Astronomical Data Analysis Software and Systems VII
ASP Conference Series, Vol. 145, 1998
R. Albrecht, R. N. Hook and H. A. Bushouse, eds.

The *INTEGRAL* Science Data Centre

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Abstract. *INTEGRAL* is a gamma-ray observatory mission of the European Space Agency to be launched in 2001. The *INTEGRAL* Science Data Centre, implemented by a consortium of scientific institutions, is the part of the ground segment which deals with the interface between the scientific community and the *INTEGRAL* data.

1. The *INTEGRAL* Mission

The International Gamma-Ray Astrophysics Laboratory is a "medium mission" of the scientific programme of the European Space Agency (ESA) to be launched in 2001. It was selected to provide the astronomical community with a gamma ray observatory capable of the best possible spectral and angular resolution in order to extend, in the early years of next century, the set of astronomical tools covering the electromagnetic spectrum well into the difficult gamma ray domain.

INTEGRAL will provide both excellent (in terms of gamma ray astronomy) spectral and imaging resolution. The three high energy detectors (the imager IBIS, the spectrometer SPI and the X-ray monitor JEM-X) all use coded mask technology. *INTEGRAL* will therefore have an angular resolution of $\simeq$ 13'. The precision of location of a bright point source will be about one arc minute. The spectral resolution will be 2 keV at 500 keV. This will allow astronomers to measure the profiles of gamma ray lines and to measure Doppler shifts within the galaxy. An optical monitoring camera completes the scientific payload.

Gamma ray astronomy is now one of the tools necessary for the understanding of a wide range of cosmic phenomena, from the study of the interstellar medium to that of active galactic nuclei. It is therefore important to open the observing program to astronomers in the whole community and not to restrict this access to those teams that build the instruments. This is not only necessary for the community in general, but it also ensures that the instruments are used to study the most relevant problems and thus increases the scientific output

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of the mission. *INTEGRAL* was therefore conceived from the beginning as an observatory mission.

2. The *INTEGRAL* Science Data Centre

A gamma ray mission open to the astronomical community at large requires that the data will be calibrated and prepared so as to be understood by non-specialists. This has led to the concept of the *INTEGRAL* Science Data Centre (ISDC). This centre is the interface between the *INTEGRAL* data and the users' community. The ISDC is provided by the scientific community (the ISDC consortium). It is hosted by the Observatory of Geneva and started its activities in 1996.

Gamma-ray instruments are complex and the data reduction and calibration rest on a detailed knowledge of the instruments. The *INTEGRAL* data reduction will therefore be based on instrument specific software modules written by the teams developing and building the instruments.

The main ISDC responsibilities are (a) to receive the telemetry in real time from the Mission Operation Centre, (b) detect gamma-ray bursts within seconds and alert the community, (c) monitor in near real time the health of the scientific instruments and investigate solutions with the instrument teams to resolve problems, (d) perform a quick-look analysis of the data within 10 hours to detect unexpected features and events (TOO), (e) convert the raw data products into physical units, (f) taking into account the instrument characteristics, (g) deduce source properties (images, spectra, light curves) from the observed data, (h) archive the final data product, (i) distribute data and some software and support the users.

