP or through a web archive browser. FTP download is more direct but requires knowledge of the exact name or location of the data, whereas the web interface allows queries to the database by object name, coordinates, time interval and other parameters. The selected data are then extracted from the archive in tar files, compressed and prepared for retrieval. Data can also be distributed by other means as is described in the next section.

4.4.5 Data distribution

A guest observer can chose the means through which the data will be made available in PGT. The typical data download rate from ISDC is 1 Gbyte/hour via FTP, and generally smooth. Consequently, the use of hard media is strongly discouraged and the re-distribution of it will not be done unless the media is either defective or was lost in the mail. Distribution takes place after ISDC has received the consolidated data from ESA, processed and archived them. The whole process takes about one month from the end of the observation. Note that ISDC does not assume any responsibility for the public network capacity in regards to the transfer of large data volumes.

Observers visiting the ISDC can have a first look at the data from their observation within a few hours. The ISDC, with the permission of ESA (amalgamated observations require the approval of all PIs), gives to an observer access to the data of their observation at the ISDC. This is true for all observers wishing to look at their data before the official distribution.

4.4.6 Data rights and source naming convention

Guest observer observations are proprietary for a period of one year from receipt of the consolidated data from the ISDC.

A source naming convention for new sources detected by INTEGRAL has been established in agreement with the IAU. Source designation is IGR J*HHMMm+DDMM* (equatorial coordinates, epoch J2000) in the case of positive declination, or IGR J*HHMMm–DDMM* for negative declination. In both cases, *HHMMm* is the right ascension of the source in hours, minutes and fractions of a minute, and *DDMM* is the declination of the source in degrees and arcminutes. Coordinates must be truncated, not rounded, to comply with this convention.

4.4.7 User support and communication

The ISDC provides support in regards to the data analysis. The INTEGRAL science analysis software, together with the associated documentation and test data, can be downloaded from the ISDC web pages at http://isdc.unige.ch/index.cgi?Soft+download. Observers are also welcome to visit the ISDC for local support and direct access to data analysis tools.

The ISDC software includes scripts to run the standard analysis and applications to visualize the data products and manage the off-line analysis. The software is available for SUN/Solaris, Mac OS X and Linux. The ISDC organizes regular INTEGRAL data analysis workshops, aiming to discuss issues relating to calibration, data analysis methods, software and results. A newsletter (http://isdc.unige.ch/Newsletter/) is used to keep the community informed and encourage communications with the ISDC. Subscription is done on the web site.

4.5 Gamma-ray bursts

Data from Gamma-Ray Bursts (GRBs) are generally treated as for a TOO (see §3.1.3). In such instances, however, three additional features are specified to facilitate follow-up observations:

- GRB position, trigger time, duration and flux estimate.
- GRB time history derived from the SPI Anti Coincidence Shield subsystem.
- Fast uplink of special OMC sub-window.

These are described in more detail below.

4.5.1 GRB position and trigger time

INTEGRAL has no on-board GRB detection and triggering system. However, it continuously downlinks its acquired data to Earth allowing for constant, near real-time, monitoring. At the ISDC all data are automatically analysed to detect transient events. In addition, a fast analysis is performed by the INTEGRAL Burst Alert System (IBAS) with several detection algorithms running in parallel.

As soon as a GRB candidate event is detected, it must pass a screening that involves a more detailed off-line analysis. The GRB position, trigger time, flux and duration are submitted to the alert generation process and broadcasted. The rate of GRBs is about one burst per month within the IBIS and SPI FOVs. Localization accuracy is a function of the event's S/N ratio, the spacecraft attitude and stability, the angular resolution, and whether the event took place in the fully or partially coded FOV. The first alert broadcast message has rather crude information. Therefore, subsequent alert messages are sent out to subscribers with more accurate information on the position and source characteristics. In order to facilitate rapid follow-up observations (e.g. using XMM, Chandra, Swift and Suzaku), data describing the GRB peak (2–200 keV, 1 sec), fluence (20–200 keV), lightcurve (20–200 keV, plot only), and duration (sec) are made available shortly after (see http://isdc.unige.ch/index.cgi?Soft+ibas for details).

