INTEGRAL

Science Operations Centre

Announcement of Opportunity for Observing Proposals (AO-13)

Overview, Policies and Procedures

SRE-OO-AO-00128

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Prepared by:

Erik Kuulkers

Originally (for AO-11 and earlier) prepared by Chris Winkler

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1 The 13th INTEGRAL Announcement of Opportunity for observing time proposals

1.1 Introduction

The ***INTE***rnational ***G***amma-***R***ay ***A***strophysics ***L***aboratory (INTEGRAL) is being operated as an observatory mission executing observations selected after a peer review process. ESA issues the 13th Announcement of Opportunity (AO-13) for observing time proposals to be scheduled in 2016. This document describes the overview, policies and procedures for this AO. Section 1 provides an overview of the forthcoming AO, its schedule and available observing time, and it summarizes recent important changes introduced into the AO process. Then, INTEGRAL with descriptions of its orbit and instruments, source naming convention and acknowledgement in publications, are introduced (Section 2), followed by a description of the science ground segment (Section 3), observations types and modes, and amalgamation (Section 4), policies on data rights (Section 5), procedures to be followed by proposers and the use of the appropriate software tools in preparing proposals, information on the proposal format, a checklist, and the Target Allocation Committee (Section 6).

INTEGRAL AOs are primarily intended for scientists of the ESA Member States and of those countries participating in INTEGRAL (Russia and USA), but proposals from other countries will be welcomed by the Time Allocation Committee. Note that there is no NASA Guest Observer funding for INTEGRAL anymore. INTEGRAL analysis of ***public*** data has been eligible for funding through the NASA Astrophysics Data Analysis program in the past years.

For a proposal to be successful, ESA recommends, that the proposer has read the complete information provided for this AO prior to the submission of the proposal. In this Section we also highlight some of the ***important changes and modifications*** applicable for this AO.

1.2 The AO schedule

As part of the cost savings implemented in 2013, ESA reverted to a single, annual AO for observing time proposals. This means that there will be ***no*** second call anymore for proposals requesting data rights (i.e., *data rights proposals*). ESA encourages previous data rights proposers to submit regular observing time proposals for their targets (or science) of interest; amalgamation has been made more flexible (see Section 4.3).

The AO-13 cycle of observations will begin on 1 January 2016 and will last 12 months. The schedule for this AO, including this call for observing time proposals, is shown in Table 1.

Table 1: Schedule for AO-13

Activity	Date
Release of AO-13: Call for observing time proposals	9 March 2015
Deadline for submission of observing time proposals	17 April 2015 (14:00 CEST)
Meeting of the Time Allocation Committee (TAC)	26 – 28 May 2015
Start AO-13 cycle of observations (duration 12 months)	1 January 2016

1.3 AO document package

The available supporting documents for this AO are listed below:

- *"Overview, Policies and Procedures"* (this document)
- *"IBIS Observer's Manual"*
- *"SPI Observer's Manual"*
- *"JEM-X Observer's Manual"*
- *"OMC Observer's Manual"*
- *"INTEGRAL AO Tools: Software User Manual"*

All documents are available from ESA's INTEGRAL Science Operations Centre (ISOC) web page, http://integral.esac.esa.int/, where proposers can also find links to AO software tools. The latter includes the Proposal Generation Tool (PGT), which is needed to prepare and submit proposals. PGT needs to be installed locally; all other tools run remotely via the ISOC website.

1.4 Scientific observing time available

There is approximately 21 Ms of INTEGRAL scientific observing time available for this AO. However, the following needs to be considered:

1) INTEGRAL observed the type Ia SN 2014J from end of January to end of June in 2014. These exceptional Target of Opportunity (ToO) observations (total exposure: 7 Ms) displaced a number of approved and planned AO-11 observations for carry-over for completion into AO-12. These carry-over observations, like the ones on SN 2014J, are located close to the Galactic anti-centre/centre visibility windows (the total annual visibility window for these regions is about 8 Ms). The carry-over of this magnitude could not be compensated by normal scheduling activities in AO-12, and thus affects AO-13 too. Therefore, the amount of time which will be made available in AO-13 for ***new*** scientific observing proposals will have to be reduced, in order to absorb the "domino" effect of the carry-over induced by SN 2014J. The exact amount of reduction in time is still to be determined, since the orbit of INTEGRAL has recently been changed (see Section 2.2.3) and the impact on the long-term plan needs to be evaluated. Note that usually another, smaller amount of carry-over will develop during the course of current AO observations due to other new ToOs or scheduling conflicts.
2) Following a recommendation made by the INTEGRAL Users Group (IUG) in June 2008, the vast majority of observing time shall be made available to non-ToO observations exceeding 1 Ms of exposure (so-called "Key Programmes").
3) About 2 Ms will be reserved for the execution of ToO observations. This is allocated for long-term planning before the start of the AO. If justified on the basis of scientific merit, more time may be allocated to ToO observations.
4) An amount of 25% of the open time is reserved for scientists from the Russian Federation in return for their provision of the launcher. Given the total amount of open science time, the corresponding guaranteed return amounts to about 5.25 Ms for this AO. The Time Allocation Committee (TAC) will award the guaranteed return on the ***same*** basis of scientific merit with all other proposals.
5) The TAC had accepted 2 new 'multi-year' proposals (see Section 1.8) in AO-12. These proposals cover observations for both the AO-12 cycle (7 Ms) and this AO-13 cycle (8 Ms), but the AO-12 TAC requested them to be re-confirmed by the PIs for AO-13 (see

Section 1.7). The AO-13 TAC will consider it, as it does for all other proposals, on the basis of scientific merit.

1.5 New INTEGRAL orbit

ESA needed to work on a possible future safe disposal of INTEGRAL after its end of life. The requirement to study such an option was put on the project, as well as all other missions in operations, after the failure of Envisat. The disposal studies found that a permanent disposal by February 2029 was feasible, with a very low casualty risk, by a major orbit control manoeuvre. Early 2015 was the earliest conceivable time. After review and endorsement by ESA's Independent Safety Office the disposal plan was approved by D/SRE. The project undertook four manoeuvres in January and February 2015 in order change the orbit of INTEGRAL. These manoeuvres used roughly half of the remaining fuel (any later option would be more costly in fuel), still leaving propellant for 6-8 more years of operation after the manoeuvre. Note that this coincides - within the large uncertainties on both - with the time frame when operations are expected to become limited by the power of the solar panels.

A side effect of the orbit change is that INTEGRAL will no longer have revolutions of 3 sidereal days. Instead, now it has a scheme of 3 revolutions in 8 days in order to keep a repeating pattern for operations, i.e., the orbit is now 64 hours compared to the 72 hours before the manoeuvres. The final orbit chosen is the best compromise found between fuel efficiency and operational use, allowing to continue science operations with minimal impact. The loss of science time due to a higher fraction of perigee passages is about 5%, and the seasonal visibilities do not change significantly. See also Section 2.2.3.

1.6 Scientific data rights

Data or science rights to the targets or science in the field of view (FOV) of the instruments proposed by the PIs in response to the current AO of observing time proposals will be allocated to these PIs with the usual 1-year proprietary period, if their proposal is accepted by the TAC.

If the PI is from a country ***other than the Russian Federation,*** the rest of the field will be made public. This way, the astronomical community at large is encouraged to analyse INTEGRAL data. This holds for normal proposals as well as ToO proposals. Since INTEGRAL has on-board coded mask instruments, it means that ***all*** these data are available to the public. ISOC and ISDC will take measures to ensure that the approved 1-year proprietary nature of the data (or science) rights of the accepted observing time proposals are respected. Any non-observance of this rule will be notified by the Project Scientist (PS) to the TAC and to the journal involved.

Accepted proposals where the PI ***is from the Russian Federation*** follow a similar kind of policy ***except*** that the rest of the field will be open ***only*** to all Russian Federation scientists currently working at Russian Federation scientific institutes. Access to these data for such scientists will be provided by the Russian Science Data Centre for INTEGRAL located at the Space Research Institute in Moscow. The data under these proposals from the Russian Federation will only be open to the public at large after the 1-year proprietary period has ended.

1.7 Non-standard observing patterns

The rectangular dithering on a 5x5 grid is the standard observation pattern. In a few, well motivated, cases a hexagonal dither pattern is allowed. Observations with, other, custom patterns such as the GPS and Galactic scans generally reduce scheduling efficiency, and increase workload for both ISOC and MOC. Because of the overall reduced manpower in INTEGRAL operations, the use of non-standard patterns is now strongly discouraged. Hence, starting in AO-13, custom patterns will be considered only for A-grade proposals, and their scheduling will be on a best effort basis (see also Section 4.2).

1.8 Multi-year proposals

1.8.1 Confirmation of on-going multi-year proposals

PIs of ***on-going*** multi-year proposals (i.e., Key Programme[i] proposals with observations spanning two AO cycles) need to re-confirm these observations for the current AO together with an update on the achieved results so far. Only ***TAC accepted observations*** of the original proposal as submitted in the previous AO can be re-confirmed. Details of the previously accepted observations ***cannot*** be changed in the confirmation. The "confirmation proposal" should consist of a brief science justification of no more than two pages in length, in which the timeliness of the science context of the original proposal is to be discussed in the light of the scientific progress made since its first submission. Where possible, the feasibility of the original proposal should be updated based on the data already taken. The "confirmation proposal" will be evaluated by the TAC together with the original proposal as submitted in the previous AO.

1.8.2 Submission of new multi-year proposals

It is possible to submit ***new*** Key Programme[i] proposals with observations spanning two AO cycles. For the first year, the scientific justification shall meet the usual requirements as detailed in Section 6.2. The proposal should describe the science case and the technical feasibility for the total observing time requested. It is the policy for the TAC to always formally approve successful proposals for the current AO only. For the next AO, and if approved in the current AO, a confirmation of the proposal will be required (see previous Section).

1.9 Cosmic Diffuse X-ray background radiation observations via Earth occultation

Following a recommendation by the IUG, a series of public observations of the Cosmic Diffuse X-ray background (CXB) was implemented into previous AO cycles. These observations were performed using the Earth as an occulting disc, and are, from an operational point of view, extremely ***non-standard***, because the Earth has to be inside the field of view (FOV), thus blinding the star trackers. Additional science time is needed prior to and after those dedicated observations for slews and special spacecraft pointings, in order to safely resume the standard observing programme. Typically, to each exposure of 13 hrs, an additional 5 hrs are needed.

The total of all CXB/Earth exposures in 2012–2013 amounts to about 535 ks. Due to the special nature of these observations all scientific data of these observations are publicly available to the scientific community at large.

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[i] *As in previous AOs a "Key Programme" is defined as a non-ToO scientific investigation which requires a significant amount of observing time (> 1 Ms) per year in order to achieve its objectives.*

From AO-12 onwards ***no*** public CXB/Earth observations are foreseen. Following IUG recommendation in November 2013, interested scientists are invited to submit specific proposals in response to this AO call for observing time proposals. Due to the available manpower, only up to two such campaigns may be accommodated during a year. The data rights policy as outlined in Section 1.6 (and Section 5) will apply to any newly accepted proposals for CXB/Earth observations.

1.10 Joint INTEGRAL with Swift or XMM-Newton observations

ESA continues to provide the opportunity to propose for coordinated observations with XMM-Newton and/or NASA's Swift satellite. A total of 300 ks of XMM-Newton observing time and a total of 150 ks of Swift observing time is available for these coordinated observations. All Swift data are public. For more detailed information, see Sections 4.1.7 and 4.1.8.

1.11 Extended INTEGRAL mission phase and future AO calls

The nominal operational mission began on December 16, 2002 and lasted 24 months. Since then, INTEGRAL is being operated in its extended mission phase. This extended phase is at this stage indicatively approved by the Science Programme Committee (SPC) to last until 31 December 2018, subject to a mid-term review in Fall 2016. An extension of INTEGRAL science operations for another 2 years beyond 2018 will be considered during the same review. Future AO cycles are planned to run on an annual basis.

2 The INTEGRAL mission

2.1 Overview of the mission

INTEGRAL was successfully launched with a PROTON rocket from Baikonour in Kazachstan on October 17, 2002 at 04:41 UTC. INTEGRAL (Figure 1 and Figure 2) is a gamma-ray mission sensitive between 3 keV and 10 MeV, whose payload consists of two main gamma-ray instruments, the imager IBIS (15 keV–10 MeV) and the spectrometer SPI (18 keV–8 MeV), and two monitors, JEM-X (2 instruments; 3−35 keV) and OMC (optical V-band, 500−600 nm). The IBIS and SPI instruments both have a very large coded field of view (IBIS: 29°×29° to zero response; SPI: 35° to zero response, corner to corner). The JEM-X instruments are also coded mask imagers, but with a somewhat smaller field of view (13° to zero response). In addition, a particle radiation monitor (IREM) measures charged particle fluxes near the spacecraft.

