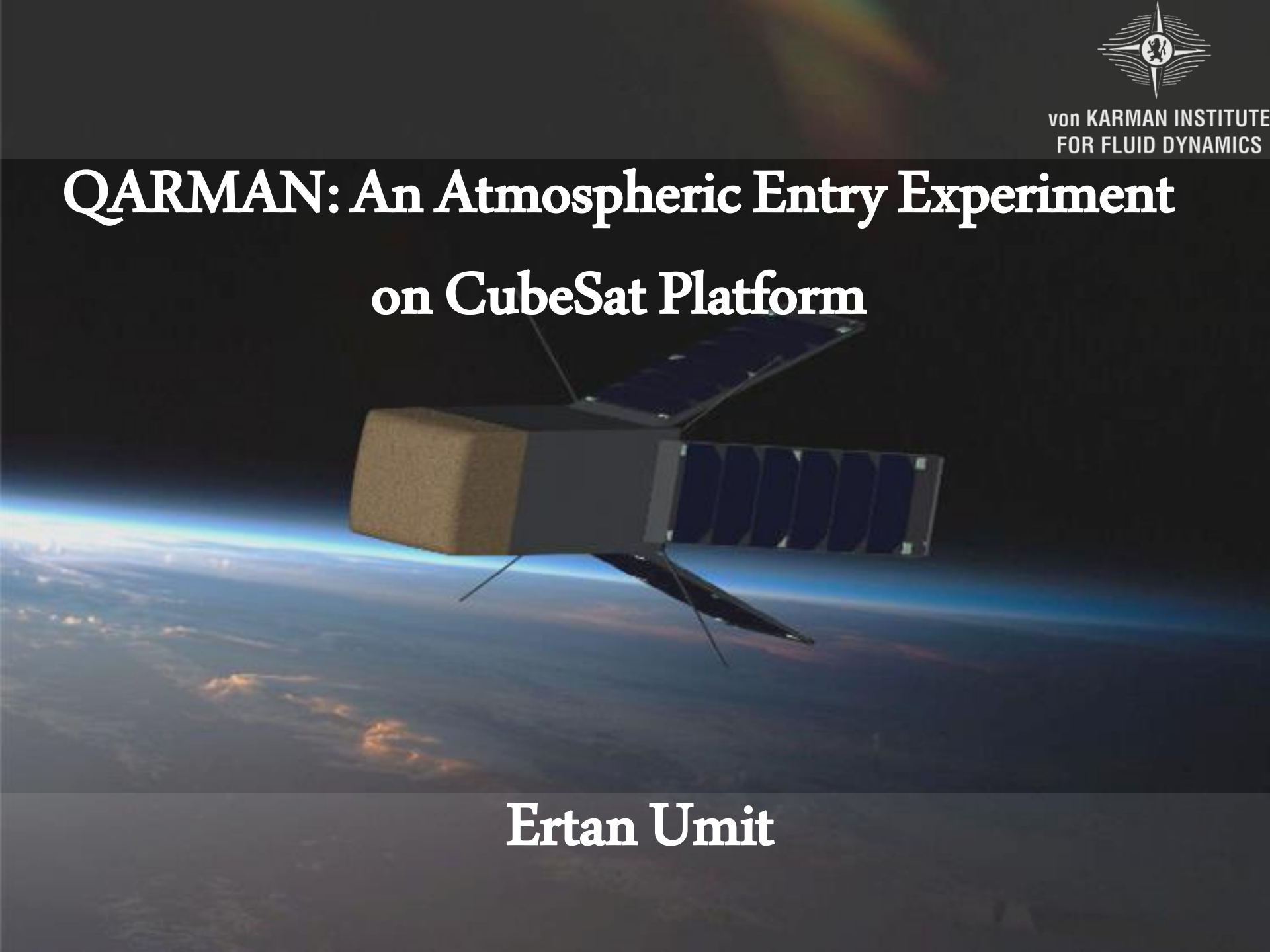


von KARMAN INSTITUTE
FOR FLUID DYNAMICS

QARMAN: An Atmospheric Entry Experiment on CubeSat Platform

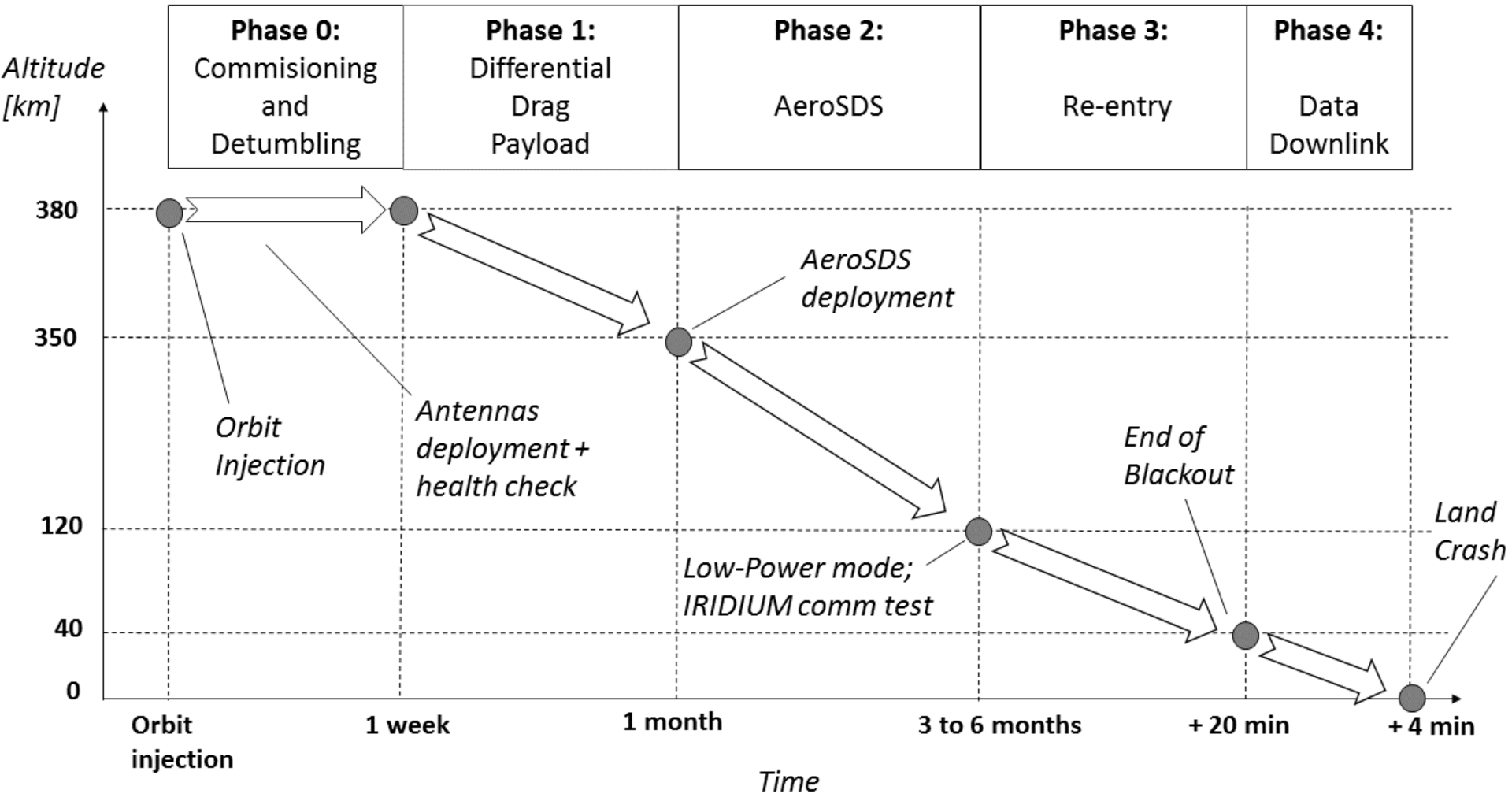
Ertan Umit

Motivations & Objectives

Demonstrate the feasibility of a CubeSat as a re-entry platform

Re-entry IOD			Orbital
Thermal and Structural design validation	Scientific Investigation (XPLs)	Communication system	In orbit demonstration of Differential Drag Maneuvers

