



Cislunar CubeSats to Measure Radiation in Support for Human Space Exploration

Paolo Guardabasso, Stéphanie Lizy-Destrez

► To cite this version:

Paolo Guardabasso, Stéphanie Lizy-Destrez. Cislunar CubeSats to Measure Radiation in Support for Human Space Exploration. 12th European Cubesat Symposium, Nov 2021, Paris, France. pp.0. hal-03550624

HAL Id: hal-03550624

<https://hal.science/hal-03550624>

Submitted on 1 Feb 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Cislunar CubeSats to Measure Radiation in Support for Human Space Exploration

Paolo **Guardabasso**¹, Stephanie **Lizy-Destrez**¹

¹ISAE-SUPAERO University of Toulouse, France

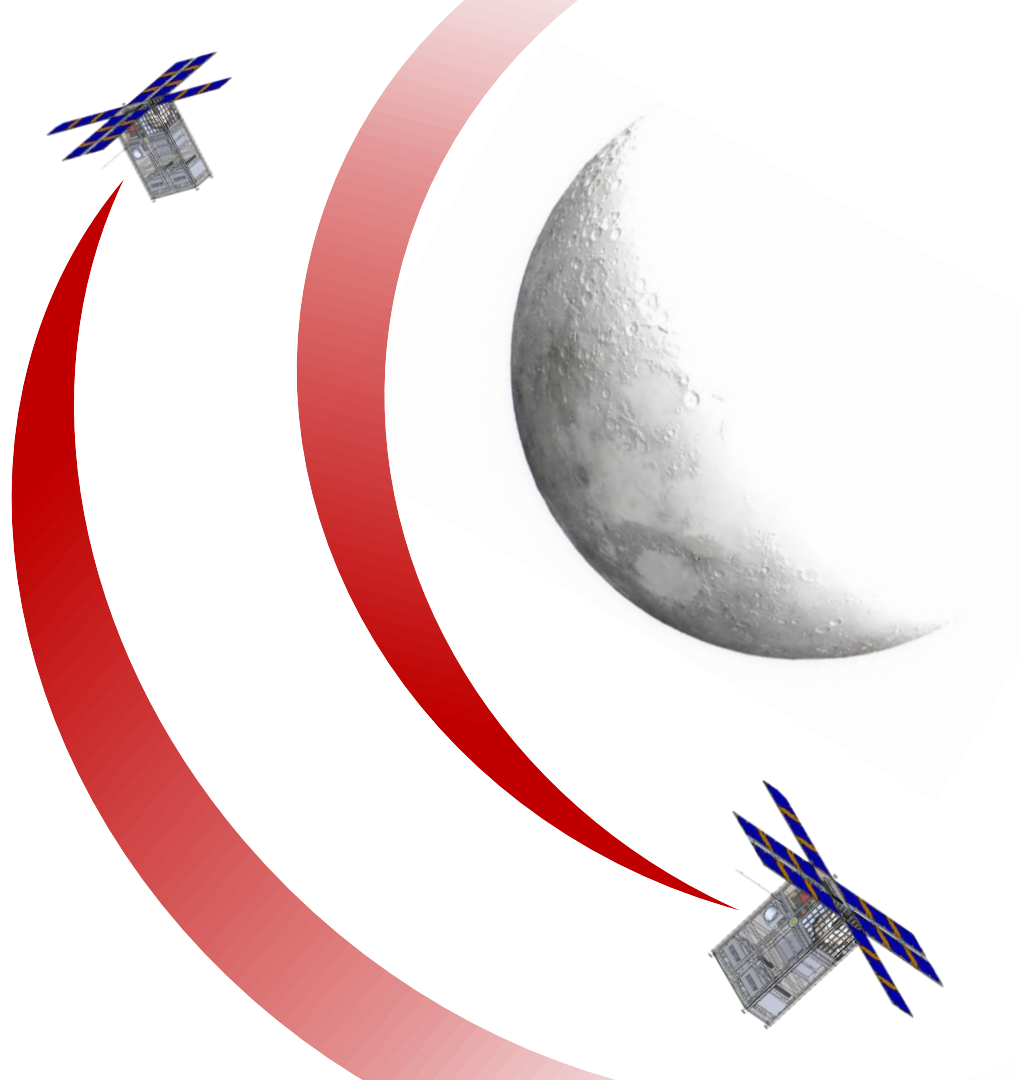
12th European Cubesat Symposium

24-26 November 2021
Ecole polytechnique, Palaiseau, FR



Outline

- ▶ **Context**
- ▶ **DRACO Mission Analysis**
- ▶ **DRACO System Design**
- ▶ **Conclusion and perspectives**



