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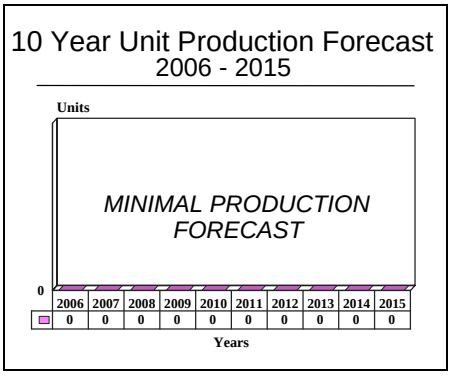
Integral/Spectrum-UV - Archived 10/07

Outlook

- Integral is successfully measuring spectral gamma sources and gamma bursts, as well as mapping the galactic plane
- Integral's nominal observation period ended in 2004 but the mission has been extended to December 2010
- Spectrum-UV mission planned for launch in 2009



Orientation

Description. Integral (International Gamma Ray Astrophysics Laboratory) is a gamma-ray-detecting satellite. Spectrum-UV is an ultra-violet-ray detecting satellite.

Sponsor. The European Space Agency (ESA) had the overall responsibility for Integral spacecraft and mission design, instrument integration and testing, spacecraft operations, and acquisition of data. NASA supplied ground stations and contributed a pulse shape discriminator to Integral. Spectrum-UV is supported by the space agencies of Russia, Ukraine, Italy and Germany.

Status. Integral was launched in 2002 on a Proton launch vehicle from the Baikonur Cosmodrome in Kazakhstan. Spectrum-UV is planned for launch in 2009.

Total Produced. One

Application. Integral provides simultaneous gamma-ray, X-ray and visible light observations of the universe. Spectrum-UV is designed to provide ultraviolet imagery of stars, extragalactic sources and solar system bodies, including circumstellar, interstellar and intergalactic matter.

Price Range. The Integral program cost approximately $600 million, including launch and operations.

The Spectrum-UV mission is expected to cost approximately $500 million, including launch and operations.

Contractors

Prime

Alenia Spazio	http://www.alespazio.it, Via Saccomuro, 24, Rome, 00131 Italy, Tel: + 39 06 41511, Fax: + 39 06 4190675, Email: communications@roma.alespazio.it, Prime

Subcontractor

Integral/Spectrum-UV

Centre d'Etude Spatiale des Rayonnements, CESR	http://www.cesr.fr/EN-index/index.html, 9 avenue du Colonel Roche, BP 4346, Toulouse, 31028 France, Tel: + 33 05 61 55 66 66, Fax: + 33 05 61 55 67 01 (SPI Spectrometer)
Danish Space Research Institute, DSRI	http://www.dsri.dk, Juliane Maries Vej 30, Copenhagen, DK-2100 Denmark, Tel: + 45 3532 5830, Fax: + 45 3536 2475 (X-Ray Monitoring)
Instituto Nacional de Tecnica Aeroespacial, INTA	http://www.inta.es/en, Carretera de Ajalvir, Torrejo de Ardoz, Madrid, 28850 Spain, Tel: + 34 91 520 12 00, Email: direccion.general@inta.es (Optics)
Instituto di Astrofisica Spaziale e Fisica Cosmica, IASF	http://www.rm.iasf.cnr.it, 100 Via del Fosso del Cavaliere, Rome, 00133 Italy, Tel: + 39 06 4993 4474, Fax: + 39 06 2066 0188 (IBIS Imager)
Max Planck Institute of Extraterrestrial Physics, MPE	http://www.mpe.mpg.de, Giessenbachstraße, Garching, 85748 Germany, Tel: + 49 89 30000 00, Fax: + 49 89 30000 3569, Email: hrs@mpe.mpg.de (SPI Spectrometer)

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Technical Data

Design Features. Integral uses a bus identical to that developed for the ESA X-ray Multi-Mirror mission. It weighed 4,100 kilograms (9,040 lb) at launch (the heaviest payload put in orbit by ESA) and is designed to last at least two years and as many as five. Integral is deployed in a highly elliptical orbit with a perigee of 9,000 kilometers and an apogee of 153,000 kilometers; inclination is 51.6°. The Integral satellite replaces the U.S. Compton Gamma Ray Observatory, which was launched in 1991 and re-entered Earth's atmosphere in 2000, and the Russian Granat spacecraft, which carries the French Sigma gamma-ray telescope. Integral carries a payload comprising a cesium iodide imager, a germanium spectrometer, a CCD optical transient camera (OTC), and a Danish X-ray imager (JEM-X) with twin detectors.