Mission Scenario



Challenges

CubeSat Format

- Limited Volume: 30 cm X 10 cm X 10 cm
- Limited weight: up to 4 kg
- Limited power

Thermal Protection

- Orbit VS Re-entry concurrent requirements
- Insulation of Vital components (*Survival Unit* concept)

4 CHALLENGES

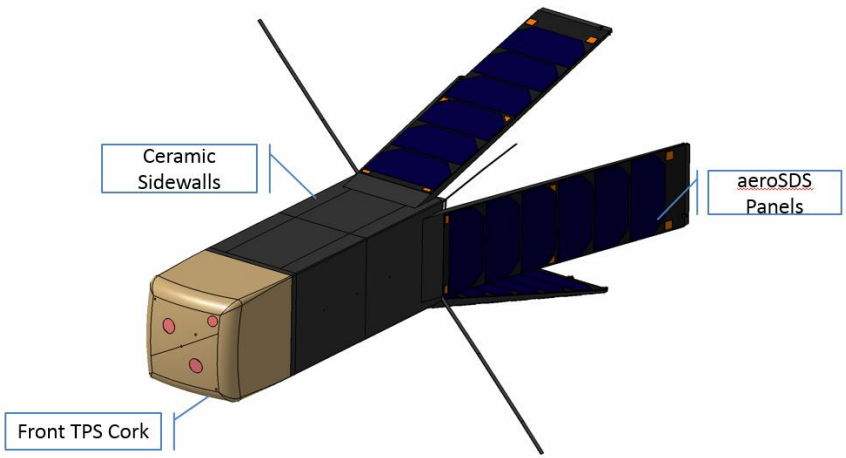
Communication during re-entry

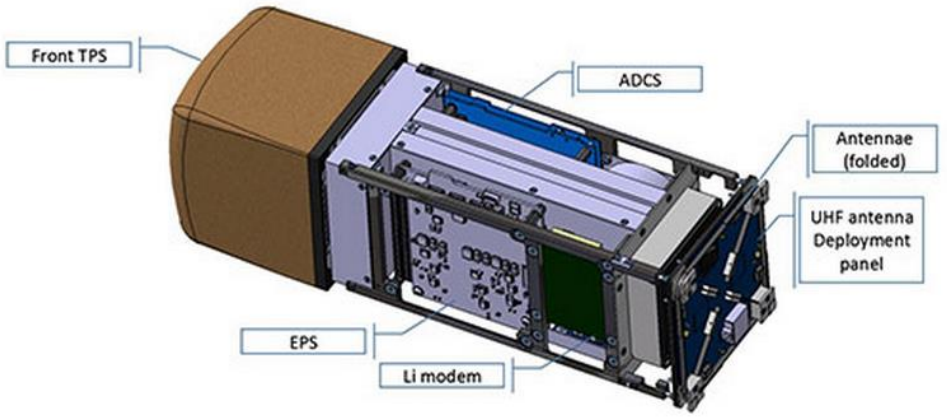
- Blackout during re-entry prevents communication
- 20 minutes of collected data to be transmitted in 3-5 min through IRIDIUM

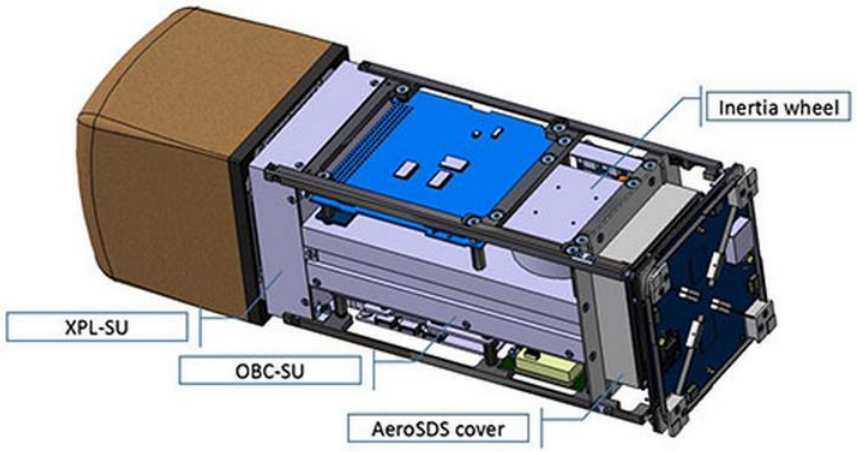
Stability

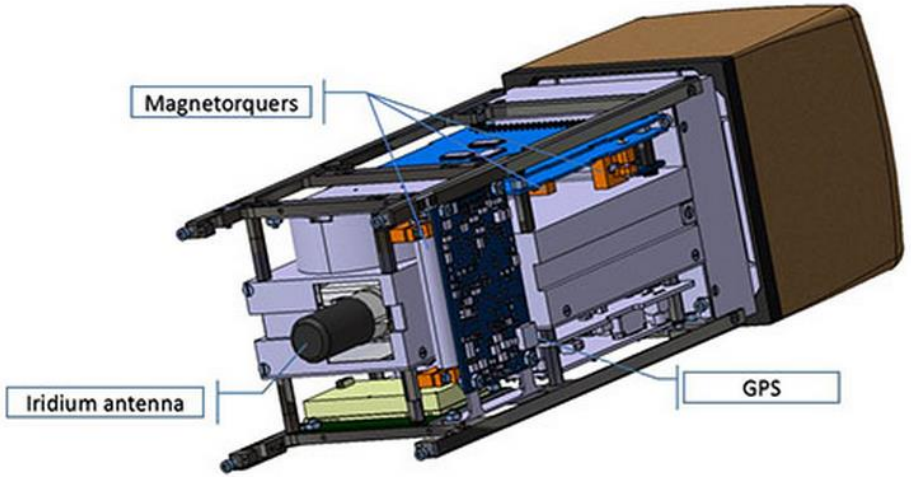
- A stable angle of attack during reentry must be maintained

