AstroBio-CubeSat a new tool for astrobiology in space

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Overview

Design and construction of a CubeSat with a new analytical platform based on the use of liquid reagents with lab-on-chip technologies capable of providing an integrated solution for the detection of biomolecules in space environments.

AstroBio CubeSat (ABCS) is an Italian 3U CubeSat to be launched with the Vega C maiden flight in 2022

ABCS hosts a micro laboratory based on Lab-on-Chip (LoC) technology able to provide a platform for an automatic bioanalytical experiments in space

The platform uses immunoassays to exploit chemiluminescence signals detected by photosensors

ABCS Team

INAF - OAA (science, design, management)

PI - John Brucato

School of Aerospace Engineering of Sapienza University (design, manufacturing, operations)

Augusto Nascetti

University of Bologna (science)

Mara Mirasoli

University of Torino (science)

Laura Anfossi

SME Kayser Italia (system integration, engineering)

Michele Balsamo

ASI (program manager)

Simone Pirrotta

Stima dell'inviluppo complessivo di FTE INAF dall'inizio a fine attività 8.4
Stima delle FTE INAF a Tempo Indeterminato dall'inizio a fine attività 0.4
Stima dell'inviluppo complessivo di FTE (includendo tutti i partners dall'inizio a fine attività) 13.0

Science & Technology

The scientific applications are:

- Search for signs of life in planetary exploration missions
- Space biolabs without human support
- Health monitoring in manned missions

- The technological aims are:
  - Functional tests of the system (delivery of reagents, mixing of chemicals)
  - LoC characterization (detection of emitted photons, noise)
  - Chemicals and biomolecules stability evaluation (reagents and antibodies employed in the experiment)

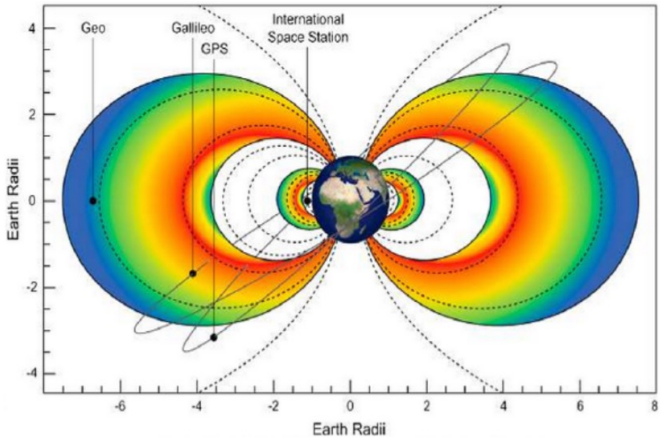
Scheduled Mission - Launch and Orbital Parameters

Vega C

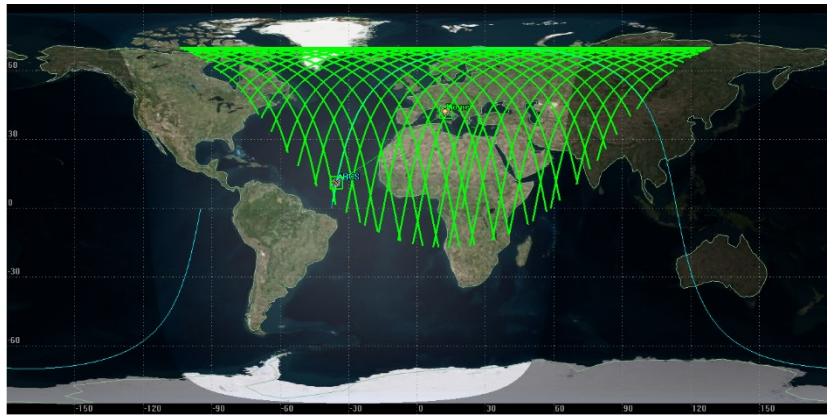
ABCS will be launched by Vega C maiden qualification flight from CSG in 2022 as secondary payload of the mission whose primary payload will be LARES 2 satellite

