34th TFAWS Interdisciplinary Paper Session

MSR-ERO Thermal design and analysis using SYSTEMA

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esa AIRBUS

Agenda

I. **Mars Sample Return** Mission introduction

II. **Earth Return Orbiter** Spacecraft description

III. **Systema** Software presentation

IV. **Trajectory modeling** External fluxes computation

V. **Submodels integration** Coupled analyses

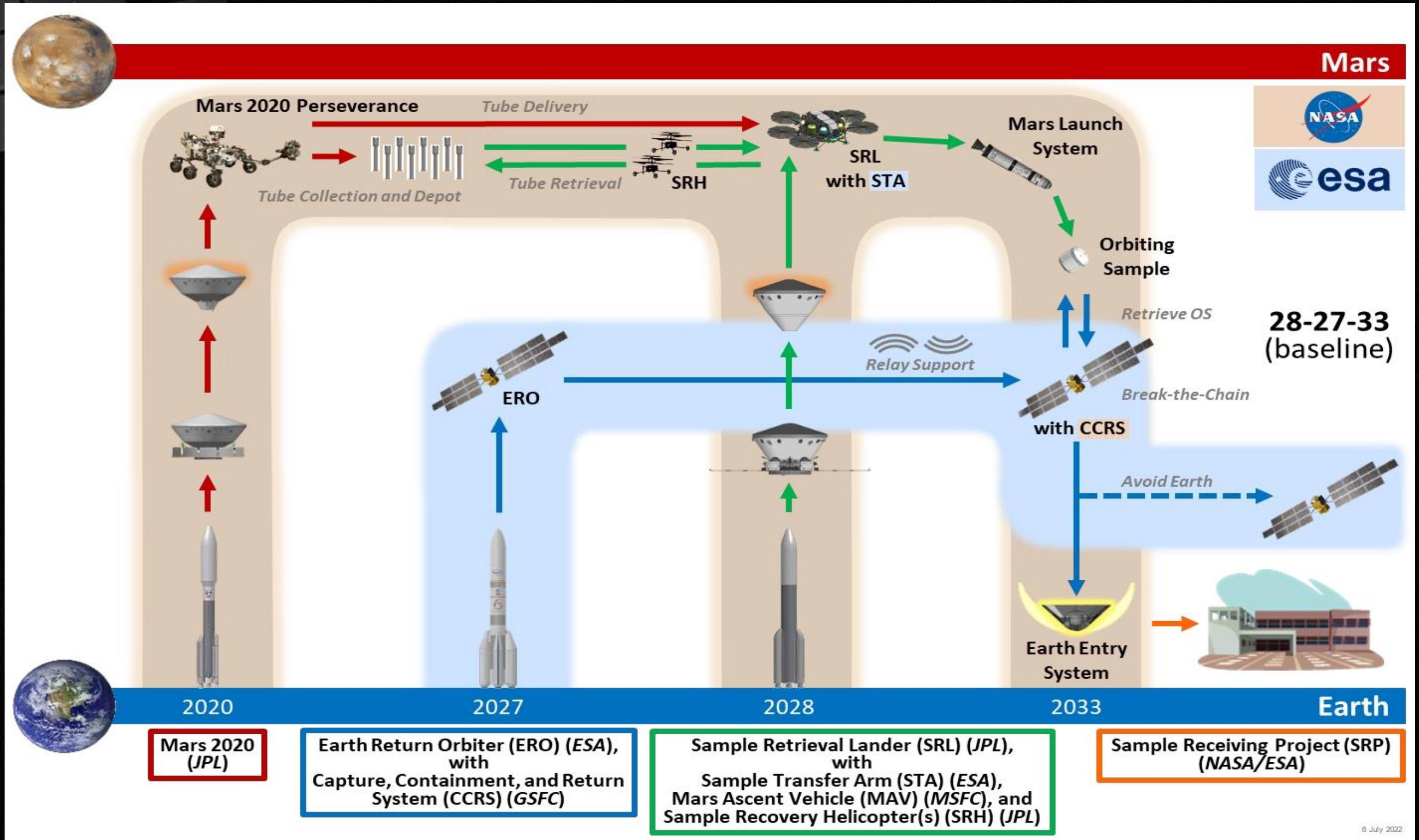
VI. **Propulsion optimization** Plasma propulsion vs. units temperature

VII. **Future milestones & perspectives**

Mars Sample Return (MSR)

A quick introduction to the mission

- **NASA-ESA** joint program
- Bringing Martian samples back to Earth by **2033**
- **Several spacecrafts** involved (*Perseverance*, ERO, SRL)
- **First sample return from another planet!**



Mars Sample Return (MSR)