Context

Lunar Exploration

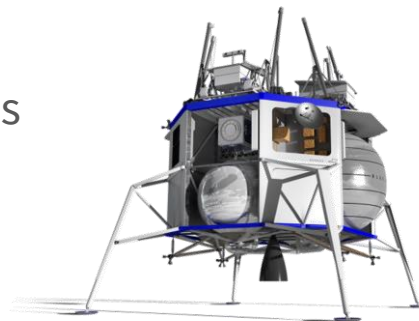
- A **new era** of exploration begins
- Assembly of a **Lunar Gateway** in a L2 southern Near Rectilinear Halo Orbit (**NRHO**).
- Involvement of **public** and **private** entities to provide **transportation** services, **logistics** and **in-situ** resources utilisation.



Lunar Gateway Station.
Credits: ESA



Orion Crew vehicle.
Credits: ESA



Blue Moon Lander.
Credits: Blue Origin



Starship Crew and Cargo.
Credits: Space X

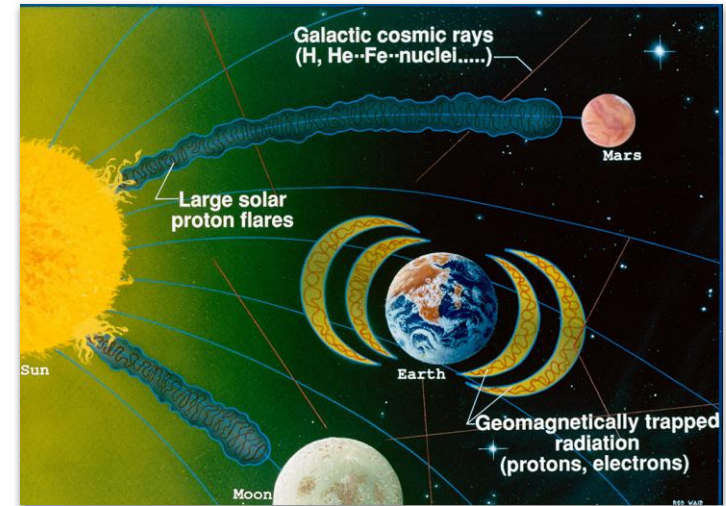
Radiation Environment

Space is filled with radiations, of 2 main types:

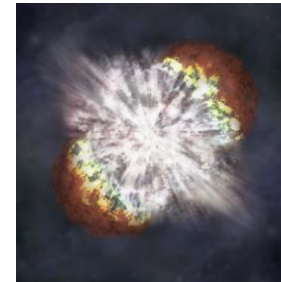
- Solar Particle Events (SPEs)
- Galactic Cosmic Rays (GCRs)

Both types have consequences on:

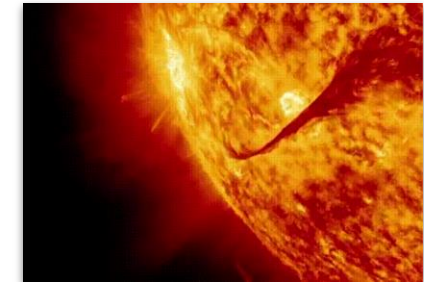
- Electronics
- Materials
- Human body



Recap of space radiation sources.