Design Overview

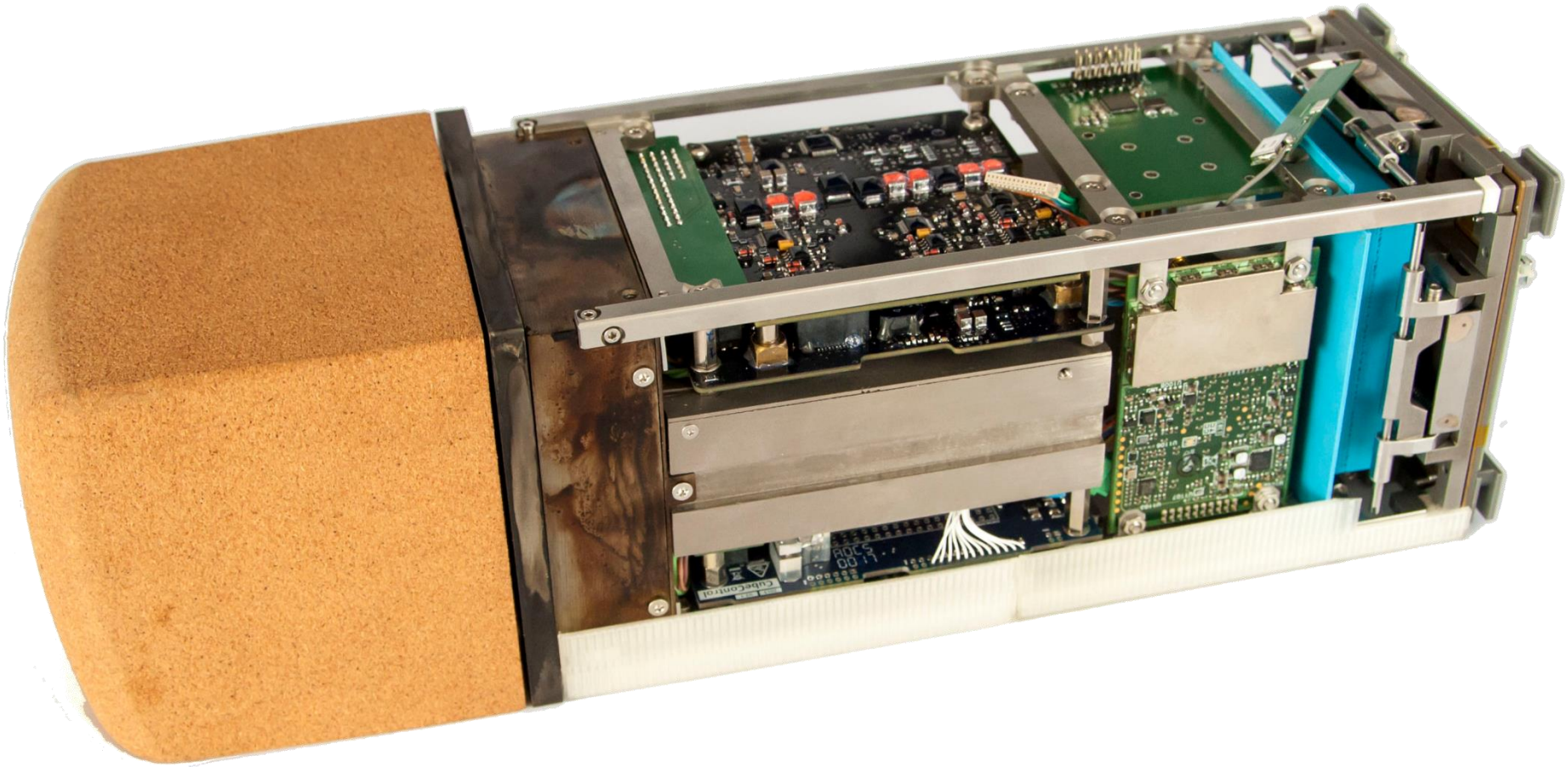




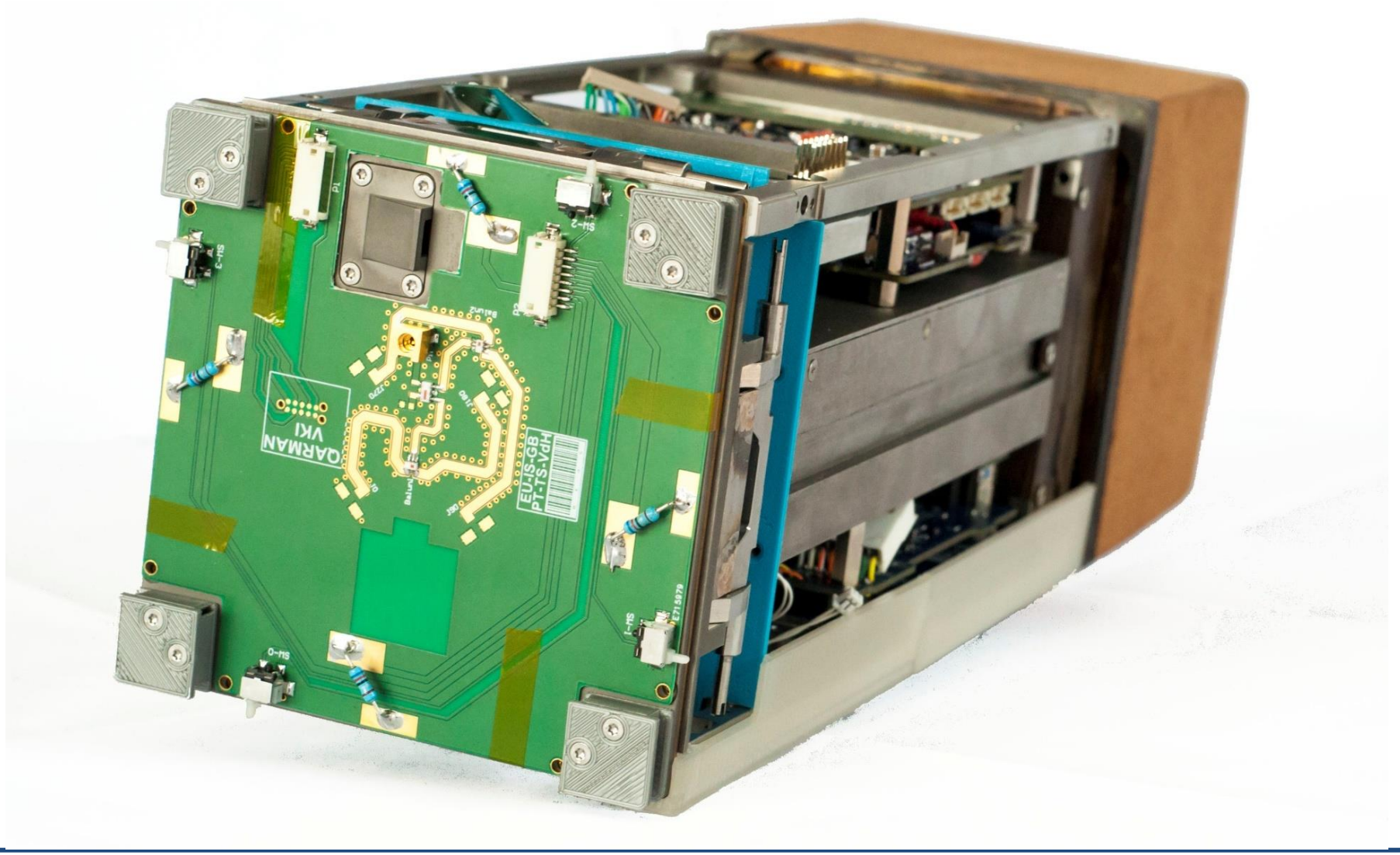




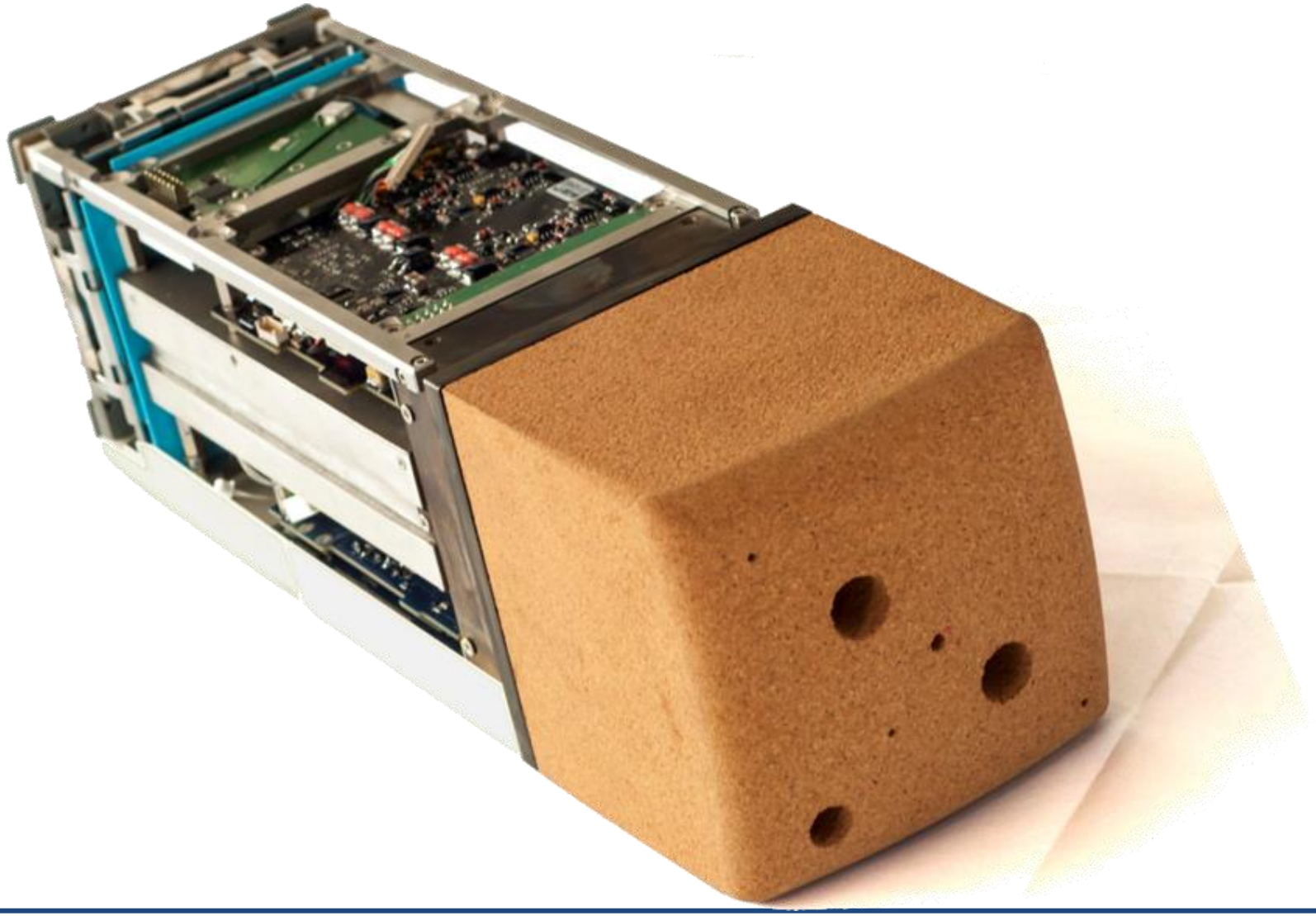
