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Planck/LFI: management of telemetry

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Abstract. This paper describes the concepts, the structure, the operations and the tools at the root of Level 1, which is in charge of telemetry handling within the of the Planck/LFI Data Processing Center.

Key words. techniques: miscellaneous – astronomical data bases: miscellaneous – space vehicles: instruments

1. Introduction

The Ground Segment (GS) of the Planck mission, will be geographically distributed among different centers. The satellite will send the data to the Ground Station of Perth (Australia), during the periods of visibility ($\sim$ 2 hours every day); telemetry data will be then forwarded to the Mission Operating Center (MOC) at ESA/ESOC. In the telemetry packets there are both Housekeeping (HK) and scientific information. The MOC examines the spacecraft and instrument housekeeping telemetry to verify the health of the system and, when needed, uplinks telecommands to update the overall spacecraft+instruments setup. All telemetry is finally delivered to the two Data Processing Centers (DPC), together with auxiliary information, such as attitude information (to reconstruct the pointing in the sky of the Planck telescope) and the timing information required to synchronize the onboard time with the universal time.

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2. LFI DPC Level 1 telemetry handling

For the Low Frequency Instrument (LFI) (Mandolesi et al. 1998) the DPC will be in charge (among other things) of the monitoring of instrument health and performance, and of the scientific processing of data (Pasian 2003). It is divided in four main levels numbered from 1 to 4 according to the progress of the data processing, from ingestion of raw telemetry to the release of the final products. Level 1 gets information from telemetry packets (containing HK or scientific information, according to their type) sent from the spacecraft. It merges information to generate homogeneous data streams of Time Order Information (TOIs). It integrates auxiliary (pointing) information from the MOC to obtain streams of scientific data (Time Ordered Data – TODs).

In addition it performs *Real Time Analysis* (RTA) on the HK telemetry data to check if the activity of the instrument is nominal, and *Quick-Look Analysis* (QLA) on the scientific telemetry data to assess their quality.

Level 1 is based on the SCOS 2000 (Spacecraft Control and Operations System) environment (Kaufeler et al. 2001) which provides all the essential functions to monitor and control a satellite in each mission phase. The system has been tailored for the needs of LFI and auxiliary software for RTA, QLA and validation of Level 1 have been created. Level 1 will be incrementally developed in parallel to the instrument. As an example, the first release of the LFI-specific version of SCOS 2000 and of the RTA and QLA software will be delivered and installed on the LFI EGSE system (Electrical Ground Support Equipment) built for the ground tests of LFI.

Level 1 operations begin when SCOS 2000 receives telemetry packets through a *Telemetry Receiver* and selects them according to their type. HK packets are decoded and analyzed by SCOS 2000 (with some support from external tools) to perform RTA over the HK data. Since performing QLA within SCOS 2000 has proven to be awkward, scientific telemetry is extracted from SCOS 2000 and analyzed separately. QLA monitors nominal operation of the observation plan, verifies normal behaviour of the instruments and checks data integrity. No processing of the scientific data is included. A *Telemetry to TOI* converter (TM2TOI) allows TOI to be created. This module collects scientific telemetry packets selected by time interval, source detector and operation mode, and sorted according to their time stamp, and extracts (possibly decompressing) the information composing the TOI. TOI, eventually integrated with auxiliary information from MOC, are sent to Level 2 for scientific pipeline processing. *QLA/TA* (Trend Analysis) is performed on TOI to reveal unexpected trends and oddities, generating alarms in the case of non-nominal instrument performance.

The development and validation of Level 1 is obtained feeding the software with a realistic telemetry stream which reproduces the true data rate of the instrument, its variations due to data compression and telemetry overhead, damages and errors in packets induced by the transmission. This allows to test performances, and prepare error recovery and error rejection strategies. A complete simulation system has been therefore set up, composed of the Mission Simulator (MS), the Scientific Telemetry Simulator (piped in output to the MS) and the House-Keeping Telemetry Simulator. The MS (Burigana et al. 1998), integrated by a Data Acquisition and Quantization module (Maris et al. 2003), simulates the observation of the sky at various LFI frequencies, according to the nominal Planck scanning strategy. The data stream in output to the MS is piped to the Scientific Telemetry Simulator which converts it into a stream of scientific packets according to ESA and LFI standards. In parallel the Housekeeping Telemetry Simulator produces a stream of synthetic housekeeping packets identical to those expected from LFI. Scientific and HK data streams are subsequently randomly scrambled, merged (if required, damaged) and sent to Level 1.

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