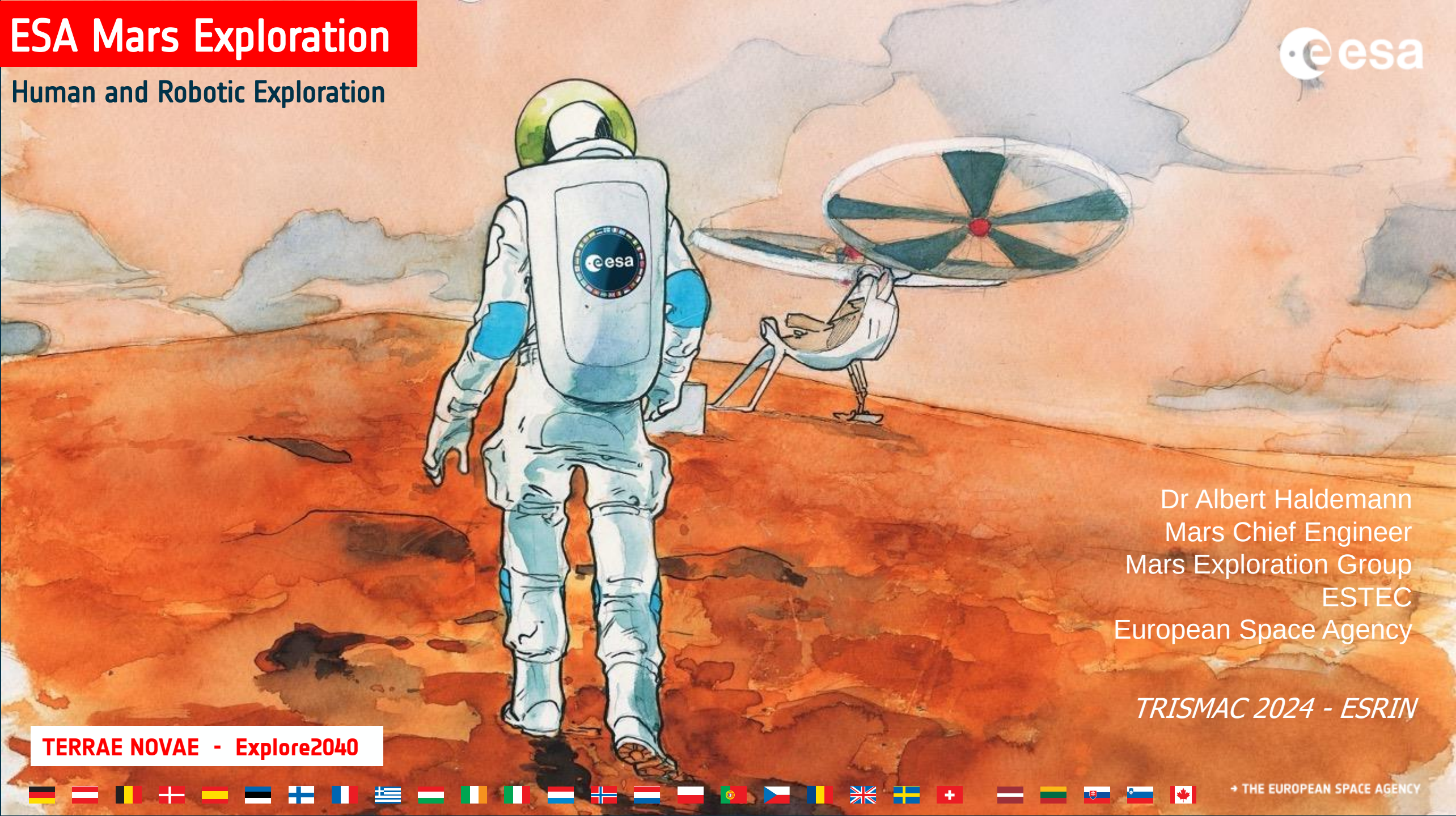
ESA Mars Exploration

Human and Robotic Exploration



Dr Albert Haldemann
Mars Chief Engineer
Mars Exploration Group
ESTEC
European Space Agency