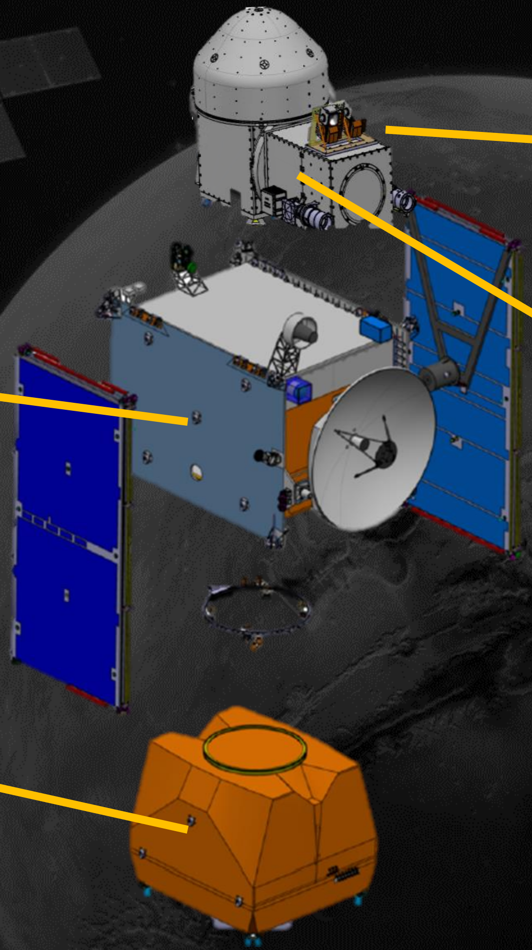
A quick introduction to the mission

Credits: NASA/ESA/JPL-Caltech/GSFC/MSFC

Earth Return Orbiter (ERO)

Spacecraft description

→ A highly **modular** spacecraft



Rendezvous Sensor Suite (*ESA*)
(Mounted on the CCRS)
Cameras & LiDARs

Return Module (*ESA*)
Avionics & communications
Plasmic and Chemical propulsion

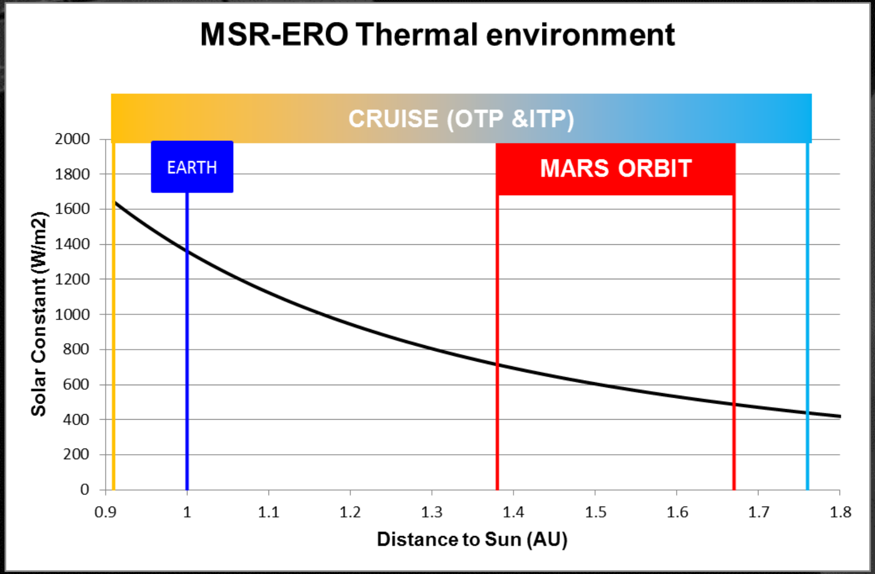
Capture, Containment and Return System (*NASA*)
(Partial separation after samples recovery)
Samples capture & biosealing
Earth jettison system

