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HouseKeeping and Science Telemetry: the case of Planck/LFI *

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Abstract.
For any scientific space mission, Housekeeping and Science Telemetry are two different kinds of data with different scope and structure; therefore a different approach is needed in their analysis. Here we will describe the rationale in the case of the PLANCK/LFI project and what was designed and developed to create the analysis and testing environment.

Key words. Space vehicles – Methods: data analysis – Telemetry –

1. Introduction

PLANCK [1] is the ESA mission aimed at studying the CMB planned to be launched in February 2007 together with Herschel. Its main target is to produce maps of sky at frequencies 30, 44, 70 GHz for the Low Frequency Instrument (LFI)(Mandolesi et al. 1998), and 100, 143, 217, 353, 545 and 857 GHz for the High Frequency Instrument (HFI), and to derive from them the cosmological parameters with an unprecedented resolution (FWHM from $\simeq 33'$ to $\simeq 5'$) and sensitivity (in the range of $\simeq 10-40$ mJy on a FWHM resolution element). The PLANCK satellite will be placed in an orbit around the libration L2 point for the Earth-Sun system, so it will be visible from the ground station for a short time each day (2 hours). In this period the people working at DPC (Data Processing Centre of each instrument) must be able to understand if the instrument and its devices are working correctly (looking at the housekeeping telemetry) and to assess the quality of scientific data (looking at the Science Telemetry). For this reason the analysis of the telemetry has a very important role in the PLANCK/LFI project but the same approach can be applied to other

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scientific space missions or to ground based telescopes to improve their performances.

2. Telemetry analysis - generalities

Telemetric data from ground and space-based instruments can be divided in two main classes: Housekeeping Telemetry and Science Telemetry. The first one represents the health state from instruments and devices monitors, the second one gathers the real observed data. The housekeeping data analysis is aimed at understanding if the instruments and devices are working correctly.

Checking housekeeping telemetry has the aim of understanding the status of the instrument so to be able modifying in real time the instrument set-up to quickly avoid errors or device breakdown; so this kind of checking requires a Real Time Analysis (RTA). Science analysis, instead, is aimed at understanding the quality of the science data obtained; its output should be a set of parameters necessary to tune the instrumentation to obtain optimum performance. Since the Science Analysis is instrument safe it doesn't require a real time performance; rather, a Quick Look Analysis (QLA) is more appropriate in this case.

3. Planck/LFI Data Flow Overview

In figure 1 the structure of the Planck LFI data Flow at level 1 (logical level responsible of RTA and QLA) is shown. This data flow was created in order to have a smooth transition between simulations, ground tests and in-flight operation. From the RTA or QLA point of view actually real data or simulated telemetry are the same. The LFI data is organized as a stream, scrambled in time, with housekeeping packets randomly inserted among science packets, which will eventually carry compressed data.

Telemetry data, received during predefined periods of visibility from the Perth ground station in Australia, will be forwarded to the Mission Operation Center

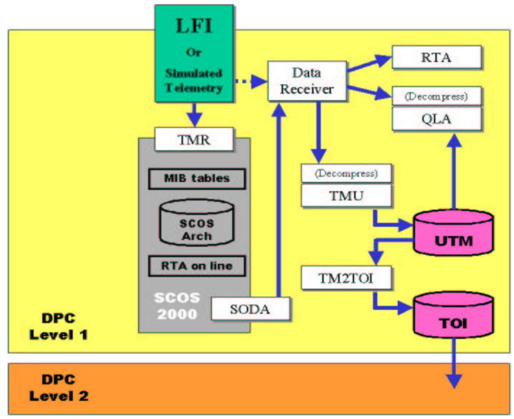

Fig. 1. Level 1 Data Flow Overview

(MOC) at ESA/ESOC which will examine spacecraft and instrument housekeeping (HK) telemetry to verify the health of the systems and to generate auxiliary information. From MOC, LFI telemetry is downloaded to the LFI Data Processing Centers (DPC) located at Trieste to be processed, and to the HFI DPC as well, if needed.

At the DPC the raw data stream coming from MOC (Mission Operation Center) is ingested by the SCOS2000 tool (Spacecraft Control and Operations System developed by TERMA s.r.l. under ESA contract) (Kaufeler, Jones, Karl 2001) where they are stored (backup purpose) and where the first RTA analysis is applied. SCOS2000 is an object oriented environment based on CORBA technology and allowing full compatibility between the LFI DPC (Data Processing Center) and MOC. Data are extracted from SCOS2000 and transmitted, through socket or files, to the QLA system that decompresses science data and performs the first analysis of scientific packets. As told before, data are scrambled in time, so they need to be unscrambled and stored in the LFI database. We will be able at this point to rerun the QLA on unscrambled data (UTM). The level 1 (Pasian 2002) final step is the creation of data streams sorted in time (TOI) each one representing an entire observation cycle.