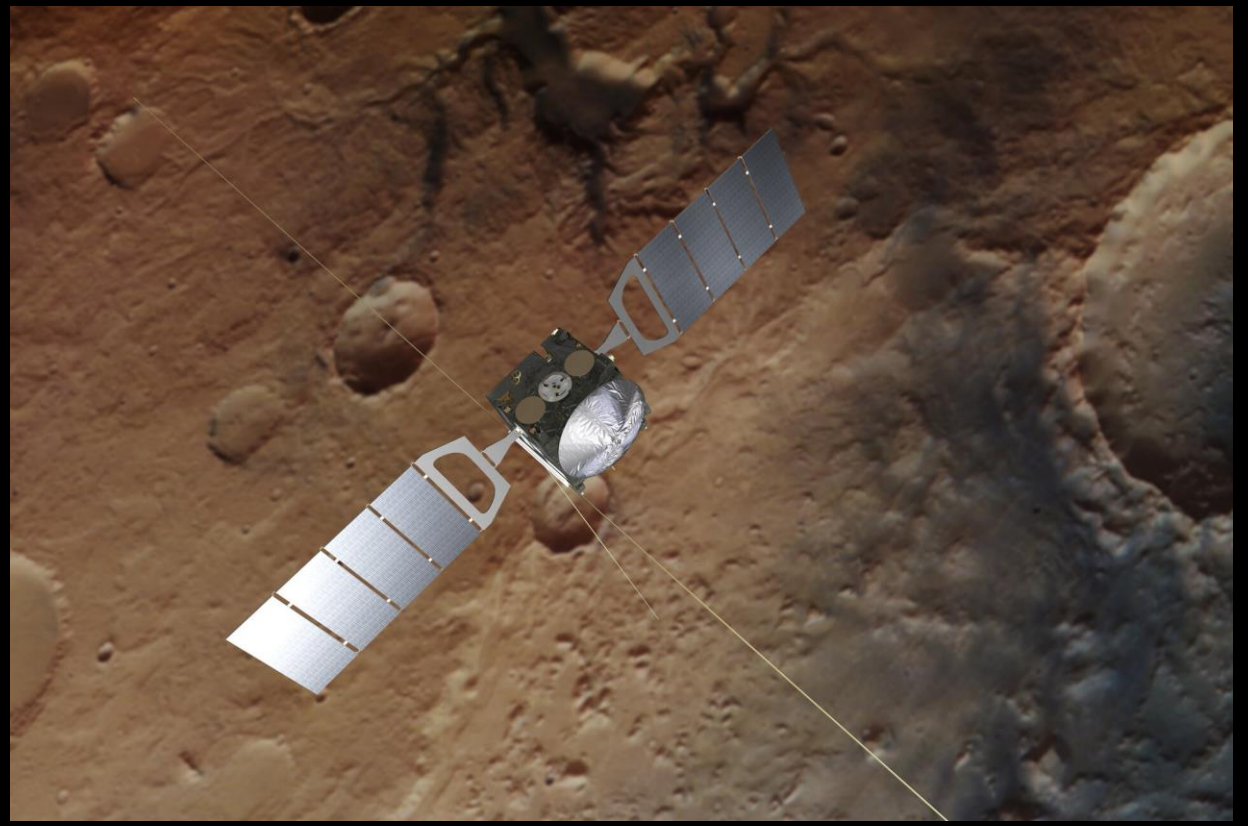
TRISMAC 2024 - ESRIN

TERRAE NOVAE - Explore2040

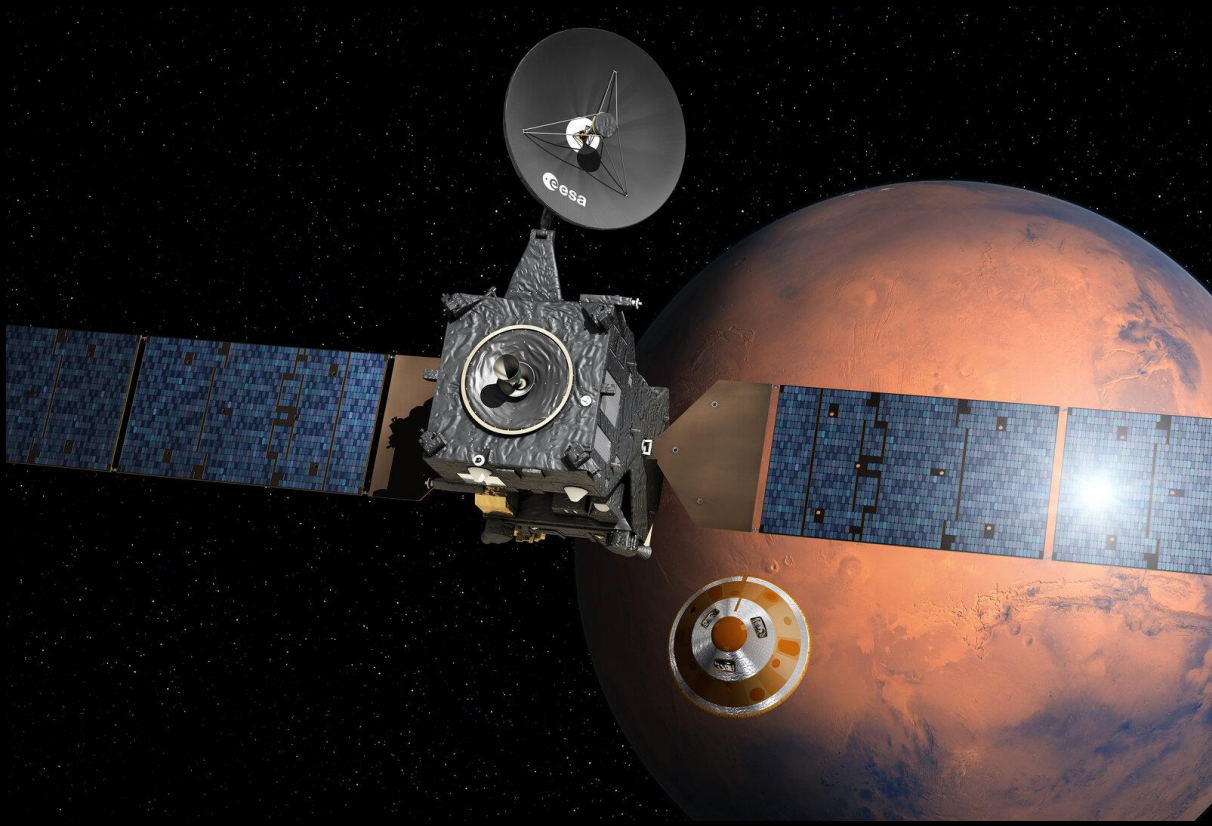
Key Drivers of the Mars 20-Year Plan

- Development of assets and capabilities leading towards future European crewed missions to the surface of Mars.
- Fully European access to the Mars surface with a steady increase in capability.
- Capability-driven Science.
- Creation of opportunities for both bigger and smaller Member States.
- Focus on recurring platforms and technologies.
- International partnerships with independent European mission elements.
- Synergies and commonalities with Lunar exploration and Launchers.