Engineering Model (I)



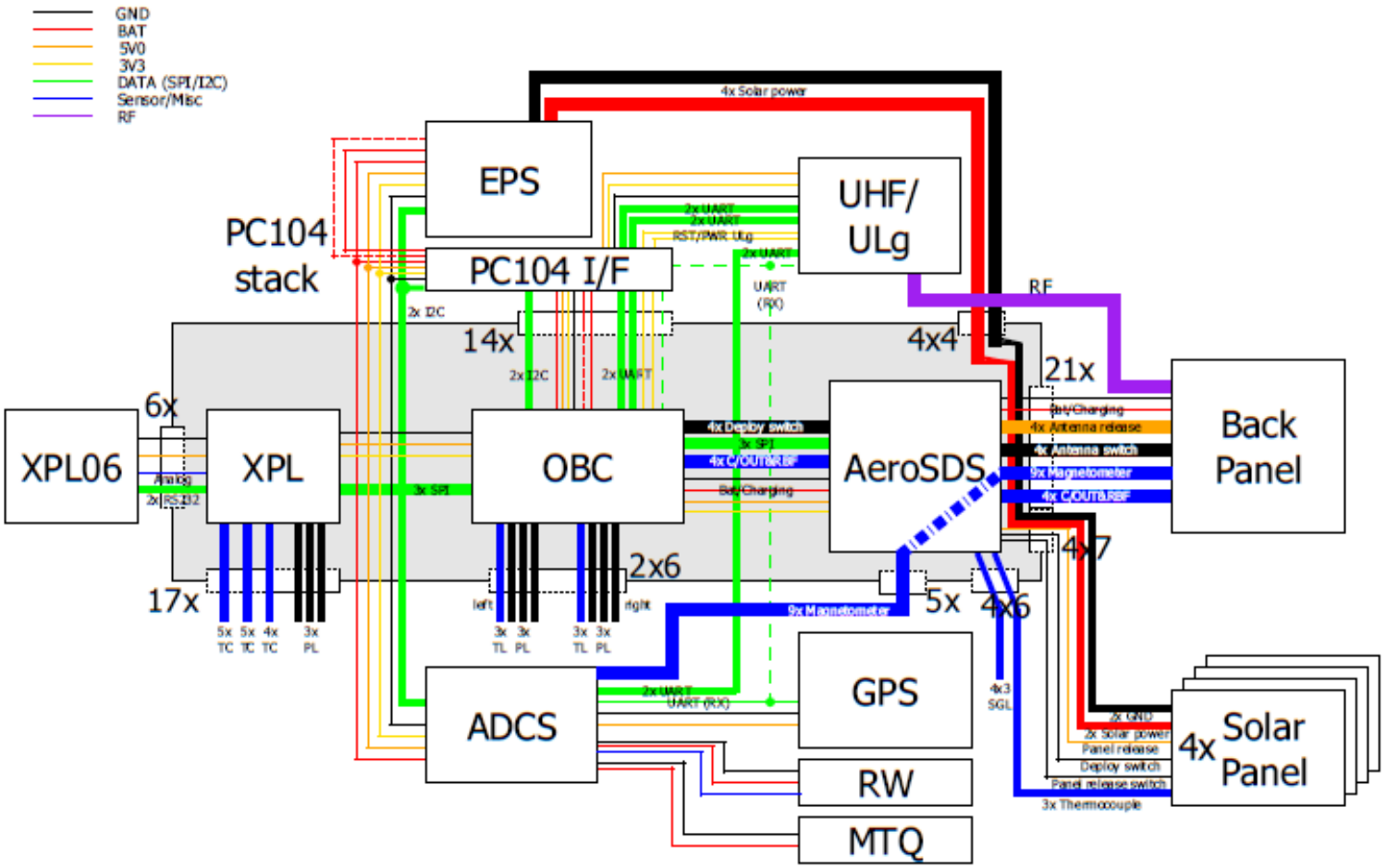
Engineering Model (II)



Engineering Model (III)