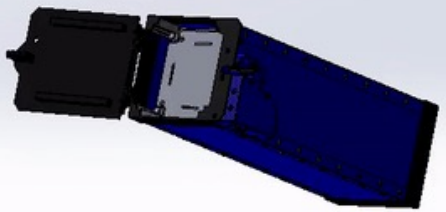
ABCS will be deployed in a circular orbit, at about 5850 km of altitude and 70° of inclination

ABCS will spend part of the orbital period within the internal Van Allen belt



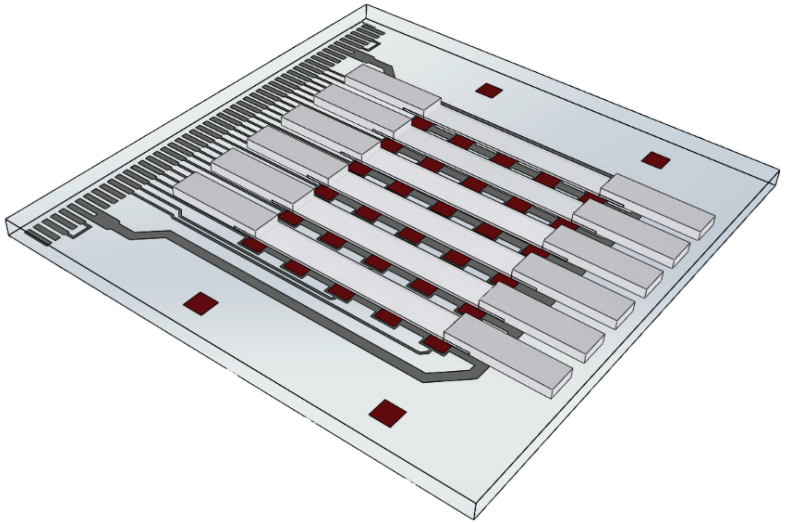
Source: Sarno-Smith, Lois. (2015). A Radiation Belt MeV Electron Flux Comparison Between RBE and GOES-15. CCMC.

