MARS SAMPLE RETURN – AN OVERVIEW OF THE CAPTURE, CONTAINMENT & RETURN SYSTEM

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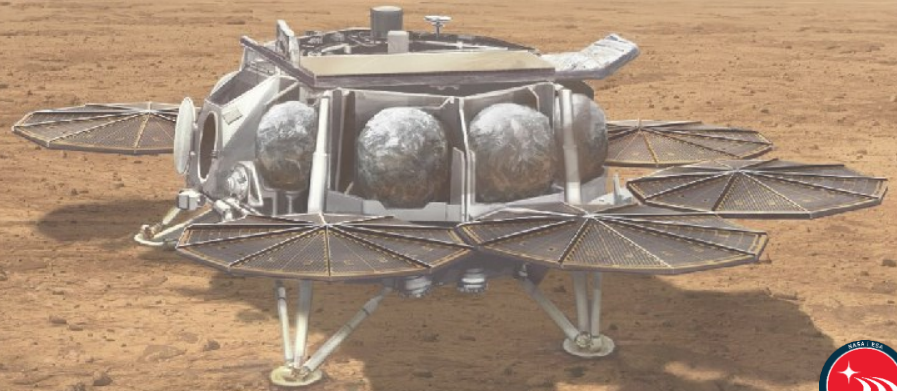
September 20, 2022