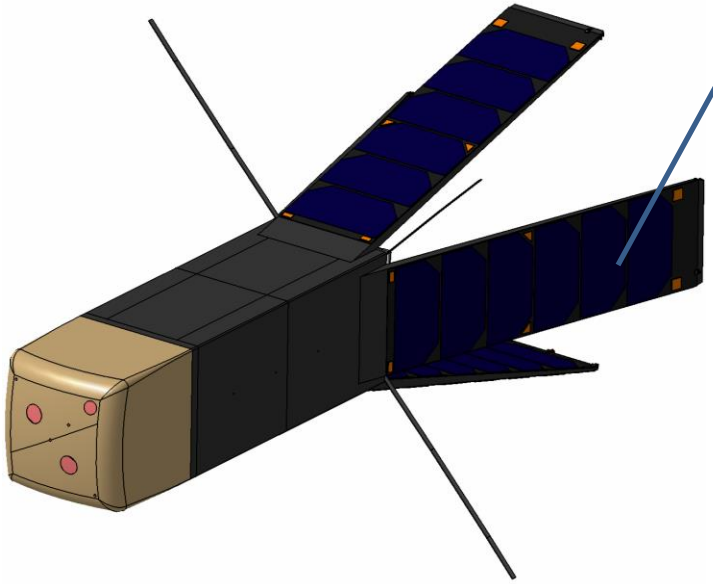


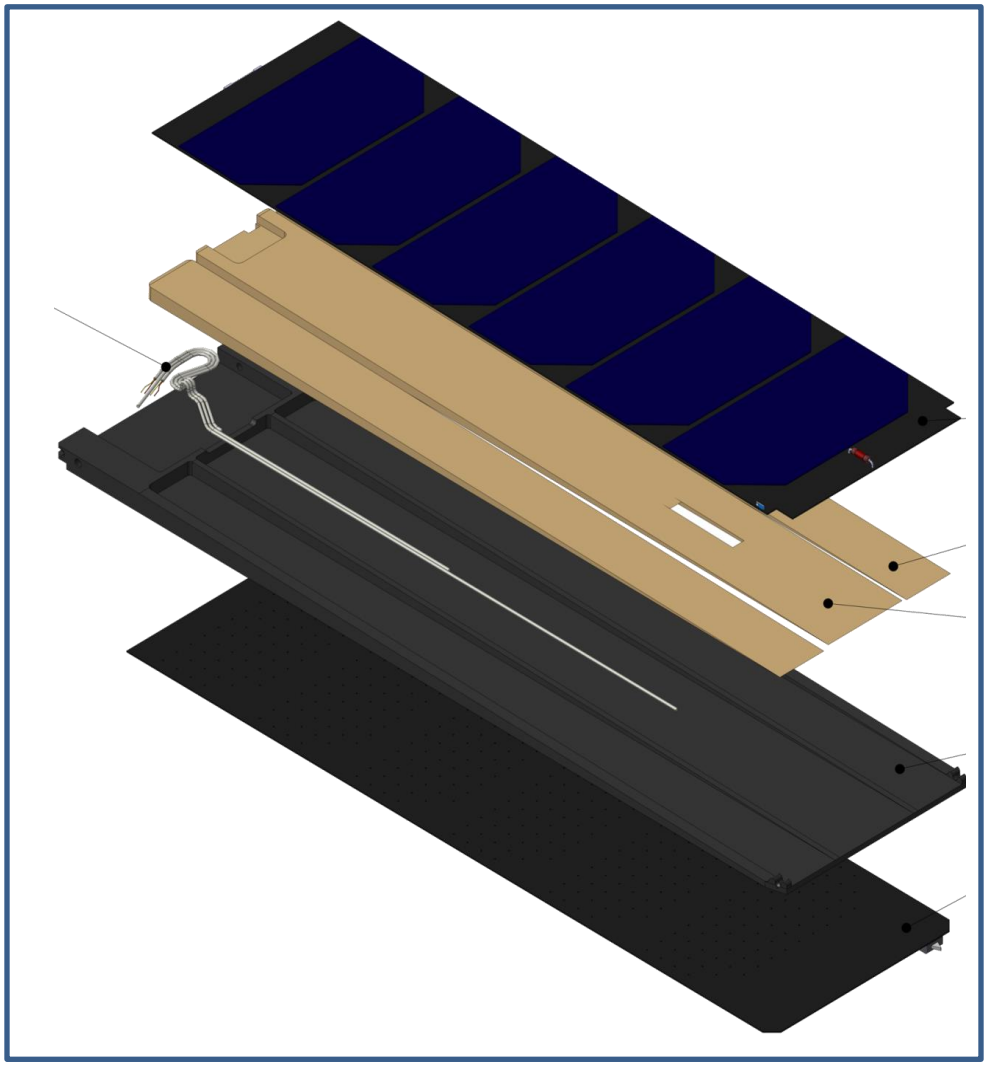
Electrical Design



AeroSDS

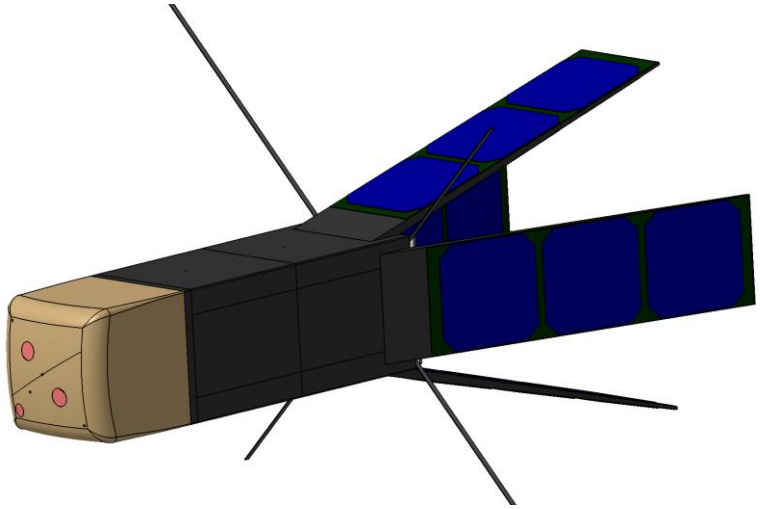
- 4 deployable solar panels
- Aerodynamic stabilization
- Custom designed hinges
  - Double motion
  - Locking mechanism
- Validated via simulations





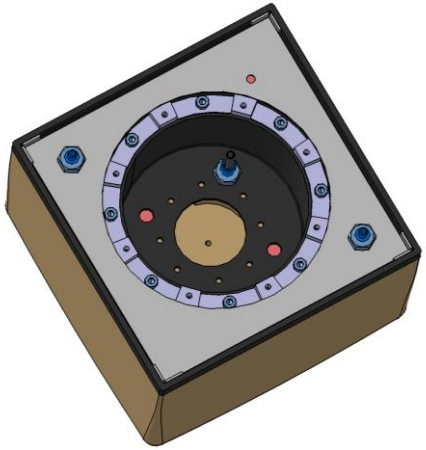
In-Flight Experiments

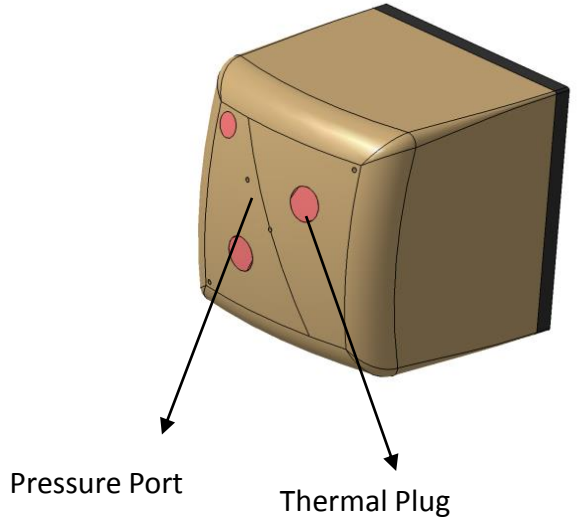
Payload	Objective	Sensor
XPL01	TPS Efficiency	Temperature
XPL02	TPS & Environment, FADS	Pressure
XPL03	Stability, FADS	Pressure
XPL04	Laminar to Turbulent Transition, FADS	Pressure
XPL05	Off-Stagnation Temperature, FADS(?)	Temperature
XPL06	Aerothermodynamic Environment and Radiation	Spectrometry