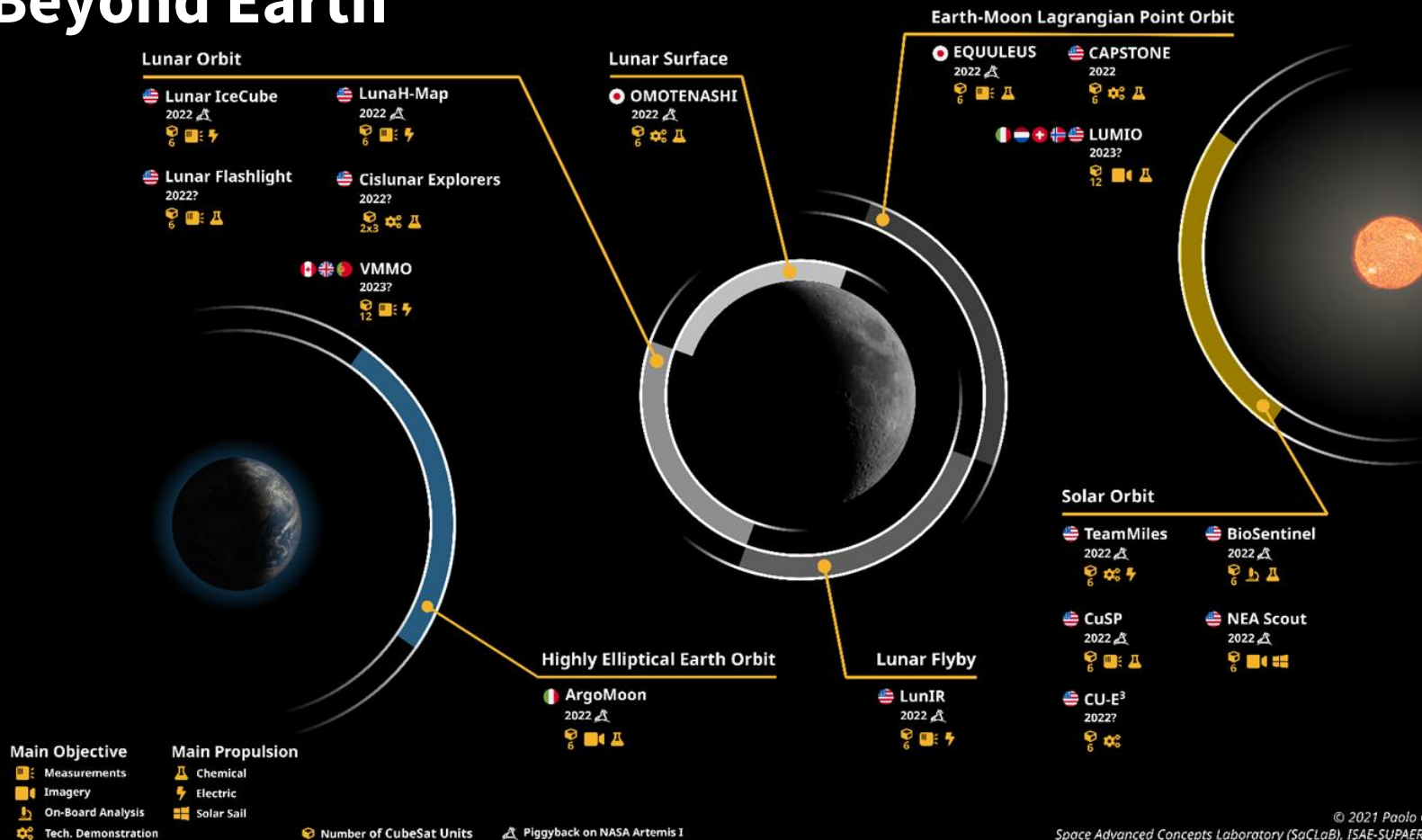


Supernova explosion
(Artist's impression).



Solar flare with Coronal Mass
Ejection (Observation).

