13th European Space Power Conference – Simulation Session

AIRBUS

A complete approach on validating satellite electrical and power sub-system using Systema

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espc 2023

Agenda

Systema and Power presentation

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.

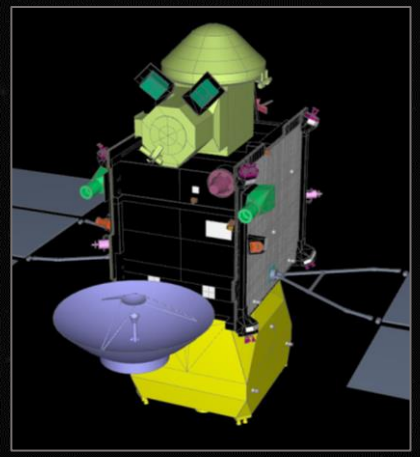
Dedicated to Space, **mission oriented**, offers a **unified framework** for dealing with several physics domains linked to space, such as **Thermal, Power, Space Physics applications**

Last release Systema-4.9.3 is available ! Ask for download on our website ! *https://www.airbus.com/en/products-services/space/customer-services/systema*

Systema and Power presentation

How does Systema work?

Geometry modeling, physical properties and meshing



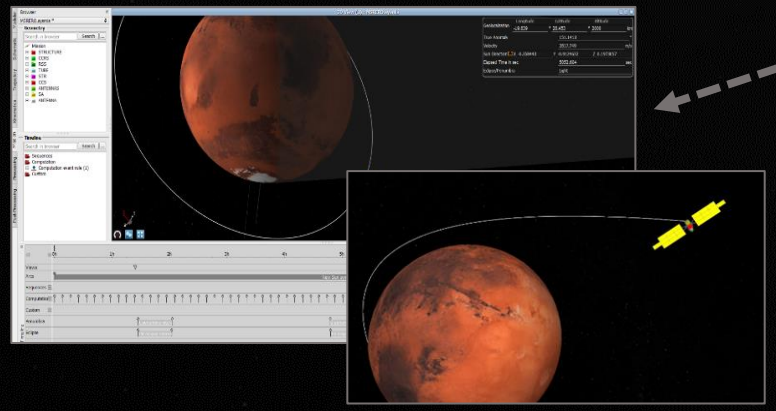
A well furnished **Python API**, to drive or customize entirely the tool

Mission modeling: orbit and pointing

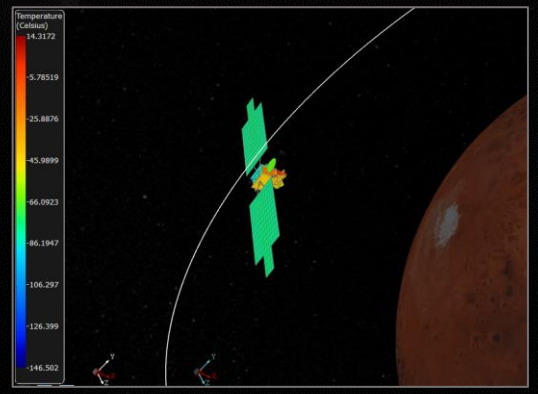
Mission definition & events (eclipses) with the trajectory based on **OREKIT** library.

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

Batch mode for automatization of parametric computations



Physical simulation:
Scientific **computation** via the applications (Power, Thermica etc)