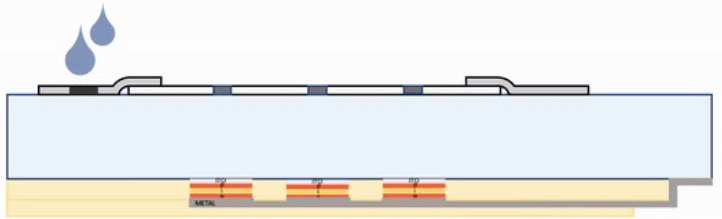




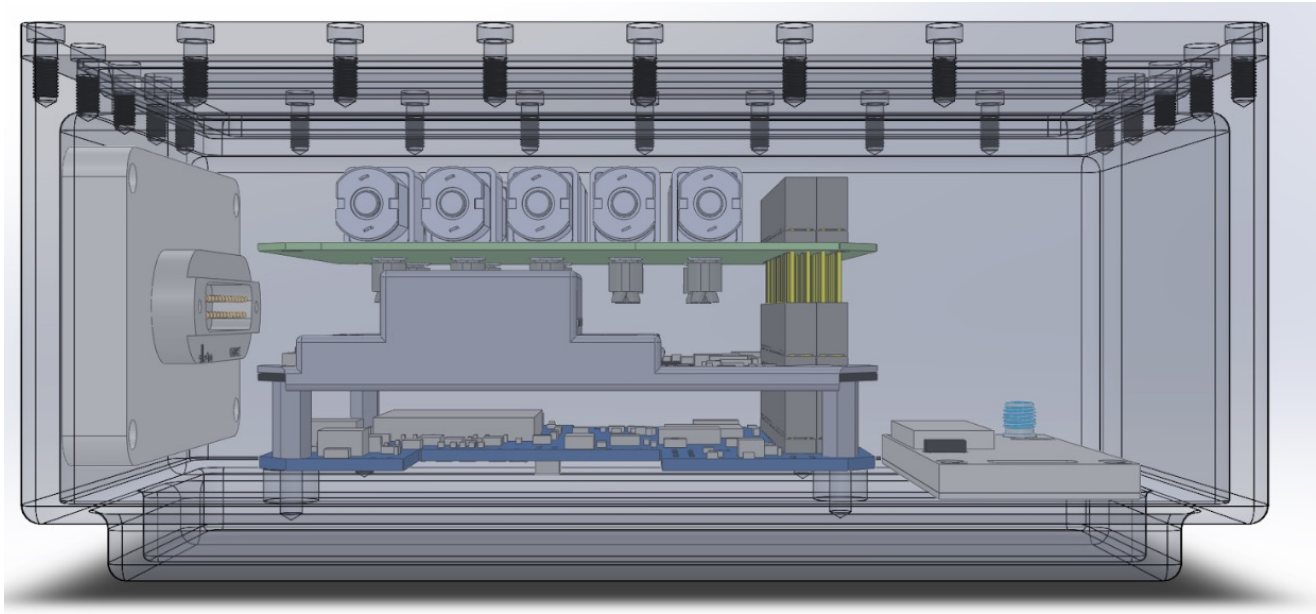
Payload/1

- Six Lateral Flow Immunoassay (LFIA) on strips with immobilized target biomolecules interfaced with a glass chip with integrated thin film sensors
- Dry reagents are deposited in a non-permanent fashion in the initial part of the strips
- Liquid reagents are provided by six pumps to each starting pad: reagents move through the strips by capillarity.
- Liquid reagents solubilize and transport the dry reagents, triggering chemiluminescent reactions in the test line
- On-chip a-Si:H photodiodes detect the emitted signal

