



UNIVERSITY OF
LEICESTER



ESA-ESTEC, SSC M-MATISSE 12 October 2023

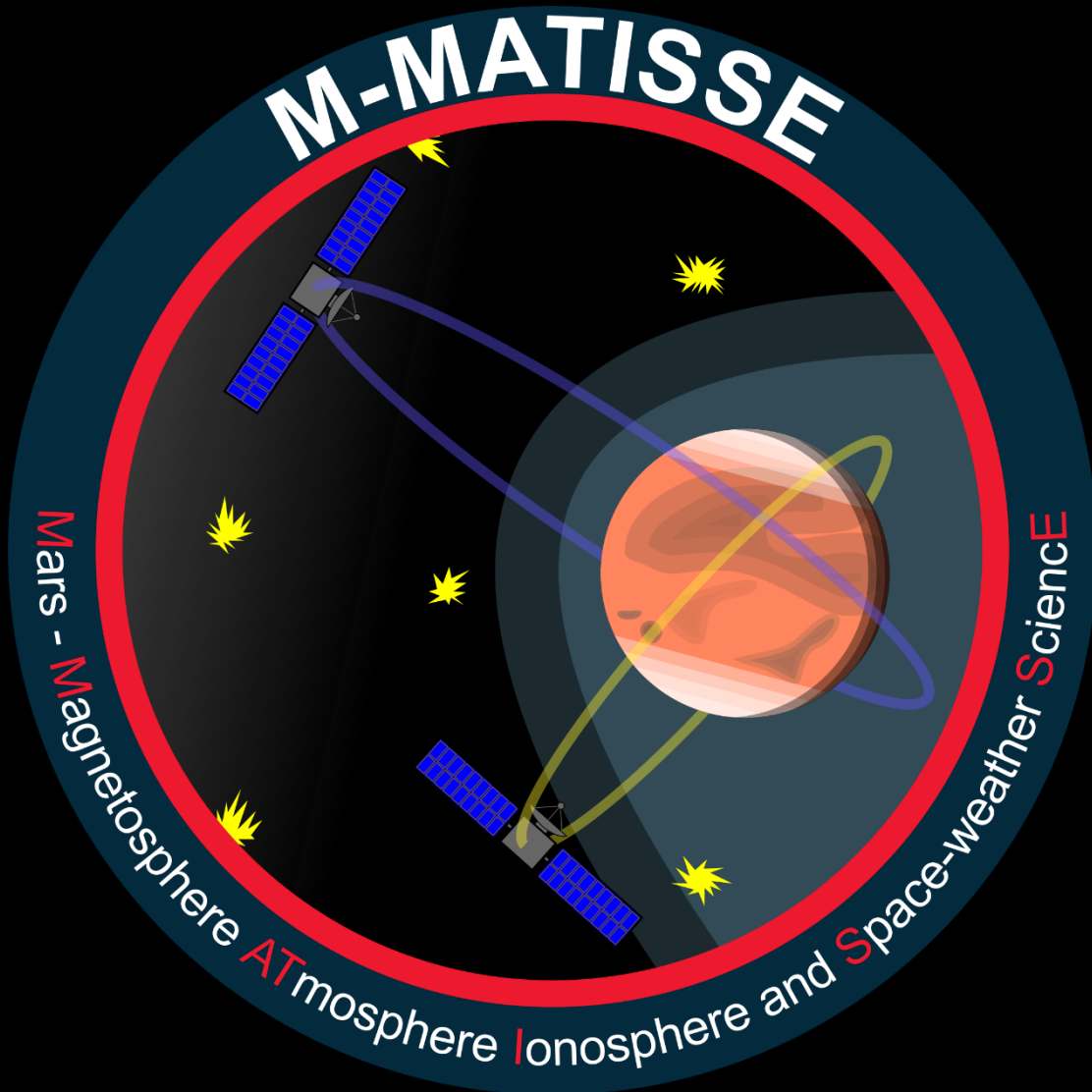


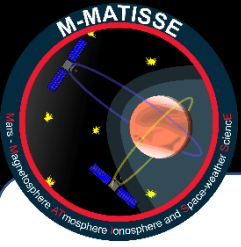
M-MATISSE

**Mars Magnetosphere ATmosphere
Ionosphere and Space-weather ScienceE**

*“The first dual spacecraft mission at Mars
to determine the response of atmospheric
coupling to Space Weather”*