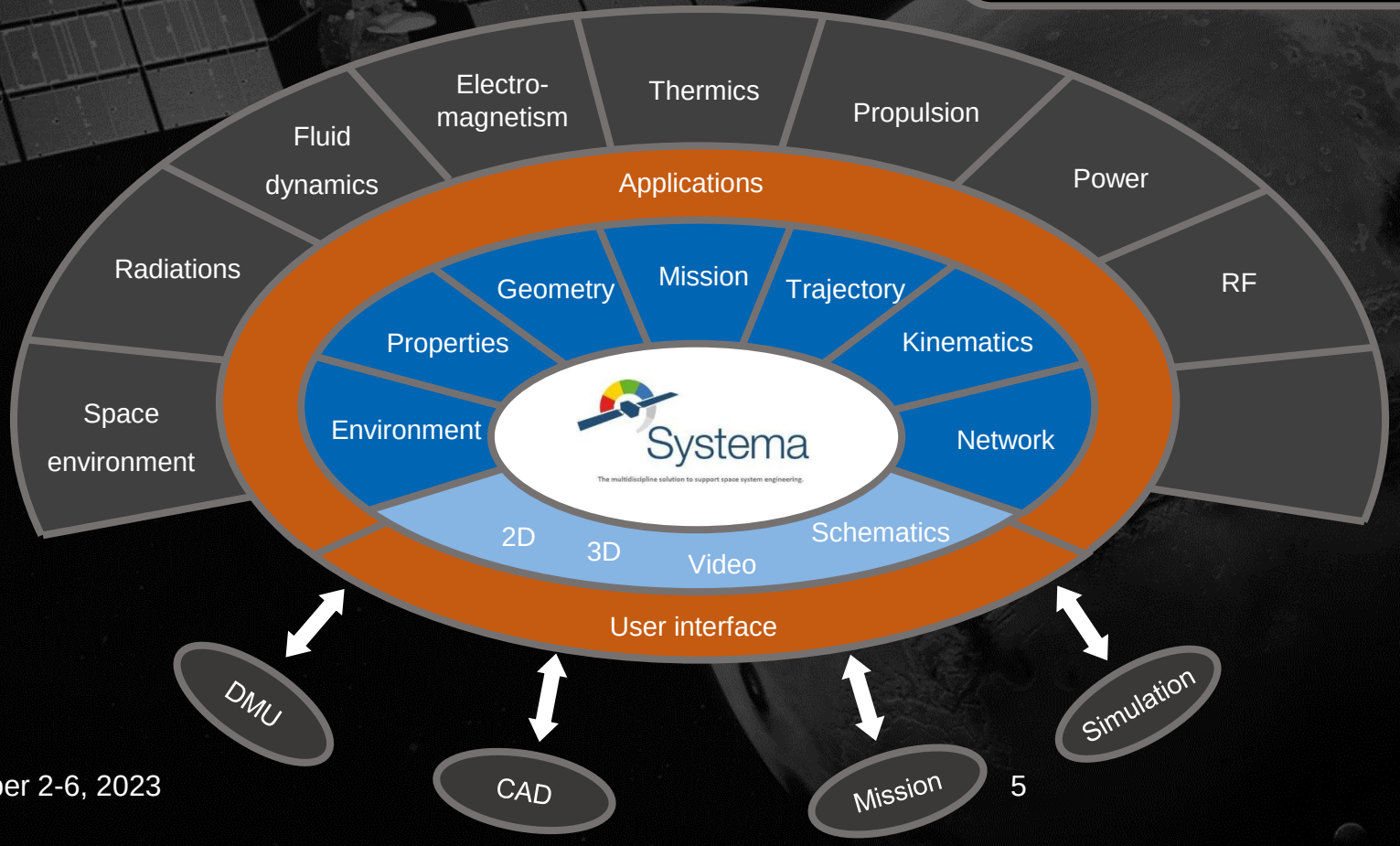


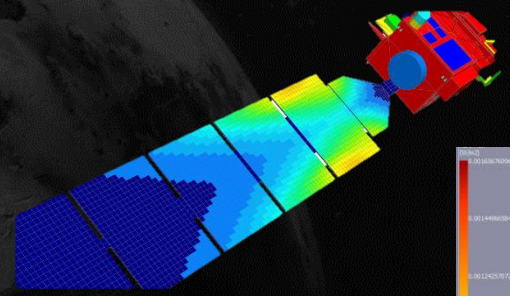
Systema and Power presentation

Software presentation

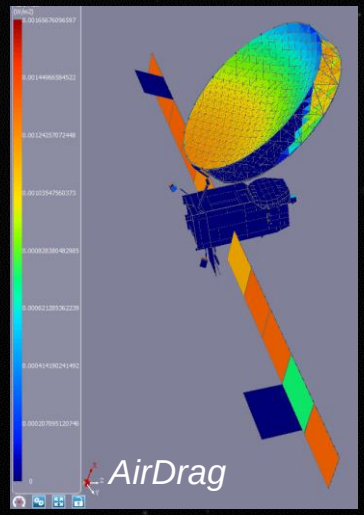
User friendly **analysis tool**

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





Plume impingement



Systema and Power presentation

Power plug-in application

Power is an application of Systema dedicated to compute in-orbit power performances and assist system power budget design

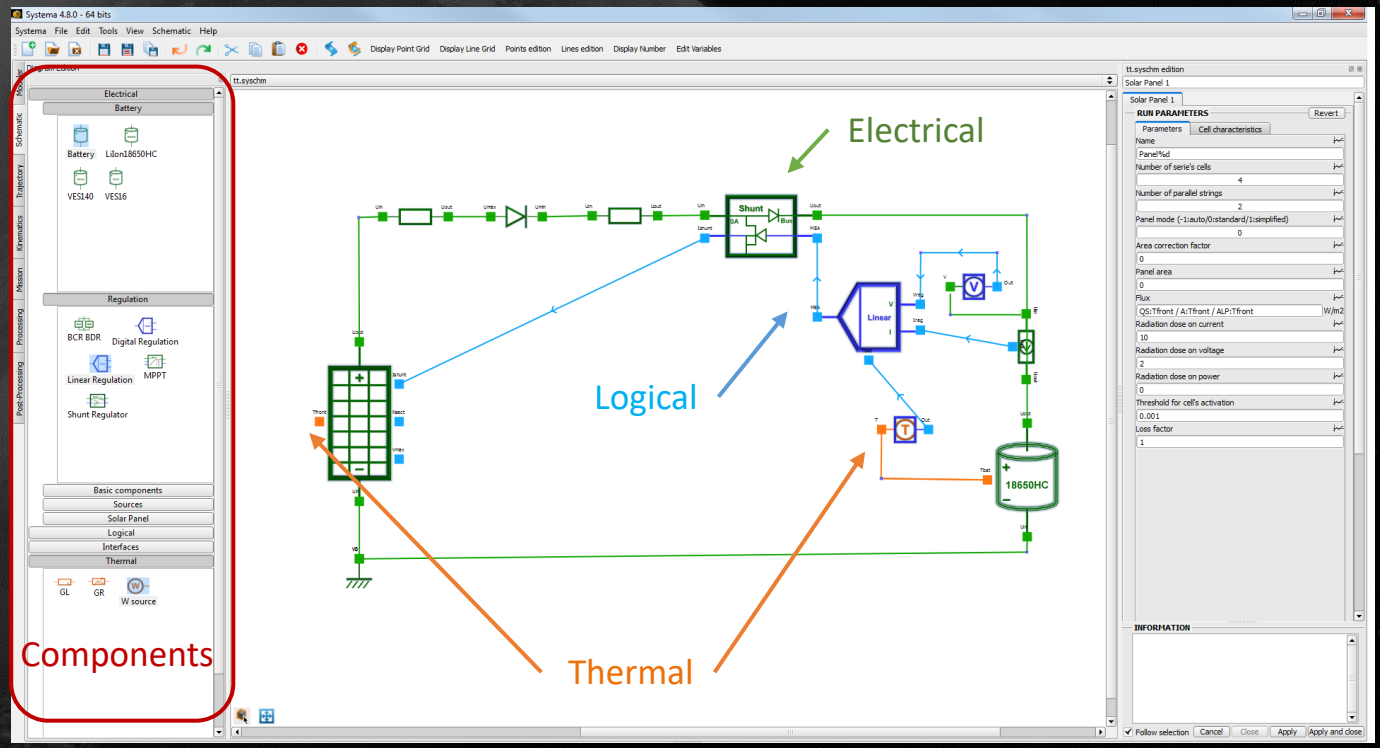
The **Power** application is based on:

An interactive schematic **editor** to build the power architecture

Set of **generic components** are provided with the application: solar array, battery, regulator, diode, resistance, power load, capacitance

Combine **electrical**, **thermal** and **logical** networks of components

User can program his **own components** using MORTRAN and C and reuse them for further analyses via the Graphical User Interface



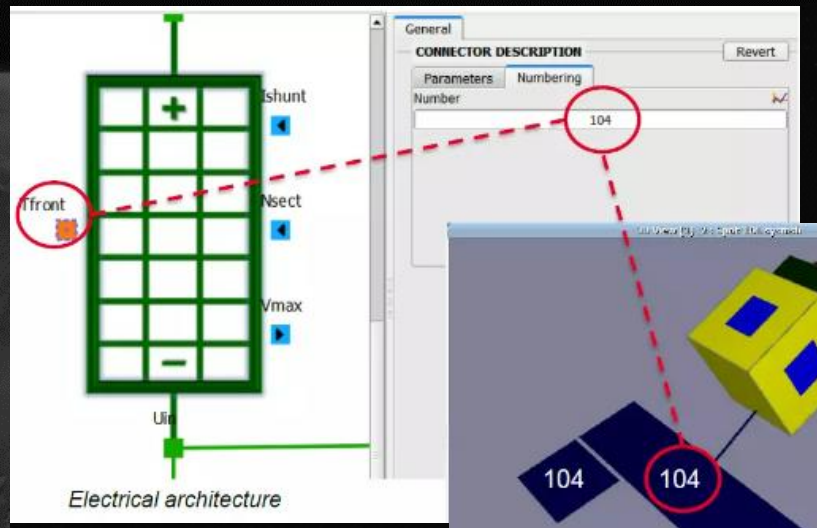
Systema and Power presentation

Power plug-in application

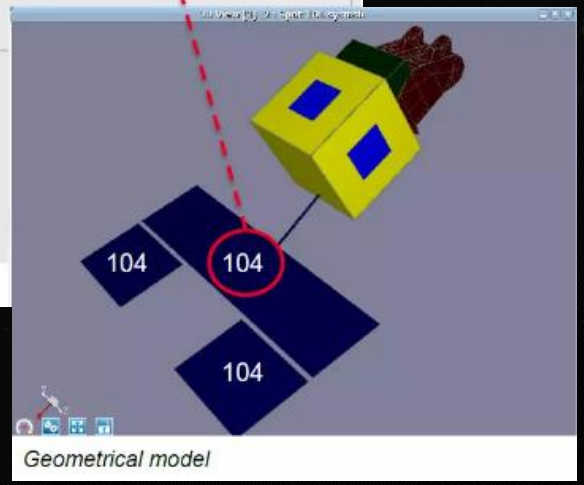
- Possibility to create a geometrical model and define a mission to compute the **external fluxes** and **radiative couplings**

- **Geometrical** (thermal) model and **electrical** architecture can be linked via thermal node numbers

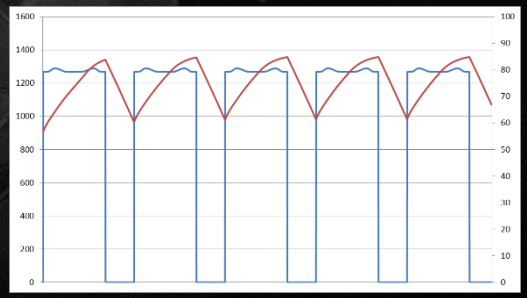
- A **coupled thermal power solver** allows to perform complete analyses taking into account thermal aspects due to space environment
  ➡ Input of solver (DCK) is a customizable code which offers a wide range of possibilities