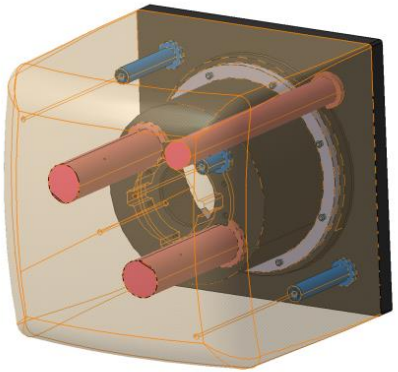


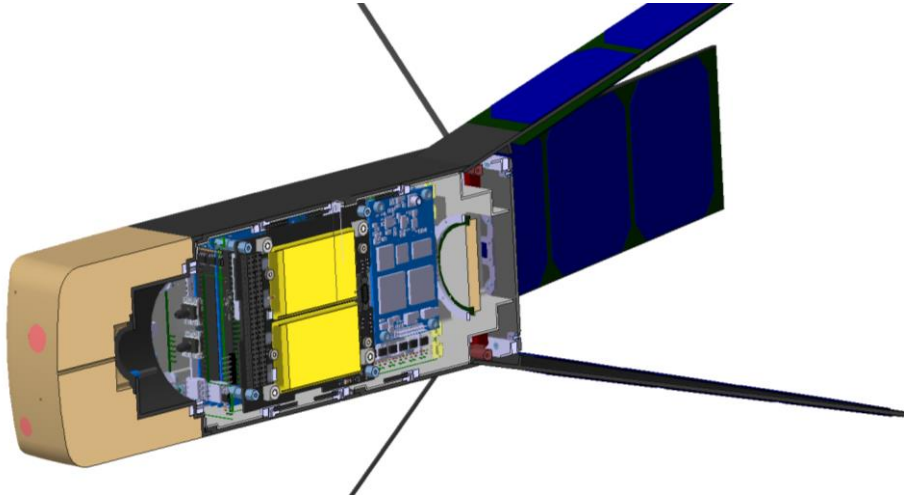
"KISS" Approach!

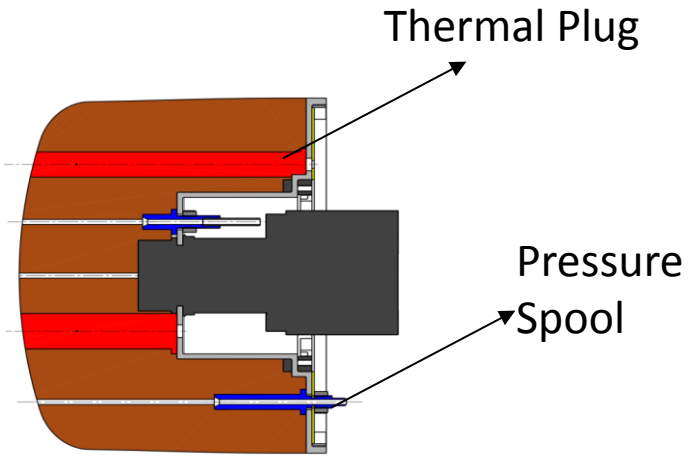
XPL01 & XPL02





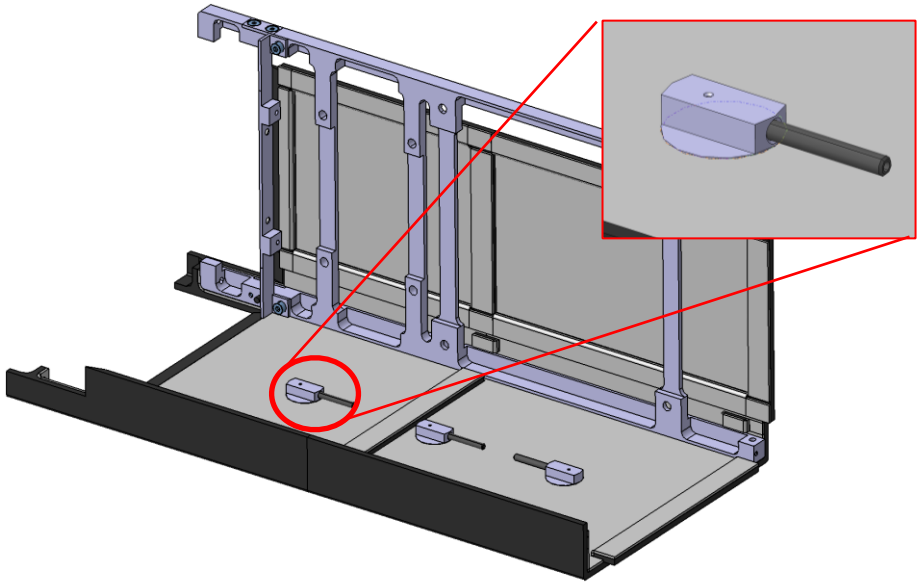






XPL03-04-05

Side Panels: Pressure and Temperature Measurements

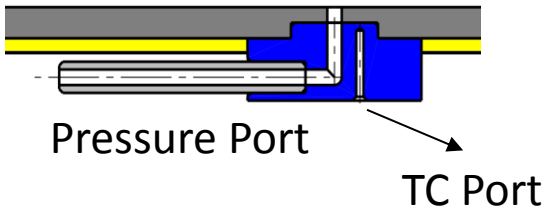


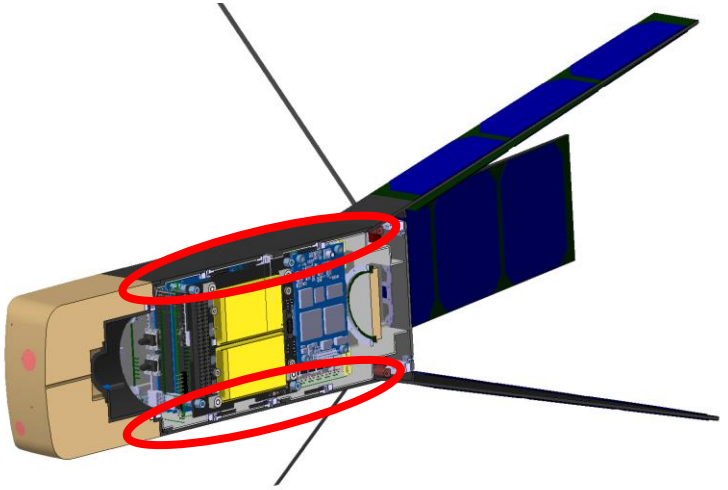
Main Objectives:

XPL03: Stability
XPL04: Transition
XPL05: Temperature measur.