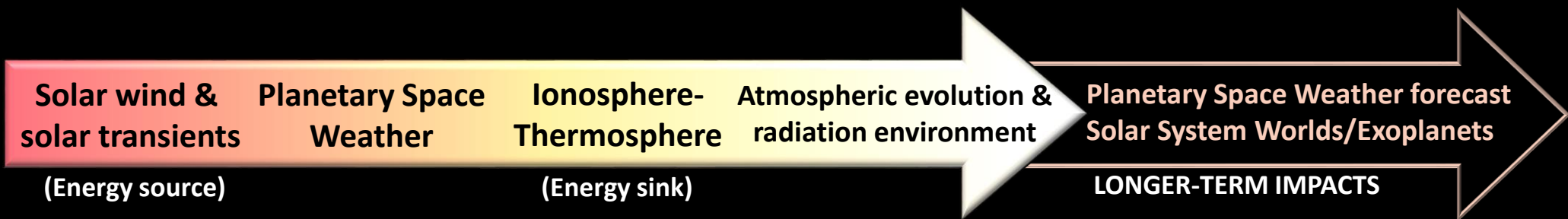
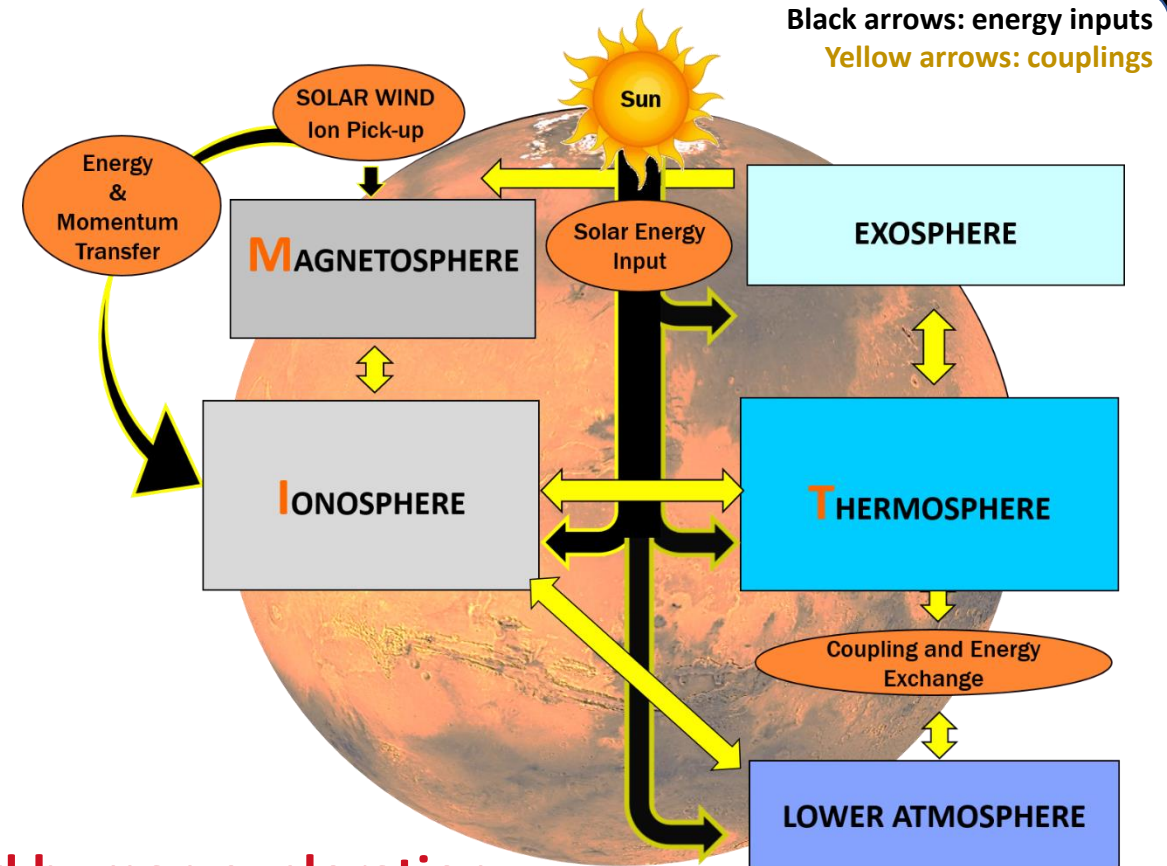
Beatriz Sánchez-Cano & François Leblanc
On behalf of the scientific team (~300 colleagues)