4. The Simulation Environment

The simulation environment was built to test the RTA and QLA. It is able to simulate housekeeping and science telemetry and merge them to generate a realistic simulated data stream. A new task on SCOS2000, based on the TCP/IP protocol using sockets, was developed to allow the connection to the simulation tool.

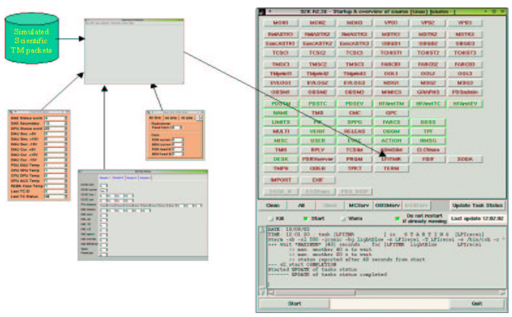

Fig. 2. The Simulation Environment

The simulation tool, called **TOOTSIE** (Totally Object Oriented Telemetry Simulation Environment), has the following characteristics:

- C++ tool under Linux;
- uses the qt library for development environment and graphical purposes;
- designed like a Telemetry editor;
- housekeeping telemetry value can be changed on the fly;
- is able to get Scientific Simulated data packets generated by the scientific telemetry simulator (Burigana et al. 1998) (Maris et al. 2001);
- is able to modify the number of packets sent each second (to allow stress test);
- is able to display the generated stream in different formats;
- is able to send the created telemetry stream through a socket.

5. The RTA (Real Time Analysis) on Housekeeping

The Real Time analysis was organized using an object oriented approach. This permits to easily select the most representative parameters (to minimize windows displays on the monitor) and, if necessary, it is possible to perform a deeper analysis.

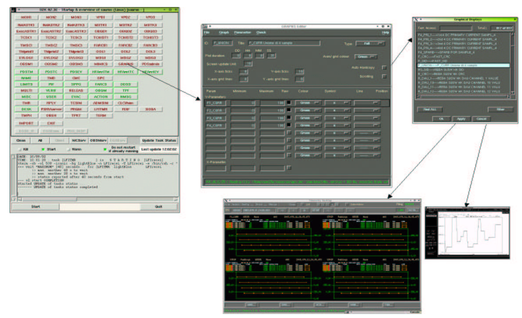

Fig. 3. The Real Time Analysis

The RTA was developed on the top of the SCOS2000 facility using graphic tools based on `ILOGviews`; its purposes is:

- to read housekeeping telemetry;
- to store it in a database with backup purposes;
- to transform raw data in to engineering values using calibration tables;
- to display data using different modes and to check out-of-boundary parameters possibly using alarm display;
- to display data in hexadecimal or ASCII format;
- to perform logical operations between housekeeping flags.

6. The QLA (Quick Look Analysis) on Science Data

The QLA is run on original science telemetry packets or on unscrambled telemetry to quickly find whether detectors need some tuning, and to figure out if the whole chain works correctly.

The first version of QLA has been developed, and now is under upgrade, by the

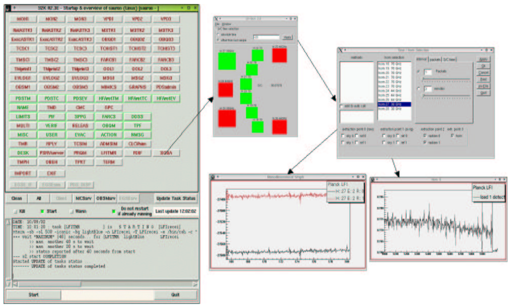

Fig. 4. The Quick Look Analysis

Geneva Astronomical Data Center team with the following main characteristics:

- it was built under ROOT (Brun and Rademakers 1996), an object oriented environment developed at CERN;
- it is able to connect to SCOS2000 through a socket to get data and open telemetry stored files;
- it is able to store data in FITS format (for backup purposes) through the TMU (Telemetry Unscrambled Task) or to ingest it in the LFI object oriented database through DMCI (Lama et al. 2003);
- it is able to display several data sets (from different detectors) on the same plot;
- it is able to apply some mathematical function to the data displayed;
- it is able to retrieve data (from FITS files or LFI object oriented database through DMCI) selected by channel, time period etc

We plan to use the same tool developed for the QLA purposes also for an off-line RTA. This should be very useful to find (if present) correlations between housekeeping telemetry value and science data in the case suspect results from the first QLA analysis occur.

7. Conclusions

The entire data processing chain, i.e. simulation, RTA and QLA was already tested on an amount of telemetry data covering many days of observations with good results from the analysis point of view. The principle used to develop RTA and QLA for PLANCK/LFI can be easily exported to different kinds of data, e.g. those coming from ground based instruments.

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