73rd International Astronautical Congress

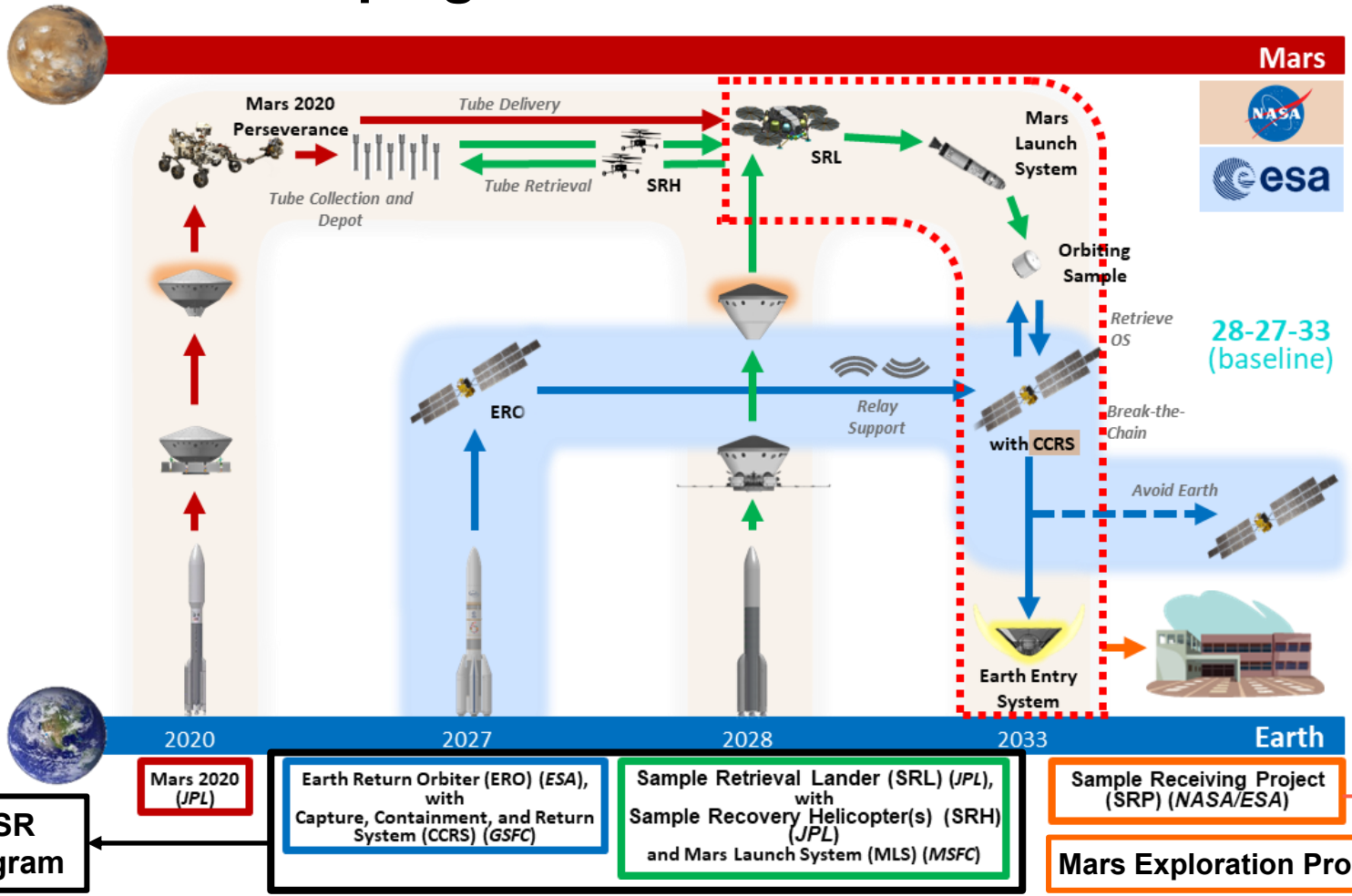
Paris, France



Outline

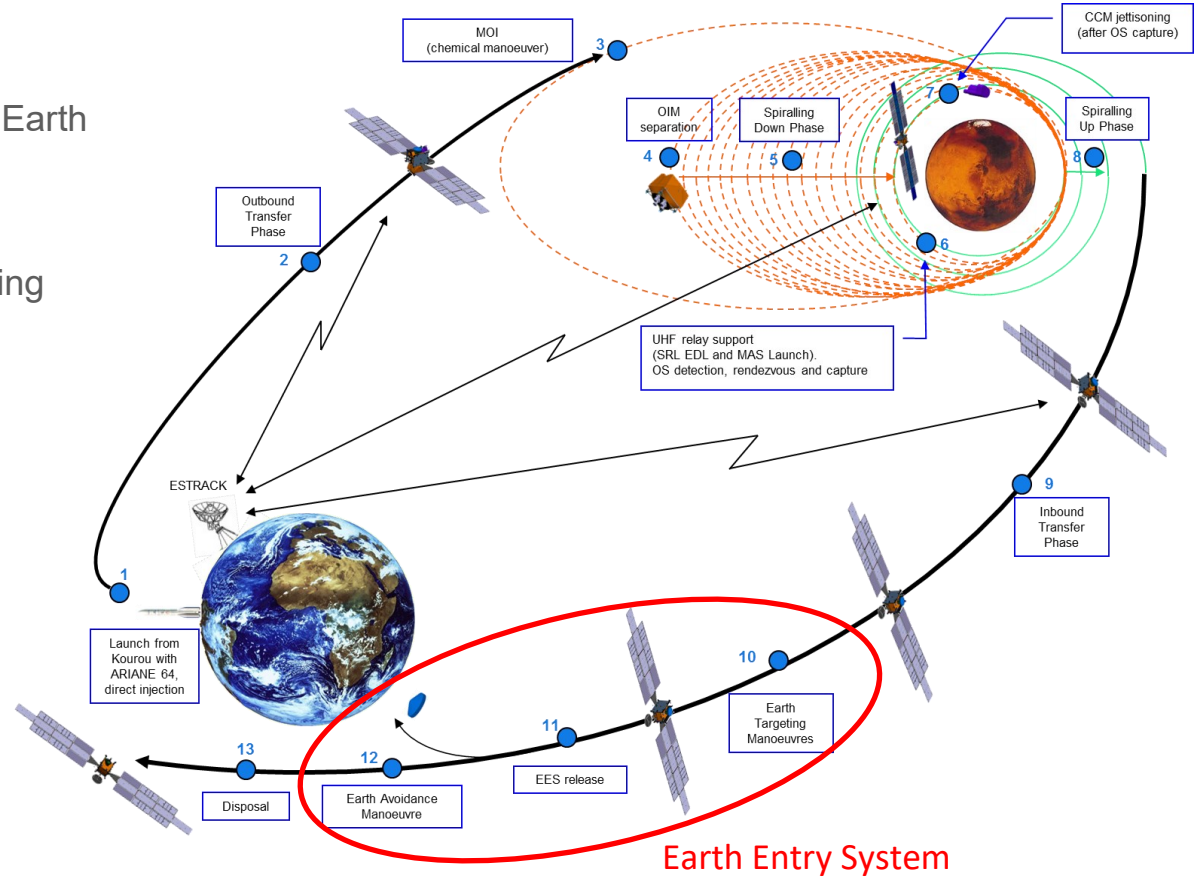
- MSR campaign overview
- ERO mission overview
- CCRS payload overview
- Planetary protection
- Implementation of backward planetary protection policies
  - Particle control
  - Sterilization
  - Redundant containment
- Conclusions