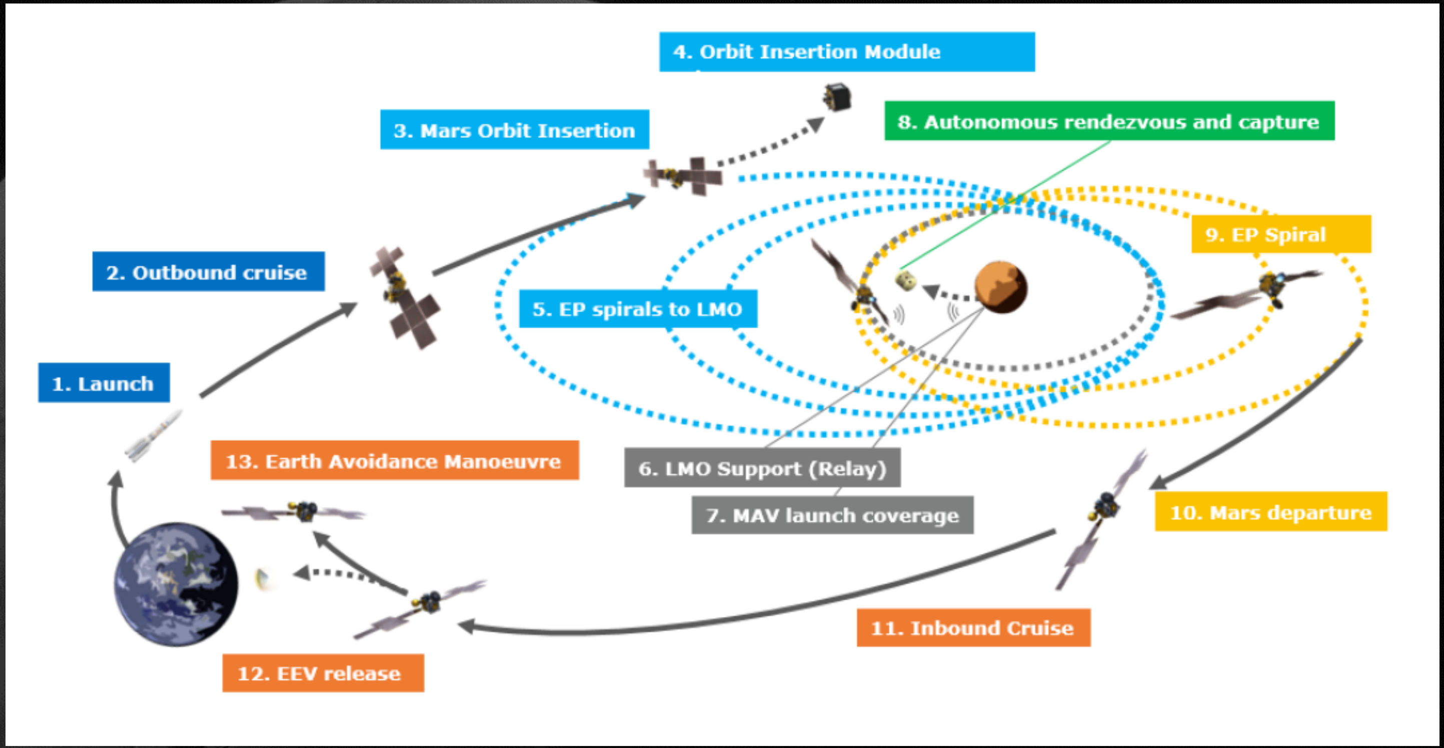
Orbit Insertion Module (*ESA*)
(Separation at Mars arrival)
Chemical propulsion

Trajectory modeling

Computation of external fluxes

Various **thermal environments**: Earth, Outbound transfer, Mars, Inbound transfer





→ Need for **precise** external fluxes computation at different key locations of the trajectory

SYSTEMA

What is Systema:

System level tool to model Spacecraft **interactions** with its **environment**

Systema is an **Airbus** product, has been existing for more than **30 years**, quite well used in Europe and throughout the world.

Systema

The multidiscipline solution to support space system engineering.

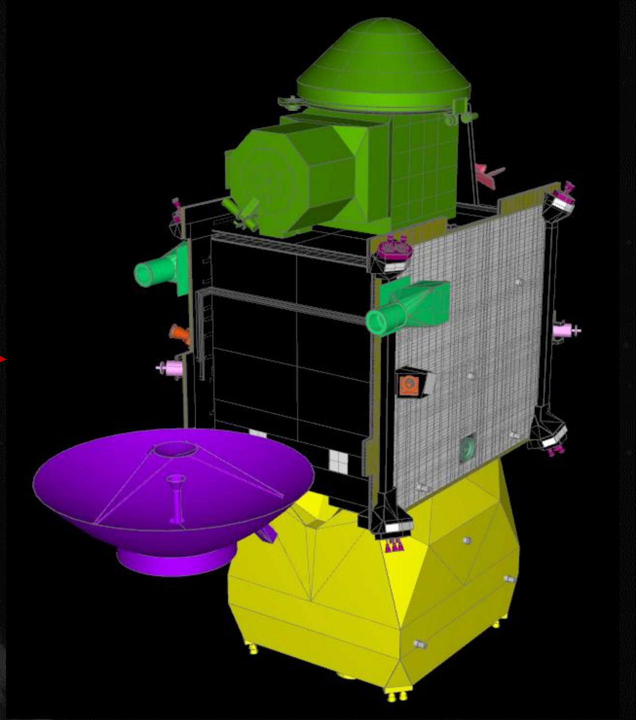
Dedicated to Space, **mission oriented**, offeres a **unified framework** for dealing with several physics issues linked to space, such as **Thermal, Power, Space Physics applications**

Currently, version Systema-4.9.2P1 is available for download on our website ! https://www.airbus.com/en/products-services/space/customer-services/systema