Electrical architecture



Geometrical model

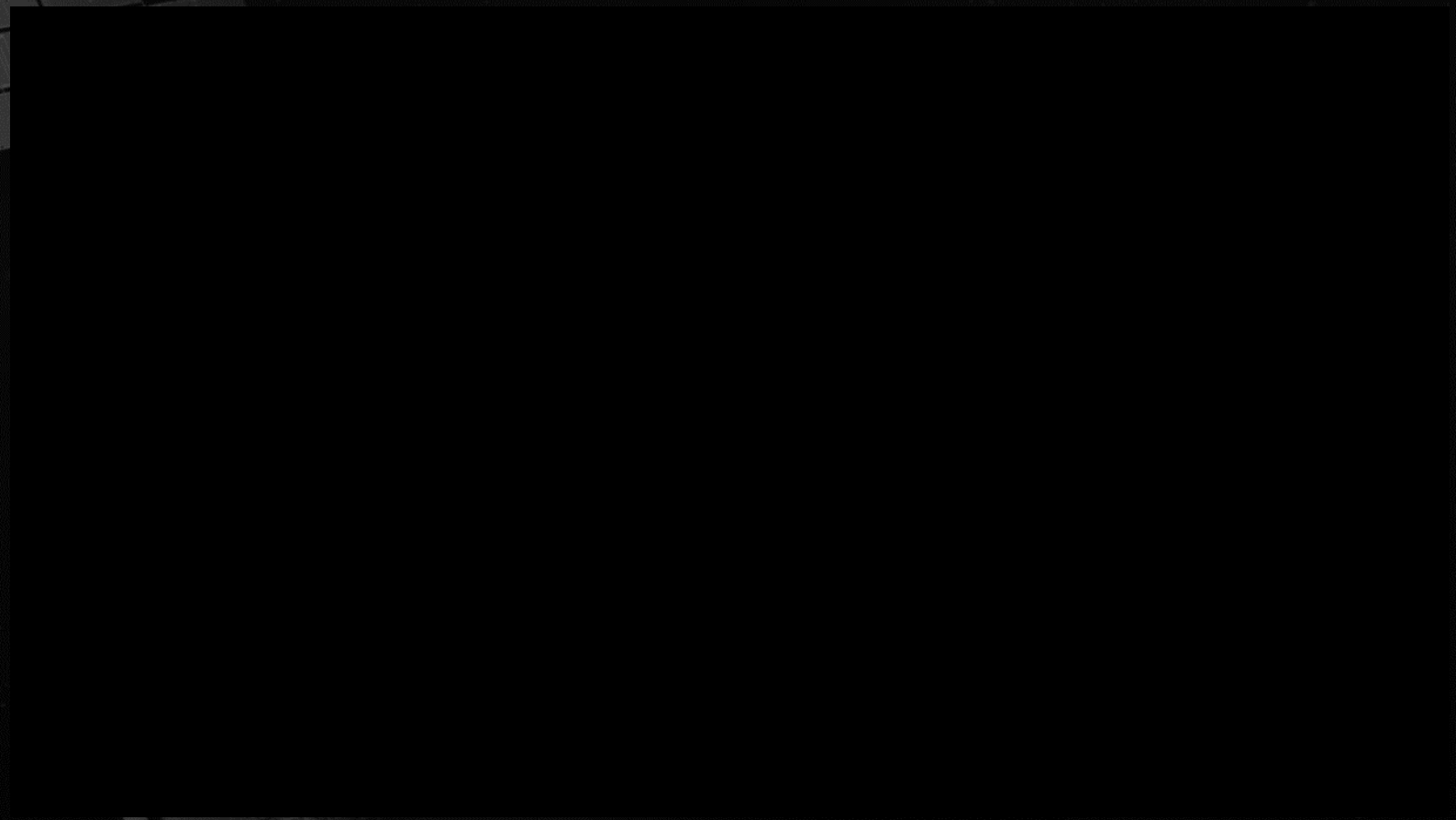


Solar flux (left scale) and battery charge (right scale)

Mars Sample Return (MSR)

A quick introduction to the mission

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

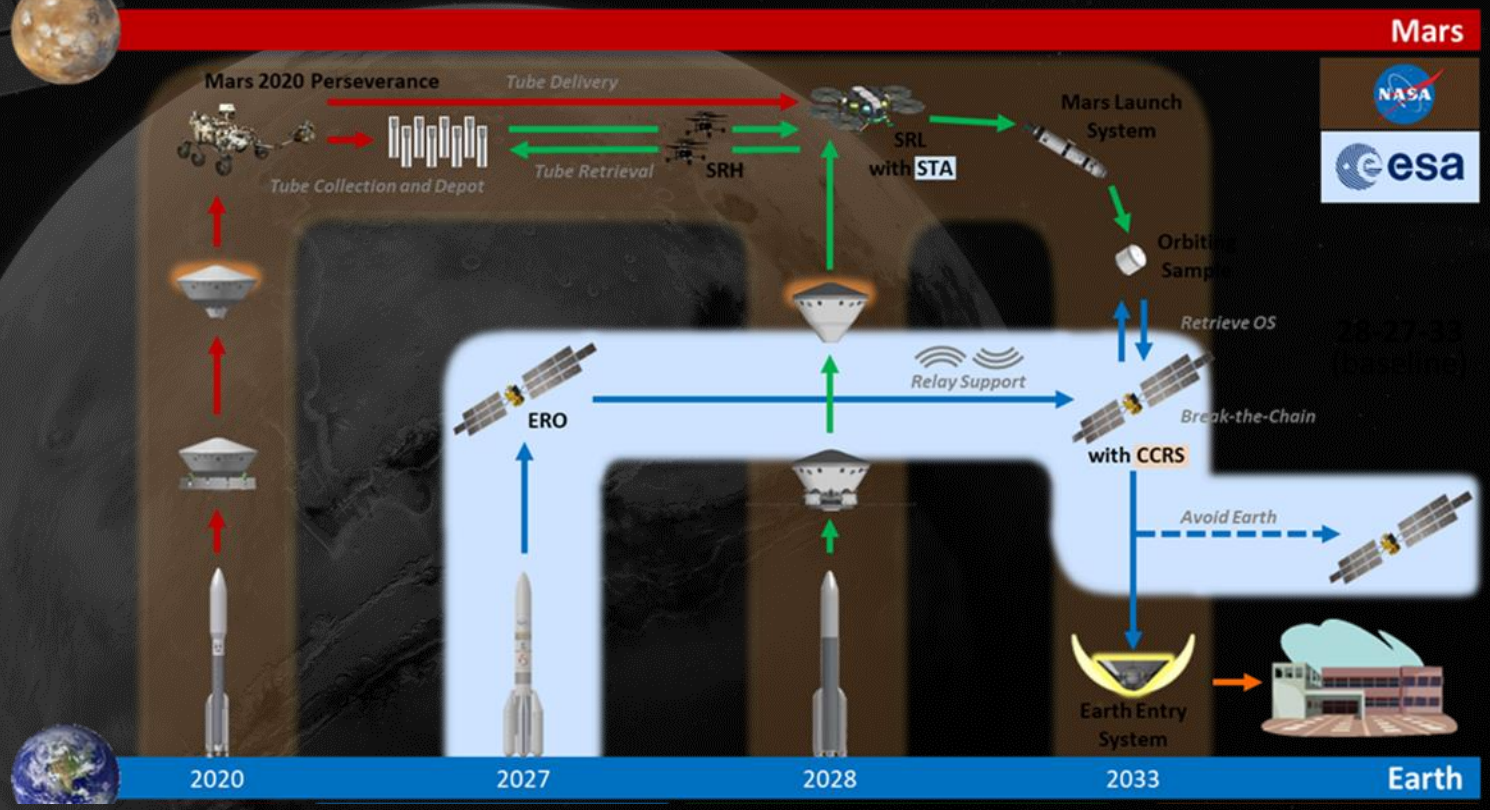


Credits: NASA/ESA/JPL-Caltech/GSFC/MSFC

Earth Return Orbiter (ERO)