Planned MSR Campaign Architecture Overview



ERO-CCRS mission overview

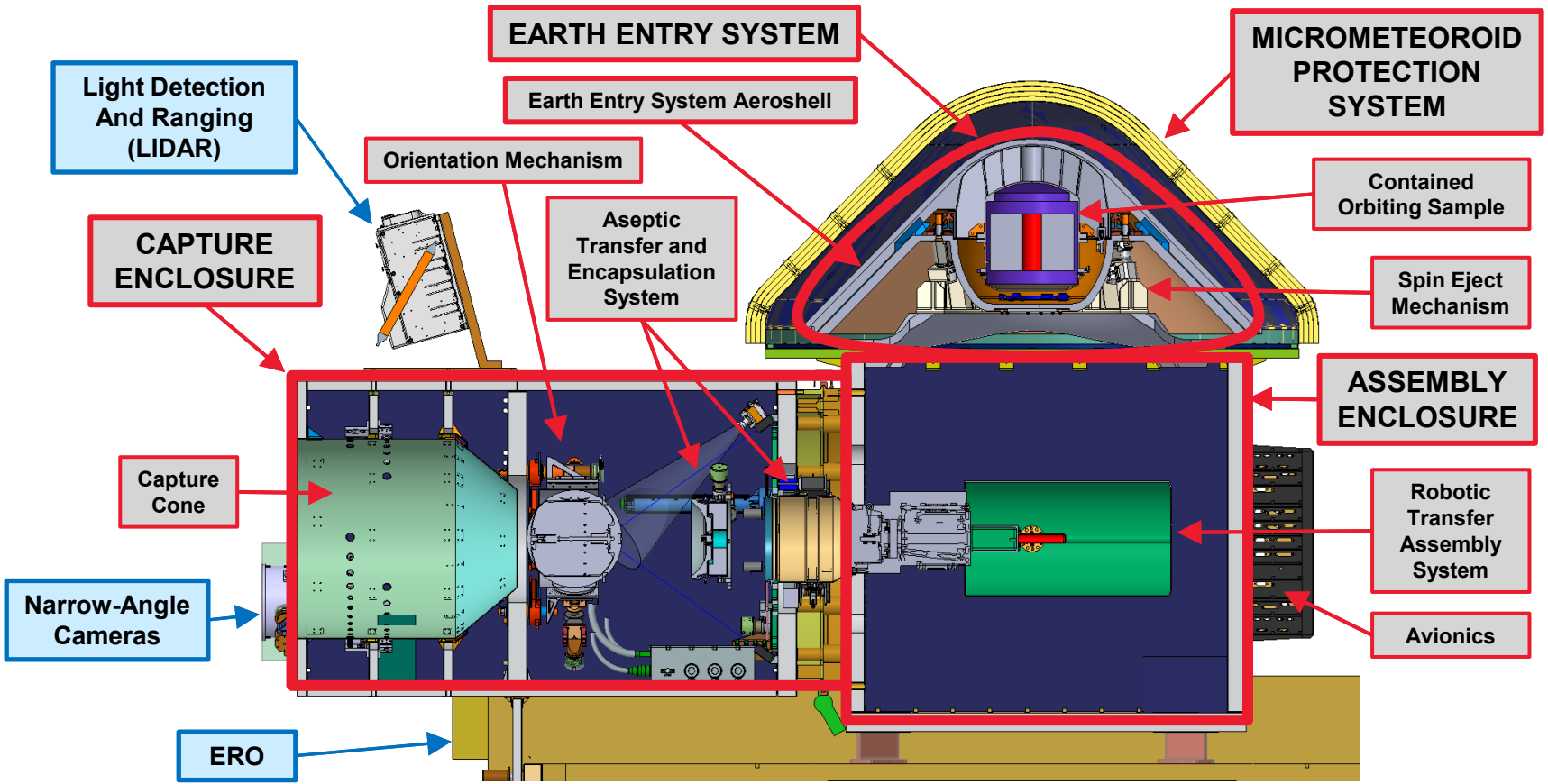
- Mission objectives:
  - Capture the OS and bring it back to Earth
  - Relay support for Mars assets
- Nominal mission (“28/27/33”):
  - Launch and near-Earth commissioning [30 days]
  - Outbound transfer with heliocentric parking orbit [3 years]
  - Mars orbit insertion [2 weeks]
  - Spiral down [<1 year]
  - Low Mars orbit (relay support, OS rendezvous, OS containment) [1-1.5 years]
  - Spiral up [<1 year]
  - Inbound transfer [1 year]
  - EES delivery phase [few days]
  - Retirement [few days]