ESA's operational Mars Fleet

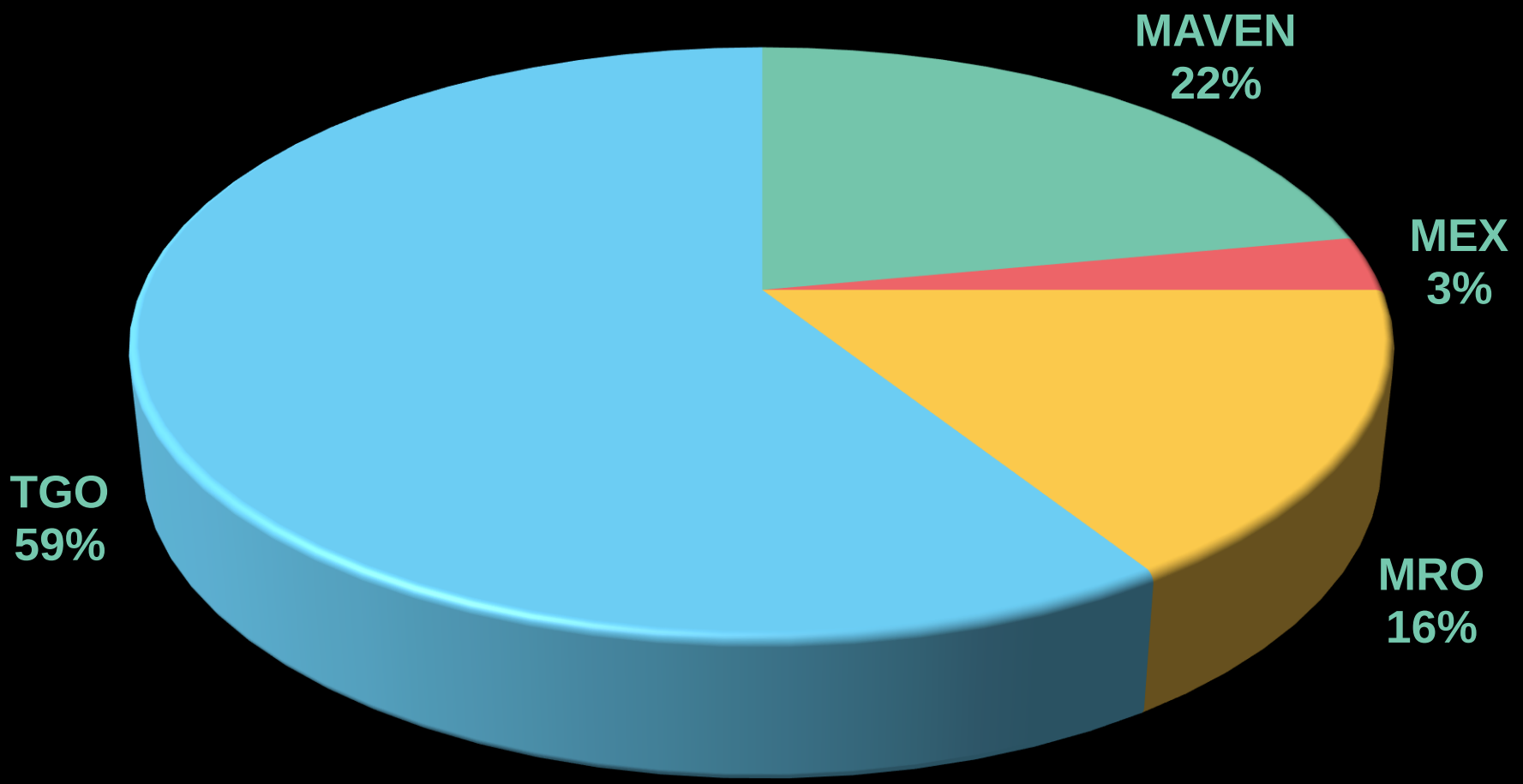


MarsExpress



ExoMars - Trace Gas Orbiter

PERCENT MARS-EARTH DATA RETURN



Rosalind Franklin Mission

New launch date 2028

New partnership with NASA, MOU signed on 16 May. NASA elements:

- Launcher
- RHU's
- Breaking Engines

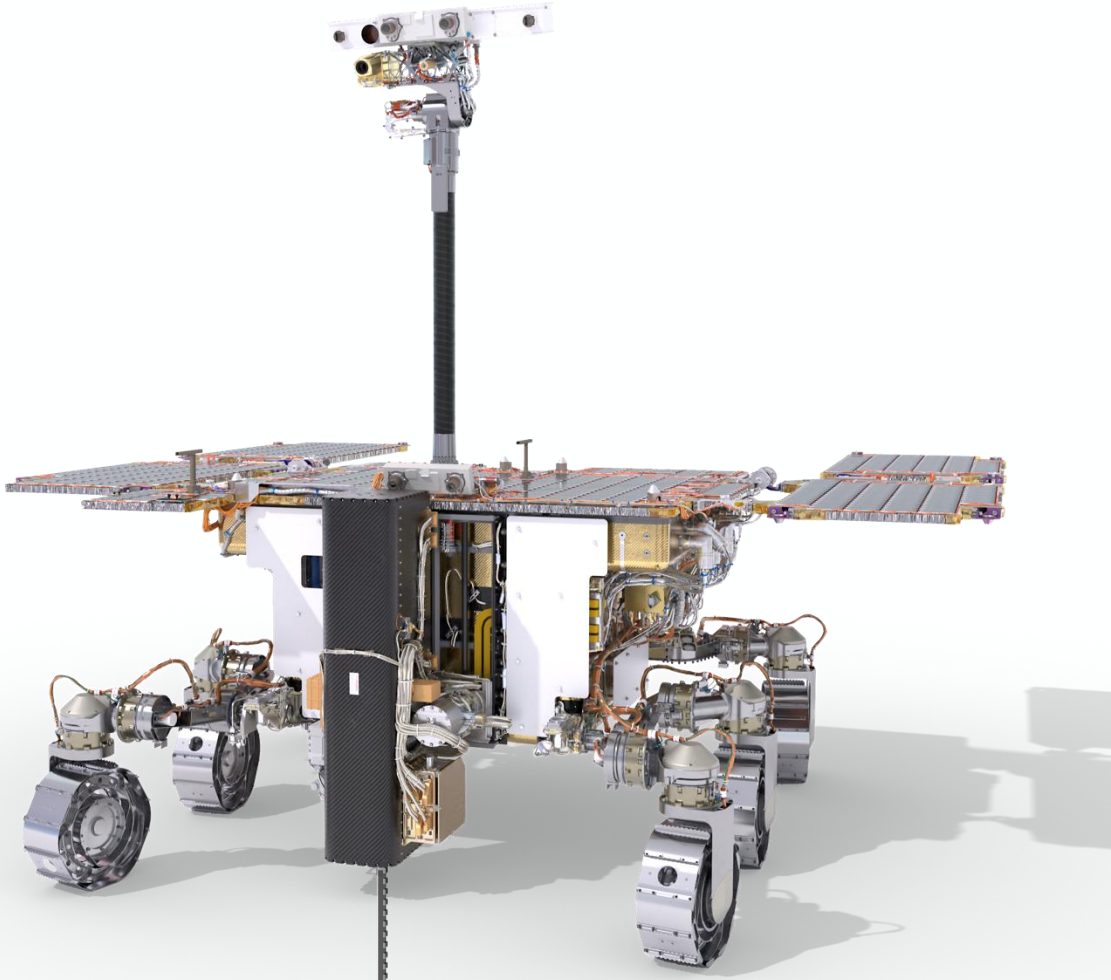
Industrial contract signed with Thales Alenia Space in Italy

All new "all-European" EDL Module ("EDLM")

Rover is being refurbished but no major new upgrades are planned; ISEM instrument replaced by ENFYS

ESA plans to fly an Am-based RHU dubbed ENDURE onboard the EDLM for thermal management of the batteries.