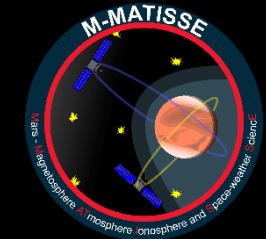




Understanding the present - Preparing the future

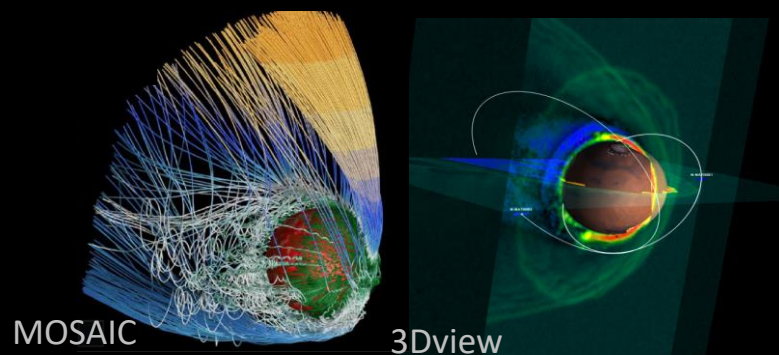
- **Quantifying the energy flow** through the system from space until the surface, **resolving temporal and spatial variabilities**
- **Unravelling the complex response** of the M-I-T coupling to Space Weather
 - **Key to understanding the evolution of terrestrial-planets climate**, as well as its past/present habitability.
 - Only possible with multi-point observations
- **Uncovering the fate of Mars' atmosphere**
 - **M-MATISSE will be essential for future robotic and human exploration**





3 Science Goals to untangle Mars plasma system as never before

Multipoint plasma measurements are needed to understand mass and energy flows throughout Mars' uniquely rich and interconnected hybrid magnetosphere

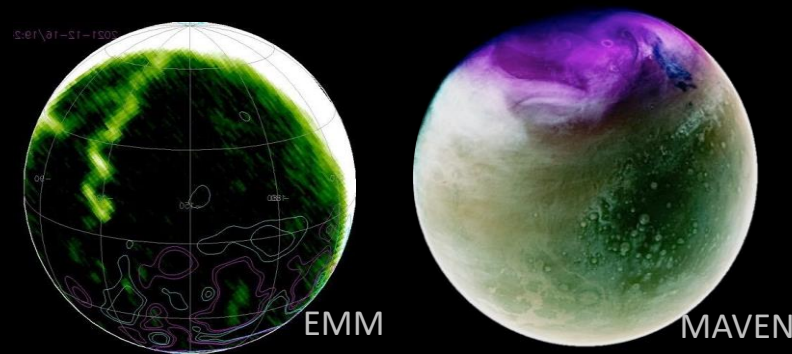


Global system Dynamics

Global dynamics of the M-I-T system as a result of the Mars - solar wind interaction, and processes driving their coupling

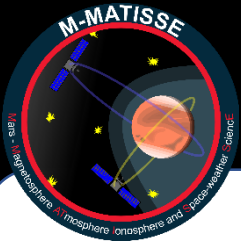
Processes that drive the radiation environment throughout Mars' M-I-T, and its response to solar wind drivers