Beyond Earth



DRACO Mission Analysis

▶ **DRACO** = **D**etection of **R**adiation in **C**islunar **O**rbits

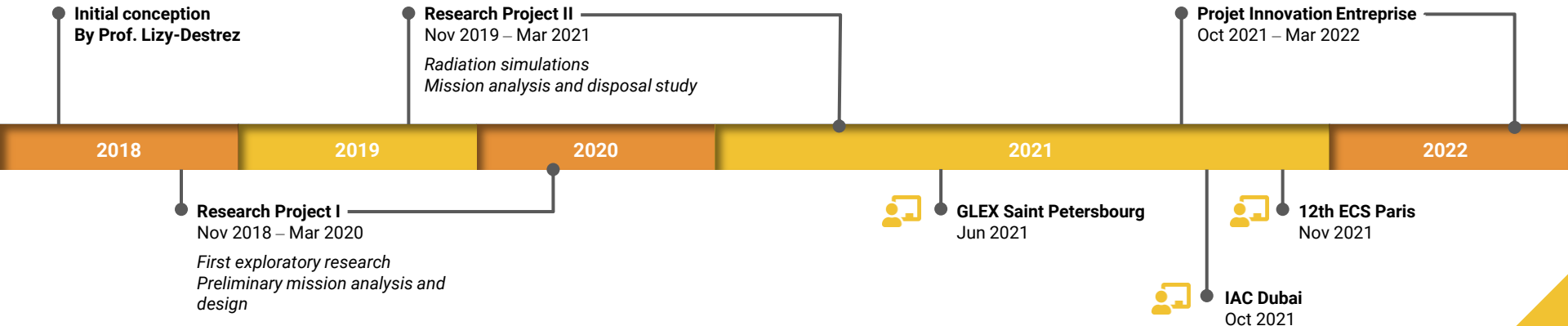
Mission statement

“Characterise the radiation environment and demonstrate the use of CubeSats on Earth-Moon Lagrangian point orbits.”

DRACO = Detection of RAdiation in Cislunar Orbits

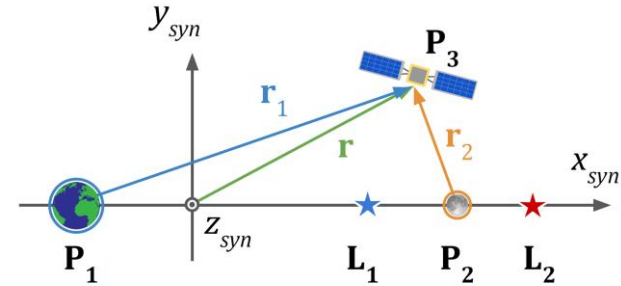
Mission statement

“Characterise the radiation environment and demonstrate the use of CubeSats on Earth-Moon Lagrangian point orbits.”

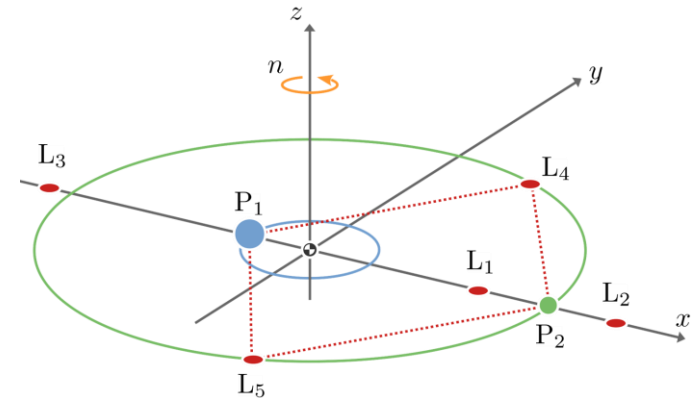


Dynamical Environment

- The Earth and the Moon dominate the “cislunar” space.
- Analysis are run in the **Circular Restricted Three Body Problem (CR3BP)**:
- There are **5 libration points** around which exist periodic solutions → **Orbits!**