The scientific goals of INTEGRAL are obtained using relatively high-resolution spectroscopy, combined with fine imaging and accurate positioning of celestial gamma-ray sources allowing the 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. Scientific topics addressed by INTEGRAL include (see also Section 6.1 for proposal categories):

Compact Objects: *white dwarfs, neutron stars, black holes, high-energy transients and GRB*;

Extragalactic Astronomy: *AGN, Seyferts, Blazars, galaxies and clusters, cosmic diffuse background*;

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

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

Galactic Centre: *cloud-complex regions, mapping of continuum and line emission, cosmic-ray distribution*;

Particle Processes and Acceleration: *trans-relativistic pair plasmas, beams, jets*;

Identification of High-Energy Sources: *unidentified gamma-ray objects as a class*;

Unexpected Discoveries.

More details about the INTEGRAL spacecraft, instruments, scientific aims and first results can be found in A&A Vol. 411 (2003), a special Astronomy & Astrophysics issue dedicated to INTEGRAL. An up-to-date list of refereed and non-refereed publications concerning INTEGRAL, complete as far as possible, and including also proceedings of INTEGRAL workshops, can be accessed at the ISOC web site[ii].

[ii] http://www.cosmos.esa.int/web/integral/scientific-publications

2.2 The INTEGRAL spacecraft and its orbit

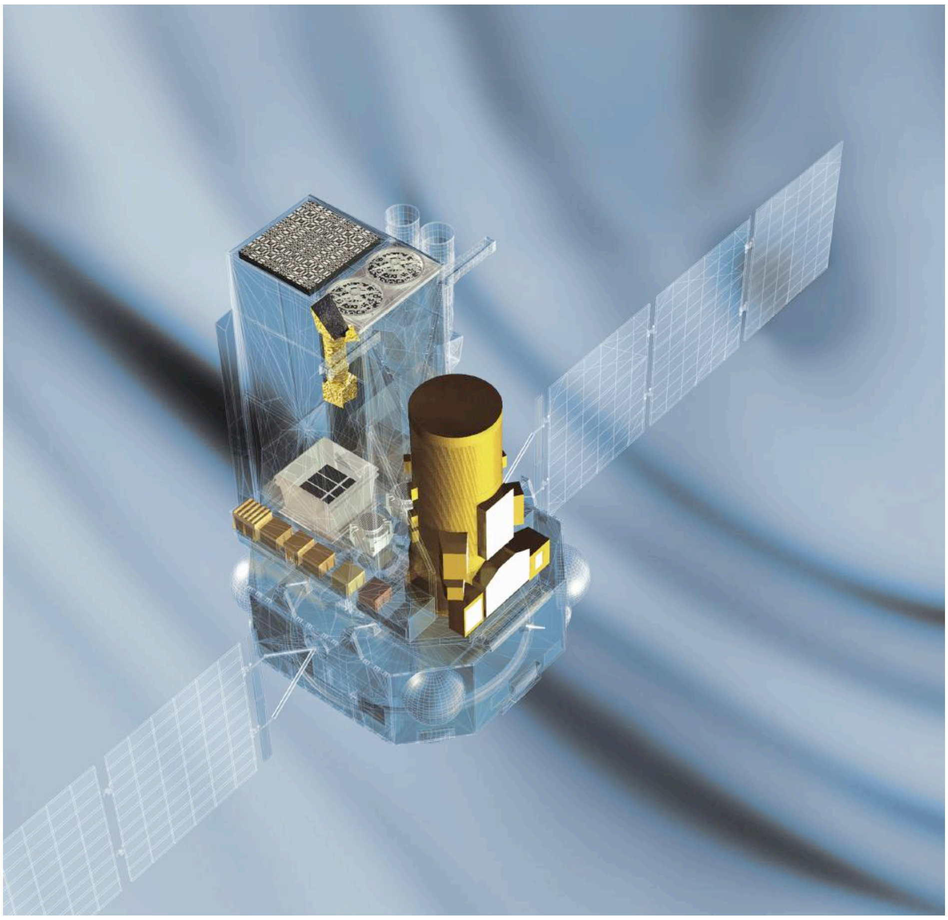

Figure 1: The INTEGRAL spacecraft. © ESA.

The INTEGRAL spacecraft (Figure 1, details in Figure 2) 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 a primary structure (central cone and shear panels) supporting the launch loads, and a secondary carrying the sub-system units and the tanks.

Thermal Control System: Consists of active and passive 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 tele-commands and telemetry using a quasi omni-directional antenna and two redundant S-band transponders.

Data Handling System: Provides the ability to acquire, process and format data for downlink. 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. Once 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%. On 21 May 2003, 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.

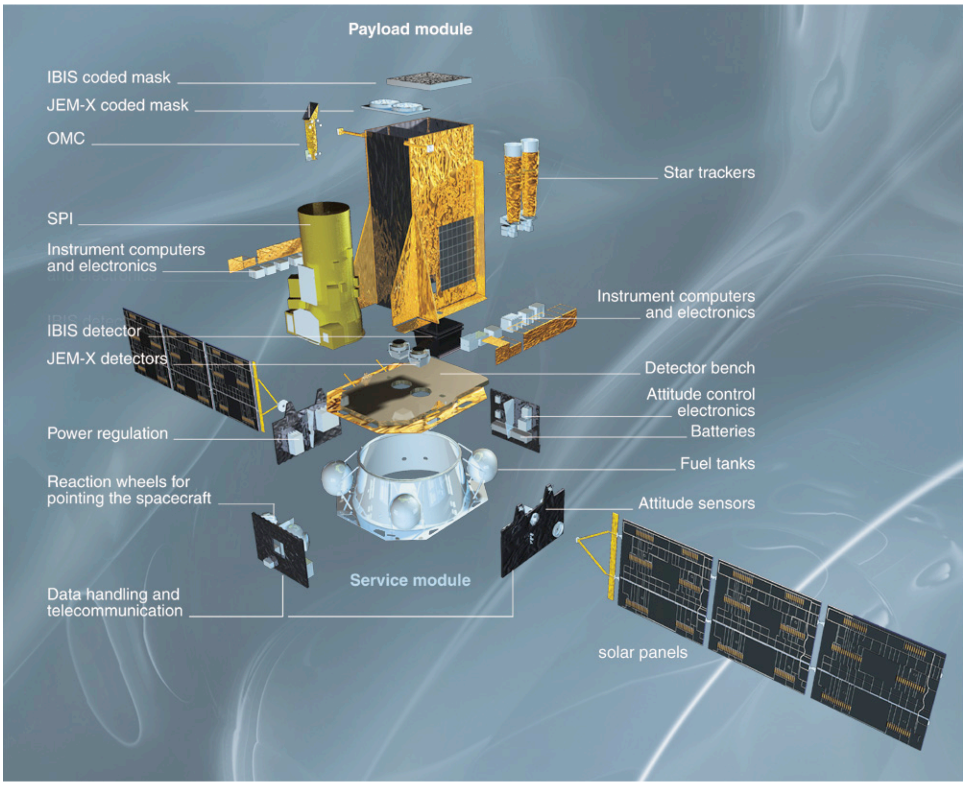

Figure 2: Exploded view of INTEGRAL service and payload modules. © ESA.

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 instruments *"Observer's Manuals"*.

2.2.3 The orbit

INTEGRAL follows a highly elliptical orbit. From launch to early 2015 this was a 72-hour orbit. In January/February 2015 it was significantly modified by a sequence of four orbit adjustment manoeuvres in order to assure a safe disposal of the satellite in early 2029, far beyond any conceivable operational limit. The new orbit has a 64-hour duration or 3 revolutions in 8 days.

The INTEGRAL orbit evolves strongly with time by natural forces. After the launch the perigee height increased for the first few years from ~9000 to ~12500 km with subsequent descent, while the apogee decreased from ~154000 to ~150000 km. In October 2011, INTEGRAL reached a perigee height of only 2756.4 km, the lowest point in its orbit since October 2002. The orbit change manoeuvres have lowered the apogee to roughly 140000 km, but had little effect so far on the perigee altitude (~8700 km at the time). Currently the orbit is circularizing somewhat again and will reach a perigee height of close to 10000 km in late 2015. In future years this will decrease again with another minimum of <2000 km in 2021. The evolution of the INTEGRAL orbit up to mid 2026 is shown in Figure 3.

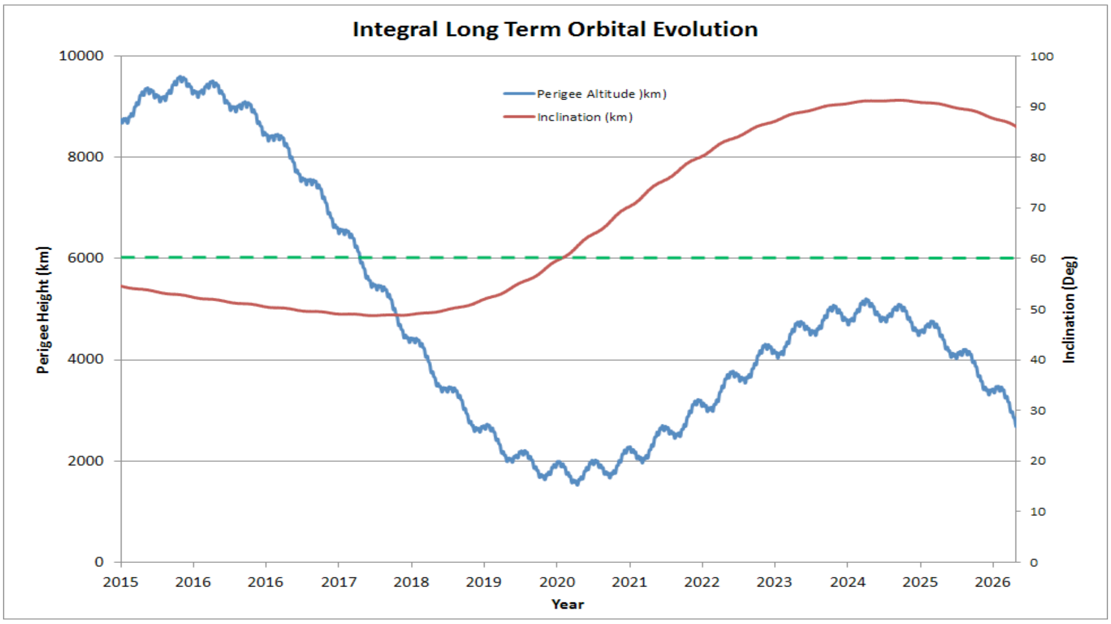

Figure 3: Evolution of perigee height (blue) and orbital inclination (red) from launch until early 2026. The dashed green line indicates the perigee altitude below which INTEGRAL passes through the proton belts during perigee passages.

To allow for undisturbed scientific measurements, and to 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. Generally, scientific observations (lasting up to about 170 ks per revolution) can be carried out if the spacecraft is at an altitude of at least 25000 km (radiation belt entry) or 50000 km (radiation belt exit). These altitude limits are variable and are regularly adjusted throughout the mission. The on-board radiation environment monitor and background data from the payload is being used to dynamically adjust and optimize this limit. Instrument operation is interrupted in case of a higher radiation environment, e.g., during a strong Solar flare.

Ground station coverage of the orbit is achieved by ESA's Kiruna station, and augmented by other stations when necessary. The requirement for maximum visibility from the ground station imposes a high inclination angle and an apogee position in the northern hemisphere.

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 is currently constrained to ± 40°. This implies that the pointing angle of the spacecraft must be greater than 50° 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 2 is a schematic summary of the complementary features of the instruments on INTEGRAL, and Table 3 and Table 4 list the key performance parameters of the payload. For more details on the instruments, please refer to the appropriate instruments *"Observer's Manuals"*.

Table 2: 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° scale
Imager IBIS	15 keV - 10 MeV	Accurate point source imaging
		Broad line spectroscopy and continuum
X-ray Monitor JEM-X	3 - 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 3: Key parameters for SPI & IBIS.

Parameter	SPI	IBIS
Energy range	18 keV - 8 MeV	15 keV – 10 MeV
Detector	19 Ge detectors[iii] (6×6×7 cm^3), @ 85K	16384 CdTe detectors (4×4×2 mm^3), 4096 CsI dets (8.55×8.55×30 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° (corner to corner)	8.3° × 8.0°
Angular resolution (FWHM)	2.5° (point source)	12'
Source location (radius)	< 1.3° (depending on source strength)	30"@100 keV (50σ source) 3' @100 keV (5σ source)
Absolute timing accuracy (3σ)	~130 μs	~90 μs
Mass (kg)	1309	746
Power [max/average] (W)	385/110	240/208

Table 4: Key parameters for JEM-X & OMC.