The radiation environment



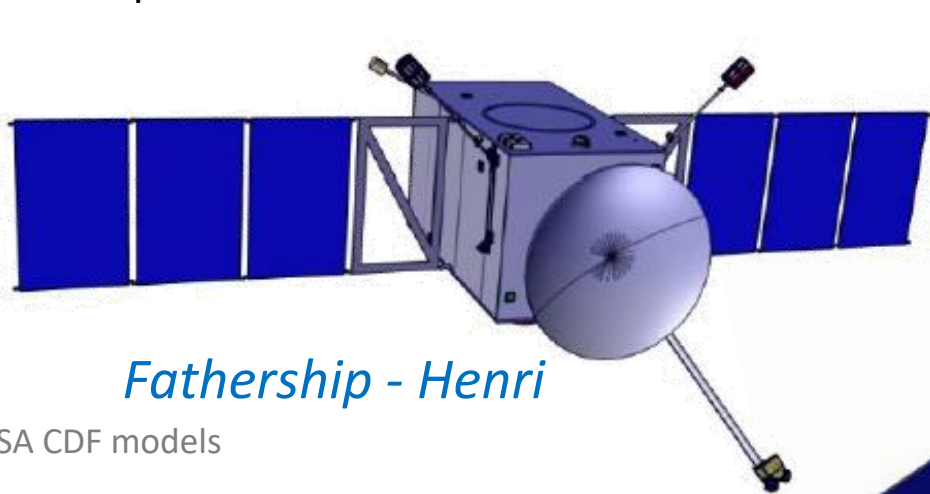
Ionosphere-lower atmosphere coupling

Mars's Space Weather effects on the lower atmosphere and so, on future human exploration



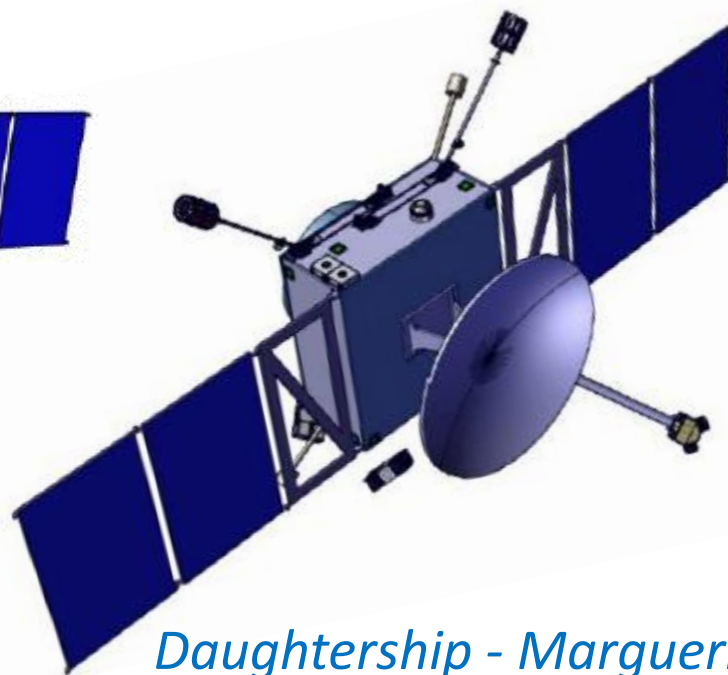
Two spacecraft – multiple vantage points

- *Henri*: In-situ observations from **3,000 km-250 km**, focus on the induced magnetosphere and upper ionosphere
- *Marguerite*: In-situ observations from **10,000-250 km**, focus on the solar wind and magneto-tail
- *Both*: remote observations of the lower-middle, upper atmosphere and ionosphere