Common Objectives:

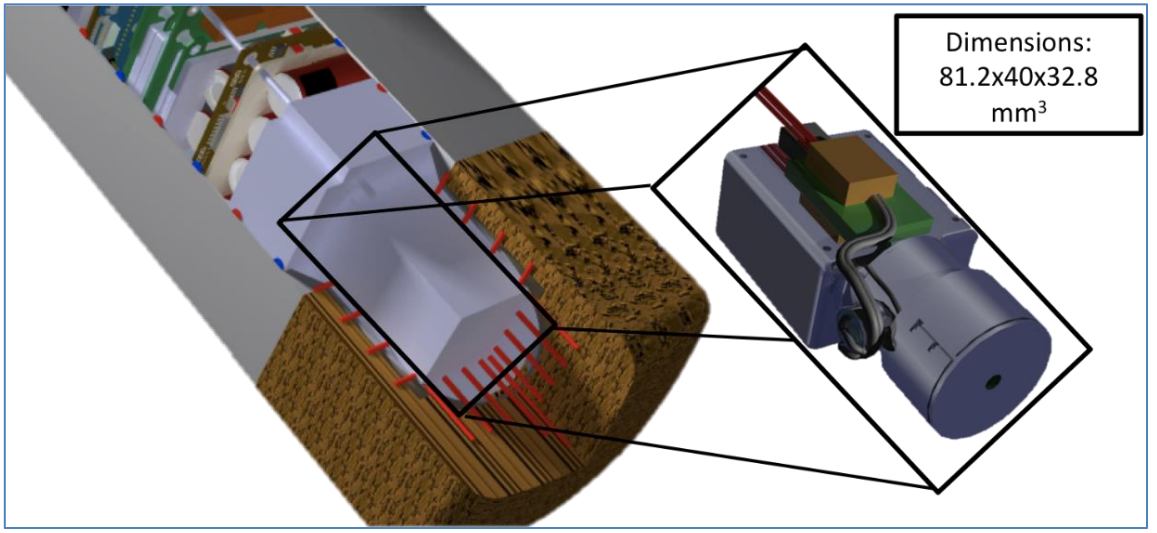
1- FADS for trajectory rebuilding
2- CFD Validation

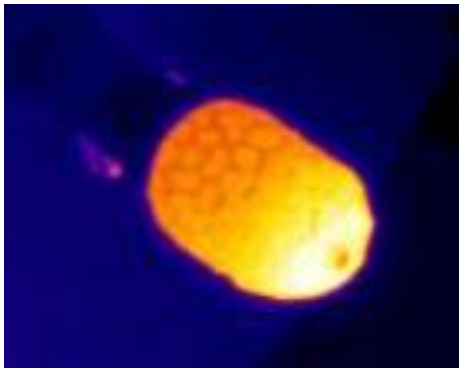


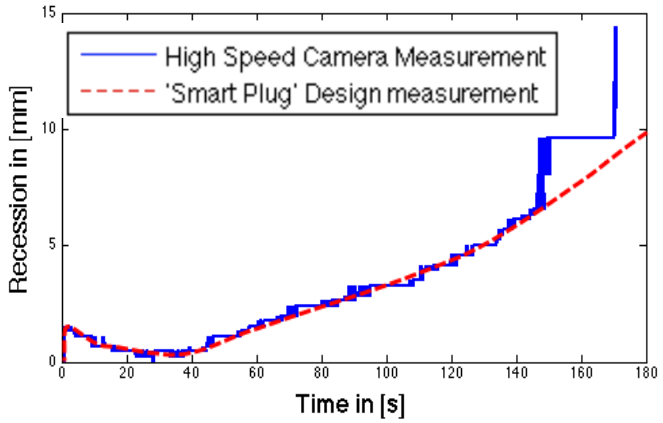


XPL06

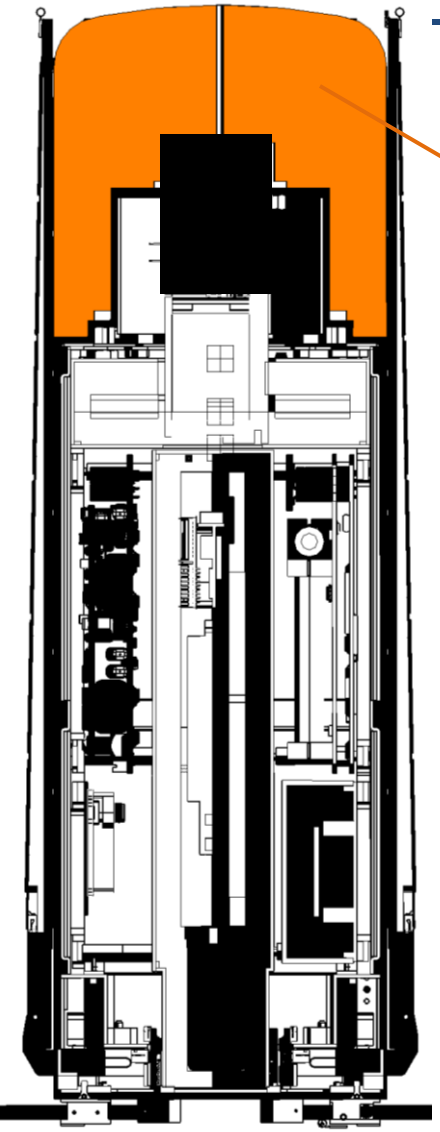
- spectrometry capabilities in a small mass/volume
  - flexible and low cost approach
- First data in the flight range form 120 km to 50 km altitude



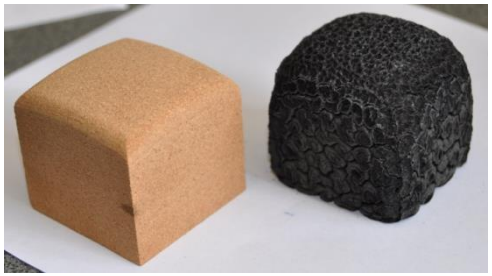


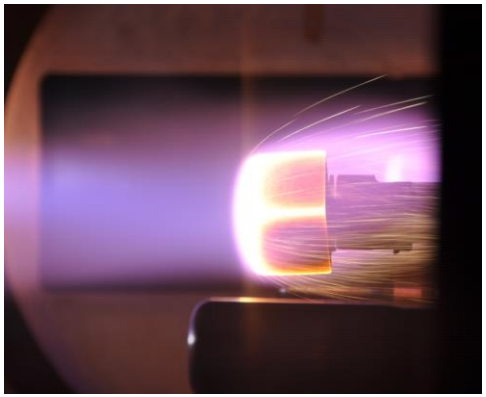


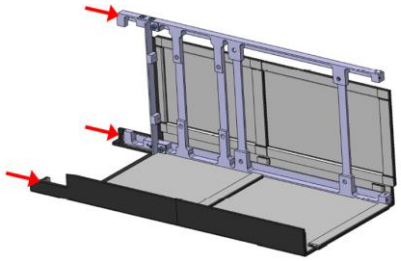
Thermal Protection

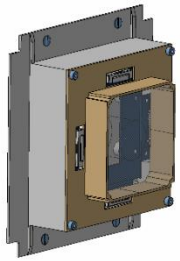


TPS front cork
Ablative material
(P50)