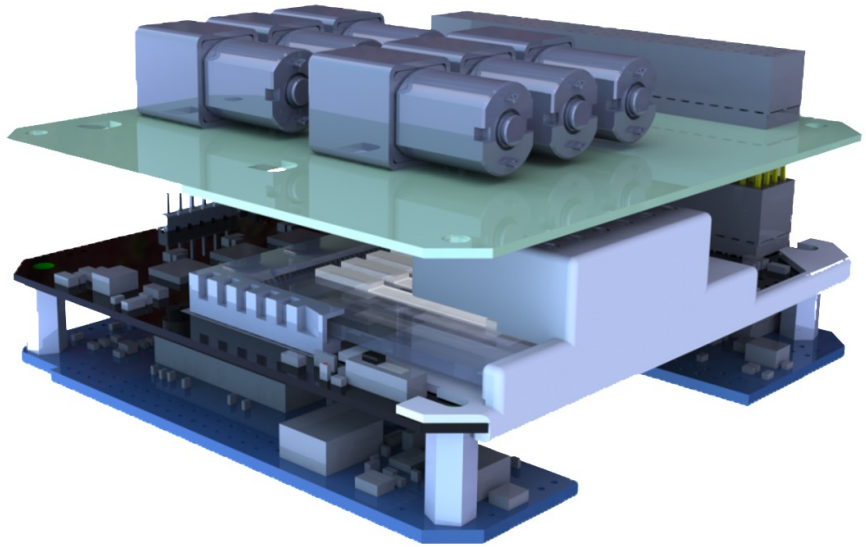




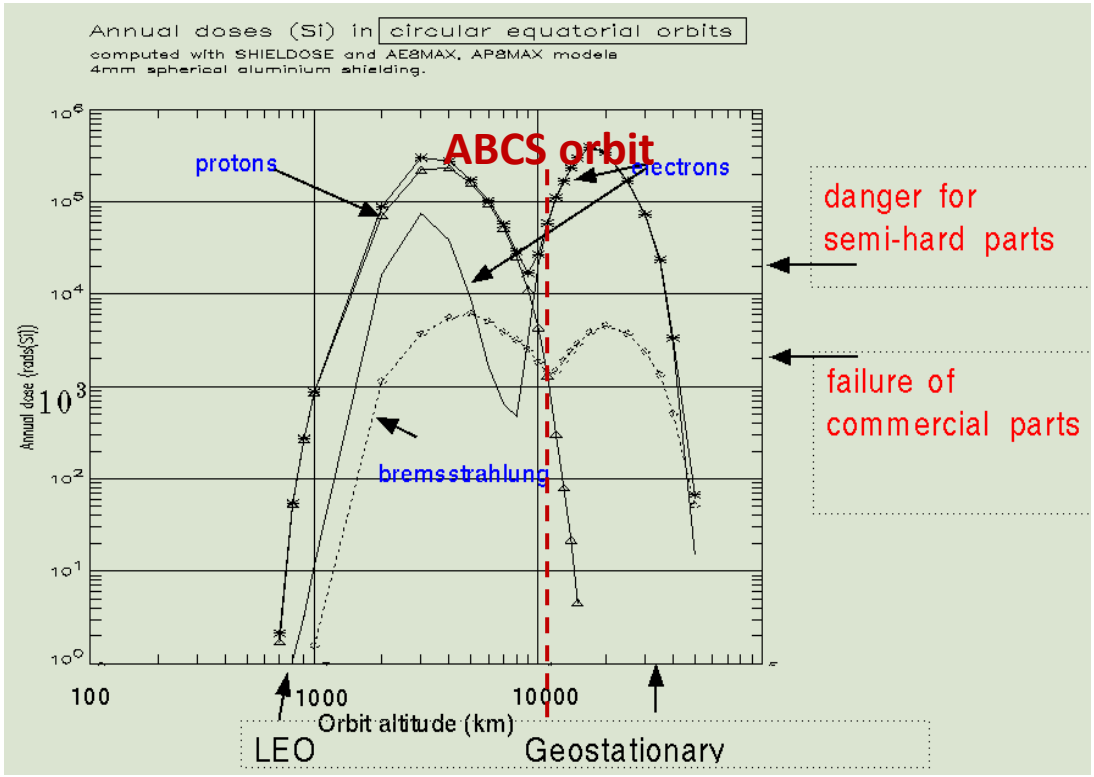
Payload/2



- Compact in size: payload box 160x106x80 mm also including OBC, radio, active thermal control, pressure/temperature sensors, RADFETs, radiation shielding, voltage regulator and battery pack
- High specificity and detectability
- Minimum reagents and power consumption
- Mechanically stable



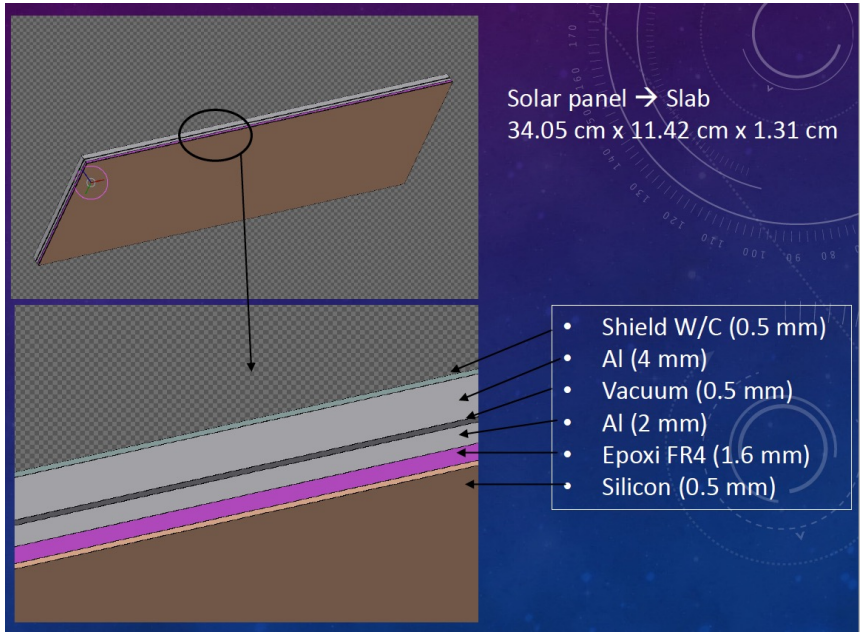
Challenges - Radiation environment



Source: E.J. Daly et al., "Space Environment Analysis: Experience and Trends" ESA 1996 Symposium on Environment Modelling for Space-based Applications, ESTEC, Noordwijk (NL)