Alerts with the coordinates of GRBs are distributed through internet sockets for robotic telescopes using the UDP transport protocol. The required software can be requested from the ISDC. Email alerts are distributed via GCN circulars. The typical uncertainty is smaller than a few arcminutes. The interactive analysis used to confirm the event and to derive the most accurate GRB position, is generally performed within a few hours after the automatic delivery of the first alert message(s).

In operating an automatic GRB alert system, users must be aware that this implies that some IBAS alerts may be spurious, i.e., unrelated to an actual GRB.

4.5.2 GRB data from the SPI anti-coincidence (veto) subsystem

INTEGRAL is well suited as the near-Earth node of the **I**nter**P**lanetary **N**etwork (IPN) providing large area detectors like SPI's **A**nti-**C**oincidence **S**hield (ACS). The ACS collects GRB data in time bins of 50 ms, time-tagged to an accuracy of 1 ms at energies above ~50–100 keV. Thus the data of about 300 (5σ) bursts per year, located mainly perpendicular to the instruments' FOV, are used by the IPN. These time series (contained in the instrument housekeeping data) are also provided via the ISDC GRB alert system to the scientific community and thus immediately publicly available.

4.5.3 OMC window handling in case of a GRB alert

Due to the limitation of telemetry rate, it is not possible to download all OMC data. Thus it is necessary to pre-define specific OMC CCD sub-windows (covering ~1% of the total CCD area) for routine observations. It is possible that a GRB, detected by IBIS via the ISDC alert system, is in principle observable by the OMC as it is taking place in its FOV, but the pre-selected sub windows (selected prior to the observation) do not cover its position. To enable GRB monitoring by the OMC, it is necessary to promptly order a change of the sub-window such that it covers the GRB, overriding the pre-defined sub-windows for the **duration of the on-going (dither) pointing only** (i.e., ≤60 minutes), until the next set of pre-defined OMC sub-window commands associated with the following dither pointing.

In order to allow a near real-time implementation of the required new OMC window commands the required functions are split between ISDC and MOC only. In summary the ISDC software:

- identifies a GRB from IBIS near real-time science data
- identifies the GRB location in IBIS detector coordinates
- converts IBIS detector co-ordinates to OMC detector coordinates
- checks whether location is within OMC FOV
- provides necessary input to MOC, only if the previous check is positive

Upon receipt of this message, MOC

- accepts and checks (syntactical) correctness of input
- generates necessary telecommands
- uplinks necessary telecommands

This process has been successfully used in flight.

The size of the new up-linked OMC sub-window is 91 × 91 pixels. The data collected from all other pre-defined sub windows during that pointing are lost. It is estimated that the new OMC sub-window will be effective about one minute after the detection of the event (nominal case). It is noted that this mechanism has been established only to provide the described functionality for the OMC. As it violates some of the basic mission principles, including safety considerations, it cannot be applied for other cases. No other commands (especially to AOCS) are sent in response to a GRB.

5 Proposal submission procedure and tools

5.1 Proposal Generation Tool (PGT)

Proposals must be prepared and submitted electronically using the Proposal Generation Tool software. *Other formats will NOT be accepted.*

PGT must be downloaded from the ISOC web page (http://integral.esac.esa.int/) and run locally. It is written in JAVA and requires the correct version of the JAVA run time libraries. PGT is used for the preparation, editing, printing and submission of INTEGRAL proposals. The scientific justification for the proposals must not be longer than five A4 pages, and is uploaded through PGT, and submitted electronically together with the rest of the proposal.

Prospective proposers may wish to 're-use' their old proposals from earlier AO's, updating them as necessary for AO-5. However, PGT has been modified for AO-5 and the old proposals are no longer consistent with the new software. To support the community in this, the ISOC will, on request only, generate a copy of an old proposal in the new format (consistent with the AO-5 PGT), and send it to the proposer. A proposer should send such a request to the INTEGRAL helpdesk, quoting the Proposal ID of the relevant proposal. ***ISOC will only send a proposal back to the original PI***.

Please see Appendix A: *"Proposals – format and checklist"*, for a description of some essential points regarding submitting a proposal using PGT, or *"AO-5 Observation Tools Software User Manual"* for more details.

5.2 Observing Time Estimator (OTE)

The Observation Time Estimator is available via the ISOC web page.

