EUSO Operations: Flight and Ground

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Abstract

The EUSO operations concept is described. Both the on-board and on-ground systems play an important role on operations. Since no permanent contact with the payload is provided, a considerable autonomy of the on-board system is required. The fulfilment of the scientific goals of the mission and the safety of the instrument require the definition of different operational modes and procedures. On-board, scientific and housekeeping data are collected and sent to ground, and control of the instrument subsystems is performed, based on on-board autonomous procedures and on telecommands sent from ground. On ground, telemetry is received, processed, monitored and archived. Telecommands are prepared for uplink, according to a defined mission activity planning.

1. Introduction

EUSO [1] operations will ensure that the scientific objectives of the mission can be achieved, optimising the use of all the available resources. It must keep the correct functioning and communication of the apparatus, and make sure that the mission data are safely collected, processed and stored on ground. The EUSO operations system is the integrated system of hardware (HW), software (SW), people and procedures that must cooperate to accomplish these objectives. The EUSO system consists of a flight and a ground segment in communication, exchanging telecommands (TC) and telemetry (TM). The flight segment contains the EUSO scientific instrument [1] and is to be installed on the Columbus module of the ISS. The ground segment is the complete ground infrastructure needed to operate EUSO. It is composed by the ISS ground stations, the Columbus Control Centre (Col-CC) and the dedicated EUSO scientific ground segment, the Science Operations and Data Centre (SODC).

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2. EUSO Operations Concept

2.1. Basic Requirements and Constraints

The EUSO operations system shall: (1) Accommodate the different scientific operation modes and collect the corresponding scientific data; (2) Control the instrument and monitor its status, making sure EUSO is always in a safe state; (3) Handle the Scientific and housekeeping (HK) TM; (4) Generate and handle TCs; (5) Assure the processing, archiving and dissemination of the scientific data of the mission; (6) Provide the interface to the atmospheric sounding system; (7) Perform the instrument calibration; (8) Follow the evolution of the instrument health and performance, providing SW and HW maintenance; (9) Handle emergency situations; (10) Maintain the mission archive, database and user interface.

The operation in the context of the ISS has specific characteristics which impact on operations. No permanent contact with is provided. Data are stored on-board and downlinked during acquisition of signal periods. Uplink and downlink capabilities are limited, and on-board data services must be shared and preplanned. Commands for uplink have to pass via the Col-CC. Furthermore, basic characteristics of operations in space have to be taken into account when planning the system: discontinuous high rate data transfer, communication delays and failures, file corruption. This requires flexible operations and recovery procedures.

2.2. Operations Overview

The global EUSO operations scenario is sketched in figure 1. On board, the different subsystems are controlled and monitored by an Instrument control and readout system (ICR), which handles science and HK data collection and controls the different instrument subsystems and provides the interface to the atmospheric sounding system. The ICR contains the on-board SW, which manages the different ongoing processes and the command sequences received from ground. Different configuration files are available on-board and loaded in agreement to the selected operation modes and conditions.

On ground, mission activity planning is carried out, taking into account the safety of the instrument and the scientific requirements, and leads to the generation of command sequences for uplink, which are prepared and verified. Software validation activities are also performed. TM is received, processed and monitored. The monitoring of the HK parameters is constantly performed. The mission archive, user interface and interface to external databases are also maintained by the ground operations system. Autonomous operations imply a particular care with ground based test and validation facilities for SW and commands. The command sequence files contain the time-sharing between the different operation modes, the sequence of operations and the scheduling of all activities. They might be short (1 orbit) or longer-term activities.