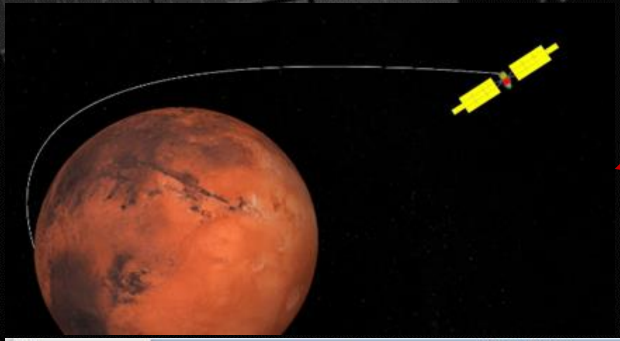
SYSTEMA

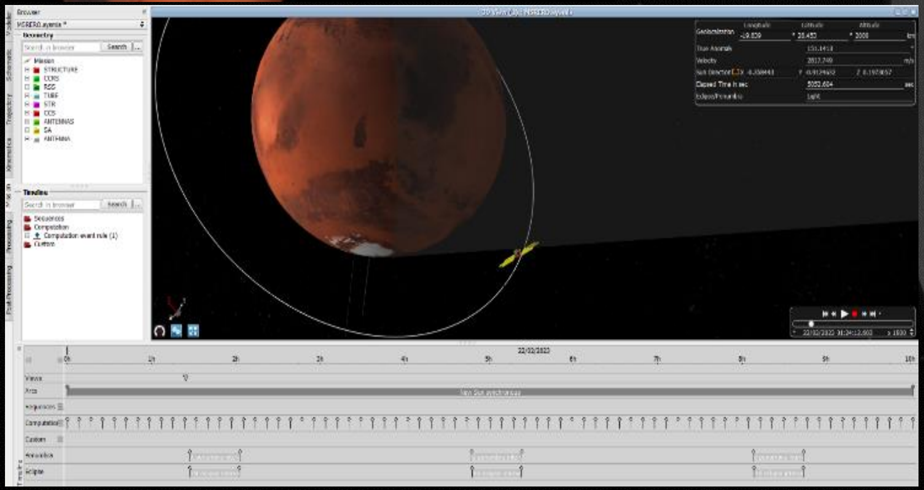
How does Systema work?