Overall, the RFM project is making great progress, and we are on track for a 2028 launch.

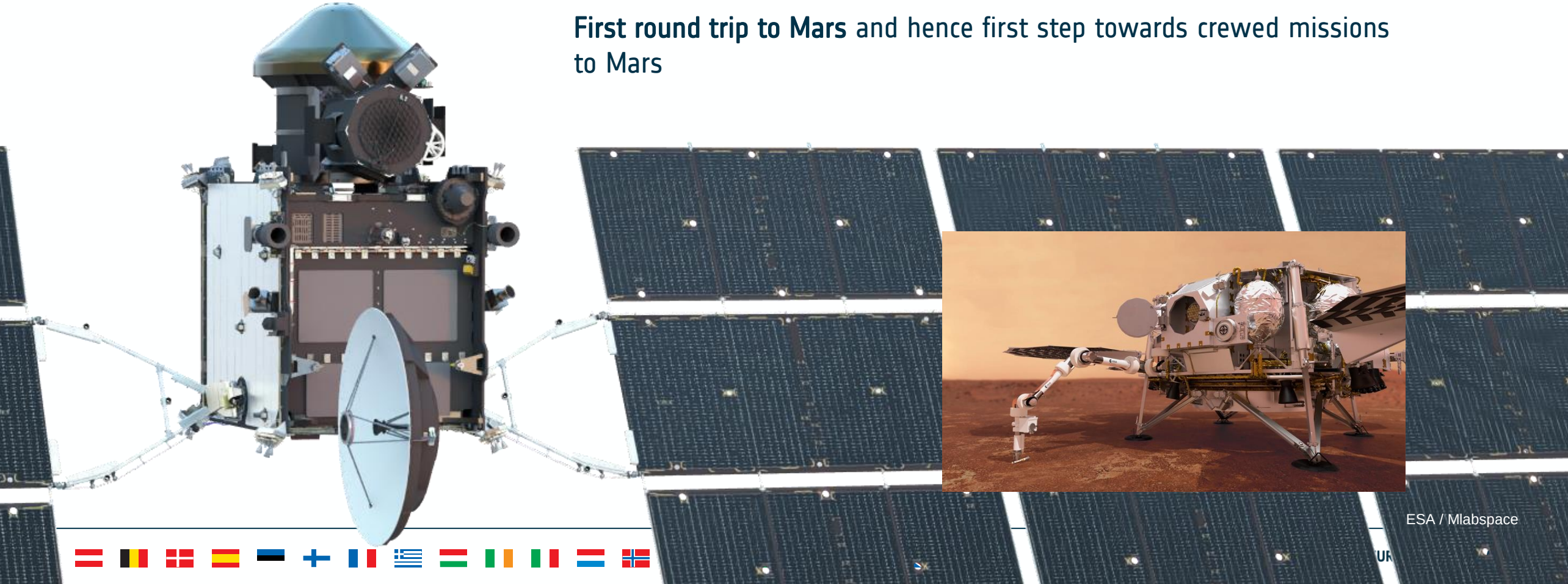


Mars Sample Return

Remains a **top Exploration priority for ESA** and ESA remains committed to providing **Earth Return Orbiter** and **Sample Transfer Arm**

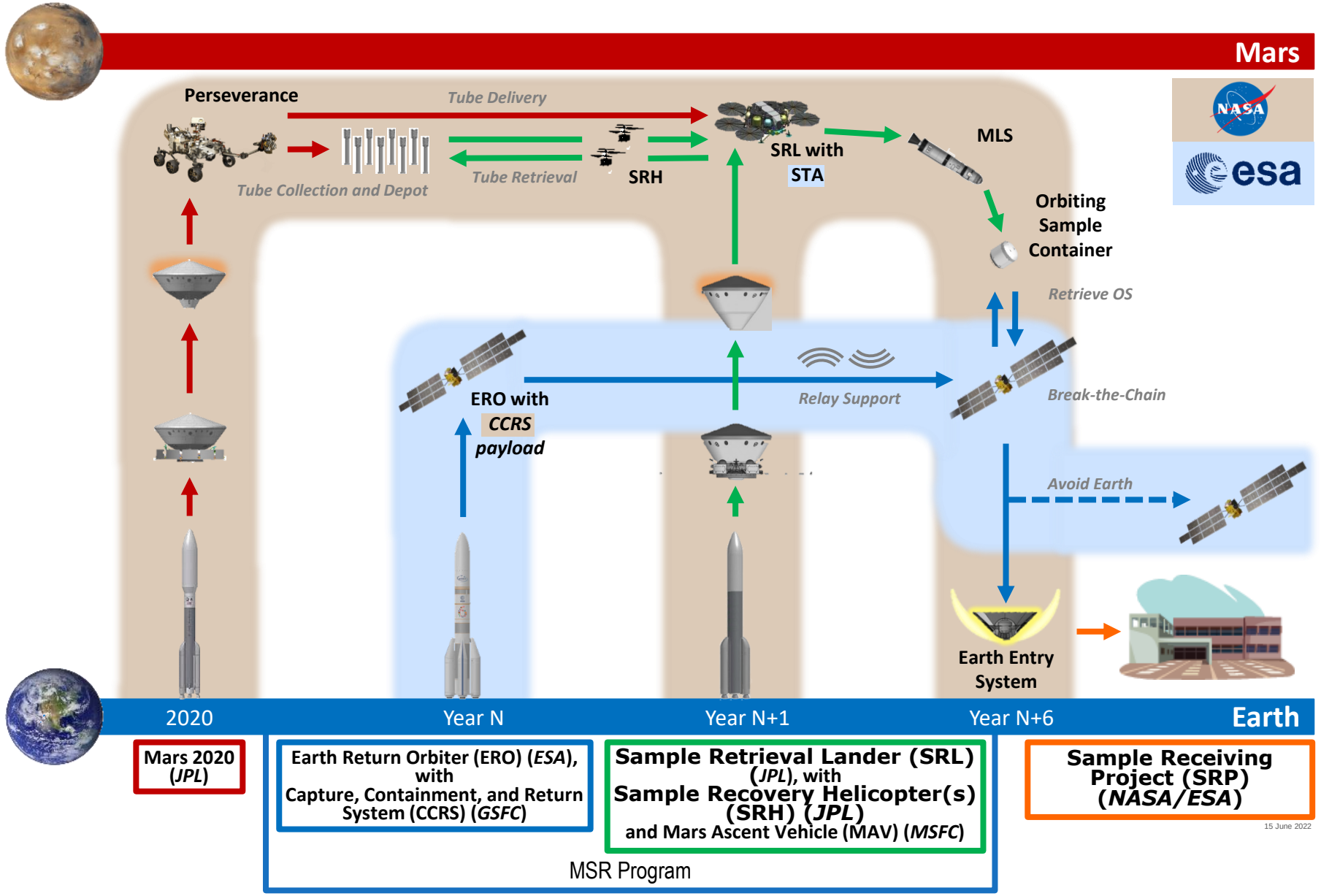
MSR and Rosalind Franklin Mission are fully complementary and together will will provide **breakthrough science**