Parameter	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)	3.6 keV @ 22 keV	--
Field of view (fully coded)	4.8°	5.0° × 5.0°
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

[iii] *SPI had 19 active Ge detectors at launch. Since then, 4 detectors have failed: Ge detector #2 in December 2003, #17 in July 2004, #5 in February 2009, and #1 in May 2010.*

2.4 Overview of INTEGRAL observation modes

Table 5 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 *"Instruments Observer's Manual"*.

Table 5: INTEGRAL observing modes.

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

2.5 Source naming convention

A source naming convention for new sources detected by INTEGRAL has been established in agreement with the IAU. The INTEGRAL source designation is IGR J*HHMMm+DDMM* (equatorial coordinates, epoch J2000.0) 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 (*HH*), minutes (*MM*), and fractions of a minute (*m*, one decimal), and *DDMM* is the declination of the source in degrees and arcminutes. Coordinates must be truncated, not rounded, to comply with this convention. For example, Sirius has the following J2000.0 coordinates: RA = $06^h\ 45^m\ 08.9173^s$, DEC = -16° 42' 58.017". In the present case, the naming convention would give IGR J06451-1642.

2.6 Acknowledgement in publications

Scientific publications making use of INTEGRAL data should acknowledge this[iv] using the following text:

Based on observations with INTEGRAL, an ESA project with instruments and science data centre funded by ESA member states (especially the PI countries: Denmark, France, Germany, Italy, Switzerland, Spain), and with the participation of Russia and the USA.

[iv] *via a footnote, to either the title of the publication on the first page, or within the Section containing acknowledgements.*

3 The INTEGRAL science ground segment

3.1 Introduction

The INTEGRAL science ground segment (SGS) is constituted by the INTEGRAL Science Operations Centre (ISOC) and ISDC Data Centre for Astrophysics (ISDC), shown in the bottom part of Figure 4.

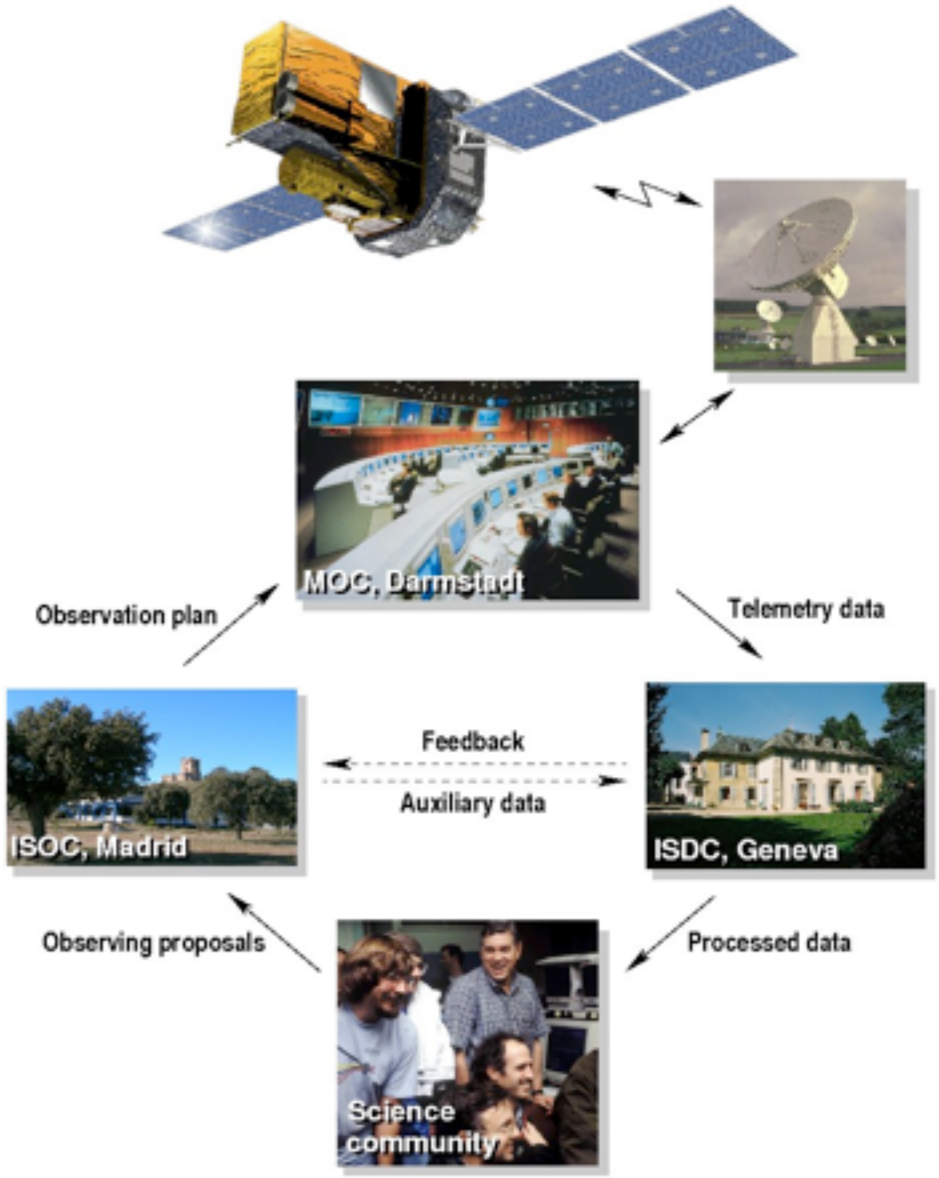

Figure 4: The INTEGRAL flight and ground segments.

ISOC receives observation proposals and optimises the accepted ones into an 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.

3.2 Support for proposers and observers

The ISOC and ISDC websites (Sections 3.3 and 3.4) provide access to important information for proposers and observers. A ***Helpdesk*** handles all questions related to the INTEGRAL mission. These can be addressed via e-mail to inthelp@sciops.esa.int. 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 at ISOC and ISDC.

The INTEGRAL science analysis, OSA (Off-line Scientific Analysis), software is based on a pipeline of high-level software components developed primarily by the instrument teams and integrated by the ISDC. It is available together with documentation and test data for download from the ISDC web page at http://www.isdc.unige.ch/integral/analysis#Documentation. The ISDC software includes scripts to run the standard analysis and applications to visualize the data products and manage the off-line analysis. It is available for Mac OS X and Linux. Observers are also welcome to visit the ISDC for local support and direct access to data analysis tools.

3.3 From proposal to observation: ISOC

3.3.1 ISOC responsibilities

ISOC (http://integral.esac.esa.int/) is located at the European Space Astronomy Centre (ESAC), near Madrid, Spain. It is responsible for the definition of scientific operations including instrument configuration for each observation, mission planning and implementation of the observing programme.

In summary, ISOC is responsible for:

- Preparing AOs, receiving the proposals, assessing their technical feasibility and transmiting the assessments to the Target Allocation Committee (TAC).
- Scheduling and implementing the observing programme. This includes sending planning files to MOC.
- Defining science related operations and instrument configuration for each observation.
- Receiving Target of Opportunity (ToO) alerts, and implementing the Project Scientist's decision in regards to the planning of an accepted ToO.

ISOC provides the following information on their website:

- INTEGRAL Announcement of Opportunity
  - AO announcement key milestones
  - AO documentation

- Proposal support tools: Proposal Generation Tool (PGT), Observing Time Estimator (OTE), Target Visibility Predictor (TVP), Exposure Map Tool (EMT), Source Grouping Tool (SGT), and Proposal Query Tool (PQT)

- INTEGRAL Target and Scheduling Information
  - Scheduling Information
  - Long and short-term scheduling
  - Approved Target List
  - ToO alert
- INTEGRAL Helpdesk.

3.3.2 Scientific mission planning

During routine observations, ISOC generates and maintains detailed observing schedules based on the approved observations, 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 (grade/rank), and any other special requirements such as fixed-time observations. Some observations are too long to be scheduled as a single time block of about 170 ks per revolution; ISOC must therefore schedule such observations as more than one separate exposure. Long-term and short-term schedules are published on the ISOC website.

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:

- ToO observation;
- Instrument or spacecraft anomaly;
- 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 from the receipt of the ISOC re-planning request at MOC to the re-orientation of the satellite can be, at times, as short as about 8 hours or even below that. Any other re-planning, related to the 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 automatically regarded as a justification for re-scheduling. If the prime instrument (IBIS or SPI) is switched off, however, the observation will generally be re-scheduled if the off time amounts to more than 15% of the TAC approved exposure time. This does not apply for ToO obervations.

ISOC aims to schedule and execute 100% of an observation’s approved time. However, ESA endorsed the TAC recommendation that any observation should be considered as “complete” if at least 85% of its approved time has been executed.

3.4 From observation to data products: ISDC

3.4.1 Introduction

The ISDC Data Centre for Astrophysics[v] 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, and started its activities as the INTEGRAL Science Data Centre. The staff is made up of several scientists and engineers funded by an international consortium with support from 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. The website http://isdc.unige.ch/ is used to share information and to provide access to the data and software.

3.4.2 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 (QLA) of the data, and alerts the astronomical community when unexpected features and serendipitous events such as gamma-ray bursts (GRBs) or transient sources are detected.

The data flows in real-time from MOC to ISDC at a rate of ~113 kbits/s. 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, in the form of consolidated data, where all recoverable telemetry losses (e.g., at station handover) have been corrected. This includes auxiliary files and the current observing plan, and are distributed in the archive to be used in the standard scientific analysis package OSA.

The ISDC performs the QLA in real-time. The purpose of the QLA is to rapidly detect bright (new or known) transient sources, (large) flux changes in known sources and instrument anomalies. The QLA results are communicated to the PI(s) of the observation and ISOC is contacted if the event could potentially trigger a ToO or follow-up observation. As good practice, sufficiently bright sources with no assigned data rights ('serendipitous' sources) detected by the QLA will also be notified to the PI(s) of the observation, as soon as possible. Data on serendipitous sources detected in non-Russian Federation proposals are, by the nature of the data rights (see Section 5), publicly available.

One 2.7-day revolution yields a telemetry volume of about 3 GBytes. Processing of this telemetry stream yields about 15 Gbytes of uncompressed data products. These data are stored in FITS files and consist of:

- **raw data** (~5 GBytes): reformatted data of the telemetry,
- **prepared data** (~7 GBytes): includes additional timing information.

They are made available to the observer in compressed format (about 9 Gbytes per revolution). Raw and prepared data are stored by ScW. The FITS standards are used throughout and for all data products. All data delivered by the ISDC are calibrated relying on the instrument teams'

[v] *http://isdc.unige.ch/*

expertise. For archive consistency, some calibrated quantities, such as the event energy, are not optimal in the archive and the user is required to run OSA as suggested in the handbooks to obtain state-of-the-art scientific products.

3.4.3 INTEGRAL archive at ISDC

The main archive, located at the ISDC, contains all INTEGRAL data, as well as calibration and response files, auxiliary data and source catalogues. Further INTEGRAL (public) archives (and mirrors) are maintained at HEASARC/NASA-GSFC and IKI Moscow (RSDC).

The ISDC provides access to the Near-Real Time (NRT) and consolidated (CONS) data.

The NRT data are typically availability about 3.5 hours after data have been taken on board. The ISDC routinely provides NRT data to the observer(s) and/or the community:

- PIs for accepted observing proposals receive e-mails before the first observation is performed, which will describe in detail how to get access to the NRT data.
- In the case the data are from a proposal where the PI(s) come(s) from a country ***other than the Russian Federation***, the ISDC maintains a publicly available list with links to the NRT data, together with the appropriate information on accepted data rights to targets (or science).

The archiving of the data takes place after ISDC has received the consolidated data from ESA, and has processed them. The whole process takes about one month from the end of the observation. Note that NRT data will be deleted when consolidated data are available. The ISDC, in consultation with ISOC, will take measures to ensure that the TAC-approved one-year proprietary nature of the data (or science) rights of the data are respected

All archived public data can be downloaded from the ISDC via rsync or through a web archive browser. Download via rsync 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 data selected through the web interface can be transferred using a script generated by the web interface. The typical data download rate from ISDC is 1 Gbyte/hour via rsync. Note that ISDC does not assume any responsibility for the public and Geneva University network capacity in regards to the transfer of large data volumes.

4 Observing with INTEGRAL

4.1 Overview and observation types

The four instruments on-board INTEGRAL are co-aligned and being operated simultaneously. Therefore, observers generally receive the data for all instruments together with auxiliary data from ISDC (Section 3.4). Typical observations can last from a few hours to a few weeks, and a single proposal may contain several observations of the same type.