Earth Entry System Delivery Phase (EDP)

Key document: CReMA, ERO’s Consolidated Report on Mission Analysis, Rev 2.0 (Apr 2022)

CCRS payload overview



What is planetary protection?

FORWARD PLANETARY PROTECTION (FPP)

From NASA Procedural Requirement NPR 8715.24:

"Planetary protection is the practice of **protecting solar system bodies** from harmful contamination by terrestrial materials to enable scientific exploration and **protecting the Earth-Moon system** from possible harmful extraterrestrial contamination that may be returned from other solar system bodies."

BACKWARD PLANETARY PROTECTION (BPP)

Also see:

1. *Article IX, UN Space Treaty* (UNOOSA 2017, Report of the Committee on the Peaceful Use of Outer Space, 60th Session, A/72/20, United Nations, New York)
2. *Planetary Protection Policy*, Committee on Space Research (COSPAR), 2021

How to implement Backward Planetary Protection?

BREAK THE CHAIN OF CONTACT BETWEEN MARS & EARTH

Active, surface-to-surface (Mars-to-Earth) process to satisfy BPP goals by prohibiting uncontrolled transmission and release of **extraterrestrial material of concern** into Earth's biosphere.

- BPP is about defining and achieving the appropriate risk posture, BTC is an implementation-focused part of it, mandated by NASA HQ.

PARTICLE CONTROL ("Leave behind")

Adhesion
Transmission
Emission

STERILIZATION ("Kill")

Inactivation
(natural or engineered)

CONTAINMENT ("Lock up")

