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AstroBio CubeSat: a nanosatellite for space astrobiology experiments

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Introduction

AstroBio CubeSat (ABCS) is an Italian Space Agency (ASI) 3U CubeSat (100x100x340 mm) selected by European Space Agency (ESA) to be launched with the Vega C qualification maiden flight, as piggy back of the ASI LARES2 main satellite, by the end of 2020. ABCS will be deployed in an approximately circular orbit, with about 5900 km altitude and 70° of inclination. It implies that ABCS will spend a significant part of the orbital period within the internal Van Allen belt, close to its maximum. The radiation environment is characterized by a very high flux of charged particles, which have a significant effect on electronic components in terms of permanent damages due to accumulated dose effects and single events. Considering the extremely harsh space conditions, the estimated mission lifetime useful to perform the payload experiments should be defined in 3 months.

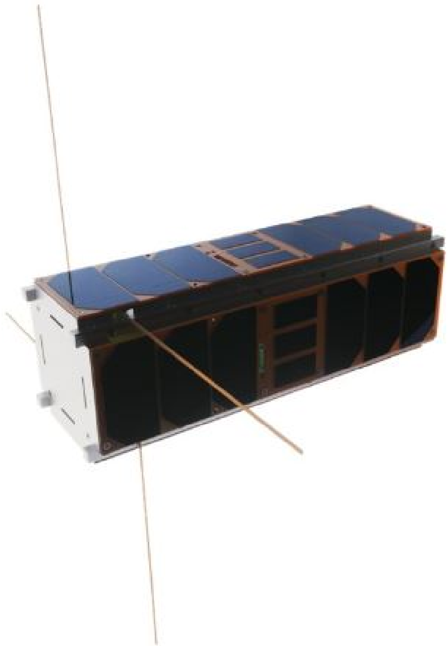

Figure 1 – Rendering of AstroBio Cubesat

ABCS Project is funded and managed by ASI in cooperation with INAF-Astrophysical Observatory of Arcetri, that will coordinate the scientific and engineering team. Partners of the projects are the School of Aerospace Engineering of Sapienza University of Rome, the University of Bologna, the University of Torino, and Kayser Italia.

ABCS Payload

ABCS will host a mini laboratory payload based on an innovative lab-on chip technology suitable for research in astrobiology. The objective is to test in space environments an automatic laboratory able to provide a highly integrated in-situ multiparameter platform that uses immunoassay tests exploiting chemiluminescence detection by means of on-chip a-Si:H photodiodes. The experiment will consist in a set of lateral flow immunoassays (LFIA) on nitrocellulose support where target biomolecules are immobilized in specific test areas. Reagents are deposited in a non-permanent fashion and in a dry form in the initial part (starting area) of the microfluidic path. When the reagents-delivery-system provides a volume of liquid reagent to the starting pad, capillary forces will guide the reagents through the LFIA microfluidic pathway. During the flow, liquid reagents will solubilize and transport along the path the deposited reagents, triggering specific reactions and allowing the chemiluminescence detection by the photodiodes.

ABCS also mounts an ancillary radiation dose payload, to investigate the degradation of of electronic components exposed to the space environment. The device has twin components protected by established radiation screens, kindly provided by Thales Alenia Space Italia and by CESI, so that the degradation can be assessed on the basis of the difference between the observed currents.

ABCS architecture and payload are based on the strong heritage gained by the research team with the ground validation of the PLEIADES (Planetary Life Explorer with Integrated Analytical Detection and Embedded Sensors) instrument, an R&D ASI project recently concluded.

Enviromental challenges

The main challenges of the project are to mitigate the effects of the expected very high flux of charged particles, keeping the correct temperature (4°C/25°C) and pressure (about 1 atm) range for the payload to prevent reagents degradation. This invoked a series of technological solution to protect the payload. The pressurized environment is ensured by an inner aluminium box, hosting both the experiment and the main subsystems (batteries, on-board data handling, telemetry, tracking and control) hermetically sealed and providing shielding from radiation and charged particles. A thermal control system, including a passive control multi-layer insulation and an active heather mounted inside the pressurized box, maintain the temperature in the desired range.

Conclusion

ABCS mission aims at evaluating the overall system functionality (delivery of reagents, mixing of chemicals, LoC characterization, detection of emitted photons, readout noise, etc.) such as the chemicals and biomolecules stability (reagents and antibodies employed in the experiment) in the extremely harsh environment.

The in-orbit validation of the proposed technology would represent a significant breakthrough for autonomous execution of bio-analytical experiments in space with potential application in search for signs of life in planetary exploration missions, space biolabs without human support, health monitoring in manned missions.