There are four classes of observations that can formally be applied for: Normal, Fixed Time, Target of Opportunity (ToO), and Key Programme observations. Calibration observations constitute another class of observations, but it is not possible to apply for these. Each class has implications for science operations and are described in detail below.

4.1.1 Normal observations

Normal observations do not have special scheduling requirements, allowing for the most efficient scheduling, if performed in the standard observing modes. In practice, they do not differ from Key Programme observations (Section 4.1.2) except that their exposure time is < 1 Ms.

4.1.2 Key Programme observations

Introduced for the first time in AO-4, a Key Programme (KP) is intended as a means to carry out scientific investigations requiring a significant fraction of the total non-ToO observing time of an AO cycle (> 1 Ms) but also accommodating various scientific aims. A KP can be presented as a "multi-year" proposal and extend over two AO cycles, but it will be subject to a yearly re-evaluation by the TAC (Section 1.8). The KP cannot be of type ToO (Section 4.1.4).

4.1.3 Fixed Time observations

Fixed Time observations have special scheduling requirements: phase-dependent observations of a binary system, or coordinated multi-wavelength observations, a sequence of observations separated by a time interval, such as three observations with each one separated by two weeks, are examples. Such observations reduce scheduling efficiency, because 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 the Proposal Generation Tool (PGT; Section 6.5). Once the proposal is approved, ISOC will communicate with the observer to determine the best scheduling strategy. Visibility constraints other than the bi-annual visibility windows for most celestial sources should be described in the scientific justification.

The reader should note that a *Fixed Time* Key Programme (Section 4.1.2) observation is, in principle, possible. However, due to the combination of both, fixed time requirement and long exposure requirement, its realisation during the ISOC scheduling process might prove very difficult, if not impossible.

4.1.4 Target of opportunity (ToO) observations

Routine INTEGRAL science operations are being implemented using a pre-planned sequence of observations as a baseline. The gamma-ray sky is highly variable and many of the mostly unpredictable Target of Opportunity events are scientifically important and often warrant to modify the pre-planned observing schedule.

Target of Opportunity observations (ToOs) have critical scheduling requirements, and are meant as a fast response to "new" phenomena, like outbursts of X-ray novae, AGN flares, supernovae (SNe), and high states of galactic micro-quasars. ToOs can be for known (e.g., 3C 273, GRS 1915+105, GRO J0422+32) or unknown sources identified by their class (see Section 6.3.3).

ToOs can have either internal or external triggers. Internal triggers are based on INTEGRAL data, that is screened in real-time at the ISDC. External triggers are based on observations with other observatories. All triggers are to be addressed to ISOC via the *"INTEGRAL ToO Notification"* web page at http://www.cosmos.esa.int/web/integral/too-alert.

Once the Project Scientist (PS) has decided on declaring a ToO, ISOC changes the planning accordingly. This updated command schedule is subsequently sent to the Mission Operations Centre (MOC) at ESOC, who further process and upload the schedule.

ToO observations require re-scheduling, interruption of the pre-planned schedule, and re-pointing of the spacecraft. They are, therefore, a very heavy load on the scheduling system and, like Fixed Time observations, significantly reduce the mission's overall observing efficiency. The typical response time from detection of a ToO to the re-pointing of the spacecraft is about one revolution. Although neither the ISDC nor the ISOC have staff on duty at 24 hrs/day, 7 days per week, the ISDC has an automatic ToO detection system and an on-call scientist outside working hours. MOC also provides an on-call service on weekends (daytime) and non-working days. ISOC is currently on-call only during working hours on weekdays.

In general, the following ***rules and guidelines*** are applicable to ToO proposals[vi]:

- The TAC is advised to accept no more than a few ToO proposals per year, all ranked according to their scientific merit as any other proposal.
- 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 observation cycle. KP observations are more difficult to displace given their importance and inherent difficulty in rescheduling.
- The proposer is responsible for ***requesting***[vii] the ToO when the trigger event occurs.
- The request is made by submitting a ToO notification using the ISOC ToO Alert web page (see above). If the request concerns a ToO which is not covered by an existing accepted ToO proposals, then this request will – if accepted for scheduling – be included in the ISOC

[vi] *A **proposal** for a ToO observation can be submitted during the normal AO process, in anticipation of the event. If accepted, its execution can be requested if its trigger criteria have been met.*

[vii] *A **request** for a ToO observation is understood to be made after a scientific event occurred which may justify such an observation. The occurrence of this event may or may not match an existing proposal, i.e., requests for ToO not covered by the database of accepted ToO proposals are possible.*

proposal database, allowing the tracking, documenting and time-line inclusion of ToO requests, in the same manner as for the proposals accepted by the TAC during the AO cycle.

- The PS or an appointed deputy must decide to declare, or to decline, 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 (earlier, pending) ToO or other high-priority observations. The PS will define the priorities and inform the proposer of his decision about the implementation of the ToO request. ToO requests accepted for scheduling will be communicated by ISOC to the scientific community.

The submission of a ToO proposal requesting a large amount of observing time, exceeding 1 Ms, e.g., for supernovae (see, however, Section 4.1.5) or Novae, is valid and technically possible. Indeed, similar proposals have been approved in the past, but note that they can significantly impact the AO programme. Due to the exposure time exceeding 1 Ms, these could be considered as a "Key Programme" (see Section 4.1.2). However, the INTEGRAL notion of Key Programmes does ***not*** include ToO observations. Gamma-ray bursts (GRBs) can be considered as a subset of ToO events (see Sections 4.1.6 and 5.3).

4.1.5 Observation of a nearby supernova as a Target of Opportunity

4.1.5.1 Introduction

The possibility of a nearby SN presents an exciting prospect for INTEGRAL. There is a significant chance of such an event during the current operations phase (the Type Ia SN2014J observed in 2014 occurred in M82, at ~3.5 Mpc). We might well learn more about that type of SN from this one object than all previous objects combined and INTEGRAL will be a key contributor. In this Section we are using the following ***definition***:

*The term "**nearby**" is understood to describe the distance to a supernova (SN) event that occurs in the Local Group up to a distance of:*

a) 60 kpc (including LMC and SMC) for core-collapse supernovae (SNII, Ib, Ic)
b) 1 Mpc (including M31) for thermonuclear supernovae (SNIa)

The modeling of typical SN explosions suggests that fluxes of brightest lines (e.g., 847 keV and 1238 keV lines of the ^{56}Co decay) are of the order of 10^{-3} photons s^{-1} cm^{-2} at the distances of 60 kpc and 1 Mpc for SNII and SNIa, respectively. At such high fluxes INTEGRAL is expected to deliver extremely valuable science. For SNII this means that a supernova in LMC and SMC would be an excellent target for INTEGRAL. For a type SNIa, an explosion in Andromeda is expected to be an equally bright event for INTEGRAL.

Following a recommendation from the IUG it has been decided that the unique and highly important event of a ***nearby*** SN should be treated as a ToO with all its INTEGRAL data to be made ***immediately public***[viii] to the scientific community at large.

This decision implies that individual open time ToO proposals for such *nearby* SNe cannot be submitted in response to this AO.

[viii] *The term "immediately public" means that general on-line access by the science community to the so-called NRT data at the ISDC will be provided by ISDC. The consolidated data, usually available few weeks after the observations, will be accessible via the public archives.*

The ***observing strategy*** for a nearby SN, defined by the IUG, using substantial input from Mark Leising (Clemson University/USA), is described below.

4.1.5.2 Discovery

The method of discovery will depend on the SN type: *core-collapse* or *thermonuclear* explosion.

1. *Core-collapse SN*: Core collapse SNe (SN type II, Ib, Ic) will most probably release neutrinos escaping the collapsing system hours before the escape of photons. The supernova Early Warning System (SNEWS, cf., P. Antonioli 2004, New J. Phys. 6, 114, see http://xxx.lanl.gov/abs/astro-ph/0406214, utilising a network of neutrino and gravitational wave detectors, notifies interested subscribers. ISOC has subscribed to the SN alert system at http://snews.bnl.gov/alert.html.
2. *Thermonuclear SN*: The discovery of Galactic SN of type Ia will probably be made in the visible regime if the event occurs at sufficiently high Galactic latitudes. These announcements are available, e.g., via the IAU Circulars or The Astronomer's Telegrams (ATels). At lower latitudes, first detection could be via X-ray or gamma-ray observations or via radio emission. Again, results would be communicated to ISOC via IAU Circular, ATel, GCN or similar channels.

4.1.5.3 Follow-up observation strategy

The science objectives can be achieved through the observation of the time evolution of fluxes (light curves) and line spectroscopy. ***It is important to observe the SN as soon as possible***.

The strategy for the first year after the event includes:

i) Observe the SN immediately and continuously for 40 days.

ii) If SN type Ia (thermonuclear): continue to observe for intervals of <TBD> Ms duration at 50% duty cycle thereafter.

iii) If SN type II, Ib, Ic (core-collapse): continue to observe for 2 Ms at 33% duty cycle thereafter.

iv) Then, possibly, observe again based on changes at other wavelengths (e.g., the onset of circumstellar interactions seen in X-rays, radio, Hα) or based on results from INTEGRAL data themselves and as decided by the Project Scientist.

Note that item i) will be implemented regardless of the SN type.

During the first 40 days of observations (i), the PS will reconvene with the IUG, and additional experts if required, to optimize and fine tune the strategy as laid out in items ii) to iv) as well as to devise a strategy for the long term (beyond the first year). One also has to bear in mind the substantial diversity of supernova properties. The observing strategy will always be optimized as to maximize the scientific return from INTEGRAL.

4.1.5.4 Data rights

All data associated with these observations are made public immediately to the community at large. This implies that the ISDC is requested to make these data publicly available with minimum delay. The Near-Real Time (NRT) data format is suited for this (Section 3.4.3).

4.1.6 Gamma-ray bursts (GRBs)

4.1.6.1 Introduction

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. A real-time detection of GRBs with a rapid distribution of their coordinates, is performed at the ISDC Data Centre for Astrophysics (Section 3.4). This system is called the INTEGRAL Burst Alert System (IBAS)[ix]. Alerts with the coordinates of the GRBs detected in the field of view (FOV) of the main instruments are distributed by IBAS via internet and can be received by any interested user. Typically, one GRB per month is detected within the FOV. In addition, IBAS provides the light curves for GRBs detected with the anticoincidence shield of the SPI instrument, outside the FOV (no position is derived).

Concerning GRB ***follow-up*** observations initiated from GRB events detected by INTEGRAL or suggested from the outside, it has to be kept in mind, that these events are of rather short duration, covering a typical range of $\sim 10^{-2}$ s to $\sim 10^{+2}$ s, compared to other ToOs. Afterglow or counterpart observations with INTEGRAL following immediately a GRB detection, are possible only if (i) the GRB event occurs inside the FOV of the on-going observation and it will be covered during the on-going nominal dithering manoeuvres, or (ii) if the event occurs outside the FOV but the spacecraft will dither onto that position during the nominal dithering manoeuvre of the on-going observation during which the event occurred. A near real-time interruption of the on-going dither pattern in order to prevent the GRB location from moving out of the FOV, or an extra near real-time slew manoeuvre onto the GRB position within a short time scale (of typically one hour or less) is ***not*** possible.

Data from GRBs in the FOV are generally treated as data from a ToO (Sections 4.1.4 and 5.3). 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 (ACS) subsystem.
- Fast uplink of special OMC sub-window.

These are described in greater detail below.

4.1.6.2 GRB position and trigger time

As soon as a GRB candidate event is detected, the GRB position, trigger time, flux and duration are submitted to the alert generation process and broadcasted, a few tens of seconds after the GRB start. The 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. These localizations have a typical uncertainty radius of 3 arcmin (90% c.l.). The first alert broadcast message has rather crude information. 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). 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, data describing the GRB peak

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[ix] See http://ibas.iasf-milano.inaf.it

(2–200 keV, 1 s), fluence (20–200 keV), lightcurve (20–200 keV, plot only), and duration are made available shortly after at http://ibas.iasf-milano.inaf.it.

The alerts with the coordinates of GRBs are distributed through internet sockets for robotic telescopes. The required software can be requested from the ISDC. E-mail alerts are distributed via GCN Circulars.