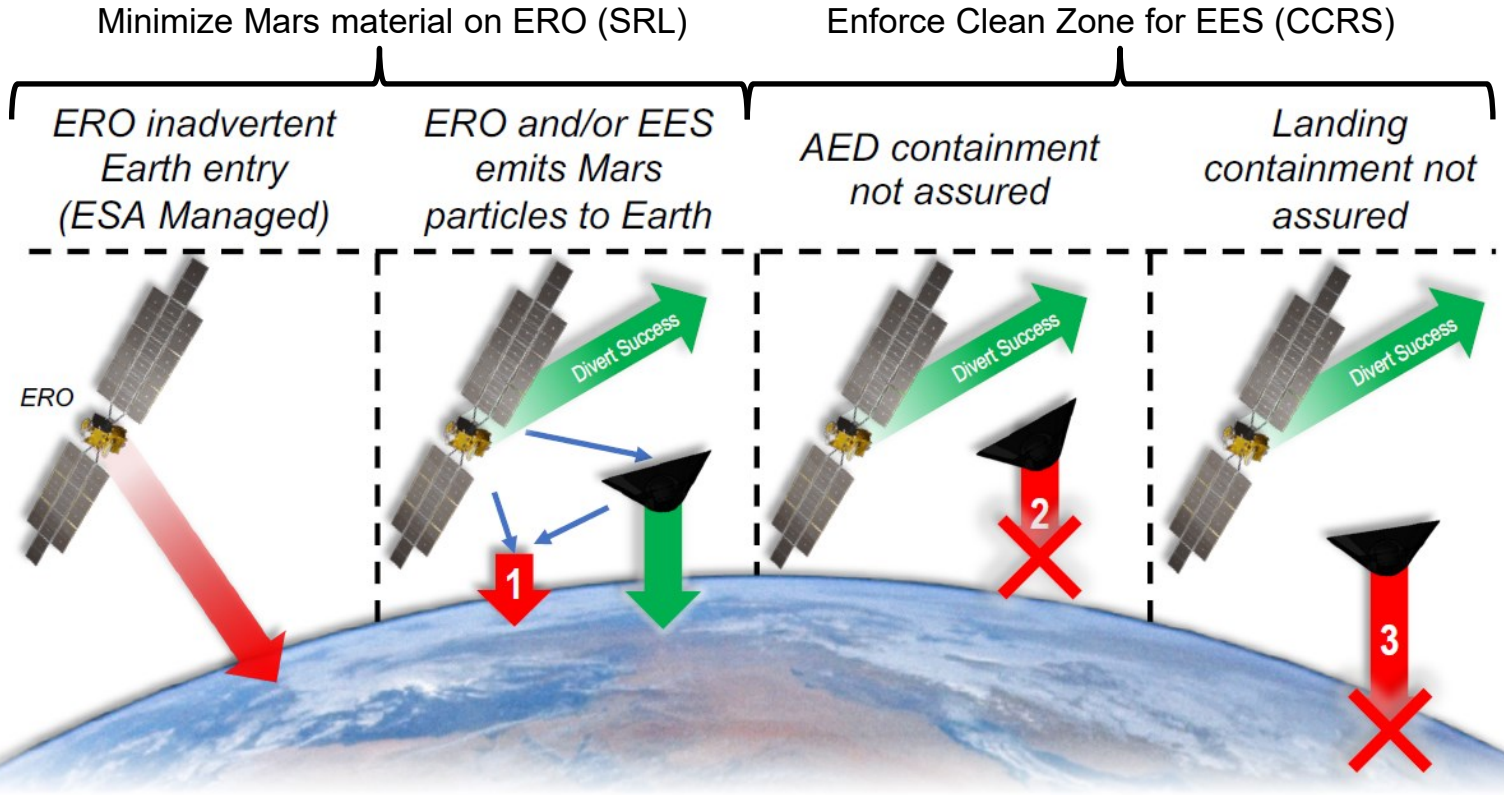
Sealing
Encapsulation
Isolation
Blocking

ASEPTIC TRANSFER

Move something from a dirty volume to a clean volume without transmitting Mars material