First round trip to Mars and hence first step towards crewed missions to Mars



ESA / Mlabspace

MSR Campaign Planning Architecture, December 2023



- Planning architecture was reviewed by a NASA Independent Review Board in mid-2023
- Based on the resulting report, NASA elected to pause certain work in late 2023 and evaluate alternative architectures
- **NASA and ESA are working together to find a viable way forward for Mars Sample Return**
- **In the interim, the MSR Program Planetary Protection team has developed an architecture-independent approach for backward planetary protection**

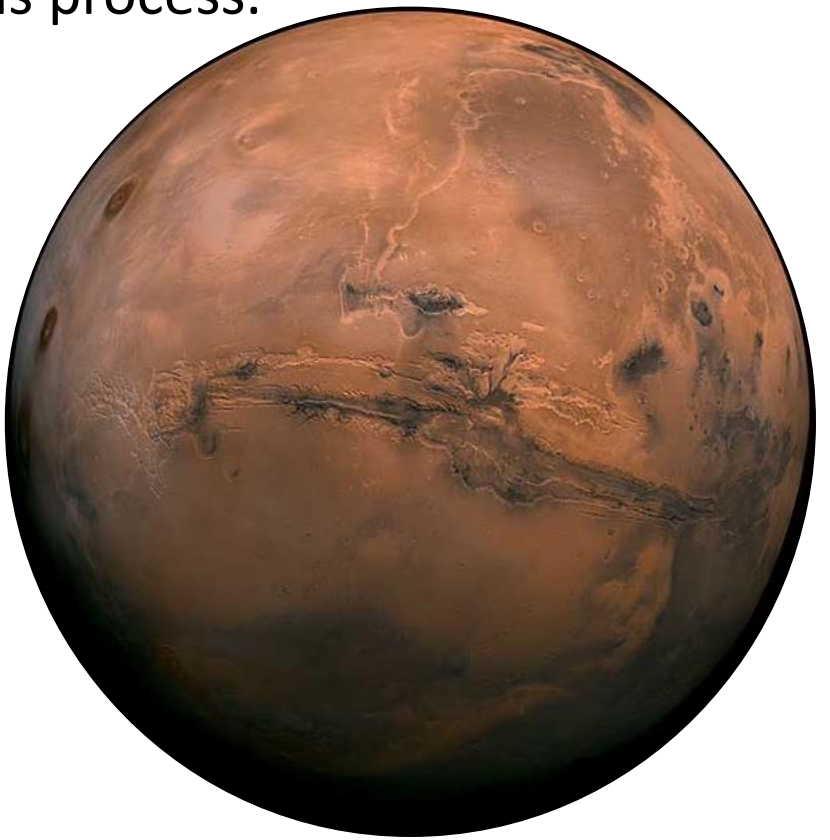
Compliance Paths for Backward Planetary Protection

- **NASA and ESA PP strategies are responsive to established policies**
  - ESA-NASA MSR memorandum states each agency shall apply “planetary protection measures based on their respective applicable policies and requirements”
- **NASA PP approach is performance-based**
  - MSR would produce an Assurance Case, a structured argument detailing quantitative and comparative metrics indicative of safe Mars material management
  - Covers the elements of SRL mission involved in Earth return as well as additional NASA-managed hardware that would perform containment and return
- **ESA PP approach is quantitative and qualitative:**
  - Probabilistic Risk Assessment (PRA) to assure the probabilistic requirement to release unsterilized material from Mars is met
  - Qualitative safety engineering process to ensure all scenarios leading to hazards are identified, adequately controlled and fault tolerant
- **ESA and NASA are evolving a Joint Management approach for PP**