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. A new kind of IBAS Alert Packet has been implemented in 2011 (see GCN Circular #11766); this will be automatically sent for possible GRBs of significance ***below*** the standard threshold currently used. IBAS users can decide to subscribe or not to this new type of alert packet which is meant mainly for ***robotic*** telescopes – knowing that in most cases these triggers will be just statistical fluctuations. Facilities, which 'automatically' create a request for extra observing time, hence impacting the existing observing schedules of these facilities should not subscribe to this new service. On the other hand, some good GRBs are expected among these low significance triggers, but in most cases there is no way to select them based only on the INTEGRAL data. Only event times and coordinates of the triggers will be distributed. In case it can be confirmed that such a trigger is indeed a GRB (e.g., through the detection of an afterglow), the relevant INTEGRAL data could then be assigned (a posteriori) with the usual notification rules (Section 5.3).

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

The prime scientific need in the SPI/ACS time history data from GRB lies in the correlation of the photon arrival timing with time histories obtained by other spacecraft constituting the Inter-Planetary Network (IPN). GRB locations obtained by the IPN often produce small GRB error boxes crucial for follow-up observations at other wavelengths. Therefore, GRB time histories as obtained from the SPI/ACS will be provided in near real-time via the IBAS system to the scientific community. The ACS collects GRB data in time bins of 50 ms, time-tagged to an accuracy of 1 ms at energies above 75 keV. Data of about 300 (5σ) bursts per year, located mainly perpendicular to the instruments' FOV, are used by the IPN. SPI/ACS triggers are publicly available at http://www.isdc.unige.ch/integral/science/grb#ACS.

Note that intense and hard GRB events which occur at large off-axis angles may also produce detectable effects on the photon detection planes of the high energy instruments, and these events are not considered in this Section any further. However, applying Compton imaging techniques, it is possible to analyse those data from the IBIS telescope (see, e.g., R. Marcinkowski *et al.* 2006, A&A 452, 113).

4.1.6.4 OMC window handling in case of a GBR 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 (see *"OMC Observer's Manual"*). 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, or 26.6′x26.6′. 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). 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 the AOCS) are sent in response to a GRB.

4.1.7 Joint INTEGRAL and XMM-Newton observations

With the aim of taking full advantage of the complementarity of ESA's high-energy observing facilities, both project teams have agreed to establish an environment for those scientific programmes that require observations with both the XMM-Newton and the INTEGRAL observatory to achieve outstanding and competitive results.

By agreement with the INTEGRAL Project, the XMM-Newton Project may award up to 300 ks of INTEGRAL observing time. Similarly, the INTEGRAL Project may award up to 300 ks of XMM-Newton time. The time will be awarded only for highly ranked proposals. The only criterion above and beyond the usual review criteria is that both sets of data are required to meet the scientific objectives of the proposal.

The allocated XMM-Newton time should not exceed the allocated INTEGRAL time. The minimum time per XMM-Newton pointing is 10 ks. No observations with a reaction time of less than 5 working days from an unknown triggering date will be considered for this cooperative programme. It is the responsibility of the PI to inform both observatories immediately if the trigger criterion is fulfilled.

It is the proposers' responsibility to provide a full and comprehensive scientific and technical justification for the requested observing time on both facilities. The ESA science operations teams for XMM-Newton and INTEGRAL will perform feasibility checks of the proposals. They each reserve the right to reject any observation determined to be unfeasible for any reason.

Proposers wishing to make use of this opportunity will have to submit a single proposal in response to either the INTEGRAL AO or the XMM-Newton AO. Although time is requested on both observatories, it will be not be necessary to submit proposals to two separate review boards. A proposal submitted in response to this INTEGRAL AO will be reviewed exclusively by the INTEGRAL TAC. *In this case proposers must flag the observations as "request XMM-Newton" in PGT.* See also Section 6.6.

Apart from the above, both missions' general policies and procedures currently in force for the final selection of the proposals, the allocation of observing time, the execution of the observations and the data rights remain unchanged.

4.1.8 Joint INTEGRAL and Swift observations

Proposers have the opportunity to propose for coordinated observations of INTEGRAL with NASA's Swift satellite. The INTEGRAL TAC may award up to 150 ks of Swift observing time for observations. INTEGRAL proposers should follow the same rules as Swift Guest Investigator proposers, as described in http://swift.gsfc.nasa.gov/proposals/swiftgi.html. For example, time-constrained observations can be requested as long as the observing window exceeds ~3 hrs. The proposed Swift time may be time-constrained, including coordinated and monitoring observations, and Targets of Opportunity (ToO; with no limit on the high and highest-urgency requests.). This Swift observing time can also include monitoring that precedes, follows and/or (in the case of ToOs) triggers INTEGRAL observing time.

Proposers wishing to make use of this opportunity will have to submit a single proposal in response to the INTEGRAL AO. Although time is requested on both observatories, it will be not be necessary to submit proposals to two separate review boards. A proposal submitted in response to the INTEGRAL AO will be reviewed exclusively by the INTEGRAL TAC. *Proposers must flag the observations as "request Swift" in PGT, when asking for Swift time.* See also Section 6.6

The primary criterion for the award of observing time is that both INTEGRAL and Swift data are required to meet the scientific objectives of the proposal. The allocated Swift time should not exceed the allocated INTEGRAL time. It is the proposers' responsibility to provide a full and comprehensive scientific and technical justification for the requested observing time on both facilities. The PIs should clearly justify why Swift and INTEGRAL are both needed to achieve their goals. They also need to provide a strong justification for the choice of the filters if UVOT filters other than "filter of the day" are requested; if no strong justification is provided, observations will be performed in "filter of the day" mode. In the case of a coordinated ToO, it is the responsibility of the PI to inform both observatories if the trigger criterion is fulfilled.

Detailed technical information concerning Swift may be found at http://swift.gsfc.nasa.gov/proposals. PIs are expected to determine if a target can be viewed by Swift (http://heasarc.gsfc.nasa.gov/Tools/Viewing.html) and whether bright stars prohibit the use of the Swift UVOT (http://swift.gsfc.nasa.gov/proposals/bright_stars/bright_star_checker.html).

Both ISOC and the Swift team will perform feasibility checks of the proposals. They each reserve the right to reject any observation determined to be unfeasible or potentially damaging for any reason, independently of the INTEGRAL TAC evaluation.

The awarded Swift time will expire at the end of the INTEGRAL AO-13 observing period, and will ***not*** be carried over to the next INTEGRAL AO cycle, unless the observation was already activated during the AO-13 observing period.

Swift data will be immediately released publicly via the HEASARC data archive. There are no proprietary rights. No funds will be provided from the Swift Project for such joint INTEGRAL/Swift investigations. However, successful INTEGRAL proposers can request funding support by applying to the Swift Guest Investigator program, provided they are eligible for funding (i.e., based at a US institution).

Apart from the above, both missions' general policies and procedures currently in force for the final selection of the proposals, the allocation of observing time, the execution of the observations, and the data rights remain unchanged.

4.1.9 Calibration observations

Dedicated payload calibration observations are occasionally executed during the normal operations phase. Observations of the Crab pulsar/nebula 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. However, we note the recent findings on the short- and long-term variations observed in the high-energy emission of the Crab nebula (C. Wilson-Hodge, *et al.* 2011, "When a Standard Candle Flickers", Astrophysical Journal Letters, 727, L40).

An initial long Crab calibration observation took place in February 2003. Currently, typically one or two revolutions per viewing period are devoted to Crab calibration observations. OMC flat field and dark current calibrations to characterise the instrument's response are performed about each month with a duration of about 3.5 hours. Performance verifications of the spacecraft (such as an AOCS calibration), are also performed. Proposers should not duplicate calibration observations in preparing open time proposals.

Public observations of the Earth were performed in previous AOs. These allow an accurate estimate of the Cosmic Diffuse X-ray Background (CXB) - an important and long-standing problem in high-energy astronomy - while providing a better estimate of the instrumental background, leading to improved background modelling. As noted in Section 1.9, proposers are eligible to submit proposals to perform further Earth/CXB observations.

Annealing of the SPI detectors is not a calibration per se, but is intended to partially recover the time-dependent degradation of the energy resolution. Annealing procedures are performed approximately every 6 months and last 6 revolutions (equivalent to about 1 Ms of science time).

The targets and frequency of dedicated in-flight calibration observations will be recommended by the PI instrument teams, which also may use special instrument settings in order to achieve the objectives. Because of the nature of the large FOV of the instruments, it is realistic to expect that, also depending on specific instrument parameters used for those dedicated calibration observations, useful scientific data can be obtained from the calibration source itself or from any other source within the same FOV. Calibration observations should, therefore, not duplicate TAC accepted observing proposals.

4.2 Observation modes

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 from the target in 2.17° steps. The integration time for each pointing on the raster is between 30 and 60 minutes, adjusted so that an integer number of complete dither patterns is executed.

There are basically three distinct observation modes: *rectangular dither (standard)*, *hexagonal dither* and *staring*. Over the years various user-customized patterns have also been used. Note, that the rectangular dither (or the so-called 5×5 dither) is the standard observing mode (Section 4.2.1). During all observations, the spacecraft provides stable pointings within 7.5″ of the pointing direction.

The only mode suitable for deep exposures is the standard, rectangular mode (see also Section 4.2.1). ***Any observation to be performed in a non-standard observing mode has to be justified explicitly by the proposer (via an entry in PGT).*** Non-standard mode observations are those, which intend to use the hexagonal dither, or staring, or any customized patterns including scans.

Observations with custom patterns, such as the GPS and Galactic scans, generally reduce scheduling efficiency, and increase workload for both ISOC and MOC. Because of the overall reduced manpower in INTEGRAL operations, the use of non-standard patterns is now strongly discouraged. Hence, starting in AO-13, custom patterns will be considered only for A-grade proposals, and their scheduling will be on a best effort basis.

4.2.1 Rectangular dithering

Rectangular dithering on a 5×5 grid is the standard observation mode. It is well suited for observations characterised by a field of view (FOV) containing multiple point sources. It is also well suited for observations of extended or weak sources that can be best studied by accumulating exposure time through a sum of individual pointings ("mosaic"). This observation mode should always 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 5. In this implementation, one pointing was with the source on-axis, and 24 other pointings with the source off-axis, each separated by 2.17^o arranged on a rectangular grid. The roll angle between pointings was always 0^o.

In AO-3, the pattern was optimised to reduce systematic effects in the IBIS images. This implies that for observations requiring several dither cycles, an offset between the centre of each dither cycle was introduced. This ensures that no pointing attitude is repeated over the course of the observation. Hence, the Centre Of dither Pattern (COP) moves around in a pre-defined manner during the course of an observation. The COP pattern is parallel to the original 5×5 dither and consists of 7×7 points centred on the target, with a step size of 0.3^o (see Figure 5). Thus, the whole COP pattern fits within the inner 3×3 points of the original dither. The 49 points in the COP pattern allow for an observation time of 2.2 Ms without repetition of a given pointing.

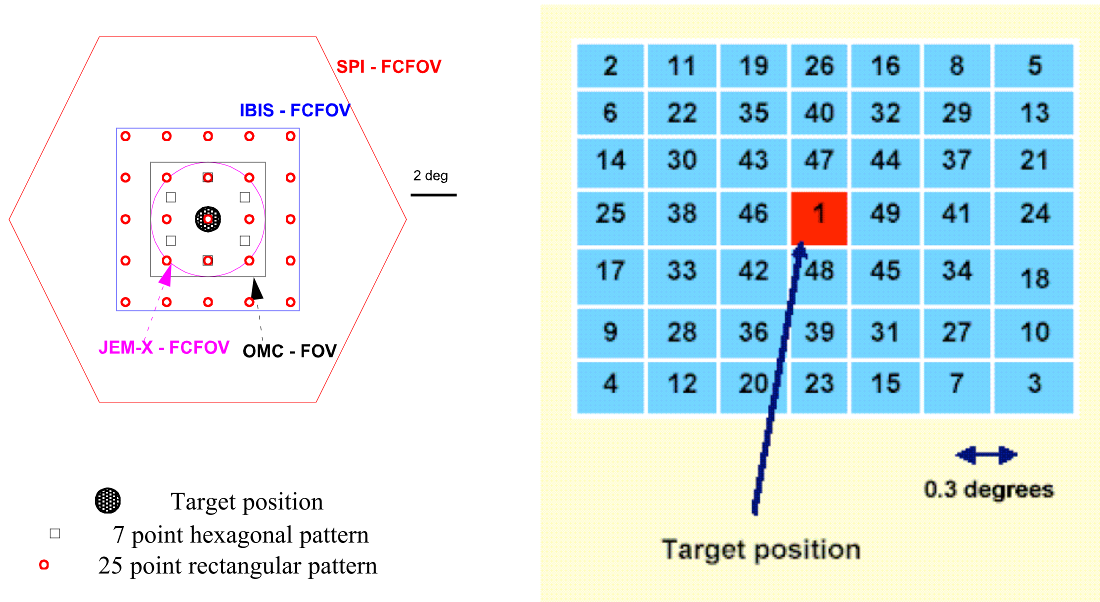

Figure 5: Schematic view of dithering patterns (left) and COP offset pattern for a 5x5 dither.