From Earth to Mars and back

- Mission duration: **6 years**
  - **Outbound** transfer: **~3 years**
  - At **Mars**: **~1 year**
  - **Inbound** transfer: **~2 years**
- Solar arrays area: **144 m²**
- Platform power: **42kW** @Earth, **20kW** @Mars



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

MSR-ERO electrical analyses

The objective of the campaign

- **Understand** and **predict** the electrical behavior of the spacecraft through a **realistic** geometrical, thermal and electrical modeling in order to **assess the global energy balance** and provide data for **propulsion** studies:
  - ✓ *Are the solar panels big enough to ensure battery charge and power consumption during the day?*
  - ✓ *Is the battery correctly sized to provide sufficient energy during night?*
  - ✓ *What is the max. power we can allocate to plasma propulsion while ensuring all internal units consumption remains unchanged?*

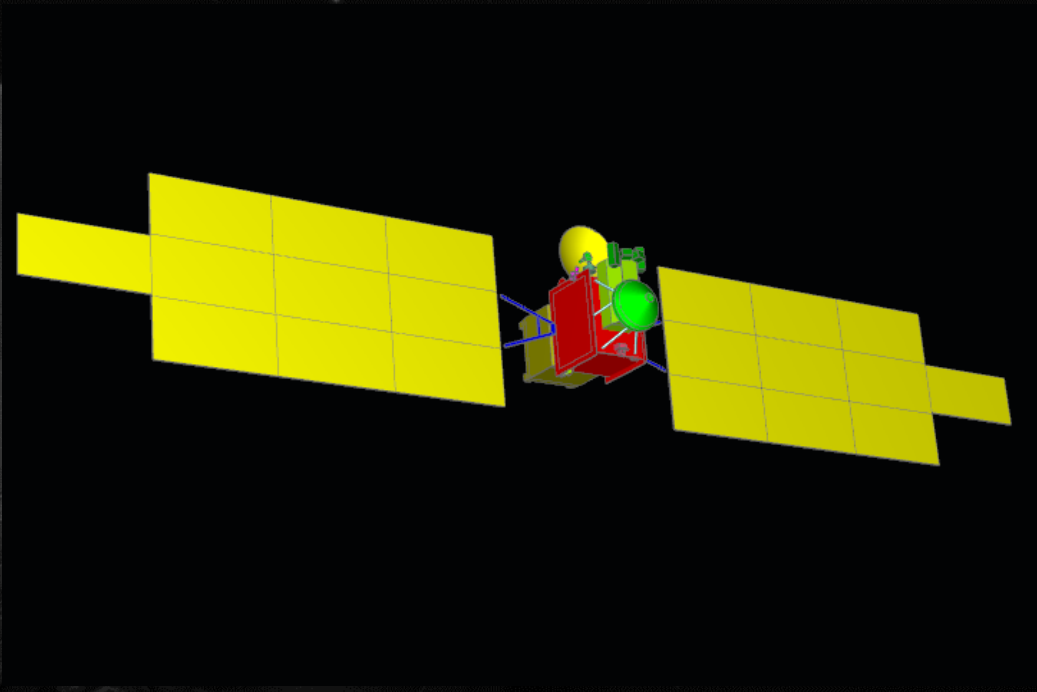
➢ Study of **7 mission phases** from LEOP to Spiraling up from Mars orbit.

MSR-ERO electrical analyses

A precise 3D model

- Detailed **structure modeling**: solar panel section, external equipment and surface definition
  - Precise computation of conductive exchanges between front and rear face of panels
  - Evaluation of shadow created by external components

- Linked **meshing** allowing user to define capacitances, coupling …
  - Adaptable node definition for each part of the space craft



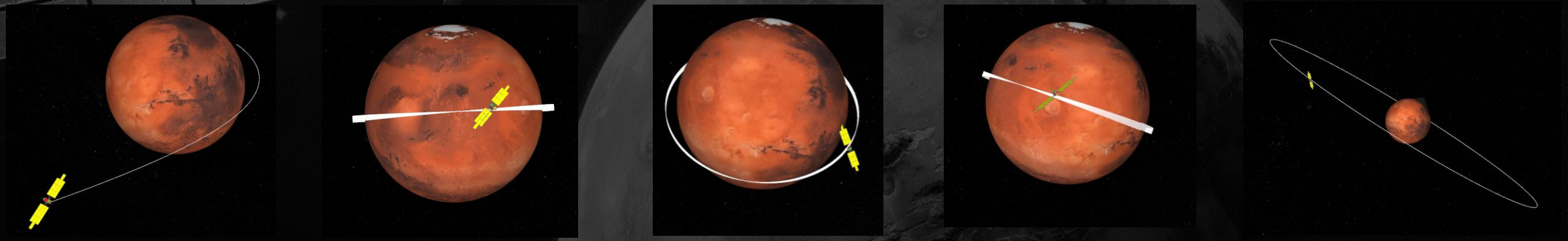
MSR-ERO geometrical model (Source: Power-Systema)

MSR-ERO electrical analyses

Context and orbit definition

- Different **spacecraft attitude and orbit** for different mission phases:

Source : Power-Systema



Mars Orbit Insertion

End of Spiraling down to Low Mars Orbit

Mars

Low Mars Orbit stabilized

Orbital Sample detection

Orbital Sample detected

OS Rendez-Vous

Start of Spiraling up from Low Mars Orbit

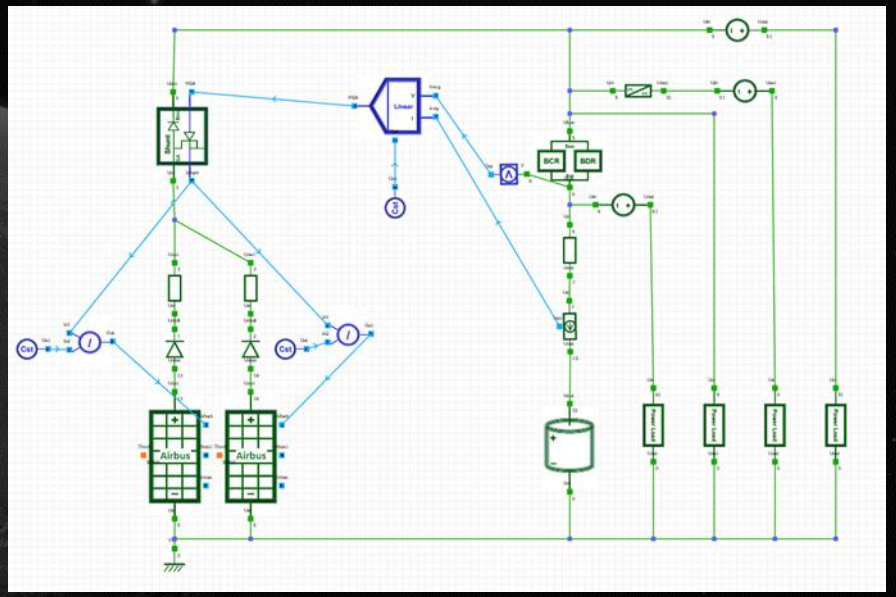
Spiraling up

MSR-ERO electrical analyses

A modular electrical model

- A complete **electrical schematic** :
  - Large set of generic components defined by a transfer function and parameters updated by the user
  - Possibility to code easily new components
  - Combination of electrical, logical and thermal nodes to simulate regulation as well as thermal behavior

- **Several iterations** to fulfill all **success criteria**:
  - Minimal voltage
  - Energy reserve
  - Taper duration
  - Average battery depth of discharge



Power-Systema schematics

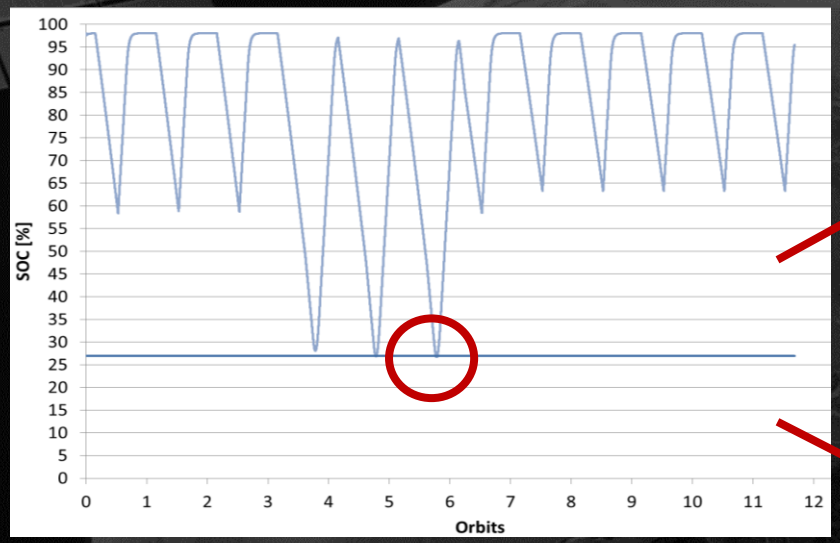
MSR-ERO electrical analyses

Simulation example

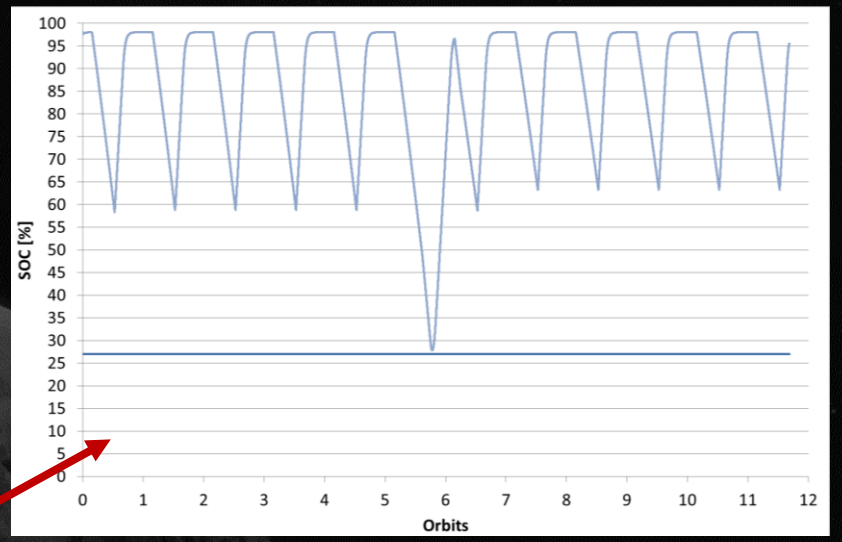
- No-convergence of the first simulation (minimum SOC threshold reached)