Science Firsts for Exploring Mars

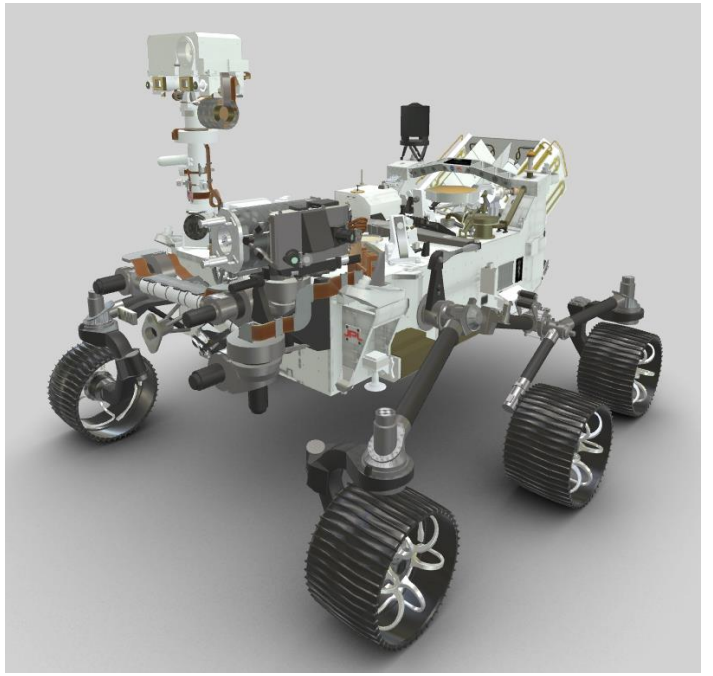
- The ExoMars Rosalind Franklin mission at Oxia Planum and Mars Sample Return campaign at Jezero Crater are complementary missions to explore ancient terrain 5000 km apart at similar latitudes, that experienced aqueous process.

- ExoMars Rosalind Franklin Mission
  - FIRST deep subsurface access (up to 2m) on another planet
  - Most ancient terrain studied to date, with payload elements beyond any *in-situ* sent before and including ability to get below upper radiation depth.
  - Higher level of protection for organic matter means higher abundance of material and more information about structural integrity.
- Mars Sample Return Campaign
  - FIRST samples from another planet brought to Earth
  - Sample return allows for unprecedented science exploration in terrestrial labs with iterative science investigation and future research potential and is applicable to a wide range of scientific fields and to human exploration.
  - Will generate transformative science applicable to the understanding of terrestrial planets in our solar system and rocky Exoplanets.



Complementary Science Missions

- Information on the molecular complexity of organic matter analyzed by MOMA on RFM will inform MSR sample analyses in order to tailor processes to optimize sample usage and schedule - analyses related to planetary protection and life detection can be targeted and samples may be released for other measurements more quickly.
- In situ analyses by RFM at Oxia Planum, in combination with Perseverance rover data from Jezero Crater, can help guide what types of studies might be most informative for MSR samples even before they have returned to Earth (e.g., information on the pristine hydration states of minerals).



NASA and ESA are strategic partners across our programs. Together, these missions build on a rich history of collaboration between the two agencies and will be a huge leap forward in our understanding of Mars and our home planet.

ESA Mars Exploration Missions

Mars Express |30 years old

Trace Gas Orbiter |15 years old |20 years old

EXM Rosalind Franklin

MSR/ERO

LightShip-1 + Spotlight

Advanced Lander - MEDaL

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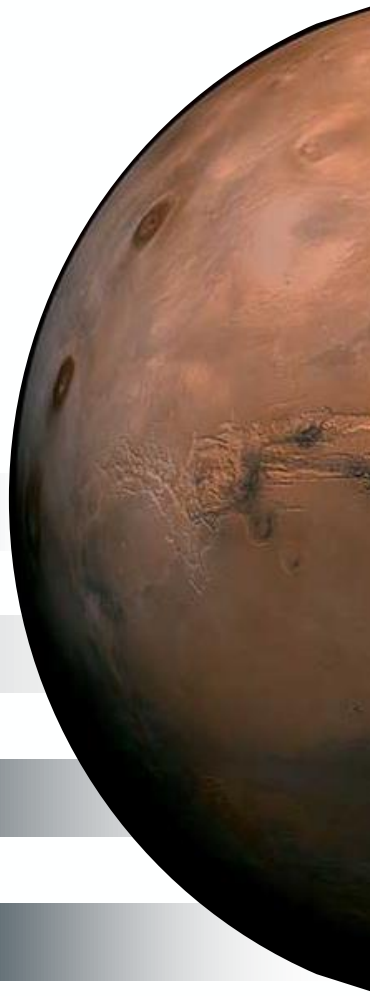
Programmes under formulation



… 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040+

Core Logic of ESA's Mars Exploration Plan

- ESA is planning to build-up orbiter and lander assets at Mars in a structured way over the coming **20 years**:
  - In an Orbiter mission – Lander mission – Orbiter – Lander… sequence.
  - Mission logics are structured around "Exploration Focused" science goals (high resolution imagery of landing sites, weather, resource maps, etc.).
  - But these missions also open-up "Exploration Enabled" science (astrobiology, planetary geology, geodesy, etc.)
- The first Orbiter mission is planned for 2032 followed by a Lander mission in 2035.
- **Enabling partnership** is a key objective of the programme:
  - More frequent, cheaper missions + missions of opportunity
  - Networked exploration
  - Aim to be a core contribution to NASA's Moon to Mars

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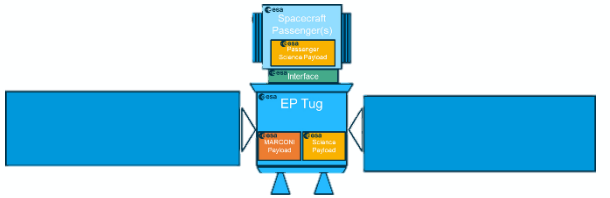
Orbital Mission 1 – “Lightship”



Lightship1 consists of 2 spacecraft, a Tug and a single Passenger, (in Phase A/B1)

Tug (5720km altitude, 20deg inclination):

- Propulsive service that remains as a comms/nav service node in a **high** Mars orbit
- Orbit selection driven by data relay, not driven by science
- Unique opportunity for of networked exploration science that can be built up over several years.
- Provision of ~30kg for science payload has been made, with a focus on science suitable for high orbit.