In addition to the moving COP, to further reduce systematic effects in deep mosaics, since June 2005 the orientation of the 5×5 pattern is set such that the axis of the dither pattern is rotated by 11.3° = arctan(1/5) with respect to the instrument axes. As the instrument axes depend on the relative position of the Sun, the exact dither pattern pointing directions depend on the time of execution of the observation.

The most recent optimization to reduce systematic noise in mosaics involves a stepping in roll angle, and was implemented at the end of November 2007. With this strategy, the roll angle for an observation with N repetitions of the 5×5 pattern spans the range from +3° to -3°, in steps of $d\theta = 6/(N-1)$.

4.2.2 Hexagonal dithering

The use of the hexagonal dithering mode is discouraged, because:

- it seriously compromises the imaging capabilities of IBIS and SPI, rendering the data useless for use in large mosaics with or without using archival data, and,
- as such it renders the data useless for any investigation of high-energy emission from celestial sources using SPI.

Therefore, the use of the *hexagonal dithering* mode ***must be very well motivated***.

Hexagonal dithering consists of a hexagonal pattern centred on the nominal target position: one source-on-axis pointing, six source-off-axis pointings 2° 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 PIs 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 are even a few sources in the FOV (see the "*SPI Observer's Manual*").

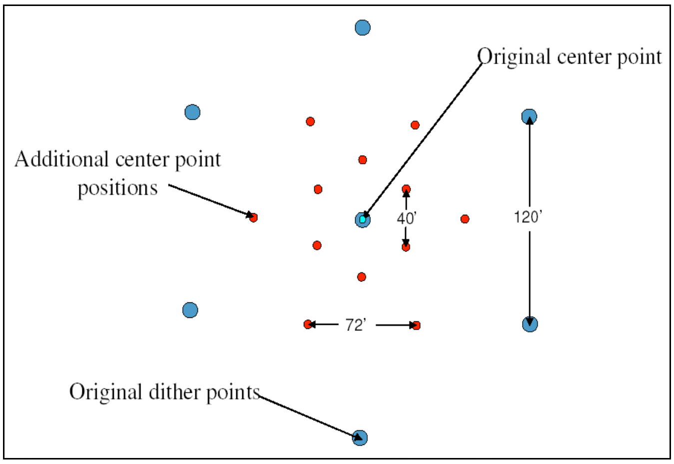

Figure 6: COP offset pattern for hexagonal dither pattern.

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

4.2.3 Staring observations

The use of the staring mode is strongly discouraged, since it very seriously compromises the imaging capabilities of IBIS, SPI and JEM-X, rendering the data useless for use in large mosaics, and in particular for the study of high-energy emission from celestial sources using SPI. Therefore, staring observations ***must be extremely well motivated***.

4.3 Multiple targets within the large instrument FOV: amalgamation

The two main gamma-ray instruments (IBIS and SPI) incorporate a very large fully-coded field of view (FCFOV) of 8.3°×8° [IBIS] and 16° (corner to corner) [SPI], respectively. In addition, the main instruments and the two monitors are co-aligned with overlapping fields of view (see Figure 7). The "dithering" around the nominal target position (Section 4.2), results in an even larger sky coverage around the target position. Since the occurrence of multiple sources in the FOV highly probable, the ISOC can combine ("*amalgamate*") close-by targets in one dithering pattern with optimized exposure time in order to save slewing time and to maximize the observation efficiency. Consequently, there will be a number of PIs having their "own" sources in the same field of view during an observation.

An example (see Figure 7) for this procedure would be the *amalgamation* of two accepted observations on SNR Cas A, and on SNR Tycho, respectively, which will be executed as one observation but with the payload line-of-sight pointing midway at about (l, b) = (116°, 0°) allowing to cover both sources in the same FOV. The *amalgamation* of these targets leads to a simultaneous exposure in a joint, *amalgamated*, observation.

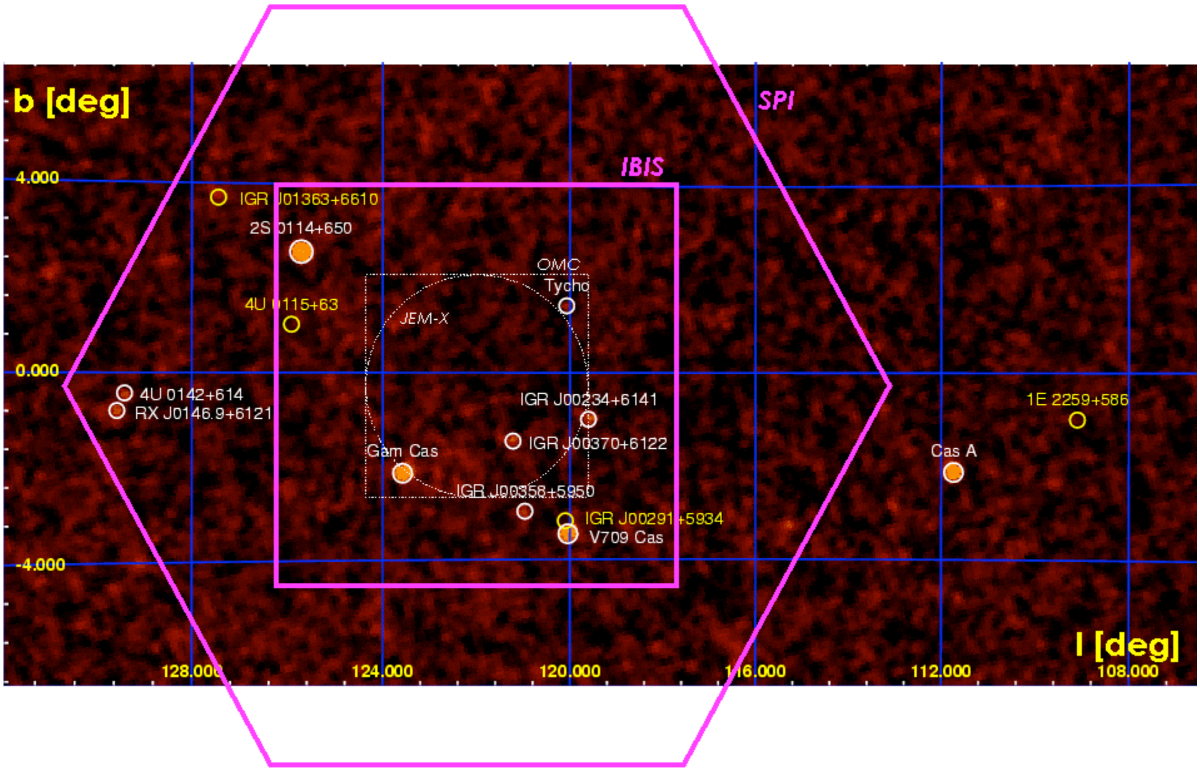

Figure 7: INTEGRAL view of the Cas A region (12-60 keV, P. den Hartog et al. 2006, A&A 451, 587) overlaid with the large (fully-coded) FOV of the INTEGRAL instruments, to illustrate the unique target multiplicity feature of the INTEGRAL mission.

4.4 Modifications to an accepted 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, hence leading to an increase of the cosmic-ray induced instrumental background, while at Solar maximum a lower instrumental background is generally expected. 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. Moreover, the TAC can also re-classify the type of an observation, but the following changes 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.

5 Data rights

The INTEGRAL Science Management Plan (SMP)[x] defines the policy on data rights on all scientific data obtained from the INTEGRAL scientific instruments. Some aspects of the INTEGRAL mission, however, require specific data rights policies beyond the SMP; these are laid out in this document.[xi]

5.1 Proprietary data rights

A proposer can never ask for "data rights for the ***entire*** FOV", or, "data rights for ***all sources*** (known/unknown) to be found in the FOV".

Each Principal Investigator (or PI) will receive the data relevant to his/her observation from all instruments. He/she will retain exclusive data rights (or science rights) to the source(s) (or science) proposed in response to the current AO of observing time proposals. The granted data rights are based on the scientific justification and as accepted (in some cases also modified) by the INTEGRAL Target Allocation Committee (TAC), for 1 year from the time the consolidated data have been dispatched by the ISDC. For a specific source, this includes the source and the surrounding background field.

If the PI is from a country ***other than the Russian Federation,*** the rest of the field will be made publicly available. This holds for normal proposals as well as ToO proposals (see also Section 5.2). Since INTEGRAL has on-board coded mask instruments, it means that **all** these data are available to the public. ISOC and ISDC will take measures to ensure that the TAC-approved one-year proprietary nature of the data (or science) rights of the accepted observing time proposals are respected, i.e., scientists (who will have gained knowledge on the other sources in the course of their analysis) will not attempt to publish data pertaining to other proprietary sources (or science) during the proprietary period. Any non-observance of this rule will be notified by the Project Scientist (PS) to the journal involved, and to the TAC, who is asked to take this into account for subsequent rounds of AO. Following the one-year data rights proprietary period, all data will be made normally publicly available through the archives, i.e., the data are freed from any data rights.

If the PI ***is from the Russian Federation***, the rest of the field will be made available ***only*** to Russian Federation scientists currently working at Russian Federation scientific institutes. This holds for normal as well as ToO proposals. Access to these data for such scientists will be provided by the Russian Science Data Centre for INTEGRAL located at the Space Research Institute, Moscow. The proposals from the Russian Federation fall under the one-year proprietary policy, i.e., for one year these data will only be accessible by scientists from the Russian Federation working at Russian Federation scientific institutes. Following this one-year proprietary period, these data will be made publicly available through the archives.

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[x] *INTEGRAL Science Management Plan, ESA/SPC(94)1, rev.4 (November 2007)* http://integral.esac.esa.int/docs/Science_Management_Plan_ESA_SPC_94_1.pdf

[xi] *The data rights policy was endorsed by the INTEGRAL Science Working Team prior to launch based on the INTEGRAL Technical Note INT-TN-1457; the amendment from AO-12 onwards was endorsed by the INTEGRAL Users Group (IUG) during and following IUG Meeting #15 in 26/27 November 2013.*

Two (or more) individual (non-ToO) observations, each individually approved and using observatory time, can be '*amalgamated'* by the ISOC, after the peer review process, into one observation using an optimised pointing pattern and exposure (see Section 4.3). The outcome being the execution of ***one*** observation containing several sources belonging to ***several PIs*** is, concerning the data rights ***identical*** to what is stated above. Note that amalgamation of a Russian Federation proposal with a non-Russian Federation proposal is ***not*** possible.

All PIs participating in the observations and having data rights for their sources (or science) will receive the entire FOV data for processing and analysis as this is required by the coded aperture characteristic of the instrumentation.

After completion of the peer review (TAC) process, and after approval by the Director of Science (D/SRE), ISOC will inform all PIs participating in an observation about all sources/extended areas, which have been allocated by the TAC to all individual proposals/PIs. A list of all approved proposals and allocated source (or science) data rights will be maintained on the ISOC website[xii].

The following special cases require further discussion that are described in the next subsctions:

- Targets of Opportunity (ToO)
- Gamma-ray bursts (GRBs)
- Split observations
- Slews
- Calibration data
- Re-processed data
- Instrument housekeeping data
- Data for public relation purposes

5.2 Targets of Opportunity (ToO) observations data rights

The main criteria determining ToO data rights are:

1. There does exist a ToO proposal accepted by the TAC.
2. There does not exist a ToO proposal accepted by the TAC.

(1) *The ToO event is covered by a TAC accepted observing proposal.* The successful proposer(s) also obtain the data rights for the ToO event for the on-going observation in which the event was detected. Note, however, that Section 4.3 on multiple sources in the field of view (FOV) may also apply for the on-going observation during which the ToO was discovered. Once the ToO event satisfies the ToO criteria as specified by the proposer (and approved by TAC), and the observation has been executed, the usual data right policy is applicable for these data as it is for any other source (see Section 5.1).

(2) *The ToO is not covered by an accepted observing proposal,* and

i. the ToO is an obvious event in the judgement of the PS (e.g., a nearby supernova, see Section 4.1.5), or the ToO observation is requested by numerous scientists: the data from a dedicated ToO follow-up observation will immediately be placed in the publicly

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[xii] *http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Target_Lists*

available archive at the ISDC. The PS (via ISOC) will announce this widely to the general community. If the ToO detection was located in the FOV of an ongoing observation and the ToO target is an approved target for the on-going observation, the data rights for that target from that ongoing observation will remain the property of those scientists having the approved target data rights of that observation.

or

ii. the ToO is requested by a particular person, and that person is an isolated voice: the PS can award the data rights of the ToO target to that person for the ongoing observation (unless the ToO event is an approved target in the FOV during the on-going observation) as well as for possible follow-up ToO observations. Once the ToO event satisfies the ToO criteria as specified by the proposer (and approved by TAC), and the observation has been executed, the usual data right policy is applicable for these data as it is for any other source (see Section 5.1).