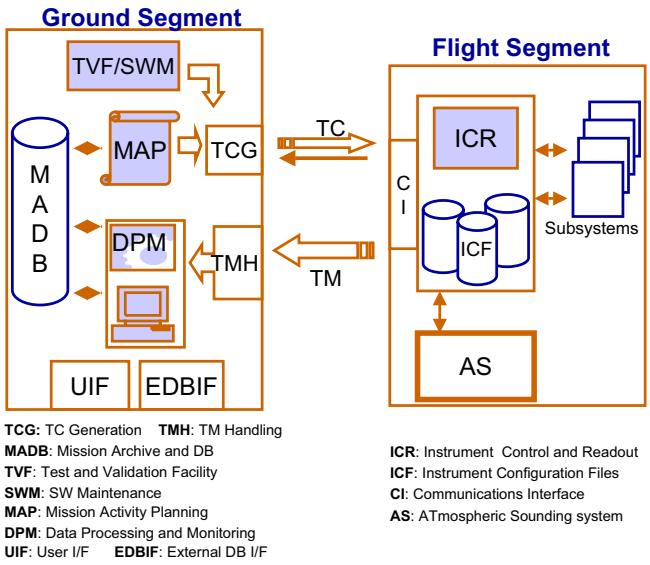

Fig. 1. Schematic overview of the EUSO operations scenario.

3. Flight Operations

The different operational states of the instrument are overviewed in figure 2, together with the possible transitions between them and the TM packets generated in each of them. The transitions between modes are controlled by the on-board control SW and can be triggered by time-tagged commands contained in the schedule files uplinked from ground, by the receptions of ISS ephemeris parameters and by the on-board subsystem monitoring processes. Mode changes caused by exception states may be triggered by both the ISS and the on-board monitoring system. Starting with the non-scientific modes: when power is applied to the on-board Trigger and Control Unit (TCU) the instrument goes autonomously to the Initialisation mode. Communications are initialised, the TCU and the on-board SW are initialised and verified. The system is ready to receive TCs and produces the HK packets related to communications and to status of the TCU. The system goes to Standby mode on the reception of a Start TC from ground. It is then powered on step by step. The full set of periodic HK parameters is generated and downlinked. The full data handling SW is initialised. Context table and SW updates may be performed at this stage. At the execution of a Get ready command, the high voltages are switched on, while the telescope shutter is kept closed.

The scientific or observation system modes correspond to the different scientific operation modes foreseen in order to meet the scientific objectives of EUSO. For each mode scientific mode there are different configuration files that

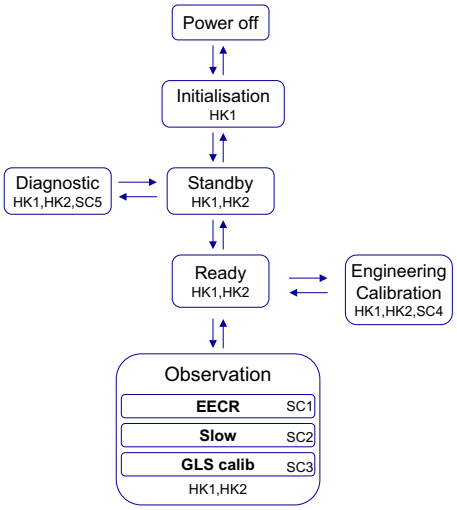

Fig. 2. Operational states of the EUSO instrument.

can be loaded. They are selected according to TC parameters or autonomously, and this depends on the observation conditions or instrument status. On the scientific modes, the instrument generates the full set of HK telemetry plus scientific packets, which format and contents depends on the specific mode. When an observation is halted the system goes into the standby mode.

The basic functions of the on-board operations system can be summarised as: (1) Collection and pre-processing of the scientific data; (2) Collection and verification of HK data; (3) Preparation of TM packets; (4) TC handling; (5) Management of the trigger configuration; (6) Management of the different instrument subsystems; (7) Management of emergency situations; (8) Interface to the EUSO atmospheric sounding system. The basic element of the on-board operations system is the TCU, which contains the on-board control and readout SW.

4. Ground Operations

The EUSO Scientific Operations and Data Centre (SODC) subsystem constitutes the EUSO scientific Ground Segment. The SODC ensures the scientific mission control and planning and addresses the issues of data collection, monitoring, distribution and archiving. The SODC is described in detail in [2].

5. References

1. see in these Proceedings O. Catalano, et al., “The EUSO instrument” and M. Teshima et al. “Physics with EUSO”
2. see in these Proceedings M.C. Espirito Santo et al., “The EUSO SODC”