Fathership - Henri

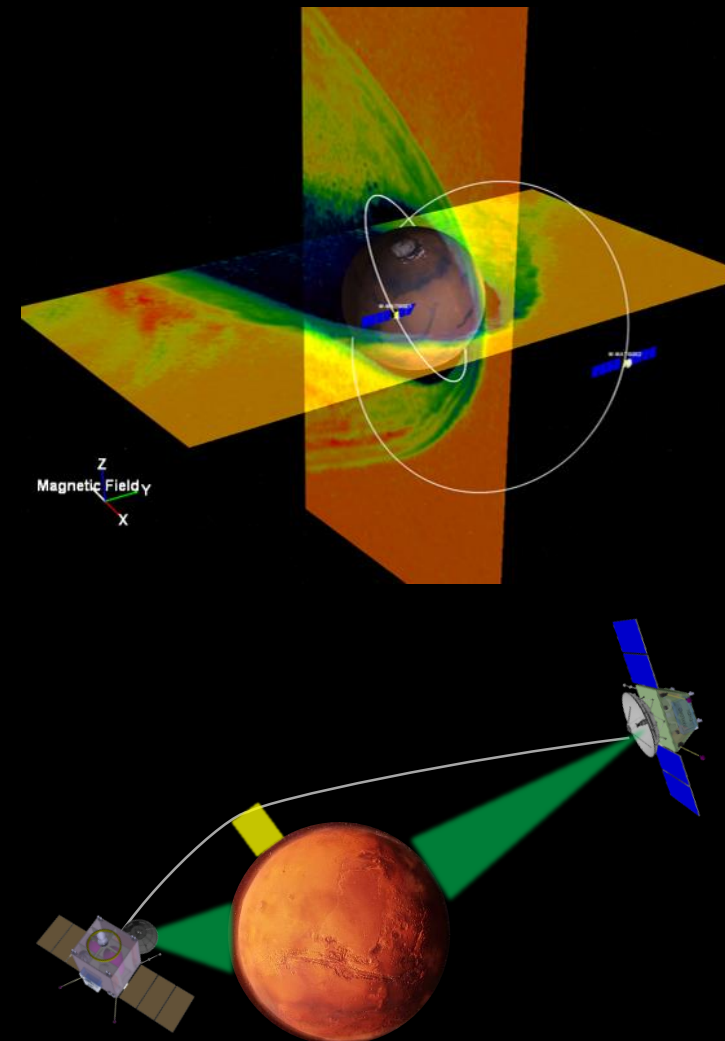
ESA CDF models

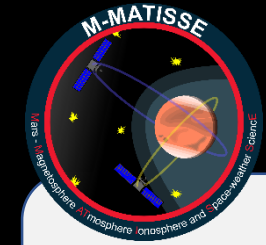


Daughtership - Marguerite

Orbit inclination of 60°

Independent communication with Earth





Scientific payload of M-MATISSE

M-MATISSE has **6 instruments** on both spacecraft, all of them with:

- High TRL, most of them already flying in other missions
- Enough time and spatial resolution and accuracy to resolve the system dynamics
- Major improvements with respect to current missions

- **COMPASS: a fields instrument with 4 sensors**

- **FGM:** A dual magnetometer
- **LP:** A dual Langmuir Probe
- **MIX:** A mutual impedance experiment
- **3DVI:** A 3D velocity of ion meter

- **M-EPI: a suite of particle instruments served by a common DPU**

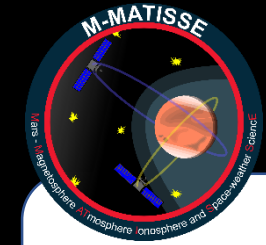
- **M-EAS:** An electron analyser
- **M-INEA:** An ion and neutral analyser
- **SP@M:** A solar particle detector