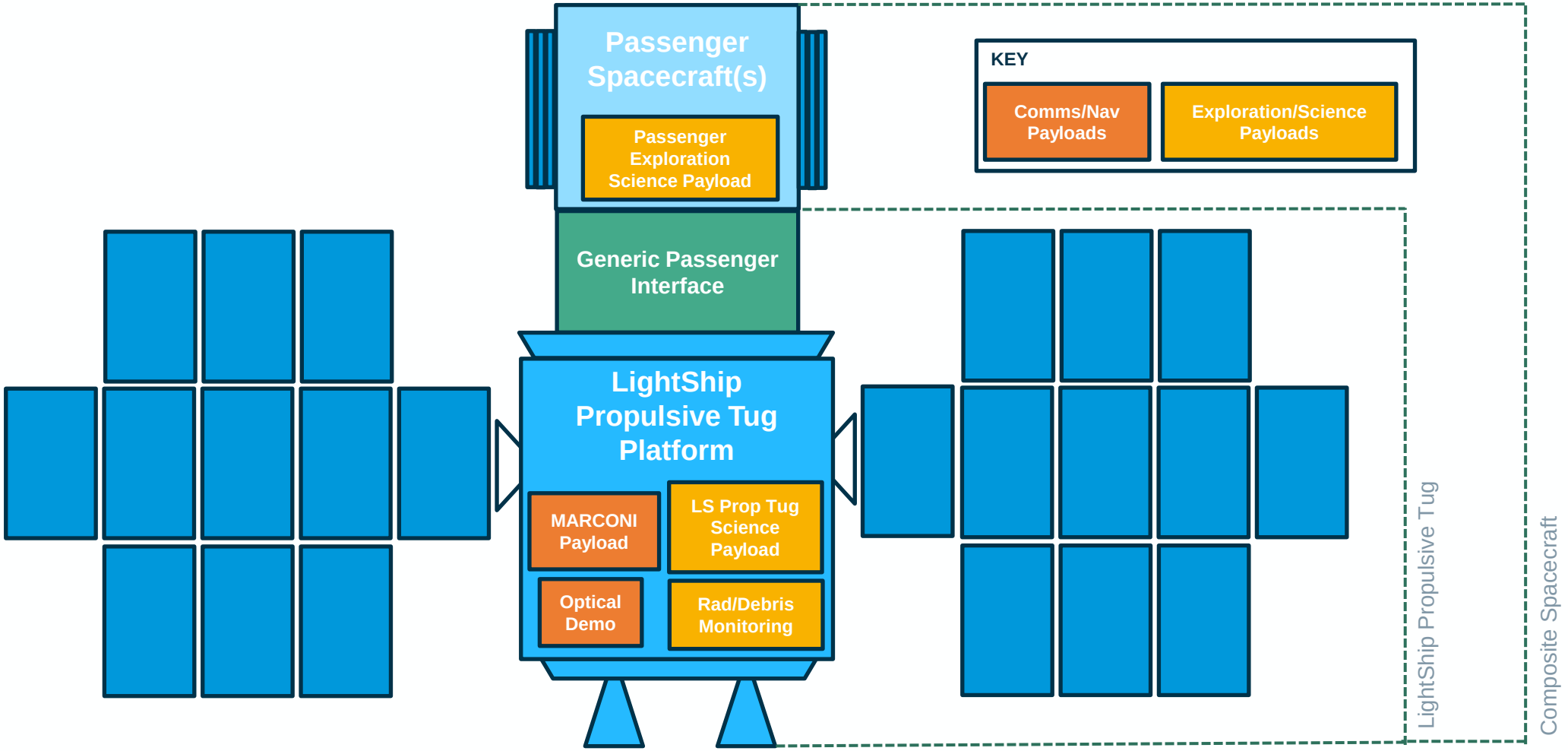
Mission 1 Passenger “Spotlight” (low altitude, high inclination):

- A European high-resolution surface imager is a priority for future heavy precision landing needs
- Iteration with industry needed in Phase A/B1 to determine what additional mass will be available for other payload(s)