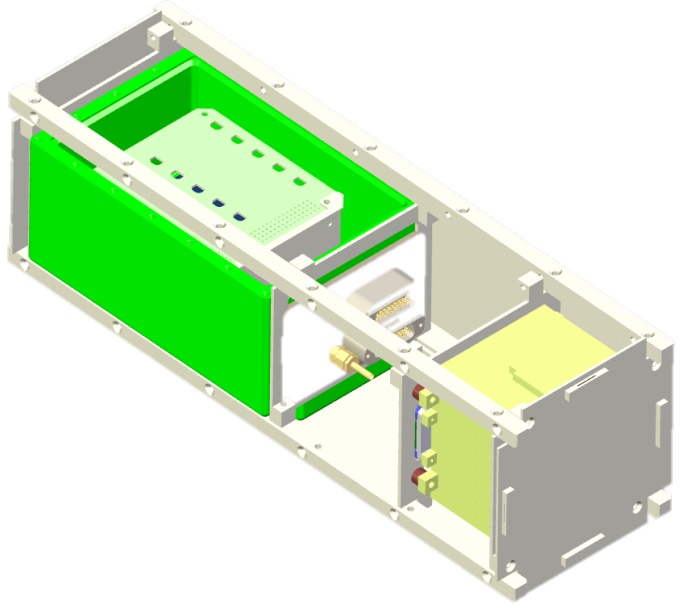
ABCS will experience a high flux of charged particles.

- Main expected impacts:
  - Degradation of the solar panels;
  - Total Ionizing Dose (TID) affects the electronics;
  - Single Event Effects (SEEs) affects the electronics.
  - Reagents stability;
  - Readout noise.