Particle Control

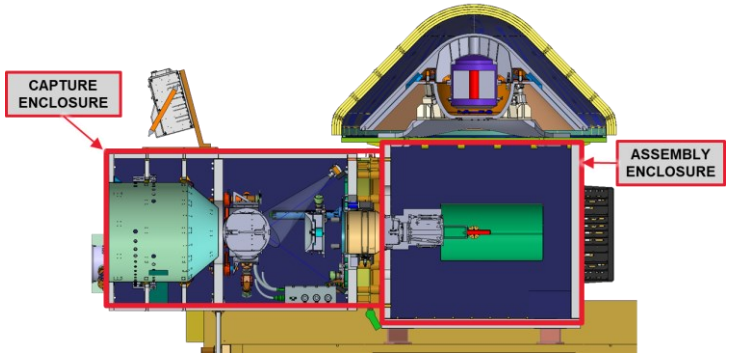
- There are 5 primary paths of Mars material that can enter Earth's biosphere
- End-to-end, physics-based, analytical framework developed to track particles on hardware

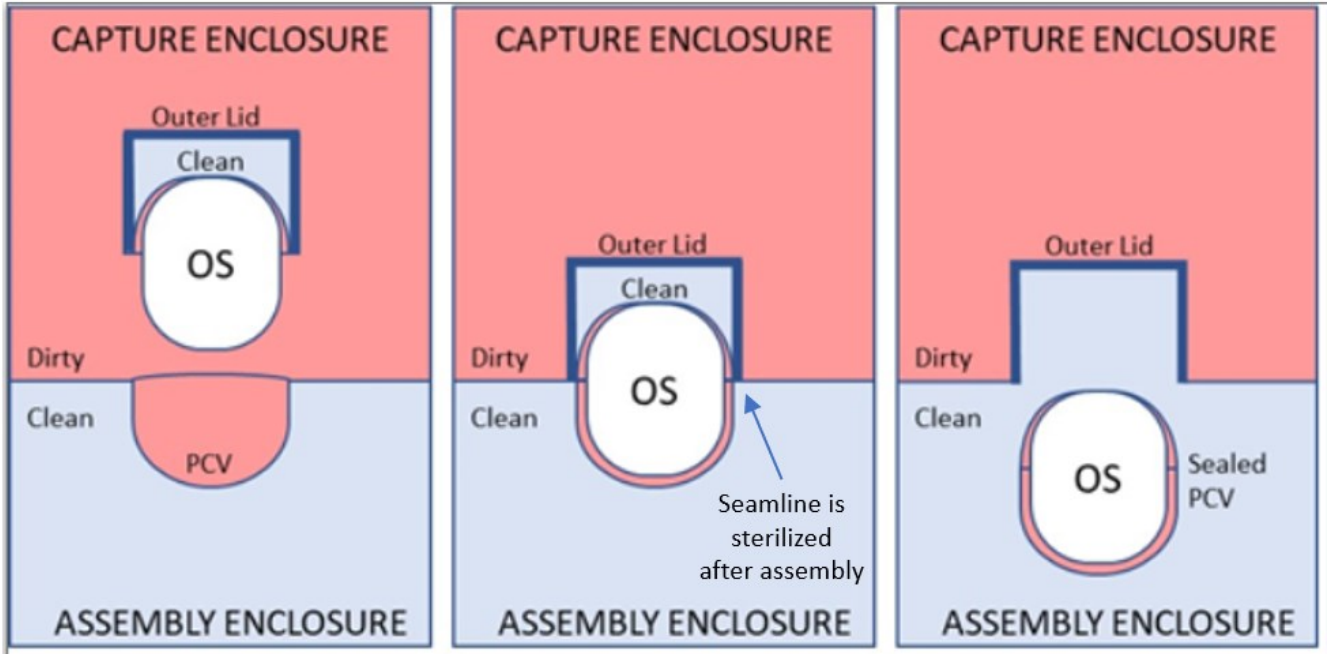


Sterilization

Potential biohazards from Mars

- **Bacterial endospores** as the bounding case for heat-resistance in whole organisms
- **Yeast prions** as the bounding case for resilient proteins that can proliferate catalytically