The OTE is the only official way to calculate the observing times for the two main INTEGRAL instruments: IBIS and SPI. It is also used by the ISOC for the check of the technical feasibility of all observations. Observers are strongly advised to use the OTE to calculate requested observing times, since it is imperative that sufficient information is provided in the proposals to allow feasibility checks to be performed by ISOC.

5.3 Target Visibility Predictor (TVP)

The Target Visibility Predictor is available via the ISOC web page.

In principle, any point on the sky is observable by INTEGRAL. This is not, however, true for any point in time. The TVP can be used to calculate visibility for each celestial source taking into account the constraints discussed below, with the exception of the SPIBIS effect (see §5.3.3), which is only considered at the scheduling level.

5.3.1 Sun and anti-Sun viewing constraints

TVP respects the constraints on the **S**olar **A**spect **A**ngle (SAA) of the spacecraft, described in §2.2.3. As a consequence of this constraint, the sun cannot be observed at any time.

5.3.2 Earth and Moon viewing constraints

In order to ensure correct functioning of the spacecraft's star trackers (see Figure 1), co-aligned with the instruments' pointing axis, the spacecraft has to point at least 15^o away from the Earth and 10^o away from the Moon limb during standard observations. TVP takes these constraints into account.

Note that observations of the Earth have been performed in AO-3, but such observations require elaborate non-standard mission planning and execution and cannot be performed as part of the routine operations.

5.3.3 Other constraints

Eclipses:

Observations are usually carried out while the spacecraft is at an altitude of at least 40,000 km. No observations are performed within 30 minutes prior to and following an eclipse (i.e. when INTEGRAL is in the Earth shadow with respect to the Sun).

SPIBIS:

SPIBIS is an effect by which a shadow of the SPI mask is cast onto the IBIS detectors. This occurs rarely and only when a bright source, like the Crab nebula or Cygnus X-1, is positioned 30–50° off-axis and within a narrow azimuth angle range around the spacecraft's Z-axis. This effect can be avoided by excluding from the scheduling, time periods during which a bright source lies within the critical area. ISOC avoids scheduling such observations as much as possible. More details can be found in the "*IBIS Observer's Manual*".

5.4 Software updates

It is highly recommended to use the latest version of the software and AO documentation. The ISOC will try to avoid updates of these between the issue of an AO and the deadline for proposals. Users are therefore advised to sign-up to the email distribution list by sending an email to the INTEGRAL helpdesk (inthelp@sciops.esa.int), with the text "update distribution list" in the subject. This will provide information on the software and documentation provided by ISOC. Observers who have signed up during previous AOs, need not re-apply. Questions concerning the instruments, the AO and anything related to INTEGRAL, should be directed to the helpdesk.

5.5 Proposal deadline

Proposals must reach ISOC by **Friday April 20, 2007 at 14.00 CET (13.00 GMT)**.

5.6 Proposal evaluation and selection

Proposals evaluated mainly on their **scientific merit** by an international TAC (§4.3.3). The TAC is advised to reject proposals for observations whose aims have been addressed or attained within the Core Programme or past AOs. Proposers should therefore carefully check any possible duplication of their observations by looking over the INTEGRAL target list available via the ISOC web page, by clicking on either 'Observing Programme' or 'Approved Target Lists'.

The TAC recommends the observing programme to the ESA Director of Science who makes the final decision. ESA subsequently notifies the proposers of the decision. **The decision of accepting or rejecting a proposal is final and non-negotiable**. Reasons for the rejection of a proposal can be provided via the INTEGRAL helpdesk upon request.

5.7 Ongoing modifications to the observing programme

During in-orbit operations, changes to the instrument performances may occur. In addition, the instrumental background varies with the solar cycle: at Solar minimum, the Sun's magnetic field can propagate more easily into the inner Solar System. These changes may influence the integration time required for the observations. The effects of any such changes on the instrumental performance are routinely monitored. If the expected changes in integration time or signal-to-noise ratio are significant, the observers will be notified, the TAC chairman will be consulted, and the integration times modified by ISOC. In principle, once an observation is approved, it will be carried out even if the required integration time increases, provided that it is still feasible. Some changes, however, are not allowed:

- Change of source or pointing direction.
- Change from standard to fixed time observation.
- Change from standard or fixed time to TOO observation.
- Change from TOO to standard or fixed time observation.