5.3 Gamma-ray bursts data rights

5.3.1 Introduction

In principle, gamma-ray bursts (GRBs) are considered as a subset of ToO events and general rules/guidelines do apply as described in the previous sections. Further specific details on data rights are described below. GRBs do occur randomly in time and space, thereby naturally both inside and outside the FOVs of the INTEGRAL payload.

5.3.2 GRB inside the FOV of instruments

Data from these events will be contained in the science data of INTEGRAL instruments operating in the modes selected for the on-going observation. Data on the GRB event itself (e.g., spectral data, event light- curve data, etc.) are treated, in principle, as a ToO event: if TAC accepted proposals for GRB events in the FOV exist and a GRB is detected during an INTEGRAL observation, then the successful PI will be granted the data rights on the GRB event and receive the GRB event data, obtained during this on-going observation, extracted within a well-specified time window (for instance the TAC recommended "duration" of GRB observation), usually much less than the duration of the observation and typically a few hours covering a number of contiguous science windows including the outburst for these events. While assigning "a posteriori" data rights to a GRB PI (usually from within a group of approved PIs, depending on various selection criteria), all participants in that observation obtaining data rights will be informed by ISOC about the time interval concerned.

GRB locations and errors, and trigger times are, due to the nature of the rapid alert system, publicly available. To facilitate rapid follow-up observations with other observatories, data describing the GRB peak flux (20 - 200 keV, 1 s), fluence (20 - 200 keV), light-curve (20 - 200 keV, plot only) and GRB duration (s) are also made publicly available (Section 4.1.6.2).

5.3.3 GRB outside the FOV of instruments

The GRB light-curve data from the SPI/ACS are part of the instrument housekeeping/engineering data (Section 5.8 below) and are publicly available via the archive.

5.4 Data rights for 'split' observations

If there is ever a gap between observations of the same target from the same proposal of about 6 weeks or longer, then ISDC will process the data before and after the gap separately, at the earliest possible time. This results in more than one data set. In other words the gap in the schedule does not cause a hold-up in the processing of the earlier data. Such a case is called a "split observation", and the data rights for each data set will be as described in Section 5.1, with each data set having its own public release date. Note that the data processing of parts of observations will be cumulative, i.e. when part N is processed, all previous (N-1) part(s) should, in general, be included (reprocessed) too.

If there is no gap longer than about 6 weeks between consecutive exposures, the entire observation will be processed together by ISDC, resulting in one data set; the data rights will be for the usual proprietary period as described in Section 5.1 of this document.

5.5 Data obtained during slews

Data obtained during long slews in between different observations will be made publicly available immediately, as they are not related to the previous or subsequent observation.

Dithering slew data are subject – for the usual proprietary period – to the same data right policies as described in Section 5.1, for the observation of the target on which the dithering manoeuvre is being performed.

5.6 Calibration data

All data obtained during dedicated in-flight calibration observations[xiii] are treated as public data.

Data from ***any*** scientific observation obtained during the observing programme may be used within the proprietary period by the instrument teams and/or by the ISDC team (through the PIs), and, if needed, supported by the ISOC/ESA team (through the ESA Project Scientist) for instrument health and performance control, engineering trend analysis and instrument (re-) calibration.

5.7 Re-processing of scientific data and additional data releases

5.7.1 Introduction

Routinely, data from any observations are processed and subsequently released by the ISDC after the data have successfully passed a number of quality checks performed at the ISDC. After release, these data will become data-rights free (and thus entirely available to the public) at the end of the proprietary period, as described in Section 5.1.

It is possible, however, that at a given point in time after the original data have been released, the ISDC may take the decision to re-process these original data and subsequently release those re-processed data.

[xiii] *Occasionally, spacecraft operations require re-calibrations of spacecraft subsystems such as the AOCS (attitude and orbit control system). In such case scientific data are being collected during these spacecraft subsystem calibrations, and the data are also publicly available.*

This Section describes the policy for additional releases (so-called Δ-releases) of re-processed data. In what follows we discriminate between "soft" and "hard" releases. Note that re-processed public data will always result in public data.

5.7.2 Soft releases of re-processed data

A number of soft Δ-releases can occur: these could include, e.g., data produced using updated/improved instrument responses and/or calibration information, improved software tools, etc. Soft Δ-releases always improve the quality of the scientific data products but still include flight data of good quality.

Soft Δ-release(s) resulting from (several) re-processing(s) of the same original data set containing one observation ***do not lead to an update of the time stamp associated with the data*** released originally, that is, the proprietary period of all further soft Δ-releases of the same original data will always be shorter than one year, and the proprietary period of all soft Δ-releases resulting from the re-processing of the same original data will therefore terminate at that point in time which is valid for the original data, that is "the clock keeps ticking".

5.7.3 Hard releases of re-processed data

Significant problems may be discovered in data which have already been released to the observer, or to the public. These major anomalies could, for example, be instrument specific, system wide (e.g., problems with on-board event timing) or severe software problems rendering wrong or corrupted data on ground. The PI has to provide strong evidence that the data are affected by these anomalies in a sense that ***the scientific objectives of the observation cannot be achieved with the existing data***. Only the re-processed data will improve the quality significantly such that these original goals can be achieved.

In consultation between the observer(s), the ISDC and the Project Scientist, ***the proprietary period of the original corrupted data can be extended for the re-processed data*** (hard Δ-release during the proprietary period, i.e., within one year) in order to guarantee the proper proprietary period ("reset of clock"). Clearly these are individual decisions made on a case – by – case basis. It is noted that a "clock reset" may be applicable only for data from individual instrument(s) manifesting significant problems.

5.8 Instrument housekeeping data

All instrument housekeeping and other engineering data obtained during an observation, will be made available, together with the scientific data. Because of the need for instrument and spacecraft experts to routinely monitor and verify the state of health and technical performance of the instruments including long-term trends, all instrument housekeeping and engineering data will be made publicly available, once these data have been archived by the ISDC. This is typically 4 weeks after receipt of the near real-time telemetry from MOC.

5.9 Data for public relation purposes

As outlined in the SMP, and in the agreement between the participating agencies (ESA, NASA, RKA), the agencies and the Russian Academy of Sciences shall have the right to use any INTEGRAL scientific data in support of their respective responsibilities or for the sole purpose of public relations. In this context, they undertake not to violate the observer's data rights.

5.10 Public data

Table 6 presents a summary of data types and conditions that lead to the release of public data, and provides the relevant section number in this document for each particular case.

Table 6: Public data from INTEGRAL.

Data type or condition	Section
Serendipitous sources in data from a non-Russian Federation PI.	**3.4.2**
Data from ToO observations of a nearby SNe.	**4.1.5**
Data where PI is from a country ***other than Russian Federation***: 1) All data *within* one year after they have been processed and dispatched by the ISDC, ***except*** that no one else other than the PI(s) can publish on the targets (or science) awarded by the INTEGRAL TAC to the PI(s). 2) All data one year *after* they have been processed and dispatched by the ISDC.	**5.1**
Data where PI is ***from the Russian Federation***: One year after they have been processed and dispatched by the ISDC.	**5.1**
Data from a dedicated ToO follow-up observation are publicly available, if there is no proposal accepted by the TAC for the event, and the ToO is an important event in the judgment of the PS or is requested by numerous scientists.	**5.2**
For GRB inside the FOV: location (and errors), trigger time, peak flux, fluence, light-curve (plot only), duration.	**5.3.2**
For GRB outside the FOV: light-curves from SPI/ACS.	**5.3.3**
All data obtained during long slews.	**5.5**
All data obtained during dedicated in-flight calibrations.	**5.6**
All instrument housekeeping and engineering data.	**5.8**
Data required in support of the activities of ESA and participating agencies.	**5.9**
Data from observations which are “public” following a specific PI request in the proposal.	**6.7**

6 Proposal submission procedure, tools, format and checklists

6.1 Proposal submission

Scientists submit proposals in response to an AO, issued by ISOC at regular intervals. Proposals must reach ISOC before the AO deadline. Requests to observe newly identified "Targets of Opportunity", however, can be submitted to ISOC at any time (see Section 4.1.4). All proposals must clearly contain one or several well-defined targets entered into the Proposal Generation Tool (PGT, Section 6.3), and the scientific justification (Sections 6.2).

Each observing proposal has to be submitted by indicating one of the three scientific categories:

1. **Galactic astronomy** (point sources only, including stellar-mass collapsed objects, both binaries and isolated systems)
2. **Extragalactic astronomy** (point sources [AGN, Blazars, Seyferts], clusters of galaxies, cosmic diffuse background and GRB)
3. **Nucleosynthesis** (including diffuse continuum and line emissions).

6.2 Scientific justification

The scientific justification shall demonstrate convincingly the case for the proposed investigation. The TAC will review proposals primarily on their scientific merit, taking into account the overall science return of the proposal to the entire mission. This implies that the scientific case has to focus on the main instruments of the mission, providing its unique hard X-ray and soft gamma-ray capabilities: IBIS and/or SPI. Besides the science case, the justification must address the observing strategy and include a description of its technical feasibility.

The guidelines given to the TAC for the proposal evaluation include:

a) Effective use of the INTEGRAL observatory (this means: is INTEGRAL the right facility to carry out this project? Can the observation(s) only be done with INTEGRAL?)
b) Scientific importance of the proposal (including: originality, clarity of thoughts/writing, soundness of proposed science, grasp of the scientific problem)
c) Technical feasibility (including: correct calculation of the predicted source intensities, likelihood of scientific success (high/low risk), is the adopted observing strategy for this project suitable for the proposed science? Choice of appropriate dither pattern.)

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 must be in PDF format. The justification should use A4 paper size, and a maximum of five pages, including figures and tables. Font size must not be smaller than 10-point. Multi-year proposals applying for their second year by submitting a "confirmation proposal" should limit the science justification to two pages (see Section 1.8).

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 checks.

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

6.3 Proposal Generation Tool (PGT)

6.3.1 Introduction

Proposals must be prepared and submitted electronically using the Proposal Generation Tool (PGT) software. ***Other formats will NOT be accepted***. PGT versions for previous AOs cannot be used, as PGT is not backwards compatible. PGT for this AO must be downloaded from the ISOC web page 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. Proposers may wish to "re-use" their proposals from earlier AOs, updating them as necessary. Requests should be addressed to the INTEGRAL helpdesk, quoting the ID of the relevant proposal. ***ISOC will send a proposal back to the original PI only.*** Below, the proposer will find some general information and rules for the inputs to PGT. Further details are provided in the "*INTEGRAL AO Tools Software User Manual*".

6.3.2 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. Coordinated observations with XMM-Newton and Swift (see Section 6.6) can be indicated here.
- The Observation Details screen, where information for each observation is given and where data rights for sources in the FOV must be claimed or can be renounced (see Section 6.7).

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. Note that there are no limits to the number of updated versions.

6.3.3 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 (J2000.0) entered into PGT for the target are correct. PGT allows the user to import a list of targets. The tool performs a validation of the coordinates using SIMBAD given the source name entered in the proposal; and 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 FOV can use coordinates (0,0) in PGT***.

6.3.4 Choice of dither pattern

The only mode suitable for deep exposures is the standard, rectangular mode, the so-called 5×5 dither (see Section 4.2.1). Any observation to be performed in a non-standard observing mode has to be justified explicitly by the proposer (via an entry in PGT). Non-standard mode observations are those, which intend to use the hexagonal dither, or staring, or any customized dither patterns including scans. Starting in AO-13, custom patterns will be considered for proposals only for A-grade proposals, and their scheduling will be on a best effort basis (see also Section 4.2).

6.4 Integration times and GRB observations

For all observations of an observing time proposal, an integration time must be specified in PGT (mandatory field). In general this integration time should be calculated using the Observation Time Estimator (OTE), which will calculate the time required to achieve a given significance for a given flux. ISOC uses OTE to perform the technical feasibility checks on the proposals (Section 6.9).

This calculation is not useful for GRBs, the maximum duration of which is of the order of 100 s, with a possible afterglow of a few hours, and thus very short compared to the typical duration of an INTEGRAL observation. Furthermore, GRBs 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 from GRBs that occurred in the FOV cannot estimate their integration times using the OTE. However, OTE can still be used to estimate the minimum detectable flux in a given energy band with the SPI and IBIS instruments, allowing to estimate the detection sensitivity for a GRB. Proposers should specify in PGT the period of time for which they want to receive the data of a 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).