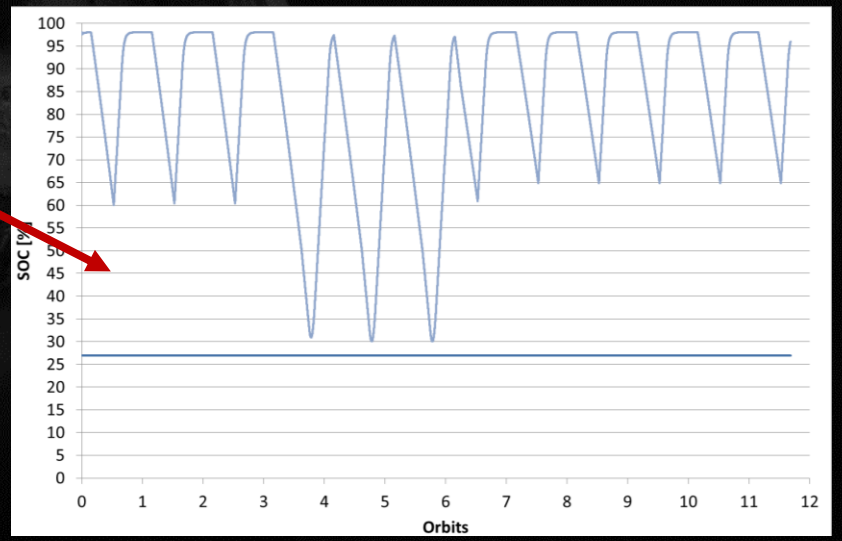
→**Several solutions**

- Modify attitude (less orbits with solar arrays fixed)
- Decrease consumption



Power-Systema simulations post-processing

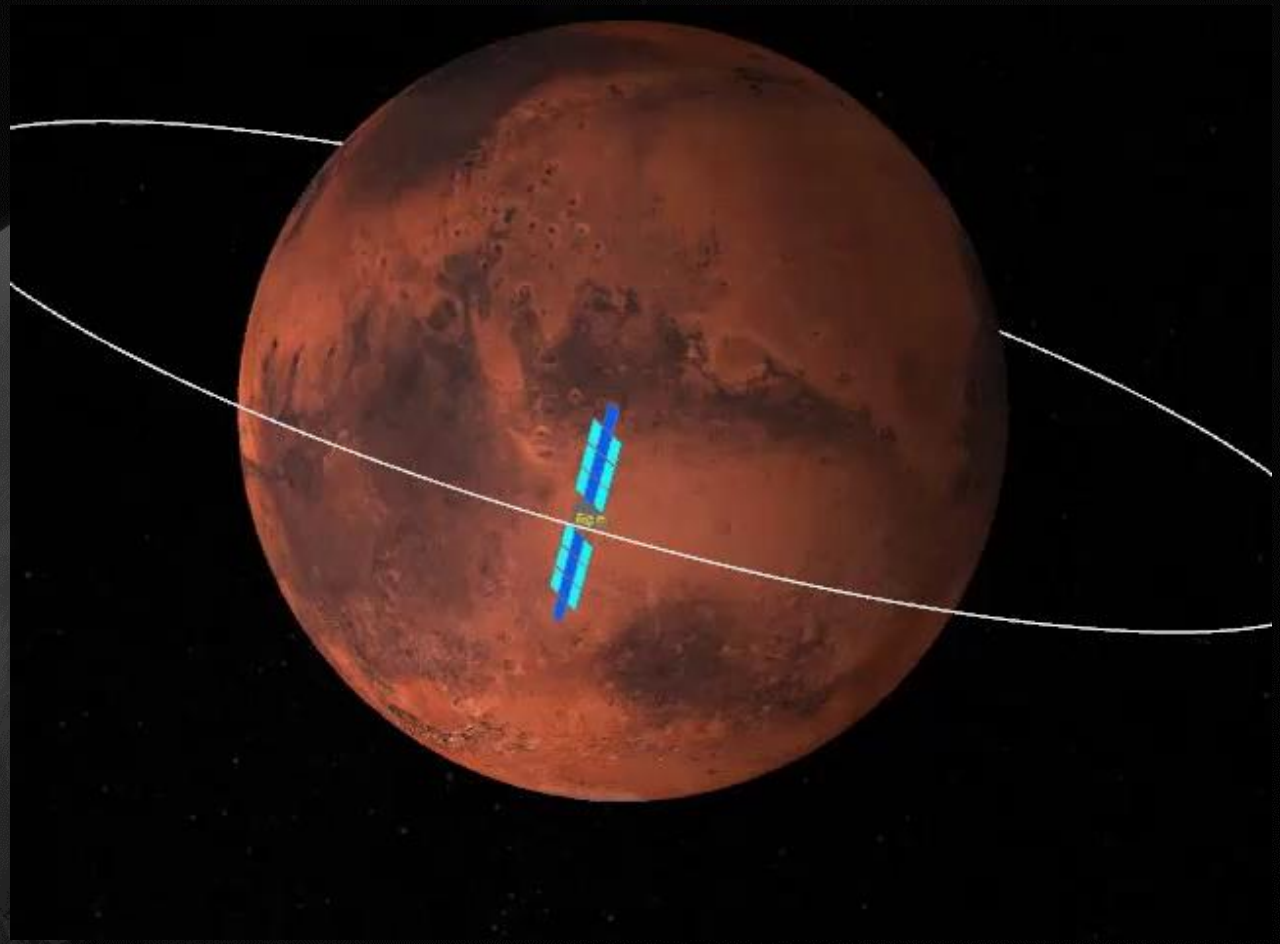




MSR-ERO electrical analyses

… in a nutshell

- **6** years of mission
- … covered through **7** different phases
- … and **90** run cases
- … for **2** main purposes (energy budget validation and propulsion demand)

