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# AstroBio CubeSat: operational design of a CubeSat for astrobiological purposes in radiative environment

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## Introduction

Astrobiology is an interdisciplinary field covered by only a few CubeSat missions so far. Moreover, no CubeSat mission has ever mounted miniaturized technology for the purpose of searching for molecular evidences of life in space.

AstroBio CubeSat (ABCS) is a 3U CubeSat selected by the European Space Agency (ESA) to be launched in spring 2022 with the Vega C maiden flight, as piggy back passenger of the ASI LARES2 mission. ABCS will host a payload assembly based on Lab-on-Chip (LoC) technology for biomarkers detection and will be deployed along a circular orbit with altitude of about 5900 km and inclination of 7°, therefore crossing the inner Van Allen belt where the radiation flux is close to its maximum. Due to the harsh environment, ABCS payload and subsystems will be likely exposed to damages and degradations of electronics and performances, thus the payload assembly and the operational architecture were designed to be as much dependable as possible. This approach should constitute the first step to implement a mature technology with the aim to check the stability of chemicals and biomolecules involved in space experiments.

This work reports an overview of ABCS architecture and the approach chosen for its operational design.

## ABCS Architecture

ABCS objective is to test in space an automatic in-situ multiparameter LoC [1], which exploits luminol injection and enzymatic bio-mimicking assays on a functionalized 3D wax-printed origami. Luminol will be transported by capillarity to reaction sites with immobilized biomolecules targets where the reactions will trigger chemiluminescence, detected by means of hydrogenated amorphous silicon (a-Si:H) photodiodes deposited on a borosilicate glass substrate and connected to a photocurrent readout board [2]. The described payload consists in an experiment board hosting the

LoC and a support board containing peristaltic pumps for luminol injection, drivers for pumps, radiation field effect transistors (RADFETs) and pressure/temperature sensors. The LoC architecture allows to repeat the experiment up to six times.

In addition to RADFETs, ABCS mounts an ancillary radiation dose sensor (ARDS), developed by Thales Alenia Space, with the aim to assess the radiation effects. The ARDS is able to measure different amounts of current, until its failure, depending on the dose acquired.

To mitigate the effects of the expected very high flux of charged particles, an extra tungsten layer shielding was mounted on each side panel and all the main subsystems (experiment and support board, batteries and EPS board, on-board computer (OBC), telemetry, tracking and control board), were placed inside a 5 mm thick aluminium box. At the same time, to keep the temperature range (from 4°C to 20°C) and operative pressure (about 1 atm) required to allow the LoC capillarity effect and to prevent reagents degradation, the box was sealed and a thermal control system, composed by a multi-layer insulation and an active heather mounted inside the box, was implemented.

**ABCS Mission Design**

ABCS will be deployed in an approximately circular orbit at about 5900 km altitude and 70° of inclination, spending a significant amount of the orbital period within the inner Van Allen belt, very close to its radiation peak point.

ABCS ground operations will be mainly performed from the School of Aerospace Engineering (SIA) Ground Station. Simulations show that SIA will have access to ABCS 4 times a day, with an average duration of about 65 minutes. For this reason, a network of radioamateurs and third part ground stations will be involved for supporting the collection of the telemetry and science data packages and possibly uplink commands.

**ABCS Operations**

The assumption we made is that ABCS should be able to perform the payload operations in a completely autonomous manner. As we know, radiation flux will most likely induce several errors on electronics and performances, causing potential mission failure due to the fact that payload operations may not start because the OBC fails to send the command to start the experiment. A possible way to reduce failure is to perform ABCS experiments where the proton flux is lower. Simulations shows that this happens when ABCS is at polar latitudes, namely outside the range [-60°; 60°]. For this reason, the payload operations, based on redundant checks and triggers, were implemented accordingly. The purpose is to automatically determine if ABCS is at a latitude useful to perform the experiments and verifying this condition by means of multiple triggers, time or position based. Each trigger is used for scheduling purposes only if the ones with higher priority are unreliable. If all the triggers are not reliable, payload operations are forced to begin, as it is better to perform eventually degraded payload operations rather than performing no payload operations at all.

**Conclusions**

ABCS is required to operate in an extremely harsh environment where radiation fluxes are likely to degrade the electronic devices. Operations should be scheduled in order to reduce the time needed to perform all the experiments. The chosen approach will lead ABCS to complete the payload operations in three orbital periods, reducing the total ionizing dose absorbed and guaranteeing the higher system reliability.

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