Geometry modeling, physical properties and meshing

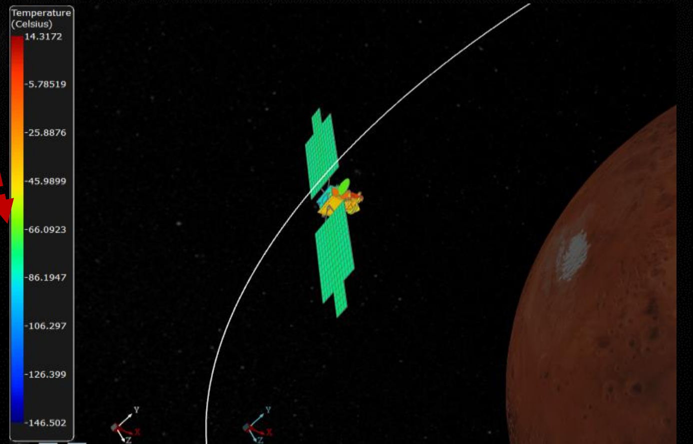


Mission modeling: orbit and pointing

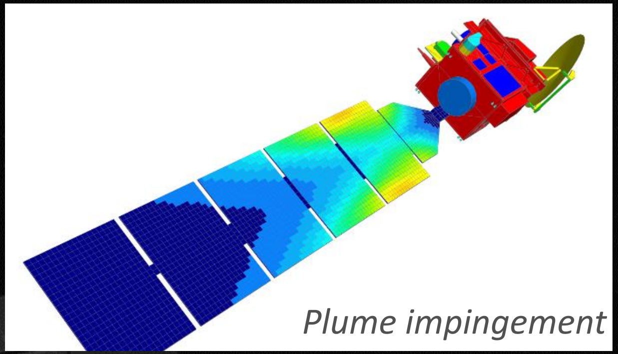


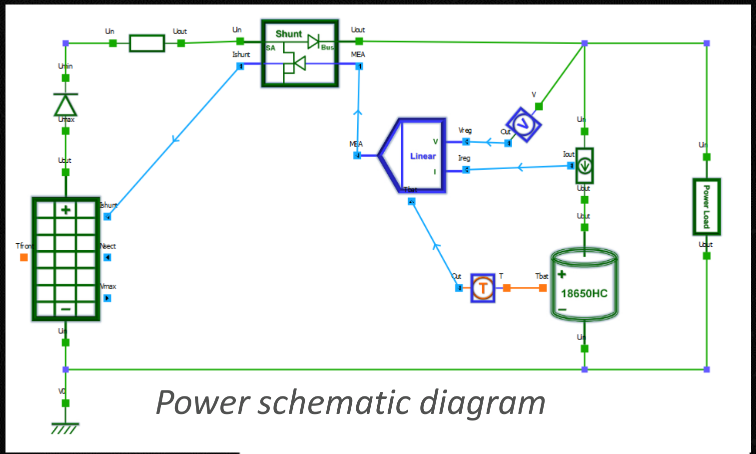


Physical simulation:
Scientific **computation** via the applications

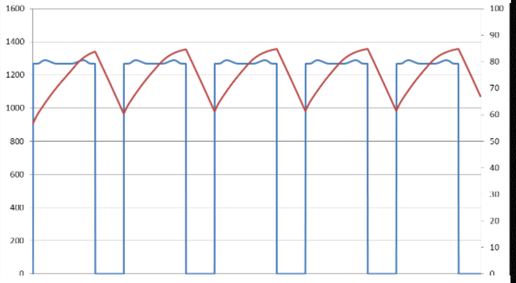


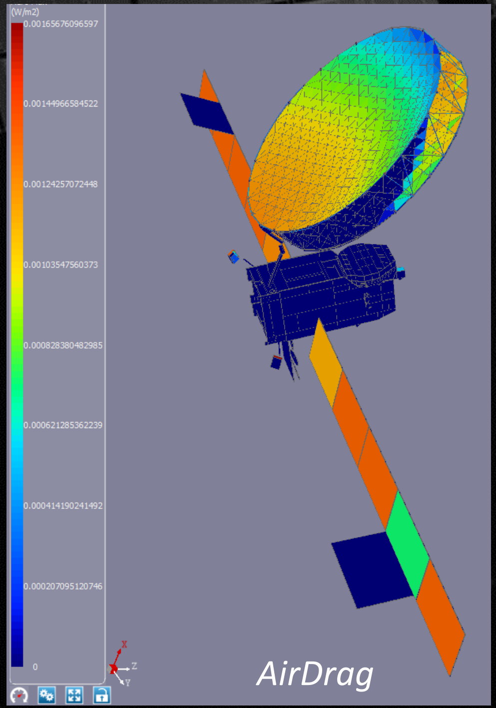
SYSTEMA
Software presentation

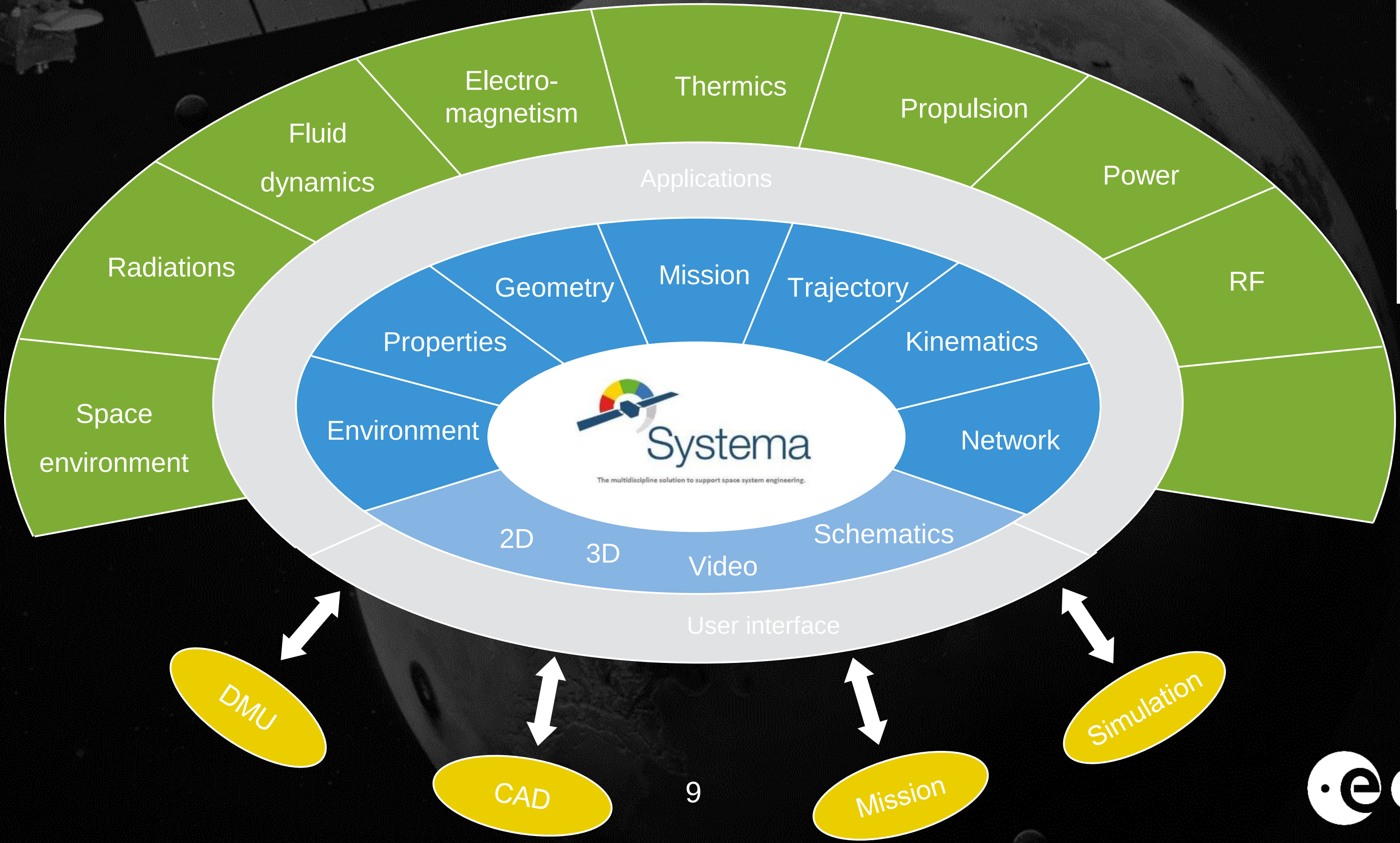

Plume impingement



Power schematic diagram


Solar flux (left scale) and battery charge (right scale)


AirDrag



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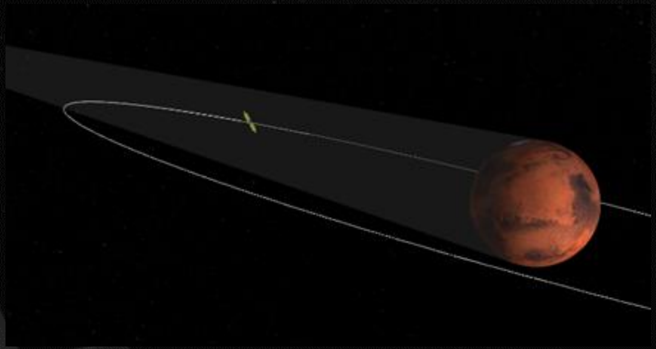
SYSTEMA

Why use Systema?



User friendly **thermal analysis tool**
(Radiation with Quasi-Monte-Carlo, Conduction with RCN method)

A well furnished **Python API**, allowing to **drive** or **customize** entirely the tool, allowing to put in a global process chain.

Systema
The multidiscipline solution to support space system engineering.

A **unique framework** allowing for the same geometrical & mission definition for **Thermal & other studies**
(Power, AirDrag, Atomox, Plume…)

Mission definition & events (eclipses) with the trajectory based on **OREKIT** library.

Able to model classical as well as **unsual trajectories** with accurate contributions from planets, moons and the Sun.

OREKIT : https://www.orekit.org/

Earth Return Orbiter (ERO)

Return Module (RM) – a few thermal figures

- Power demand up to **42 kW** → peak **power dissipation** of **5 kW**
- **Telecom satellite** typical thermal control design

150 **heat pipes** embedded & surface

$22m^2$ **MLI** surface

$12m^2$ **OSR** surface

5 kW installed **heating power** ⟶ **140 N + 140 R + 13 T** heaters

Earth Return Orbiter (ERO)