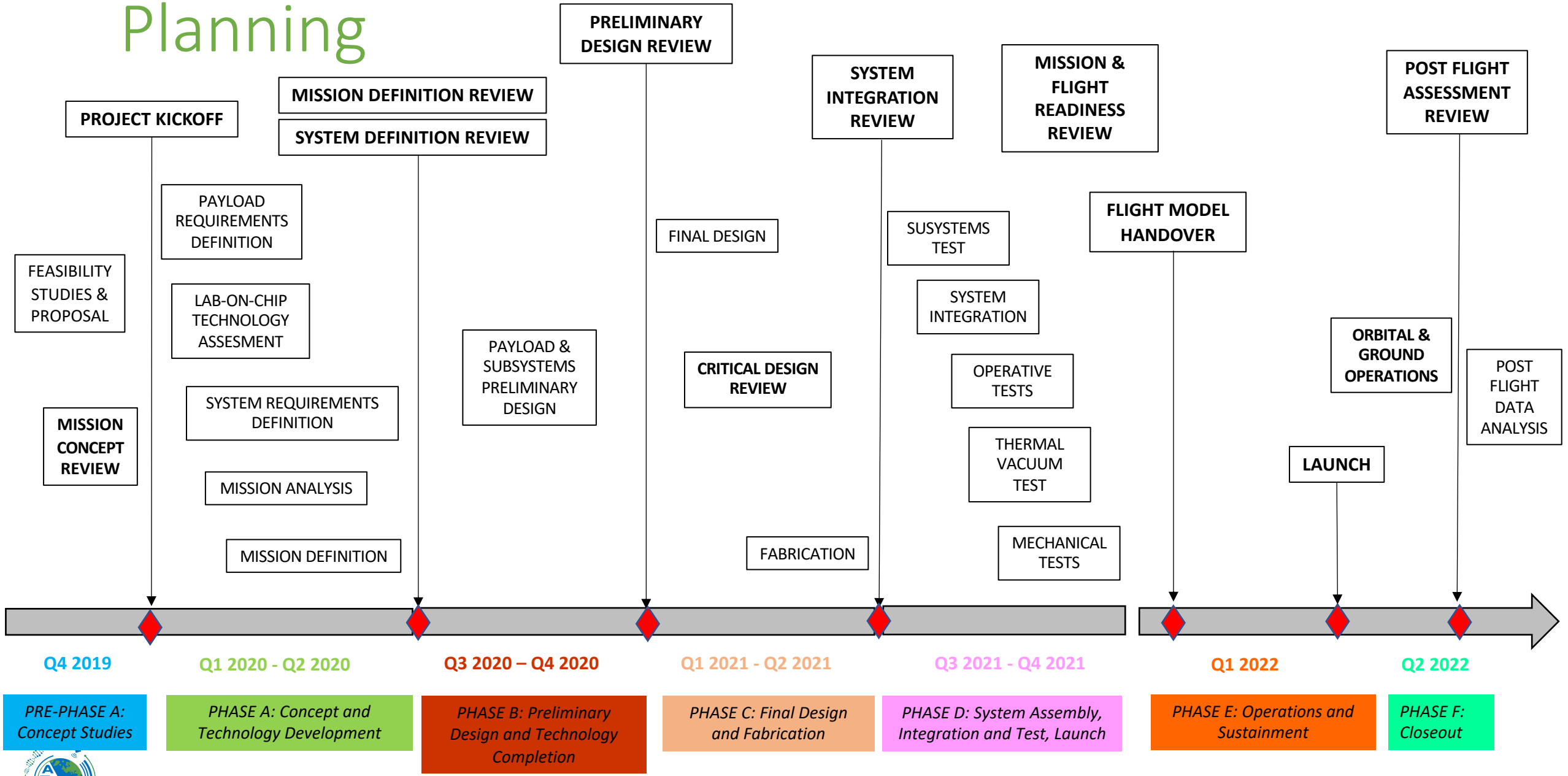


Technological Solutions

- The subsystems are mounted inside a pressurized aluminum box, which is hermetically sealed.
- The box provides a shielding from radiation and charged particles.
- Main advantages are:
  - Pressurized environment facilitates heat exchange due to air conduction (no natural convection) and exploits passive thermal control;
  - Electronics benefit from the shielding and contributes to heating;
  - Batteries operate at atmospheric pressure.



Planning


PRELIMINARY DESIGN REVIEW
MISSION DEFINITION REVIEW
SYSTEM DEFINITION REVIEW
PROJECT KICKOFF
SYSTEM INTEGRATION REVIEW
MISSION & FLIGHT READINESS REVIEW
POST FLIGHT ASSESSMENT REVIEW
PAYLOAD REQUIREMENTS DEFINITION
FINAL DESIGN
SUSYSTEMS TEST
FLIGHT MODEL HANDOVER
FEASIBILITY STUDIES & PROPOSAL
LAB-ON-CHIP TECHNOLOGY ASSESMENT
SYSTEM INTEGRATION
ORBITAL & GROUND OPERATIONS
PAYLOAD & SUBSYSTEMS PRELIMINARY DESIGN
CRITICAL DESIGN REVIEW
OPERATIVE TESTS
POST FLIGHT DATA ANALYSIS
MISSION CONCEPT REVIEW
SYSTEM REQUIREMENTS DEFINITION
THERMAL VACUUM TEST
LAUNCH
MISSION ANALYSIS
MISSION DEFINITION
FABRICATION
MECHANICAL TESTS
Q4 2019
Q1 2020 - Q2 2020
Q3 2020 – Q4 2020
Q1 2021 - Q2 2021
Q3 2021 - Q4 2021
Q1 2022
Q2 2022
PRE-PHASE A: Concept Studies
PHASE A: Concept and Technology Development
PHASE B: Preliminary Design and Technology Completion
PHASE C: Final Design and Fabrication
PHASE D: System Assembly, Integration and Test, Launch
PHASE E: Operations and Sustainment
PHASE F: Closeout

Budget

Accordo ASI/INAF

Stima inviluppo complessivo intera attività (k€): 350
Stima inviluppo complessivo per la parte di attività INAF dall'inizio a fine attività (k€): 185
Stima fondi acquisiti da INAF fino al 2020 (k€): 0

Proposta Addendum all'Accordo ASI/INAF

Leadership INAF

PI-ship ABCS mission

Proposta TASTE (vedi scheda) selezionata da ASI per il bando «Future Missioni per Cubesat» oggi in fase di congruità economica

Brevetto INAF per la lotta contro il COVID19

Critical Issues

L’ Accordo nasce in un momento di criticità nei rapporti ASI-INAF:

Non vengono riconosciute le spese per il personale non staff!

Problema generale che discende dal particolare:

Che fare delle professionalità che sono state formate in attività che durano anni?

Capital budget

- Source ASI, ESA, EU
- Covering the costs of the project:
  Engineering, Design, Construction

Operating Budget

- Source INAF (hopefully)
- Laboratory operational & maintenance costs
- Data exploitation post mission operation.

Thank you for your attention!