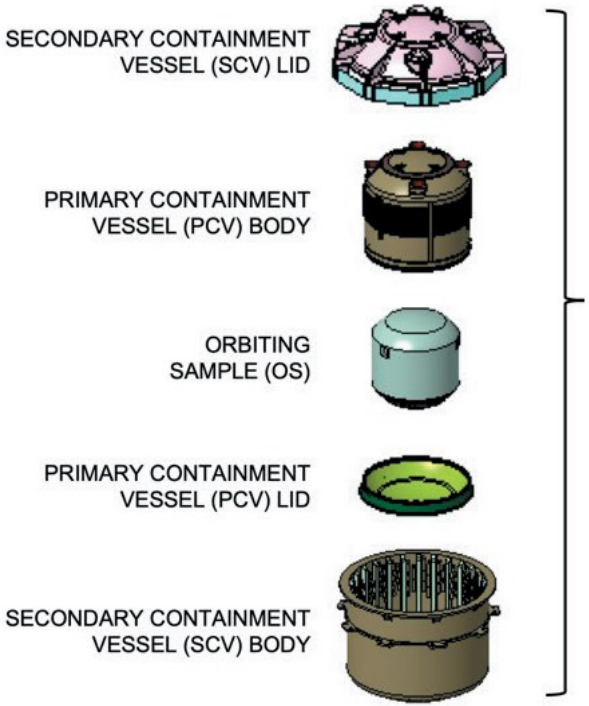


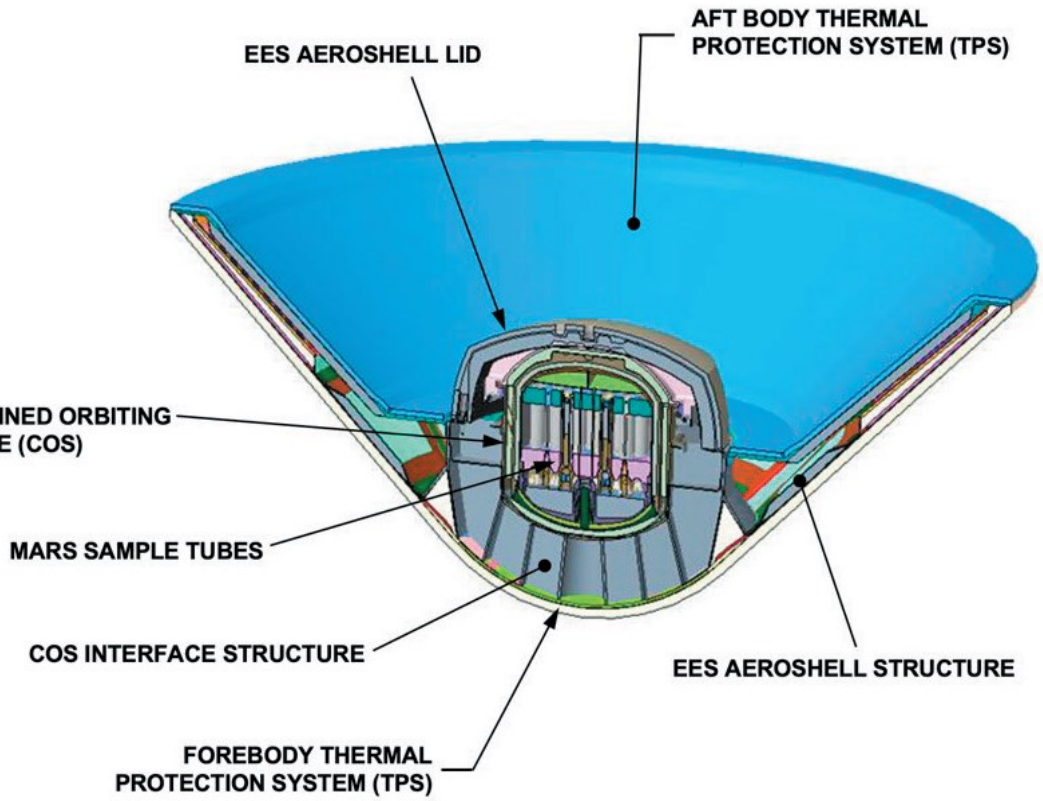


- Prior to the heated shrink fit operation, preloaded joints prevent particles from migrating from Mars dirty to Earth clean regions.
- The heated shrink fit insertion occurs above 500°C, thereby also sterilizing the surfaces.

