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

The Ground Support Facilities for the BeppoSAX Mission

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Abstract. The BeppoSAX "Satellite per Astronomia X", a program of the Italian (ASI) and the Netherlands (NIVR) Space Agencies, was launched on April 30th into a circular orbit of 590 km altitude and 3.9 degrees inclination.

The Ground Support System components are presented in order to highlight the end-to-end operation approach to the scientific mission. The software systems are described following the forward and backward data flow to/from the satellite: starting from the Observation Proposal reception and archiving, the long term observation scheduling up to the detailed weekly planning and telecommands sequence uplinking, and vice versa the scientific and housekeeping raw telemetry acquisition and archiving, quick look data analysis, data reformatting and distribution as a Final Observation Tape to the Observation Proposal PI. Among these components the Quick-look Data Analysis system is emphasized. The main tasks of this system are both health monitoring of the BeppoSAX instruments and quick-look inspection of the scientific results with the goal of detecting and locating major changes in X-Ray sources and searching for X-Ray transient phenomena up to high energy events as Gamma Ray Bursts. This is carried out by performing both Data Accumulation and Data Presentation and Analysis by using the raw payload telemetry data stored on orbital basis.

1. Introduction

The ground support facilities for the BeppoSAX Mission are split among different ground systems components:

- the Ground Station, located in Malindi (Kenya), for the telecommands uplinking and telemetry retrieving when the satellite is directly visible (approximately only 10 minutes of each 96-100 minute long orbit)
- the Operation Control Centre (BSAX-OCC), which handles spacecraft orbital management and payload monitoring activities
- the Scientific Operation Centre (BSAX-SOC), where the detailed planning of the onboard scientific activities is prepared, the orbit-by-orbit raw telemetry is archived and made immediately available to the quick-look processing
- the Scientific Data Centre-Mission Support Component (BSAX-SDC/MSC), where observation requests from the astronomical community are collected

and checked, long range observation plans are prepared and raw data from the entire mission are archived and delivered to the final users as Final Observation Tapes.

Although all facilities are split into further components (OCC, SOC, SDC/MSC are located in Telespazio, Rome), their design and overall integration allow efficient and successful management of the mission operations.

2. The BeppoSAX forward and backward Data Flow

The aforementioned system components are described following the forward and backward data flow to/from the satellite.

The BeppoSAX Data flow starts at BSAX-SDC/MSC with the reception and management of the Observation Proposals:

- Proposal Reception via e-mail and ordinary mail
- Proposal Checks for completeness, consistency and syntax
- Proposal archiving using database technology
- Proposal Feasibility Checks: target observability and viewing windows, target visibility, bit-rate evaluation

Proposals approved by the Time Allocation Committee and successfully checked contribute to the Mission Plan file preparation. The Mission Plan File is the main input to the Proposal Scheduling steps performed at the BSAX-SOC:

- Long-Term Planning: an optimized timeline designed to maximize satellite performance taking into account the observability and operative constraints and the proposer's specified priorities
- Short-Term Planning: a one-week detailed timeline containing for each requested pointing the attitude sequences, the orbital links, SAGA passages and the on-board instruments set-up
- Urgent Observation (e.g., TOO) Management: TOO feasibility checks, quick replanning of the current short-term schedule

The Short-Term Planning products are the main input to the Spacecraft and Payload command sequence generation. The observation execution involves activities which are performed at the BSAX-OCC:

- Telecommand uplink, Telemetry acquisition
- Spacecraft and Payload Monitoring & Control
- Satellite ephemeris determination: prediction and reconstruction
- Satellite attitude determination and post-facto reconstruction

During the Observation execution the raw telemetry (housekeeping and scientific) is collected at the BSAX-SOC:

- Orbit-by-orbit telemetry acquisition and processing
- Telemetry Data Quality checks for completeness, integrity, consistency and accuracy
- Temporary Telemetry filing (data from the last 60 orbits are always on line)
- Quick-look Data Analysis

Telemetry data, grouped by Observing Period (several orbits time span) and Auxiliary data such as On-Board-Time/Universal-Time conversion Data, Reconstructed Attitude and Satellite ephemeris are then stored in the BeppoSAX Mission Raw Data Archive at the BSAX-SDC/MSC. Its organization and management is done according to the following baseline:

- Optical Disk media as final support for the data archiving
- A relational database to catalogue data and address data files on media
- Optical jukebox in order to keep more media on-line and optimize data retrieval

The last step in the BeppoSAX data flow facilities (BSAX-SDC/MSC) is the data delivery to the final user:

- Observation Data (housekeeping, scientific and auxiliary) retrieving from the BeppoSAX Mission Raw Data Archive, on the basis of the PI proposal
- Data reformatting and storing on the requested media support (e.g., DAT, Exabyte)
- Product delivery to the PI

3. Quick Look Data Analysis System

The Quick Look Analysis (QLA) is mainly conceived as a quick-look system to allow feedback to the BeppoSAX satellite as soon as possible, typically within a few orbital periods from when the relevant events were generated on board.