- **M-MSA: an ion mass spectrometer**

- **M-EUVM: an EUV monitor**

- **MaCRO: 2-spacecraft radio-occultation**

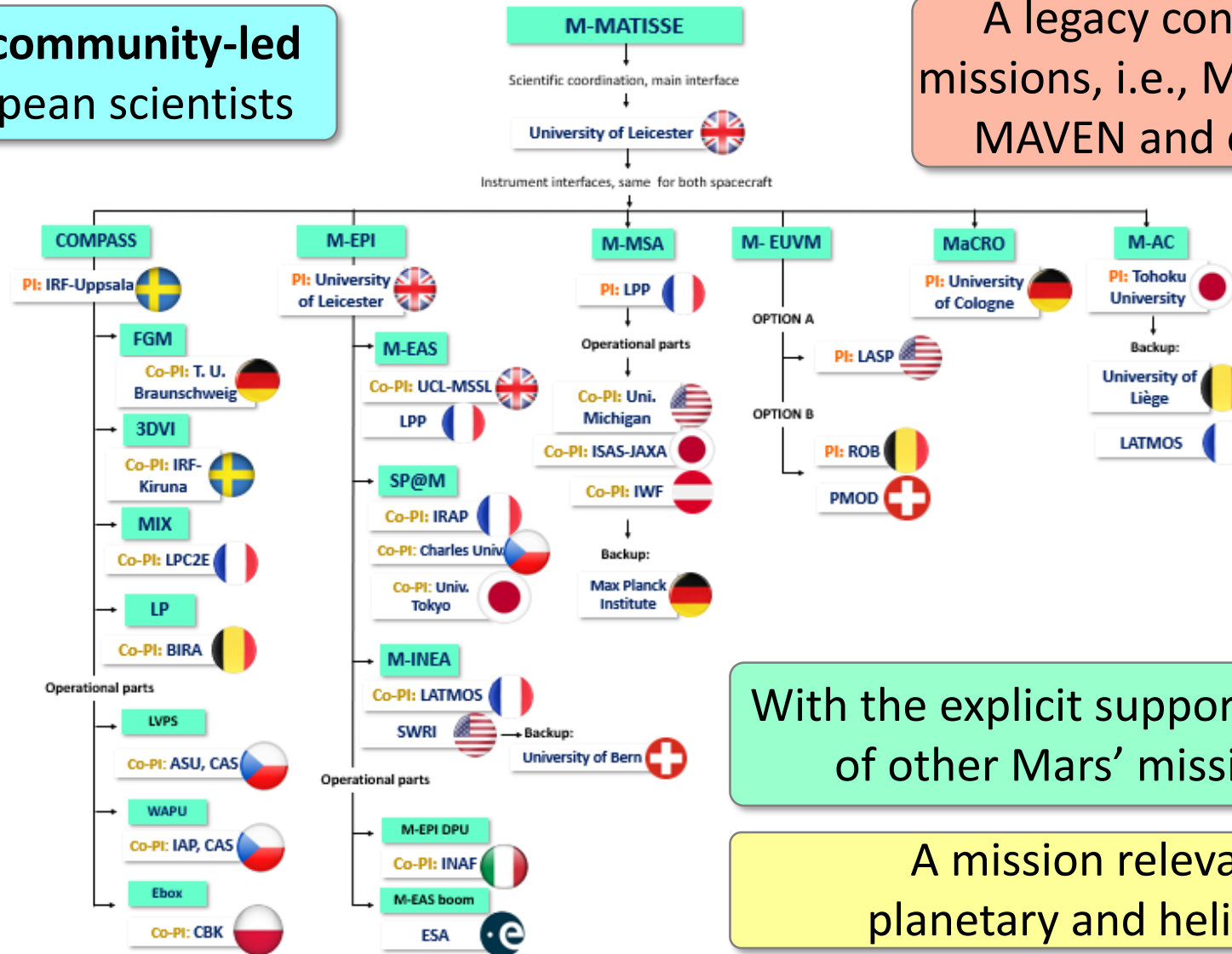
- **M-AC: an auroral and dust camera**



A large, organized and experienced consortium

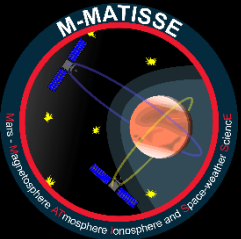
M-MATISSE is a **community-led mission** by European scientists

A legacy concept from pioneer missions, i.e., Mars Express, TGO and MAVEN and experienced teams



With the explicit support of the science teams of other Mars' missions, and agencies

A mission relevant for plasma, planetary and heliophysics science



A need for the scientific community

ASTRONET Europe roadmap 2022-2035
(pages 98-99)

Mars' plasma system
Scientific potential of coordinated multi-point missions:
"The next generation"

A White Paper submitted to ESA's Voyage 2050 Call

Contact Scientist:
Beatriz Sánchez-Cano

ESA Voyage-2050 white paper

Voyage 2050
Final recommendations from the Voyage 2050 Senior Committee

Voyage 2050 senior committee recommendation (page 21)

NASA Planetary Decadal Survey 2023-2032 white paper

Coordinated multi-spacecraft observations of the Martian plasma environment

Whitepaper #145 submitted to the Planetary Science and Astrobiology Decadal Survey 2023-2032. Topics: Mars; other science themes: PLASMA

by Beatriz Sanchez-Cano, Majd Mayyasi, Kerstin Peter, Cesar Bertucci, Xiaohua Fang, Christopher M. Fowler,