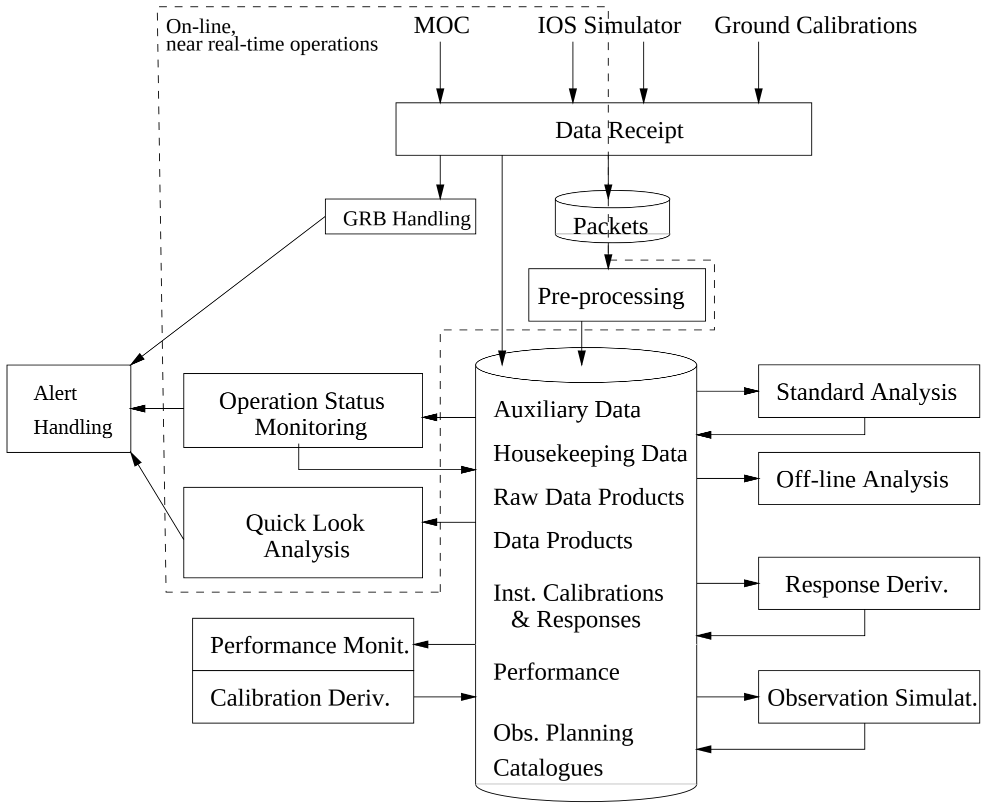
3. The ISDC Software System

The ISDC software system is made of data structures, analysis executables, pipelines and applications.

Data structures are tables and multidimensional arrays stored in FITS files. A typical *INTEGRAL* observation will be split into a few hundred short (20 minutes) pointings and slews. Each pointing will result in

- 10^5 to 10^6 events and several images for the high energy instruments
- 600 images for the optical camera
- 200 housekeeping records per instrument
- auxiliary data (attitude, orbit, timing, planning, radiation monitoring data).

The data structures, raw to processed, that correspond to a pointing will be grouped together. All data corresponding to an observation will form a group of about 5000 data structures for the high energy instruments and 10^5 data structures in total. All those data structures will be grouped in a hierarchy that



is described in the data themselves. The data and their hierarchy are available through the ISDC Data Access Layer (see Jennings et al. this proceedings). In addition to the standard groups created for the proposed observations, any group of pointings can be created for archival studies.

Analysis executables are C or F90 programs reading their inputs from and writing their outputs to the FITS files and reading their parameters from IRAF parameter files. The analysis executables are compatible with the FTOOLS standards, with some extensions. Analysis executables are standalone and do not require any other software to run.

Analysis pipelines link analysis executables together through flow control instructions. The parameters of each executable are defined at the pipeline level from pipeline parameters, data or database queries. Data structures are not modified at the pipeline level but always through analysis executables. The current baseline for pipeline scheduling is to use the OPUS system developed for the HST. The data access layer supports data storage in shared memory to accelerate data transmission when necessary.

Analysis applications are written to support interactive analysis of the data as well as automatic display of the data. Interactive applications call analysis executables for data manipulation and use native functions of the environment to generate displays and interact with the users. The object oriented framework ROOT developed at CERN is currently under study for writing analysis applications.

4. Development Phases

After a phase of requirement definition, system libraries development and interface specification, the architecture of the ISDC system is being built. Several subsystems will be under development starting early in 1998 and will be integrated and system tested during 1999. Overall tests involving the full ground segment will be conducted during the year 2000.

Additional information on the different elements of the ISDC can be found on the World Wide Web pages of the ISDC (`http://obswww.unige.ch/isdc/`).