Containment Assurance

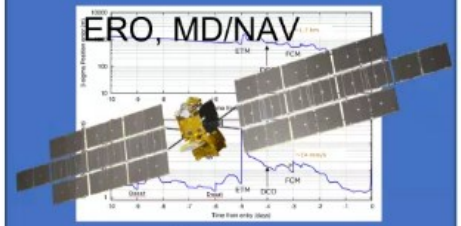
PRELIMINARY MSR EES CONCEPT (Cross-Sectional View)



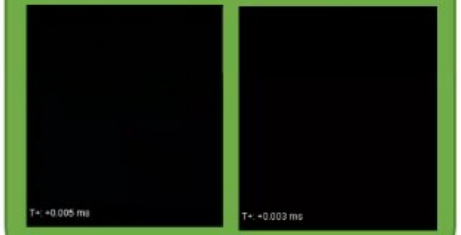


Containment Assurance

Targeting is Successful

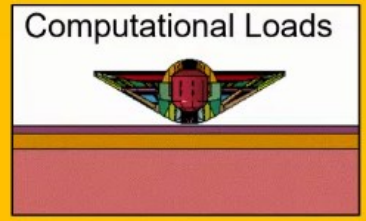


Survives Entry Environments



Aerodynamics as Expected

Survives Landing Loads



Conclusions

Robust protective measures are being designed to protect Earth's biosphere

- Assessing the risk
  - Sampling location and conditions present an **extremely low likelihood** of presence of hazardous biological material.
- Safety first
  - Securely **contain** all **unsterilized** Mars material returned to Earth.
- Break the chain
  - Containment engineering and verification activities that sequentially reduce the potential that any unsterilized Mars material could be released into Earth's biosphere.
  - Many of these protective measures provide layers of **redundancy** throughout the mission and would enable safe sample return under a variety of mission conditions.
- Orbital trajectory
  - The EES would be **pointed away** from Earth until a few days before the planned landing, allowing a final decision to be made about proceeding with Earth entry using all available information collected during the entire mission.
- Materials to tolerate extreme conditions (high velocities and forces)
  - The EES would enter the Earth's atmosphere at nearly 27,000 mph, experience forces nearly 125 times greater than gravity while slowing to just 90 mph, and land using only the ground as its cushion.
  - The cone-shaped vehicle and its components are being **robustly designed and tested** on Earth to demonstrate their ability to withstand forces well beyond those that would be experienced during entry and landing.
- Care upon landing - Treat as if they could be hazardous biological materials
  - The EES will be quickly enclosed in **additional layers** of containment, using procedures based upon the proven principles and techniques used by hazardous material response teams, and will be maintained through transport to a dedicated Mars sample receiving facility.
  - Such a Mars sample receiving facility would have design and sample handling requirements equivalent to those of biological safety laboratories used for research studies of infectious diseases.

Acknowledgments

- Co-authors:
  - Brian Childs — JPL
  - James Corliss — NASA LaRC
  - Brendan Feehan — NASA GSFC
  - Peter Gage — NASA ARC
  - Justin Lin — JPL
  - Suparna Mukherjee — NASA GSFC
  - Mark Neuman — NASA GSFC
  - Fernando Pellerano — NASA GSFC
  - Bruno Sarli — NASA GSFC
  - Christine Szalai — JPL
  - Leo Teeney — NASA GSFC
  - Jeremy Vander Kam — NASA ARC
  - Todd White — NASA ARC
  - Calinda Yew — NASA GSFC
  - Carlie Zumwalt — NASA GSFC
- The entire CCRS team

Any questions?

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