NASA heliophysics decadal survey 2024-2033 white paper

Heliophysics and space weather science at ~1.5 AU: Knowledge gaps and need for space weather monitors at Mars

Christina O. Lee^{1*}, Beatriz Sánchez-Cano², Gina A. DiBraccio³, Majd Mayyasi⁴, Shaosui Xu¹, Phillip Chamberlin⁵, Emma Davies⁶, Camilla Scolini⁶, Rachael J. Filwett^{7,8}, Robin Ramstad⁹, Erika Palmerio⁹, Benjamin J. Lynch¹, Janet G. Luhmann¹

NASA Planetary Mission Concept Study, Planetary Decadal Survey 2023-2032

MOSAIC
MARS ORBITERS FOR SURFACE-ATMOSPHERE-IONOSPHERE CONNECTIONS

AUGUST 2020
Mission Concept Study
Planetary Science Decadal Survey

PRINCIPAL INVESTIGATOR: Robert Lim, University of California, Berkeley
CO-PRINCIPAL INVESTIGATOR: Stephen Barlow, University of California, Berkeley
JPL POINT OF CONTACT: Steve Malin, JPL, Malin Space Science Systems, California Institute of Technology

ASTRONET
THE ASTRONET SCIENCE, VISION & INFRASTRUCTURE ROADMAP 2022-2035

A STRATEGIC PLAN FOR EUROPEAN ASTRONOMY
Executive Summary

ESA SciSpacE White Papers

ESA SciSpacE white papers – Final 15 Dec 2021

White Paper #02: Astrophysics

Contributors:
Gianfranco Bertone, Oliver Buchmueller, Christer Fuglesang, Mats Holmström, Mark Lester, Savita Mathur, Etienne Parizot, Alexander Shapiro

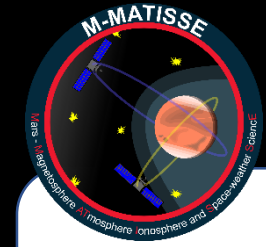
I Foreword

Understanding the origin and evolution of the different elements constituting our Universe has been the main motivation for the research done in Astrophysics. To answer the open questions of that field, observations, modelling, and theory are clearly intertwined leading to a tight connection in the development of these different approaches. During the last decades, Space observations have taken a leap forward. Thanks to the development of new technologies, telescopes are becoming more and more performant, yielding to more precise observations into our Universe and enabling us to explore it further than ever understood. This is made possible by a tremendous amount of high-quality data. Access

ESA Terrae Novae 2030+ "to prepare the horizon goal of Europe being part of the first human mission to Mars."

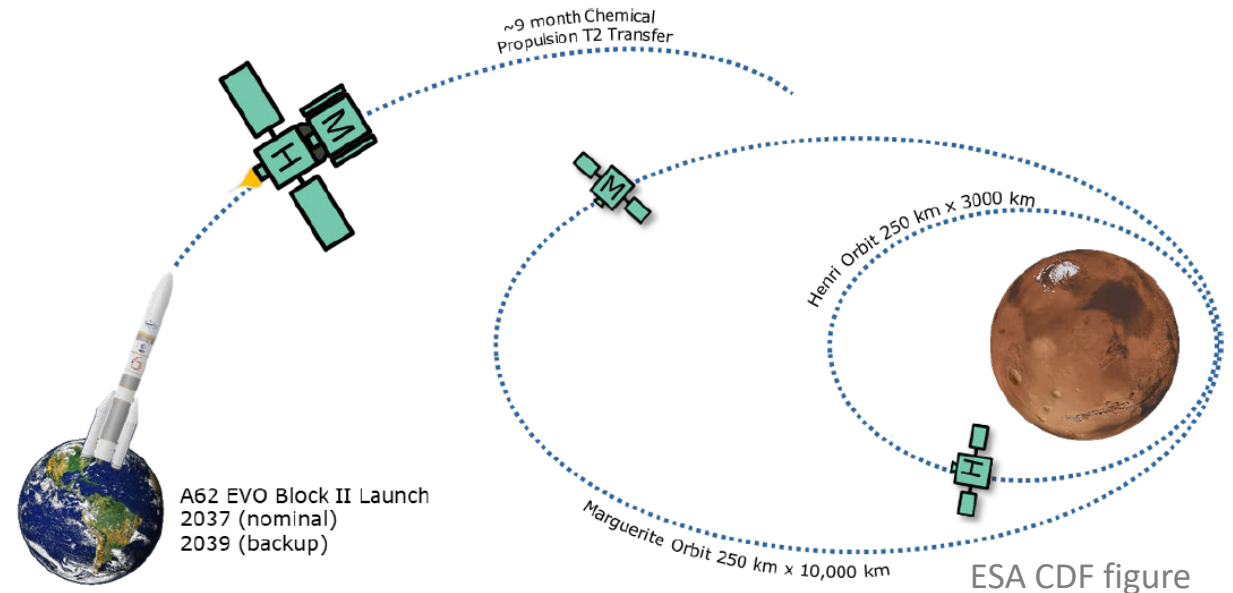
ESA UNCLASSIFIED - Released to the Public