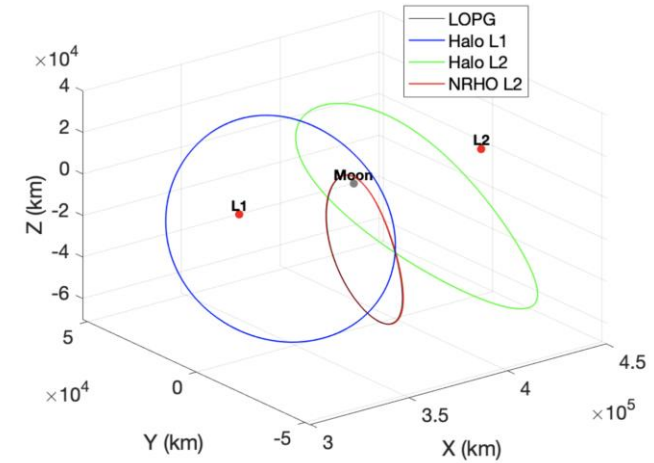
The Earth-Moon system in the rotating “synodic” frame



A rotating frame, used to study the Restricted Three Body Problem. The 5 Lagrange points are highlighted.

DRACO mission Conops

- Phase I.** Release from Gateway of **DRACO-1** and **DRACO-2** to NRHO- L_2 and calibration.
- Phase II.** Transfer **DRACO-1** and **DRACO-2** to science **Halo** orbits around L_1 and L_2 .
- Phase III.** Exchange science Halo orbits.
- Phase IV.** Disposal of both CubeSats with **impact** on the lunar surface.



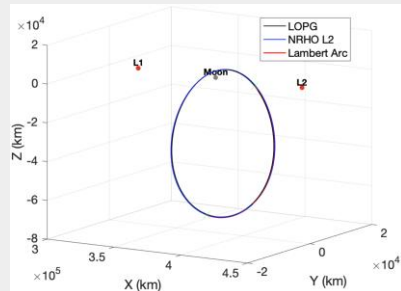
The orbits involved in the DRACO preliminary study [1]

[1] M. Burnichon, E. V. Llamazares, Á. C. Serrano, P. Guardabasso, and S. Lizy-Destrez, “Mission Analysis to Measure Radiation Dose About the Earth-Moon Lagrangian Points” presented at the Global Space Exploration Conference (GLEX), Saint Petersburg, Russia, 2021.

Trajectory Analysis

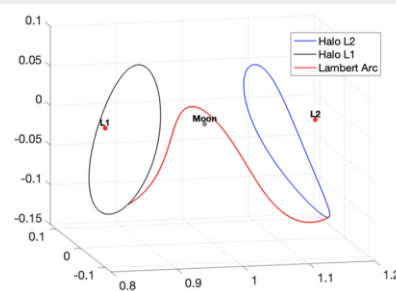
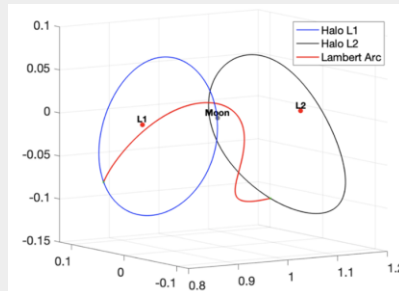
Phase I

~ 5 m/s



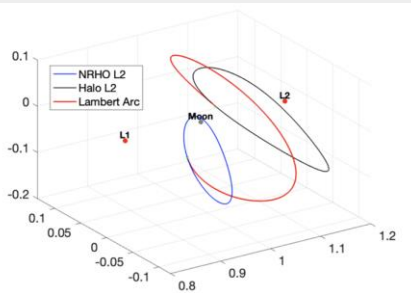
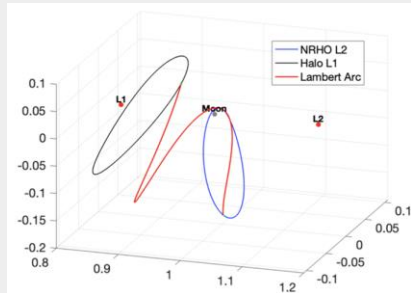
Phase III