Appendix A: Proposals - format and checklists

A.1 Introduction

The only interface for submission of proposals is the PGT software. Here, you will find some general information and rules for the inputs to PGT. More details are found in the "*AO-5 Observation Tools Software User Manual*".

A.2 PGT inputs

The PGT inputs are split into several screens:

- The Main screen, where the Proposal ID can be entered.
- The Admin Details screen, where the administrative details of the PI and Co-Is need to be entered (e.g., names, addresses etc.)
- The Proposal Details screen, where general information about the proposal is given (title, abstract, category and scientific justification). The scientific justification is appended to the proposal as an attachment.
- The Observation Details screen, where information for each observation is given.

The Proposal ID is assigned by the Proposal Handling System at ISOC and sent to the observer by email upon successful reception of the first proposal submission. It is needed subsequently only for submitting an updated version of the same proposal.

A.3 Target coordinates

While ISOC does perform verifications on the validity of the source coordinates, it is nonetheless ultimately the responsibility of the proposer to make sure that the coordinates (J2000) entered into PGT for the target are correct. (PGT performs a validation of the coordinates using SIMBAD given the source name entered in the proposal; only a warning is given if the values of the coordinates do not match those returned by SIMBAD). Since changes to the source or pointing are not allowed after TAC approval (except in the case of obvious errors discovered by the proposer), observations for which target coordinates are incorrect could be lost. *Proposals for new (unknown) TOOs or GRBs in the field of view can use coordinates (0,0) in PGT.*

A.4 Scientific justification

The scientific justification has to be written in English and should be attached to the proposal in the Proposal details panel, using the "New Attachment" button at the bottom of the page. The attached file should preferably be in PDF format. In case PDF format is not possible, a postscript file is also acceptable. The justification should use A4 paper size, and a maximum of 5 pages, including figures and tables. Font size must not be smaller than 10-point.

The Observation Details panel in PGT allows only a small amount of information on the source flux to be entered in the proposal. In many cases this may not be sufficient information to judge the technical feasibility of the proposal, and the proposer is advised to give details on fluxes, spectral shape, line strength, line width, etc. for his sources in the scientific justification. These details will be taken into account by ISOC when doing the technical feasibility check.

Only targets included in the PGT will be considered for approval. Observations mentioned in the scientific justification or abstract but not entered into PGT will not be considered.

A.5 Integration times and GRB observations

For all observations other than those associated with the KP, proposers must specify an integration time in PGT (this is a mandatory field in PGT and cannot be left blank). In general the integration time should be calculated using the Observing Time Estimator software (OTE), which will calculate how much time is required to achieve a given significance for a given flux. ISOC will use the same software to perform the technical feasibility checks on the proposals.

This is not the case for observations of GRBs in the FOV. The duration of these events (of the order of 100 seconds) and the possible afterglow of a few hours, are short compared to the typical duration of an INTEGRAL observation. Also these cannot be treated as standard TOO follow up observations, since no re-pointing is possible on such short time scales. Therefore, observers interested in data of GRB sources in the FOV cannot estimate their integration times using the OTE, since they are basically interested in receiving data for a period of time around the GRB event. However, OTE can still be used to estimate the minimum detectable flux in a given energy band with the SPI and IBIS instruments, thus allowing to estimate the detectability of a GRB. In such cases, proposers should specify in PGT the period of time for which they want to receive the data of the detected GRB. This can be before and after the event (the split between the time before and after the event needs to be specified in the scientific justification).

A.6 TOO and fixed time observations

For Targets of Opportunity (TOO) and Fixed Time observations, the proposer has to fill in a short justification for each observation in PGT in addition to the scientific justification for the proposal. These justifications must be entered in the appropriate window in the PGT observation details screen. For TOOs this should specify why this observation should be regarded as a TOO, and when the TOO should be triggered (flux levels, etc.). Note, however, that it is the proposer’s responsibility to inform the Project Scientist that the TOO trigger has been met. (For TOOs discovered in the field of view of INTEGRAL and for which a proposal exists, the proposer will be informed that this TOO is active, after which the proposer decides whether to activate the TOO follow-up observation or not). The TOO alert form on the ISOC web site should be used only to request that a TOO be scheduled. The form can be found at the ‘Target of Opportunity Alert’ link on the ISOC home page, or directly via the URL:

http://integral.esac.esa.int/isoc/html/too/my_too_alert.html.