The two main instruments – the spectrometer SPI (Spectrometer on Integral) and the imager IBIS (Imager on Board the Integral Satellite) – bring major improvements in both spectral and angular resolution of observations. Integral's instruments are 50 times more sensitive than those on earlier missions. This improvement in sensitivity gives access to a substantially increased portion of the universe that is observable in this part of the spectrum.

With its germanium detectors, which have a much better spectral resolution and are more sensitive than the scintillation counters used until now, the spectrometer is able to study typical radiation from violet processes in the 15 keV to 10 MeV region, such as nuclear excitation, positron annihilation, and cyclotron emission. It observes diffuse gamma-ray emissions, while the main task of the imager is the observation and mapping of weak sources.

The IBIS provides diagnostic capabilities of fine imaging (12 arcmin FWHM), source identification, and spectral sensitivity to both continuum and broad lines over a broad energy range. The imager exploits simultaneously with the other instruments on Integral celestial objects of all classes, ranging from the most compact galactic systems to extragalactic objects. The auxiliary instruments study the same part of the sky as the main instruments, but in different bands of the spectrum.

Since gamma-ray astronomy is unable to use mirrors to concentrate photon fluxes, the SPI and IBIS use coded masks to differentiate photon sources. Data processing is used to deduce the images of these sources from those of the shadows cast by the mask on the detectors. This technique, which provides statistical images, has been used for 15 years on gamma-ray telescopes flown by balloons. On Integral, the spectrometer, the imager, and the X-ray monitor are fitted with masks, each defined according to the type of observation to be carried out by the relevant instruments. The mask for the imager, consisting of 2,000 elements, has the ability to rotate; this eliminates background noise likely to blur the obtained images.

Variants/Upgrades

Spectrum X-ray Gamma. This mission appears to have been canceled. The SXG instrumentation was to consist of four telescopes: the TAUVEX UV telescope, the MART-LIME X-ray imaging and spectroscopic

telescope, the Joint European Telescope for X-ray astronomy (JET-X), and the Far Ultra Violet Imaging Telescope Array (FUVITA). The SXG was to be placed in a highly elliptical orbit with a perigee of 10,000 kilometers, an apogee of 200,000 kilometers, and an inclination of 51.5 degrees. The Russian Space Research Institute (IKI) was responsible for production, launch, and operations.

Spectrum-UV. An ultraviolet space observatory planned for launch on a Soyuz rocket in 2009. Design consists of a 1.7-meter T-170 telescope with three UV spectrometers. Other instruments on the Spectrum-UV will consist of a direct imaging camera and two spectographs: one Rowland spectrograph and a High Resolution Double Echelle Spectograph (HIRDES).

The Spectrum-UV will be placed in an extremely elliptical orbit in the first year, with a perigee of 500 kilometers, an apogee of 295,000 kilometers, and an inclination of 51.5 degrees. In the second year the orbit is not so extreme, with a perigee of 49,000 kilometers, an apogee of 240,000 kilometers, and an inclination of 64.7 degrees.

Program Review

Background. Following one year of study, the ESA's Space Science Advisory Committee recommended in 1993 that the ESA select the Integral gamma-ray satellite as its next medium-size science mission (M2). Part of the ESA's Horizon 2000 science program, Integral competed against the Marsnet probe to Mars, the Prisma star observatory, and the Step physics satellite. M1, the Huygens probe, was launched on board the American Cassini Saturn probe in 1997.

