EUSO in the Context of ESA Human Spaceflight Directorate

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Abstract

By providing in-orbit infrastructure, the International Space Station (ISS) allows for performing world-class space research and commercialisation. The Human Spaceflight Directorate of the European Space Agency (ESA) is implementing ambitious utilisation plans for external payloads with the advantage of long duration missions with limited astronauts involvement. Currently the Extreme Universe Space Observatory (EUSO) is under study as one of ESA External Payloads of the future generation.

1. Introduction

Unlike a conventional satellite, which orbits the Earth keeping the same direction (unless commanded otherwise), the ISS orbits like an airplane keeping its main axis parallel to the local horizon. This is a great advantage for both an all-sky monitor experiment and Earth observation investigations, since the relevant field of view can automatically scan most of the sky and Earth during the 90 minute ISS orbit. In order to exploit this unique capability of the ISS, ESA is implementing ambitious utilisation plans aimed at world-class research and commercialisation in the external space environment [1]. EUSO, originally proposed to the ESA Directorate of Space Science as a Flexi-Mission [2], has been handed over for feasibility study to ESA Directorate of Human Spaceflight and is now an important element of the ESA utilisation plans for the ISS. This feasibility study, being jointly performed by the two ESA Directorates, will define the basis for implementing the EUSO mission on board the ISS (Fig. 1, left panel).

2. The EUSO Mission

Devoted to the investigation of the highest energy processes accessible in the Universe, by using the Earth's atmosphere as a giant cosmic ray detector, EUSO will observe the flash of fluorescence light and the reflected Cerenkov light produced when an Extreme Energy Cosmic Ray (EECR, with energy 3×10^{19} eV)

pp. 1093–1096

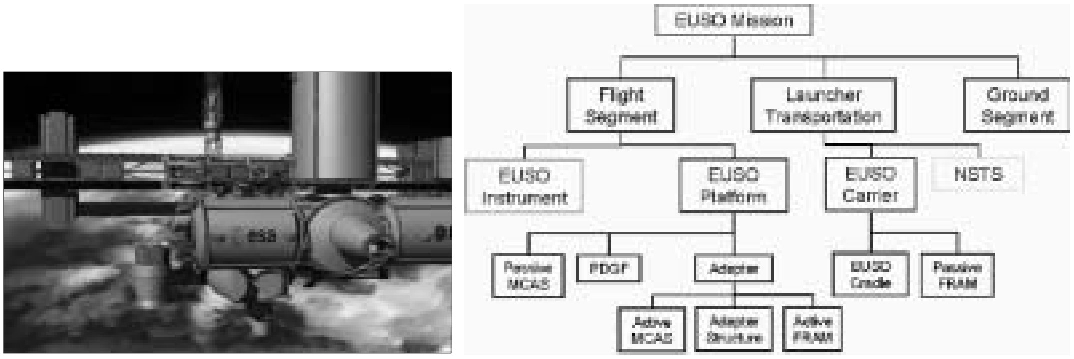

Fig. 1. *Left panel)* EUSO accomodation on the ISS; *Right panel)* EUSO Mission elements (courtesy of Alenia Spazio).

interacts with the Earth atmosphere. EUSO will take advantage of the continuous Earth pointing provided by the lowest balcony of the ISS European module Columbus and, by looking nadir with a 60° field of view, will detect events with high statistics allowing a sensitive search for objects producing EECR. The EUSO mission elements are shown in Fig. 1 (right panel). The integrated payload consists of the scientific package provided with the elements, which allow its transportation and robotic handling. Due to its large dimensions (2.7 m diameter and 4.5 m length), EUSO will need a dedicated carrier and will entirely occupy the lower Columbus External Payload Facility (EPF) balcony (see Fig. 2). The integrated payload will be launched inside the National Space Transportation System (NSTS) cargo bay. Once on-orbit the ISS robotic arm will unlatch EUSO from the dedicated carrier, which remains inside the cargo bay and it is returned to Earth, and will install it on Columbus EPF by means of adapter. During its operational life, EUSO will send to ground the collected signals via the dedicated Science and Housekeeping telemetries download channel. Columbus Control Center will receive those data and will distribute to other research centers interested in EUSO scientific mission via Facility Responsible Center (FRC, Fig. 3). The FRC or Science Operations and Data Center (SODC) in case of EUSO constitutes the EUSO scientific Ground Segment. At the end of its operational lifetime, EUSO is returned to Earth by the NSTS.