The QLA is performed by a team of eight Duty Scientists working shifts to ensure 24h data monitoring.

Input data for the QLA are payload telemetry data stored in the BSAX-SOC Archive for a time span encompassing the last 60 orbits.

The main tasks accomplished by QLA are both health monitoring of the BeppoSAX instruments and quick-look inspection of the scientific results with the goal of detecting and locating major changes in X-Ray sources and searching for X-Ray transient phenomena up to high energy events such as Gamma Ray Bursts. These latter events, triggered by the on-board Gamma Ray Burst Monitor, are analysed by the Duty Scientist Team following a well-tested procedure and up to now several real Gamma Ray Bursts have been identified and located, giving input to follow-up observations in different energy bands. In order to accomplish the QLA goals the system provides both Data Accumulation, Data Presentation and Analysis tools. Implemented accumulation functions provide scientific telemetry data retrieving, packet information extraction to perform accumulation of X-Ray events information and integration of on-board accumulated data structures. Data visualization and general analysis are based on a Motif Graphical User Interface developed by Telespazio with the PV-WAVE analysis environment. Based on PV-WAVE Widget Toolbox applications, the ad-hoc software developed using PV-WAVE processing routines provides a data analysis/manipulation system with optimum ease of use.

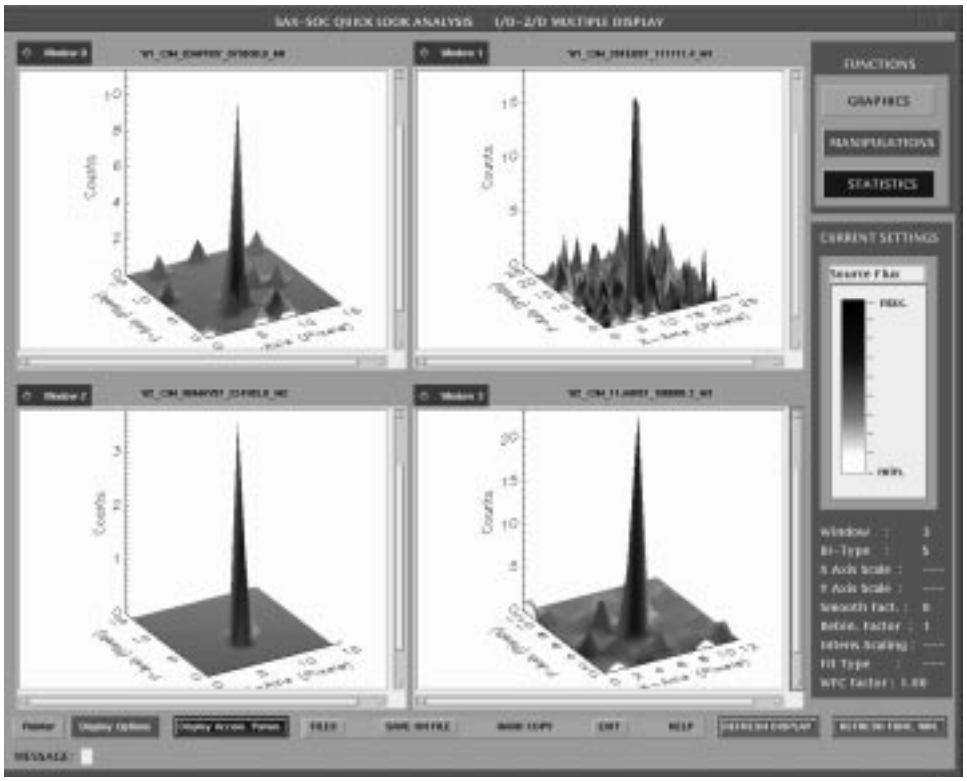

Figure 1. 3D Images of four Gamma Ray Bursts discovered by BeppoSAX (GRB970111, GRB970228, GRB970402 and GRB970508)