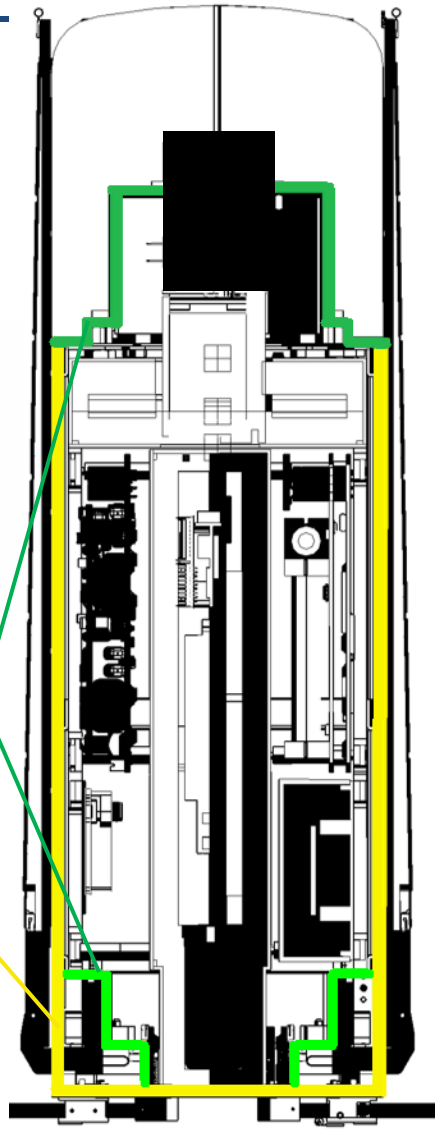




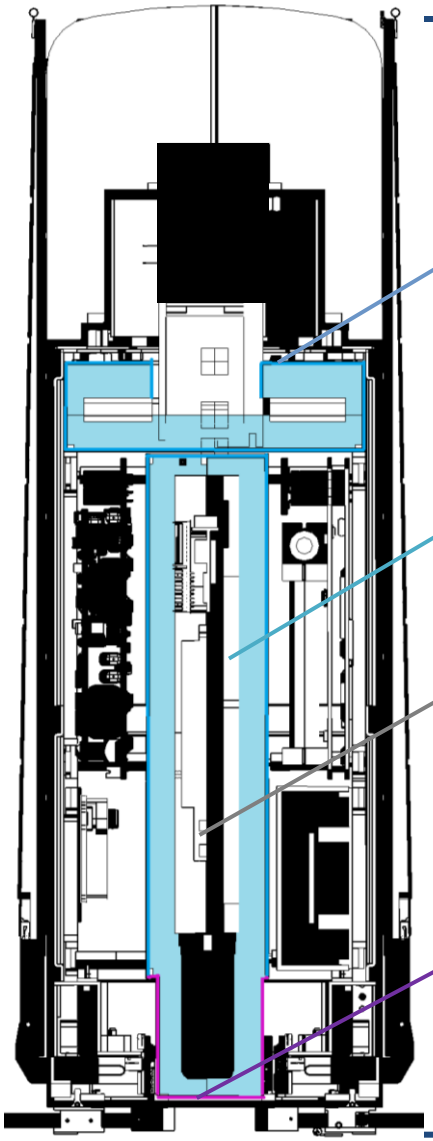


Front and AeroSDS cover
SiC TPS

Side Panels
SiC TPS
Fiberfrax insulation



Survival Unit

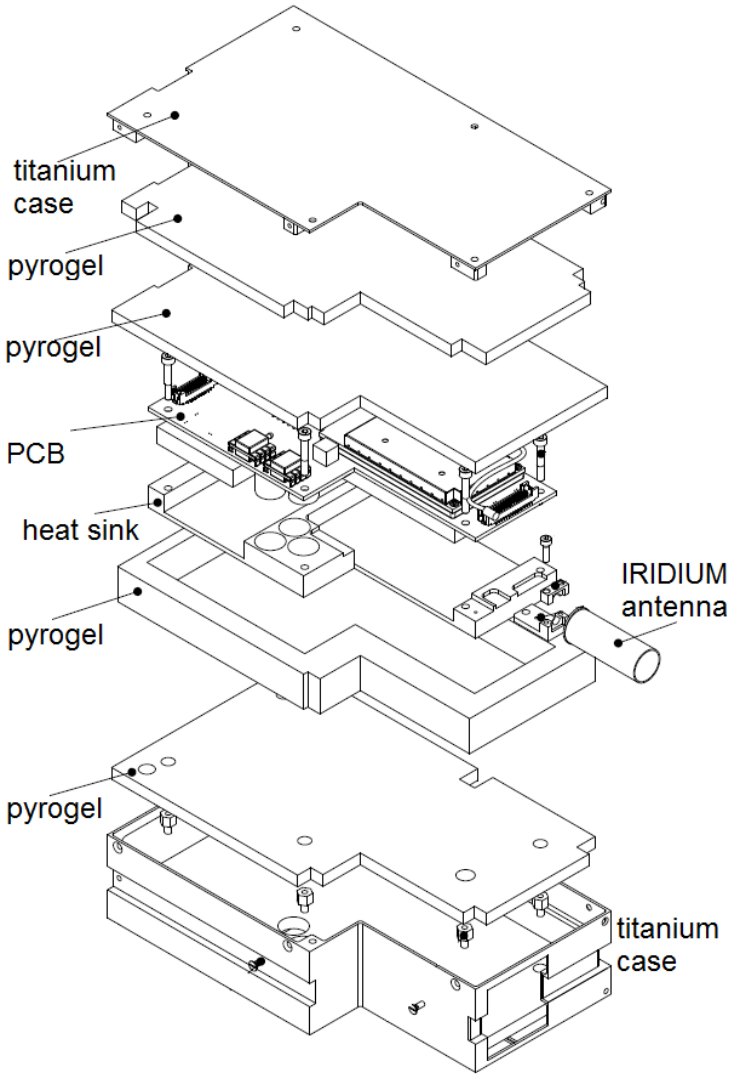


Titanium Enclosure
Heat capacitor
Mechanical interface

Pyrogel Insulation
From 7,5 mm to 12,5 mm; Low conductivity and density

Heat Sink
3mm thick aluminum plate to spread the heat

Ceramic Enclosure
RF transparent (shielding for Iridium antenna)



Communication System

Communication System During Re-entry

- Blackout prevents communication during phase 3 (reentry)
- 20 minutes of data to be transmitted in 4 to 5 minutes

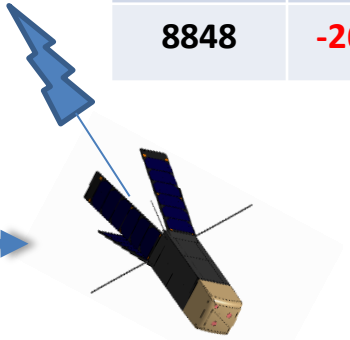
Crash height	data Margin
0	8,72%
474	5,13%
3027	-10,3%
8848	-26,2%

IRIDIUM transmission

Data storage

Data compression

Data prioritization



Data Transmission

Re-entry Black-out
18’

Transmission
4.5’

120km

45km

0km

Conclusions

- QARMAN is a re-entry platform respecting the CubeSat standard format
- 4 main challenges to be faced
  - Thermal protection
  - Stability
  - Data downlink
  - CubeSat standard to be respected
- Scientific Objectives

Thank you! Questions?

- This project is supported ESA GSTP #4000109824/13/NL/MH

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