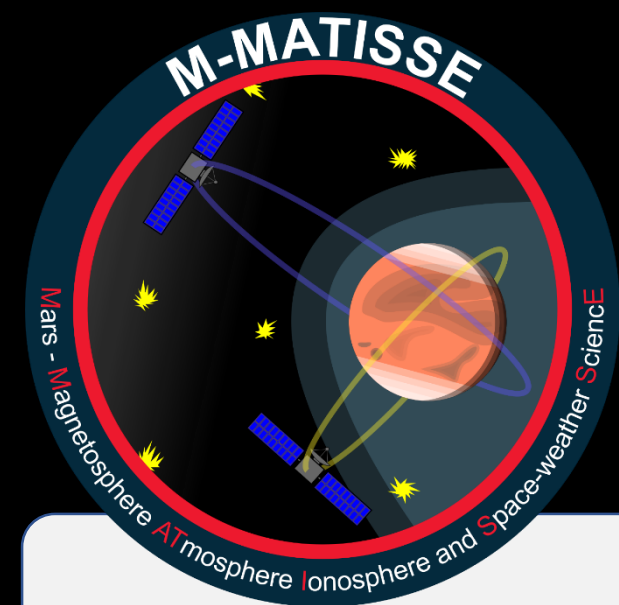
Terrae Novae 2030+ Strategy Roadmap
June 2022



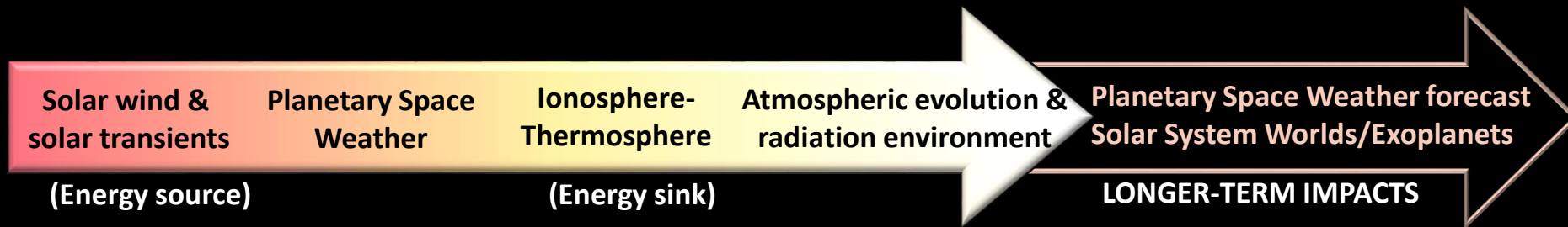
M-MATISSE CDF and MDR results

- The mission is compatible with a Phase-0 investigation and it is considered under control.
- No identified technical or programmatic showstoppers for the M7 M-MATISSE mission.
- All the review objectives have been fully achieved and the MDR can be considered successful.
- A solid work plan for the science instruments is planned for the Phase-A.





M-MATISSE: “the first flotilla to another planet”



- A dual spacecraft approach with an optimal set of plasma instruments and radio-occultation experiment
- A **unique capability** to track solar perturbations from the Solar Wind down to the surface
- A mission dedicated to understand planetary space weather at Mars
- An **essential step** for future robotic and human exploration
- A **large organized and experienced** international consortium