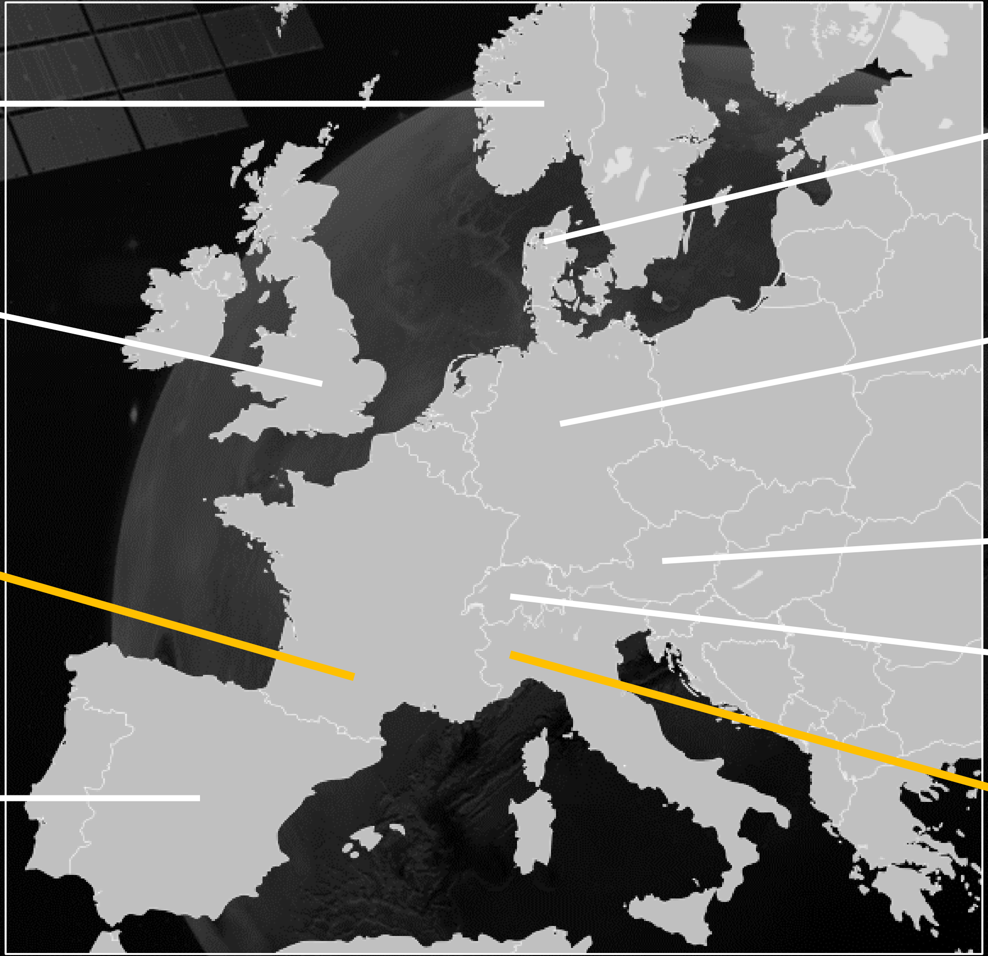
A wide European industrial consortium

Kongsberg (SADA)

Airbus (CPS, Structure)
Critical Soft. Tech. (ISVV)

Airbus (Prime contractor)
Airbus (OBC, IMU)
3D Plus (MCAM)
EREMS (RIU)

Airbus (Structure)
Sener (TPM)
Crisa (PCDU, PPU)



Rovsing A/S (E-SIS)

Airbus (Solar arrays)
ArianeGroup (Propulsion)
Jena Optronik (STR, LiDAR)
Rockwell Collins (RW)

Terma (RF Suitcase)

Almatech (MLI)

TAS (Assembly and tests)
TAS (OIM, PIU, Antennas…)

Coupled analyses

Submodels integration

- Around **40 reduced thermal submodels** to be included for coupled analyses of MSR-ERO

→ integration represent a high amount of time

- Ensuring a realistic **thermal behavior** of those models is essential (especially at S/C interface)

→ need for **acceptance runs**

→ **Standard process** for **model exchange** between Airbus and its suppliers

- … but still efforts to do (compatibility between softwares)

AIRBUS	MSR-ERO	Ref. : [redacted] Issue : 1 Date : 02/06/2020 Page : 7

1 INTRODUCTION

This document describes the generic recommendations applicable for equipment, subsystem and system thermal model delivery. These recommendations are written by AIRBUS Defence and Space TLS thermal analysis teams with the objective of minimizing the time spent on the integration and validation of thermal models delivered by external organizations.

This document provides:

- General requirements on deliveries (analysis report, nomenclature…),
- Specific requirements on reduced thermal model and its format to be delivered,
- Specific requirements for Coupled Launcher Analysis model to be delivered.
- A compliance matrix template

Coupled analyses

Submodels integration process

If needed

Format conversion

→ **Model verification**
- Numbering
- Coatings
- Materials
- Conditionning

Coherence between specifications and model is checked

→ **First acceptance run**

Using radiative couplings and external fluxes ***provided by supplier***

If discrepancies here, error source is likely **mathematical** model

→ **Results comparison**
- Temperature
- I/F fluxes

→ **Second acceptance run**

Using radiative couplings and external fluxes ***computed with SYSTEMA***

If discrepancies here, error source is likely **geometrical** model

→ **Results comparison**
- Temperature
- I/F fluxes

↓

Submodel ready for integration!

Optimization of plasma propulsion

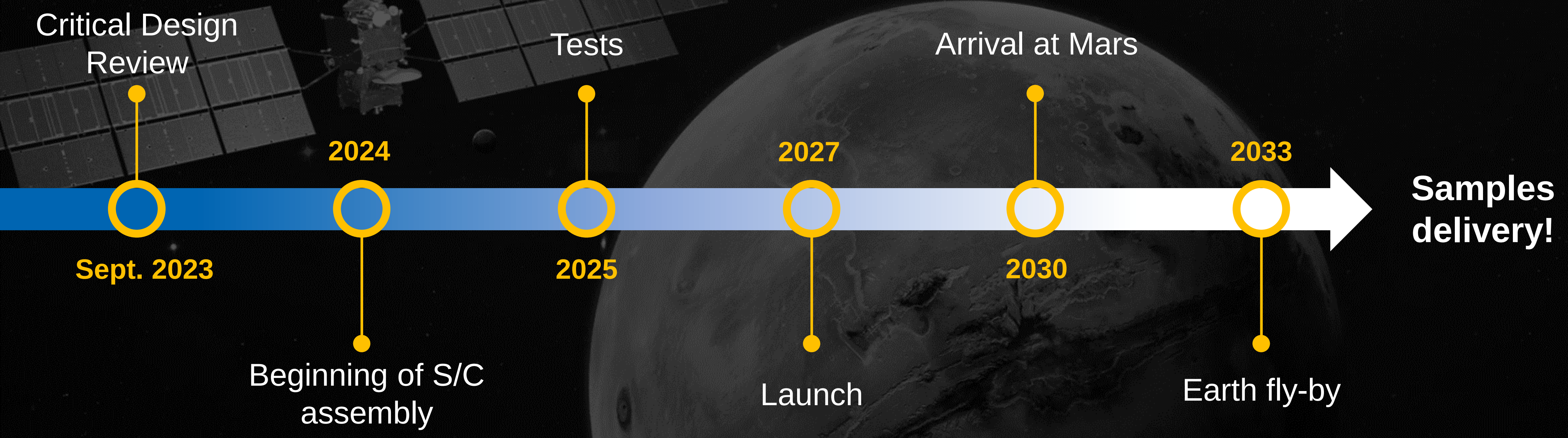
Optimizing plasma propulsion vs. units temperature