In the case of fixed time observations the proposer must specify in the scientific justification, why a fixed time observation is required, and when the fixed time observation should be performed (if this is known). This information will be used by ISOC to determine when to schedule the observation. Note that for fixed time observations, for which a time or date for the observation is already known, it is imperative that the proposers check the visibility of their sources using the Target Visibility Predictor for the dates and times they want their observation to be performed. (See §3.1.3 for a discussion on TOO observations.)

A.7 Coordinated observations with other facilities

ISOC will support coordinated observations with other facilities. Proposers are particularly encouraged to apply for coordinated observations with XMM-Newton where appropriate.

Proposers who want their observation to be coordinated with another facility should enter it as a fixed time observation, indicating that the reason for the fixed time is that it is coordinated with another observatory: specifying its name. ISOC will try to accommodate the coordinated observation, but the proposer remains responsible for the coordination between observatories. ISOC mission planners are nonetheless, in regular contact with mission planners on other missions such as RXTE, XMM-Newton, Suzaku, Swift and Chandra. Note that since INTEGRAL observations are generally long, it may be easier for other observatories to follow the INTEGRAL scheduling (especially ground based observatories).

A.8 Association with Key Programme

Proposers who wish their proposal to be associated with a KP should check the checkbox "Associate with Key Programme". The KP pointings and instrument configurations are pre-defined so the only information the user has to provide is related to the target source he requests data from. Therefore certain information in the "Observations Details Panel", such as settings and dither pattern selection for example, will be blocked.

A.9 Checklist for the proposal

The proposal text must contain at least the following three items:

- the scientific case
- the observation strategy
- demonstration of the feasibility of the observations

The proposal should be checked against the following questions:

- Is your science justification complete? Does it contain the mandatory three sections mentioned above?
- Have you filled in the Observations Details Panel for *all* observations of *every* source in the proposal?
- If your observation has any scheduling constraints, have you marked it as a fixed time observation in PGT?
- If your proposal is for GRB data, have you supplied the trigger criteria and the time interval of the data you request?
- If your proposal is for KP data have you selected the button labelled "Submit as Key Programme Association"?
- If you are not using the standard 5 × 5 dither, have you justified the use of the alternative dither pattern?
- If you plan to observe a region of the sky which will be observed in the Core Programme, or has been observed in the Core or Open Time programmes, have you explained what new science will be addressed by your proposed observations?
- Why can your programme only be done with INTEGRAL? If so, why can't it be done using archival data?
- Have you checked the latest news on the INTEGRAL WWW?

Appendix B: Glossary of Terms

ACS	ANTI COINCIDENCE SYSTEM
AFEE	Analogue Front End Electronics
AGN	Active Galactic Nucleus
AMA	Absolute Measurement Accuracy
AO	Announcement of Opportunity
AOCS	Attitude and Orbital Control System
APD	Absolute Pointing Drift
APE	Absolute Pointing Error
ASIC	Application Specific Integrated Circuit
BACODINE	BATSE Coordinates Distribution Network
BATSE	Burst And Transient Source Experiment
BGO	Bismuth Germanate
BH	Black Hole
BHC	Black Hole Candidates
BHXB	Black Hole X-ray Binaries
BOM	Begin of Mission
CCD	Charge Coupled Device
CDMU	Command and Data Management Unit
CGRO	Compton Gamma-Ray Observatory
COMPTEL	Imaging Compton Telescope
COP	Center of Pattern
CP	Core Programme
CR	Cosmic Rays
CSA	Charge Sensitive Amplifier