6.5 ToO and Fixed Time observations

For 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 the observation should be regarded as a ToO, and what are the trigger criteria (flux levels, energy range, instrument, etc.). It is always the proposer's responsibility to inform the Project Scientist (PS) that a trigger has been met. For ToOs 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 website can be used to either request that a TAC-accepted ToO be scheduled, or to request a new ToO for which there is no accepted proposal (see Section 4.1.4).

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 (TVP; Section 6.11) for the dates and times they want their observation to be performed.

6.6 Coordinated observations with other facilities

ISOC provides support for coordinated observations with other facilities. Proposers are particularly encouraged to apply for coordinated observations with XMM-Newton and/or Swift (see Sections 4.1.7 and 4.1.8).

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, and specify its name. If the proposers want to apply for coordinated observation time with XMM-Newton and/or Swift, the proposers should add these missions from the drop-down list in the Proposal Details panel and add the requested exposure time for these missions. 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 high-energy missions such as Chandra, NuSTAR, Suzaku, Swift, and XMM-Newton. Note that since INTEGRAL observations are generally long, it may be easier for other observatories to follow the INTEGRAL scheduling.

6.7 Claiming (and renouncing) data rights

With a proposal being accepted, the proposer obtains data rights on the source/target, which are subject of his/her proposal. Detailed information concerning the source/target has to be provided by the proposer in the Observation Details panel in PGT. In addition, the proposer can claim additional data rights for other point-like sources, or for extended areas which are located within the FOV of his/her accepted observation, or for given energy intervals including gamma-ray lines. These claims shall be provided via a separate input panel within PGT.

The TAC will review the proposed claimed data rights, which can only be made for sources which are compatible and consistent with the scientific objectives of the proposal itself.

It is also possible for a proposer to renounce any data rights associated with the proposed observations, which would make the data obtained publicly available. For this, the proposer deletes all targets in the data rights panel, including those which have been automatically included from the Observations Details panel.

6.8 Exposure Map Tool (EMT)

The Exposure Map Tool (EMT) is available via the ISOC web page. EMT is used to calculate the exposure time at a given point in the sky. The result is the accumulated time that INTEGRAL has observed at this point according to the exposure maps from IBIS or SPI.

6.9 Observing Time Estimator (OTE)

The Observation Time Estimator (OTE) is available via the ISOC web page. 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 evaluating the technical feasibility of observations. Observers should use OTE to calculate requested observing times: it is imperative that sufficient information is provided in the proposals to allow for feasibility checks by ISOC.

6.10 Source Grouping Tool (SGT)

The Source Grouping Tool (SGT) is available via the ISOC web page. This tool serves to determine an efficient grouping for a set of coordinates, given a maximum angular separation from a source to the corresponding group's centroid. It has been developed to provide the means of going from a list of individual sources to a list of observations giving optimal coverage.

6.11 Target Visibility Predictor (TVP)

The Target Visibility Predictor (TVP) 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. 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 Section 6.11.2), which is only considered at the scheduling level.

6.11.1 Sun, anti-Sun, Earth and Moon viewing constraints

TVP respects the constraints on the Solar aspect angle of the spacecraft, described in Section 2.2.3. As a consequence of this constraint, the sun cannot be observed within the FOV at any time. It can, however, be observed indirectly through the SPI/ACS.

In order to ensure correct functioning of the spacecraft's star trackers (see Figure 2), co-aligned with the instruments' pointing axis, the spacecraft has to point at least 15° away from the Earth and 10° away from the Moon limb during standard observations. TVP uses these constraints.

Note that observations of the Earth have been performed in AO-3, and AO-9 till AO-11 (see Section 1.9 for details). Such observations require elaborate non-standard mission planning and execution, involving both ISOC and MOC, and hence are ***not routine***. Proposers who are interested in continuing these Earth occultation observations, should submit normal observing time proposals in response to the current AO. Although past experience has demonstrated the technical feasibility of such observations, due to the work involved and the available manpower, only up to two such observation campaigns may be implemented during a year (i.e., one AO).

6.11.2 Other constraints

Eclipses:
Observations are usually carried out while the spacecraft is outside the Earth's radiation belts at an altitude of ~50000 km or more. The exact limits are occasionally adapted, as required by changes in the extent of the belts. 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 bright source casts a shadow of the SPI mask 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 current AO's "*IBIS Observer's Manual*".

6.12 Software updates

It is compulsary to use the latest version of the software and AO documentation, as they are not backwards compatible. ISOC normally avoids 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 to re-apply. Questions concerning the instruments, the AO and anything related to the mission, should be directed to the Helpdesk (Section 3.2).

6.13 Checklist for the proposal

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

1. **the scientific case;**
2. **the observation strategy;**
3. **a demonstration of the feasibility of the observations.**

The proposal ***must*** be checked against the following questions:

- Is your science justification complete? Does it contain the mandatory three sections mentioned above? Do you have a special justification if requesting more than 1 Ms?
- Can your programme only be done with (new) INTEGRAL observations? Can't it be done using archival data?
- Have you filled in the Observations Details Panel for ***all*** observations for ***every*** source?
- If your observation has any scheduling constraints, have you marked it as Fixed Time, and have you provided the details in the PGT form also?
- If you propose for a ToO, have you provided the trigger criteria (flux levels, energy range, instrument) and a strategy how to observe it (e.g., one observation using the total time, or several observations distributed over a period of specified time)?
- If your proposal is for GRB data, have you supplied the trigger criteria and the time interval of the data you request?
- If you are ***not*** using the standard rectangular (5×5) dither, have you justified the use of any other pattern?
- Could your programme benefit from joint INTEGRAL/XMM-Newton and/or INTEGRAL/Swift observations (Sections 4.1.7 and 4.1.8)? If so, have you selected one of them from the drop down list in the Proposal Details panel in PGT?
- In case you want to submit a multi-year proposal (Section 1.8), have you checked the appropriate box in PGT? Did you fill in the observation times for this AO and the next AO?
- Submit a re-confirmation proposal if you want to seek TAC approval of your multi-year observation for the ***second*** year.
- If you want to obtain data rights on certain sources in the FOV, did you list the sources in the PGT form?
- If you want your data to become public immediately, did you renounce the data rights in PGT?
- Remember that proposals for observing ***nearby*** SNe (see Section 4.1.5 for a definition of "nearby") are ***not*** accepted.

- Have you checked the latest news on the ISOC web page (http://integral.esac.esa.int/)?
- Have you read the entire AO documentation package (see Section 1.3) and are you aware of the most recent updates to it?

6.14 Time Allocation Committee

The Target Allocation Committee (TAC) evaluates each proposal on the basis of its scientific merit, but considers also its feasibility and related technical issues. Each accepted proposal will receive a grade (A, B, C) and a mark. The grades define the scientific scheduling priority for ISOC (A = highest, C = lowest). Marks indicate the quality of its contents. 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 "*we request the data of all observations with sources from the supplied list/or from all observations with sources of type 'x' in the field of view (FOV), but do not request any extra time*".

***Each requested observation of a proposal must be entered into the proposal using PGT, otherwise it is not considered by the TAC for evaluation. Targets which are listed in the scientific justification only, but not entered in PGT, are not considered by the TAC for evaluation of the proposal*.**

The Principle Investigator (PI) can request a PGT-compatible version of their proposal submitted in response to an earlier AO via the Helpdesk. Instructions on downloading and using PGT and other supporting observation tools are given in the next subsections.

After the deadline for an AO, ISOC will perform a technical feasibility of the submitted proposals using the TVP and the OTE, and forward the proposals to the TAC for scientific assessment. Proposals asking for coordinated exposure time with either XMM-Newton and/or Swift will also undergo a technical feasibility study by a team from the respective observatories.

A single, international TAC will review all proposals on their scientific merit. The TAC will be guided by a list of evaluation criteria. The TAC consists of three panels covering the range of scientific topics relevant to INTEGRAL.

The TAC is advised to reject proposals for observations whose aims have been addressed or attained within past AOs. Proposers should therefore carefully check any possible duplication of their observations by consulting the INTEGRAL target lists available via the ISOC web page.

The TAC is advised to only accept proposals asking for non-standard patterns (such as GPS or scans) if the proposal receives an A-grade. This does not apply to proposals asking for observations using the Hex pattern.

The TAC is advised to allocate time for an oversubscription factor of up to about 1.5 to increase scheduling efficiency. This means, that not all accepted proposals can be scheduled within the AO. Preference will always be given to the highest graded proposals.

The TAC is advised to accept only a limited number of ToO proposals. Scheduling of ToO observations reduces the overall efficiency of the mission.

The TAC will evaluate GRB proposals following the same procedure as for all other proposals. However, they only receive a final mark, not a grade, as they have no scheduling priority.

Based on the results of the assessments, the TAC will recommend for each proposal its approval (i.e., all requested observations), partial approval (some of the requested observations, possibly with reduced observation time), or rejection. It will also review and update observing strategies and trigger criteria, if necessary. The recommended programme will be submitted to ESA's Director of Science (D/SRE) for approval. ***The decision of accepting or rejecting a proposal is final and non-negotiable***. The TAC must provide comments for each proposal, including the reasons for rejection, and these are subsequently communicated to each proposer by ISOC.

Following the TAC assessment and the endorsement by the D/SRE of the recommended observing programme, the PIs will be informed, and a database of approved observations is created and maintained by ISOC[xiv]. A subset of these data is made available to the ISDC. Both the accepted proposals and the list of data rights to approved targets (or science) will be published on the ISOC website.

[xiv] http://www.sciops.esa.int/index.php?project=INTEGRAL&page=Target_Lists

7 List of acronyms and abbreviations

ACS	Anti-Coincidence Subsystem
AGB	Asymptotic Giant Branch
AGN	Active Galactic Nucleus
AO	Announcement of Opportunity
AOCS	Attitude and Orbit Control System
ATel	The Astronomer's Telegram
CCD	Charge Coupled Device
CDMU	Command and Data Management Unit
CdTe	Cadmium Telluride
CH_4	Methane
^{56}Co	Cobalt 56-isotope
Co-I	Co-Investigator
COP	Centre Of dither Pattern
CsI	Caesium Iodide
DEC	Declination
D/SRE	Director of Science and Robotic Exploration
EMT	Exposure Map Tool
ESA	European Space Agency
ESAC	European Space Astronomy Centre
FAQ	Frequently Asked Question
FCFOV	Fully Coded Field Of View
FITS	Flexible Image Transport System
FOV	Field Of View
FWHM	Full Width at Half Maximum
Gbyte	Giga bytes
GCN	Gamma-ray burst Coordination Network
Ge	Germanium
GRB	Gamma-Ray Burst
GRO	Gamma-Ray Observatory
GRS	GRanat Source
IAU	International Astronomical Union

IBAS	Integral Burst Alert System
IBIS	Imager on-Board the INTEGRAL Satellite
IDA	ISOC Data Archive
INTEGRAL	International Gamma-Ray Astrophysics Laboratory
IPN	Inter-Planetary Network
ISDC	INTEGRAL Science Data Centre
ISM	Inter-Stellar Medium
ISOC	INTEGRAL Science Operations Centre
IUG	INTEGRAL Users Group
JEM-X	Joint European X-ray Monitor
K	Kelvin
kbps	10^3 bits/s
keV	10^3 electron Volts
KP	Key Programme
kpc	10^3 parsec
LMC	Large Magellanic Cloud
MeV	10^3 keV
MOC	Mission Operations Centre
Mpc	10^3 kpc
NASA	National Aeronautics and Space Administration
NRT	Near Real Time
OMC	Optical Monitoring Camera
OS	Operating System
OSA	Off-line Science Analysis
OTE	Observing Time Estimator
PDF	Portable Document Format
PGT	Proposal Generation Tool
PI	Principal Investigator
PQT	Proposal Query Tool
PROTON	Russian launch vehicle
PS	Project Scientist
QLA	Quick-Look Analysis

RA	Right Ascension
RKA	Russian Space Agency
ScW	Science Window
SGR	Soft Gamma-ray Repeater
SGT	Source Grouping Tool
SMC	Small Magellanic Cloud
SMP	Science Management Plan
SN	Supernova
SNe	Supernovae
SNEWS	Supernova Early Warning System
SNR	Supernova Remnant
SPC	Science Programme Committee
SPI	SPectrometer on INTEGRAL
TAC	Time Allocation Committee
TBD	To Be Defined
ToO	Target of Opportunity
TVP	Target Visibility Predictor
V-band	Johnson V-band
WR	Wolf-Rayet
Xe	Xenon
XMM-Newton	X-ray Multi Mirror observatory