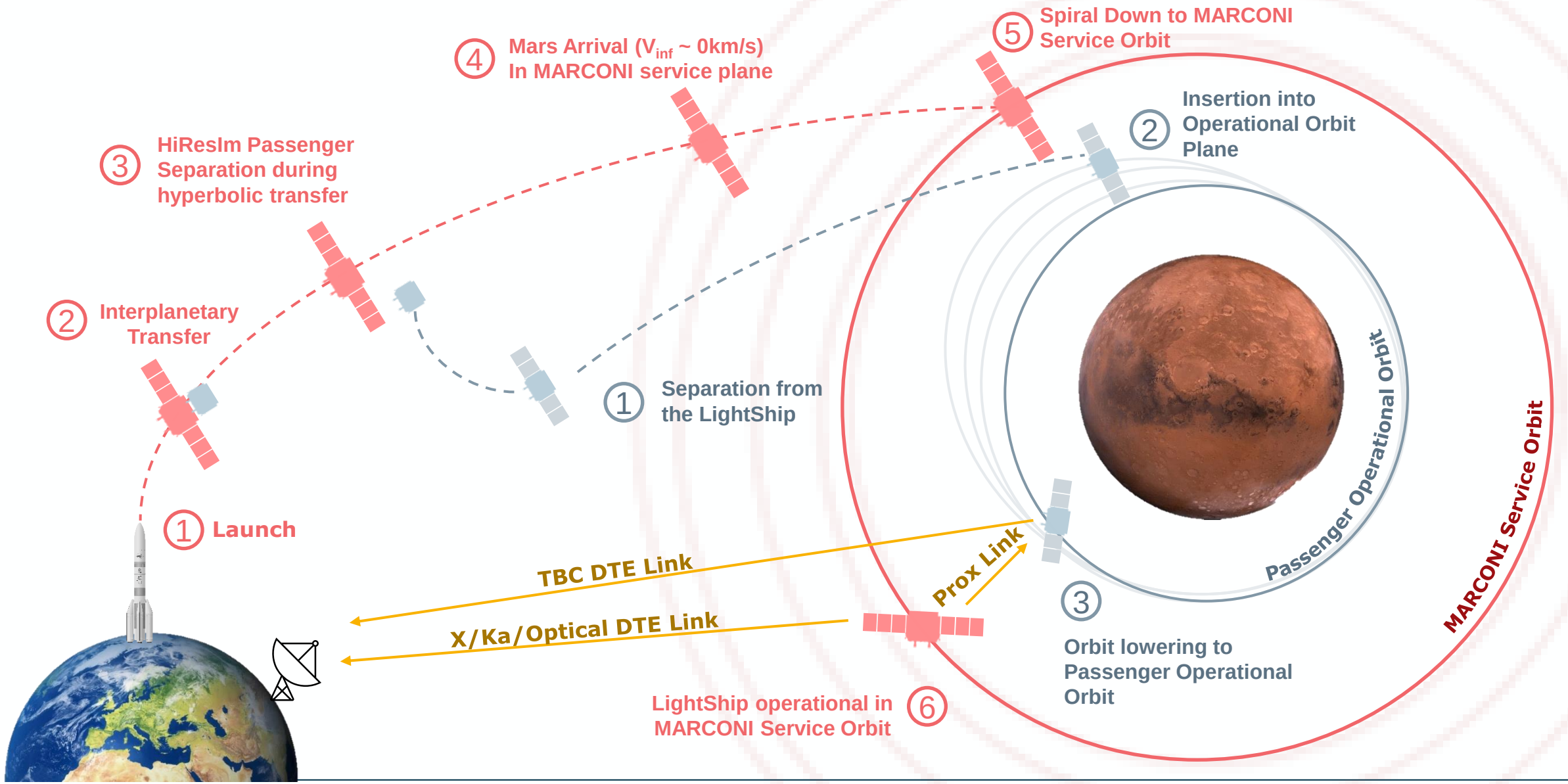
Mission 2 Passenger and beyond…

- Lightship2 passenger mission has not yet been determined
- Could be any exploration science, missions of opportunity, ESA member state / international partner science instrumentation

Generic LightShip Spacecraft Elements



LightShip-1 Mission Context Diagram

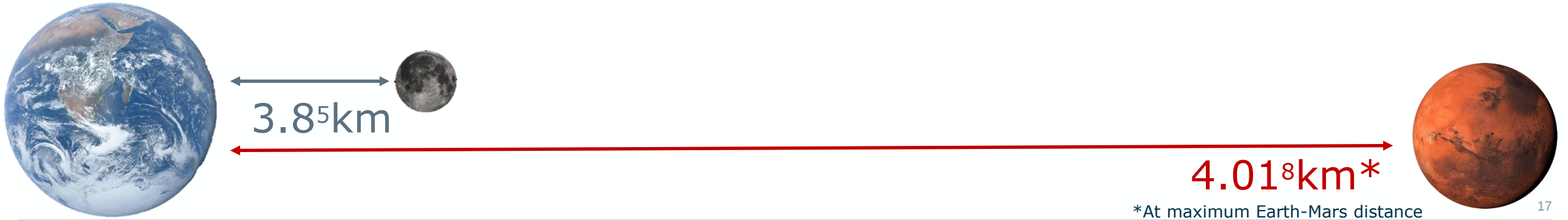


Transportation and Comms/NAV in One Service

LightShip1 mission represents the first block of infrastructure to enable future lower cost missions to Mars. Each new Lightship mission will offer:

1. **Transportation to Mars** with standard interfaces that can deliver multiple spacecraft to their intended operational orbits or entry trajectories (reducing the propulsion system requirements and costs of the individual spacecraft).

2. A new node in a robust **Mars telecommunications relay and NAV network** that also supports PNT services for orbiters and landed vehicles (reducing comms requirements on individual assets); **interoperability with partner assets is a requirement**.



*At maximum Earth-Mars distance

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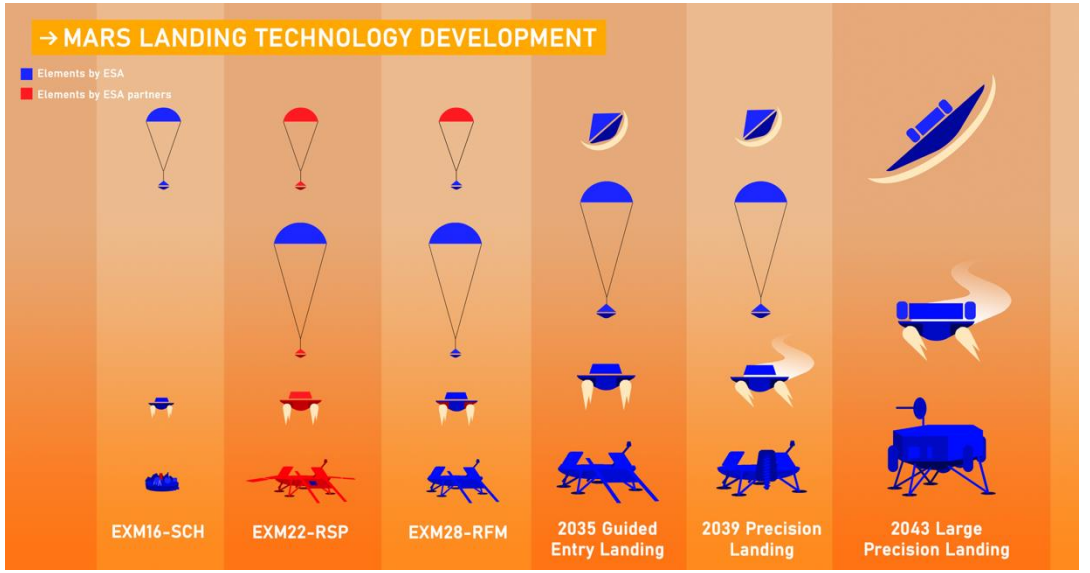
ESA' Mars Landing Technology Development Plan

- Steady build-up of capability over time starting with ExoMars EDLM lander:
  - More landing precision with each new lander mission
  - Increased landed mass with each new lander mission
- Aiming for evolution not revolution, though there will necessarily be some major jumps in technology (deployable thermal shields, etc.)
- Make strong use of the orbital assets (high-res imagery of landing sites, comms/nav, data relay, etc.)

Mission	Precision	Landed Mass	Launch
RFM/EDLM	100 km	1 T	2028 PDR
MEDaL	< 10 km (<2 km goal)	1.5 T 150 kg P/L	2035 Pre-Phase A
Precision Lander	< 1 km (< 100 m goal)	1.5 - 2 T	2039
Large Precision Lander	< 1 km (< 100 m goal)	> 5 T	2043



ESA'S Mars Plan aims to:

- Steady build-up orbital assets to secure Comms/NAV capability at Mars for Europe and International Partners
- Steady build-up of EDL capability to support Science and Future Moon to Mars partnerships
- ESA's Mars Plan is designed for partnership and connectivity