DBB	Detector Bias Box
DBOB	Data Base of Observable Bins
DCR	Document Change Record
DFEE	Digital Front End Electronics
DLT	Digital Linear Tape
DPE	Data Processing Electronics
DSN	Deep Space Network
DVD	Digital Versatile Disc
DXB	Diffuse X-ray Background
EEM	End of Extended Mission
EGRET	Energetic Gamma-Ray Experiment Telescope
EM	Engineering Model
ENM	End of Nominal Mission
ESA	European Space Agency
ESAC	European Space Astronomy Centre
ESAM	Emergency Sun Acquisition Mode
ESOC	European Space Operations Centre
ESTEC	European Space Research and Technology Centre
EW	Equivalent Width
EXOSAT	European X-ray Observatory Satellite
FAQ	Frequently Asked Questions
FCFOV	Fully Coded Field of View
FIFO	First In First Out
FITS	Flexible Image Transport System
FM	Flight Model

FOV	Field of View
FTP	File Transfer Protocol
FWHM	Full Width at Half Maximum
GCDE	Galactic Central Radian Deep Exposure
GCN	GRB Coordinates Network
GO	General Observer
GPS	Galactic Plane Survey
GRB	Gamma-Ray Burst
GT	Guaranteed Time
GUI	Graphical User Interface
HEAO-1	High Energy Astrophysics Observatory
HEPI	Hardware Event Processor
HMXB	High Mass X-ray Binaries
HURA	Hexagonal Uniformly Redundant Array
HV	High Voltage
IASW	Instrument Application Software
IBAS	INTEGRAL Burst Alert System
IBIS	Imager on board INTEGRAL spacecraft
ICCS	ISOC Configuration Control System
ILS	Instrument Line of Sight
INTEGRAL	International Gamma-Ray Astrophysics Laboratory
IPN	Interplanetary Network
IREM	INTEGRAL Radiation Environment Monitor
ISDC	INTEGRAL Science Data Centre
ISGRI	INTEGRAL Soft Gamma-Ray Imager

ISM	Interstellar Medium
ISOC	INTEGRAL Science Operations Centre
ISWT	INTEGRAL Science Working Team
JEM-X	Joint European Monitor for X-Rays
KP	Key Programme
LEOP	Launch and Early Operations
LMXB	Low Mass X-ray Binaries
MCE	Module Control Electronics
mCrab	milli Crab
MDU	Modular Detection Unit
MLI	Multi Layer Insulation
MOC	Mission Operations Centre
MRU	Main Bus Regulation Unit
MSGC	Microstrip Gas Chamber
NASA	National Aeronautics and Space Administration
NS	Neutron Star
OBDH	OnBoard Data Handler
OGS	Operational Ground Segment
OMC	Optical Monitoring Camera
OMC	Optical Monitoring Camera
OPP	OMC Pointing Parameters
OTE	Observation Time Estimator
PAD	Proposal Administrative Data
PCFOV	Partially Coded FOV
PDU	Power Distribution Unit

PEB	PICsIT Electronics Box
PGT	Proposal Generation Tool
PHA	Pulse Height Amplifier
PI	Principal Investigator
PICsIT	Pixellated Imaging Caesium Iodide Telescope
PIN	Positive Intrinsic n-type
PLM	Payload Module
PLSA	Point Source Location Accuracy
PMT	Photomultiplier Tube
PS	Project Scientist
PSA	Pulse Shape Amplifier
PSAC	Plastic Scintillator Anti Coincidence subassembly
PSD	Pulse Shape Discriminator
QLA	Quick-look Analysis
QPO	Quasi Periodic Oscillations
R.A.	Right Ascension
RCS	Reaction Control System
RKA	Russian Space Agency
RPE	Relative Pointing Error
RSA	Russian Space Agency
RTU	Remote Terminal Unit
RW	Reaction Wheels
S/C	Spacecraft
S/N	Signal to Noise
SA	Standard Analysis

SAA	Solar Aspect Angle
SGS	Science Ground Segment
SIGMA	French Coded Mask Telescope
SMP	Science Management Plan
SN	Supernova
SNR	Supernova Remnant
SPI	Spectrometer for INTEGRAL
STM	Structural and Thermal Model
SVM	Service Module
SXRT	Soft X-ray Transients
TAC	Time Allocation Committee
TBC	To be confirmed
TM	Telemetry
TOO	Targets of Opportunity
TVP	Target Visibility Predictor
UDP	User Datagram Protocol
URL	Universal Resource Locator
UTC	Universal Time (Coordinated)
WR	Wolf-Rayet
WWW	World Wide Web
XMM-Newton	X-Ray Multi Mirror Mission