3. EUSO project status

EUSO Phase A study, with Alenia Spazio as industrial contractor, has been started in March 2002, aiming at demonstrating the feasibility and viability of the payload configuration, including the investigation and elaboration of launch and transportation scenarios dedicated to the EUSO class of payloads. This can be summarised as follows: • Instrument architecture optimisation and payload

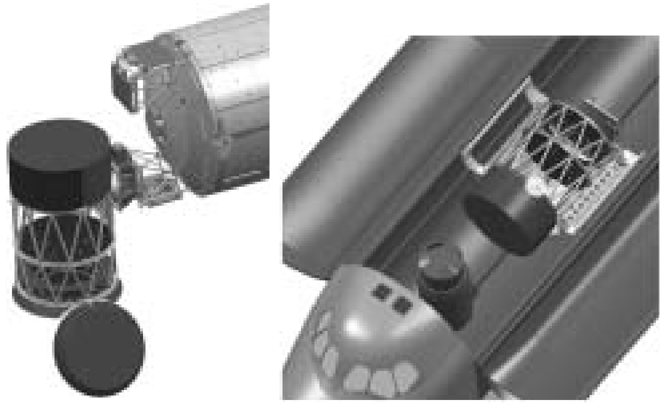

Fig. 2. EUSO on-orbit and launch configurations (courtesy of Alenia Spazio).

interface consolidation. • Payload accommodation at Columbus EPF and minimisation of relevant resource needs (thermal, power, volume, mass, data handling) to be shared with other payloads. • Payload launch, transportation and robotic handling for delivery to Columbus EPF. • Payload system level design (mechanical, thermal, electrical, radiation and contamination) and Instrument interface optimisation. • Consolidation of the Operational Modes and corresponding data volume/rates • Payload AIV (Assembly Integration Verification) Model Philosophy & AIT approach. • End-to-end flight operations and Ground Segment • Procurement of utilisation of support hardware for large class payloads. • End-to-end schedule and associated estimate of cost to completion of the payload development and mission implementation, excluding Instrument elements. Due to the incompatibility of the EUSO payload mass with respect to the Columbus EPF mass constraints an assessment study was performed by Columbus in co-operation with EUSO to identify and evaluate impacts on Columbus EPF for the accommodation of the payload. The study results demonstrated that an optimised EUSO payload configuration is compatible with the Columbus EPF on-orbit mass carrying capability (maximum 1500 Kg) with some restrictions: • No Columbus EPF tilting possible with EUSO mounted on it • Columbus EPF design load to be reassessed • Columbus EPF bottom balcony entirely occupied by EUSO • EUSO instrument mass up to 1170 Kg. Columbus re-certification activities have been started in order to formalise the updated Columbus EPF on-orbit mass carrying capability and center of gravity requirements. The Phase A study is currently finalising the payload configuration reconsidering some technical assumptions made for the payload installation and accommodation scenarios as well as the mission end-to-end schedule and cost to completion. Moreover an updated instrument configuration that includes the LIDAR (an atmosphere sounding device, which provides "real time" knowledge of the atmosphere scattering and light absorption properties) has been recently introduced by the Instrument Consortium in the

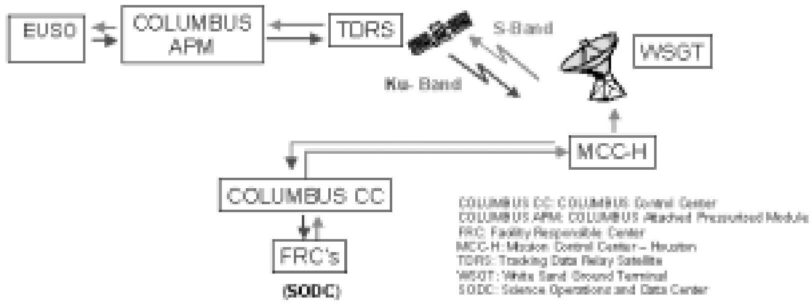

Fig. 3. EUSO End-to-end Communication concept.

payload configuration. This will be evaluated in the final part of the Phase A study, which is now planned to end in October 2003. Following the Phase A completion the Phase B will be commenced, provided the: • successfull completion of the Phase A • Agreements between ESA and the Instrument Consortium (or Funding Agencies) • Cooperation agreement between the two ESA Directorates (Space Science and Human Spaceflight) for the B and C/D Phases • Introduction of EUSO into Future Science Program of ESA.

4. Conclusion

The ISS provides unique capabilities to perform world-class space research and commercialisation in a wide field of disciplines. ESA is elaborating ambitious plans to utilise the ISS for external payloads with the advantages of long duration missions with limited astronauts involvement. Further to the payloads currently under development, other missions such as EUSO are currently under study. Based on the preliminary outcome of the running EUSO Phase A, it has been demonstrated that it is possible to accommodate such a class of large payloads at the Columbus EPF, provided the total mass to be placed at each EPF balcony remains below 1500 Kg. Assuming a successful conclusion of the Phase A study and mission funding approval, Phase B (and subsequently Phase C/D) will be commenced with the goal of achieving readiness for flight in 2009, at the earliest.

5. References

1. 1. G. Gianfiglio, December 2002, ESA Plans for Future ISS External Payloads, "On-station " article
2. L. Scarsi et al., 2000, "EUSO - Extreme Universe Space Observatory", Proposal for the ESA F2/F3 Mission