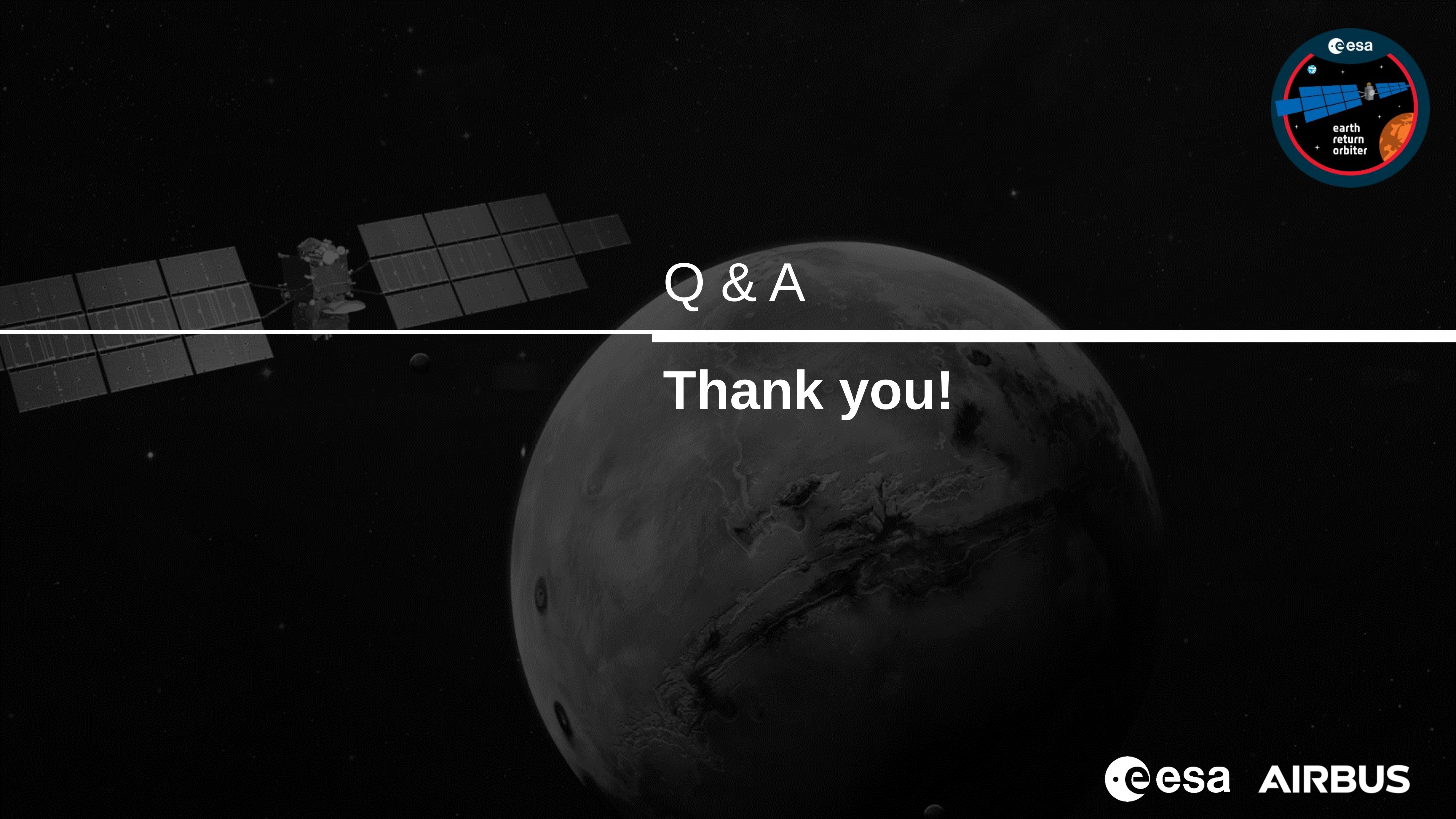
- Plasma propulsion system is demanding high power
- High thermal dissipation
- Need to find a balance between propulsion power and respect of temperature specifications
- 4 PPUs and 3 PPUs configurations

→ Objective: thrust as much as possible

Future milestones & perspectives

What’s next for MSR-ERO?




Q & A
Thank you!