United Kingdom Withdraws Support

The Integral payload evaluation and selection process, which started in 1995, suffered a major crisis when the U.K. withdrew from participation due to lack of funding. As a result, revised proposals were resubmitted with no U.K. involvement. Areas of ESA payload support were identified and agreed to following efforts to reduce the procurement costs for national agencies. Construction of the Integral flight model began in the third quarter of 1998. The Integral engineering model was completed in mid-1999.

The Integral spacecraft was launched on a Russian Proton booster. The Arianespace Ariane 5 expendable launch rocket and the Lockheed Martin Commercial Titan III competed for the task, but neither could match the venerable Russian booster's price – the rocket was made available for the mission free of charge in return for Russian access to Integral data. Using the Proton guaranteed that Integral's 2-ton payload would be placed in a high enough orbit (higher than 46,000 km) to keep it relatively clear of the Van Allen radiation belt. Its elliptical orbit guarantees long, uninterrupted observation, with 80 percent of orbit time engaged in this activity.

Integral's primary mission is to observe the galactic plane and center, but it will also be looking for extragalactic gamma-ray sources, such as nuclei of active galaxies or clusters of galaxies and the mysterious gamma-ray bursts. Another priority is the study of compact objects (neutron stars or black holes) and novae.

Most of the observing time is made available to the worldwide astronomy community through a guest observer program. The rest of the mission will be reserved for the research institutes responsible for developing the payload.

Integral Provides Unique Perspective

Designed to study supernovae, black holes, and neutron stars, Integral is proving itself a key player in the elusive field of gamma-ray bursts. The bursts, which occur randomly and fade within seconds, have been detected by Integral at a rate of nearly one per day. Believed by scientists to signal the birth of a new black hole, gamma-ray bursts can shine with the intensity of millions of suns. Integral's unique perspective, provided by the germanium spectrometer, cesium iodide imager, X-ray monitor and optical camera, has triggered many follow-up observations. Integral team members discussed their findings in March 2003 during a meeting of the High Energy Astrophysics Division of the American Astronomical Society in Quebec.

Significant News

Fourth Announcement of Opportunity – The Director of the ESA Scientific Program, Prof. David Southwood, released the fourth Announcement of Opportunity (AO-4) for proposals for use of Integral in March 2006. The announcement solicited proposals for observations to be carried out in the period – from August 2006 to August

2007. All proposals are now subject to an independent peer review by the Integral Time Allocation Committee (TAC). The deadline for proposals submission was April 21, 2006. (ESA, 3/06)

Timetable

Month	Year	Major Development
Jan	1992	Phase A study begins
Apr	1993	Integral selected as second medium-size mission
Oct	2002	Integral launched on Proton
Jun	2003	AO-1 complete
Dec	2003	AO-2 observation period begins
	2009	Spectrum-UV scheduled to launch on a Soyuz

Forecast Rationale

Integral continues to provide highly valuable data, and its follow-on spacecraft, the Spectrum-UV, seems to be on strong footing, with expected contributions from most of Europe and China already lined up. This spacecraft will launch on either a Soyuz/ST or a Long March 3B in 2009.

According to IKI, the Spectrum-X mission is still under consideration, but given all the difficulties in lining up support for this program, a restart seems extremely unlikely. We have issued a somewhat skeptical forecast for production of the Spectrum-UV in 2009, but the program could slip by two years to 2011 considering the large investment that Russia has made both in the International Space Station and in numerous Soyuz spacecraft.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

		High Confidence Level			Good Confidence Level				Speculative			
Space System	**thru 05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Total 06-15**
ALCATEL ALENIA SPACE												
INTEGRAL GAMMA-RAY SAT.	1	0	0	0	0	0	0	0	0	0	0	0
Subtotal - ALCATEL ALENIA SPACE	1	0	0	0	0	0	0	0	0	0	0	0
RUSSIAN SPACE RES. INSTITUTE												
SPECTRUM-UV (WSO)	0	0	0	0	1	0	0	0	0	0	0	1
SPECTRUM-X	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal - RUSSIAN SPACE RES. INSTITUTE	0	0	0	0	1	0	0	0	0	0	0	1
Total Production	1	0	0	0	1	0	0	0	0	0	0	1