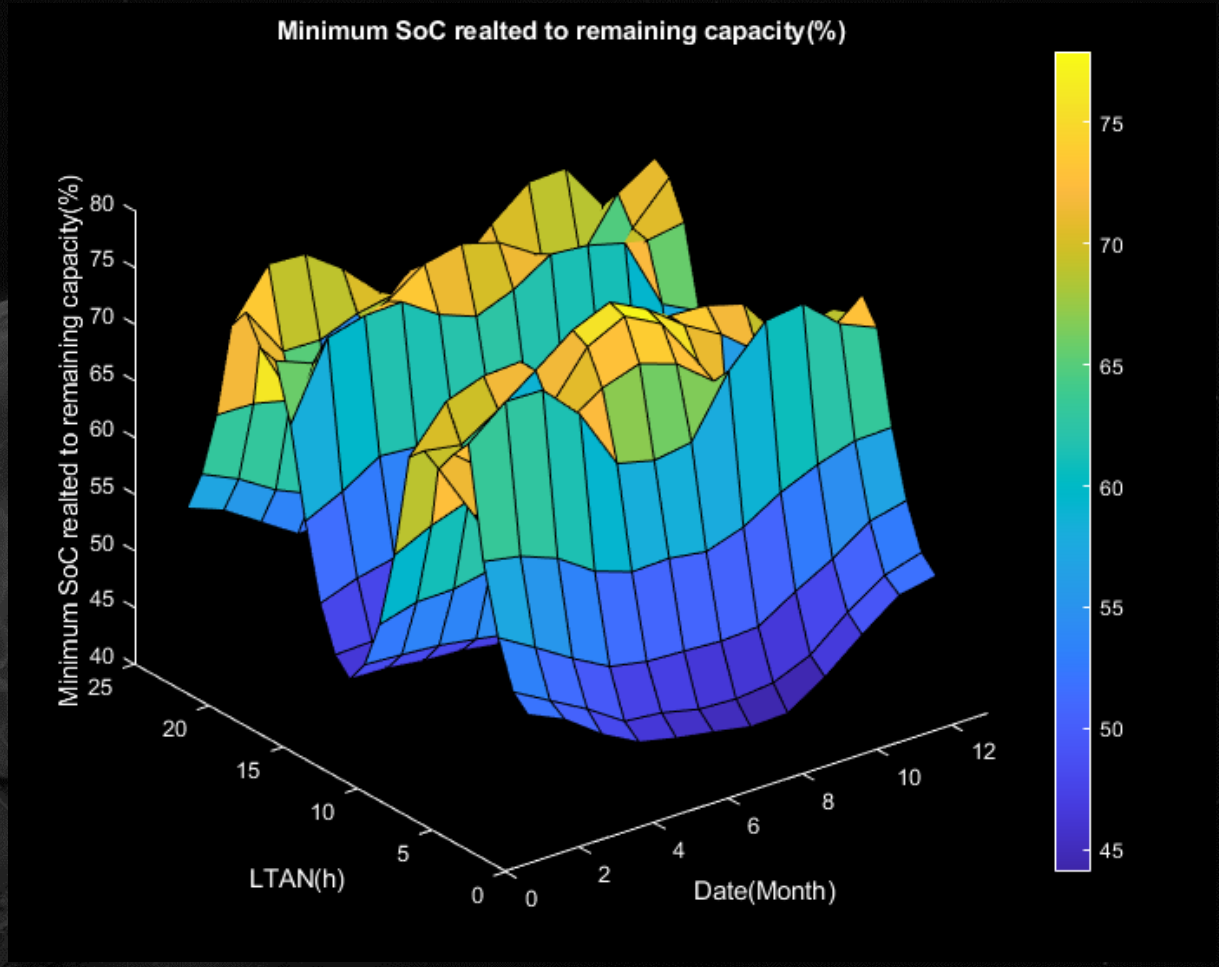


Other Systema analyses

A multi-purpose tool

- Systema-Power is very accurate for **Energy Budget simulations**, but it can also be used for:
  - Electrical components validation
  - In-orbit ageing correlation
  - Batch computation (thank to a complete Python API)

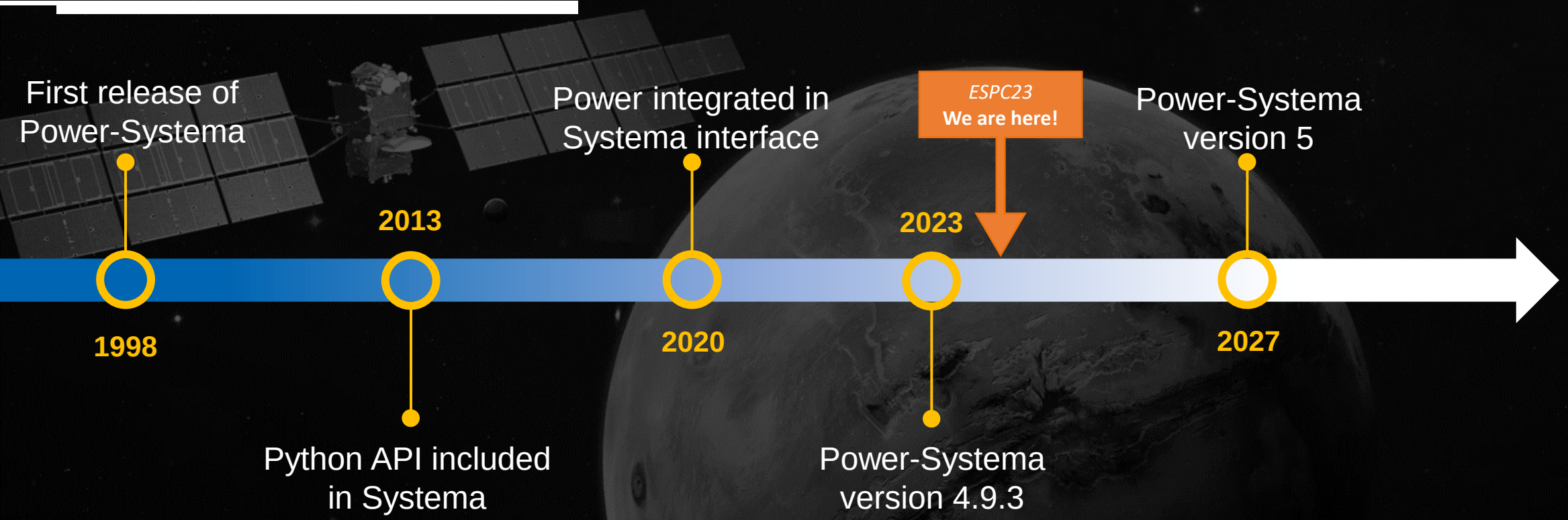
- Systema also offers other **plug-ins**:
  - Dosrad
  - Plume
  - Debris
  - Perturbations
  - Atomox
  - Outgassing



Batch computation results

Future milestones & perspectives

Systema in constante évolution



Q & A

Thank you!