~ 300 m/s



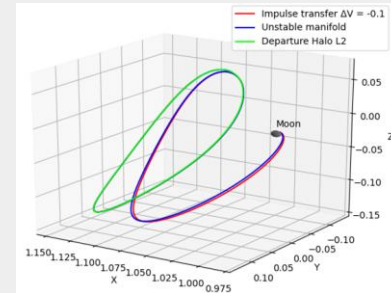
Phase II

~ 250 m/s



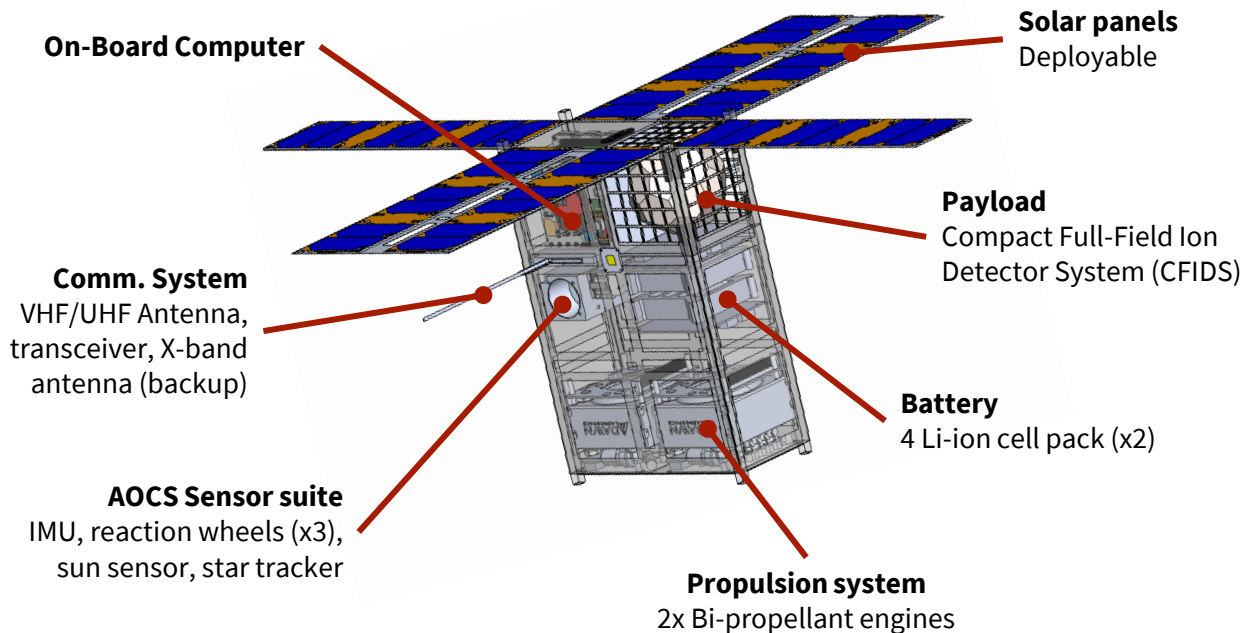
Phase IV

~ 10 m/s



DRACO System Design

Preliminary System Design

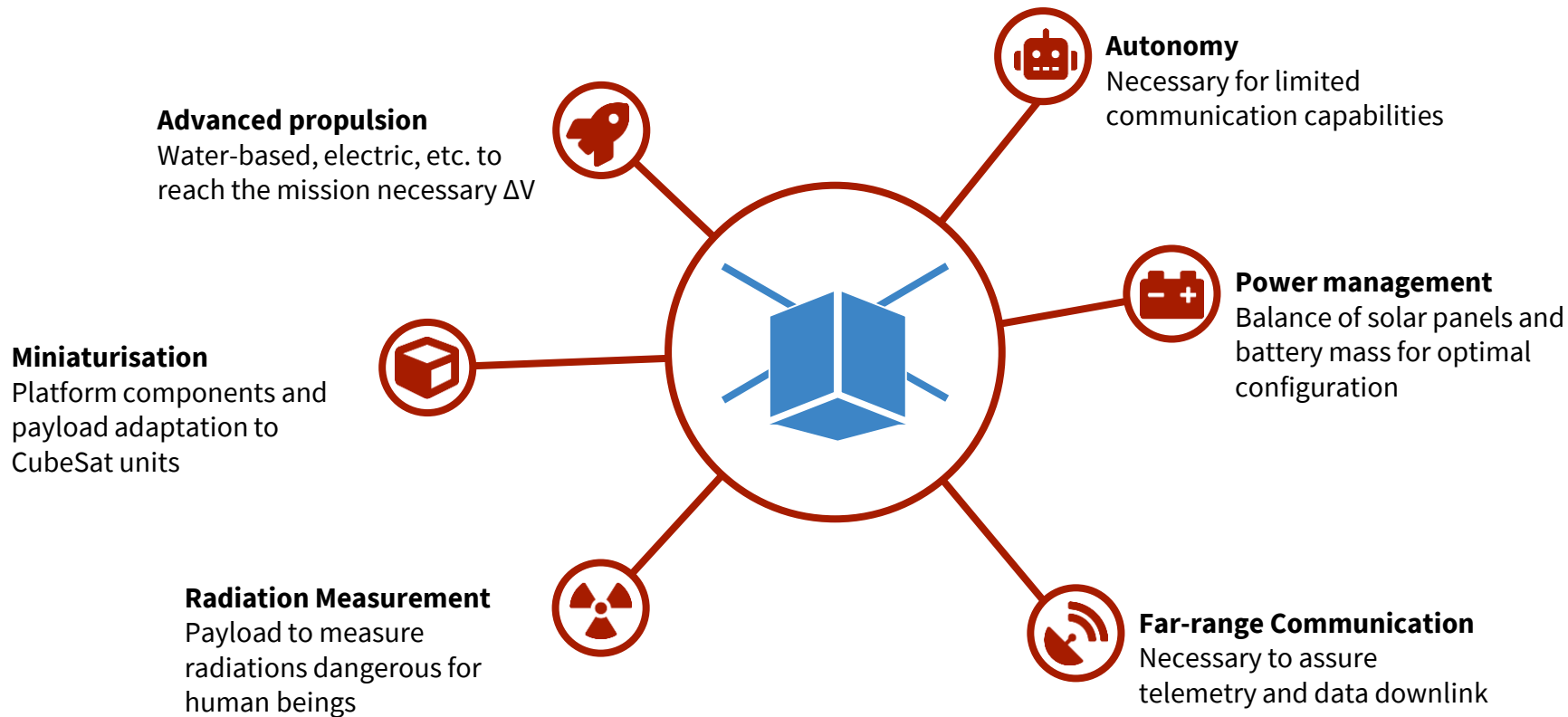


Dry Mass	9.4 kg
Propellant	1.6 kg
Final Mass	11 kg



Nominal	20 W
Peak (transfer)	47 W

Key technologies



Conclusion and future work

Conclusions...



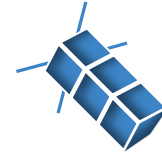
Science and Payload

Review of available models
Preliminary dose simulations



Mission Analysis

Analysis of science orbits
Computation of transfer ΔV



System design

Components technology scouting
Preliminary mass and power budget

Conclusions...and future work



Science and Payload

Review of available models

Preliminary dose simulations



Detailed **review** of existing missions and sensors

Experiment **requirements** preparation



Mission Analysis

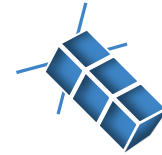
Analysis of science orbits

Computation of transfer ΔV



Transfer and **stationkeeping** redesign and optimisation

High-fidelity trajectory refinement



System design

Components technology scouting

Preliminary mass and power budget



Evaluate other **CubeSat configurations** (3U)

Prepare **parametric model** for generalised **system budgets**

Cislunar CubeSats to Measure Radiation in Support for Human Space Exploration

Thank you for your attention!
Any questions?



paolo.guardabasso@isae-supaero.fr

12th European Cubesat Symposium

24-26 November 2021
Ecole polytechnique, Palaiseau, FR