National Aeronautics and Space Administration

HEOMD Overview

March 16, 2015

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NASA Strategic Plan Objective 1.1

Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.

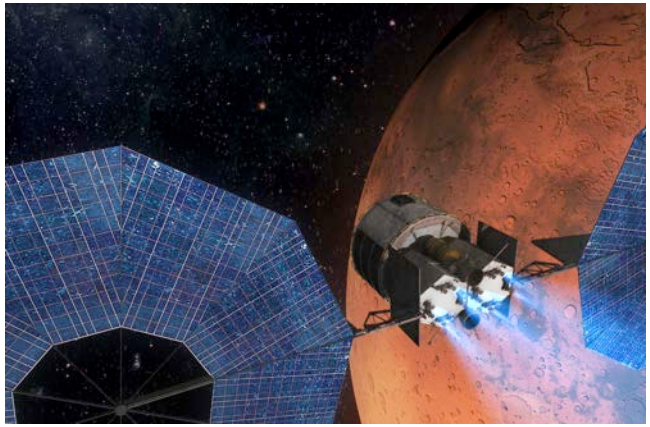
Evolvable Mars Campaign Goal:

Define the pioneering strategy and operational capabilities required to extend and sustain human presence in the solar system including a journey towards the Mars system in the mid-2030s

Strategic Principles for Sustainable Exploration

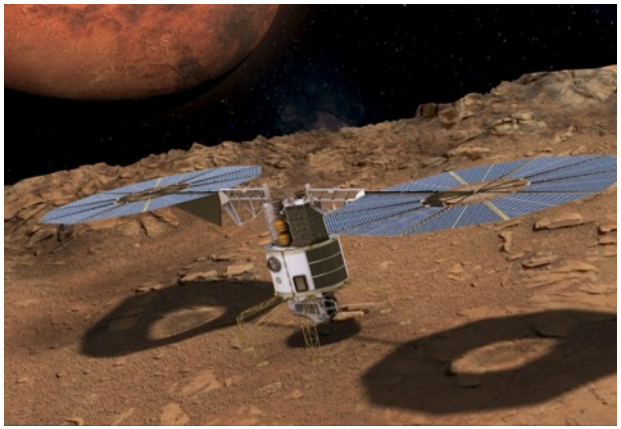
- Implementable in the ***near-term with the buying power of current budgets*** and in the longer term with budgets commensurate with economic growth*;*
- ***Exploration enables science*** **and science enables exploration***, leveraging robotic expertise for human exploration of the solar system*
- Application of ***high Technology Readiness Level*** (TRL) technologies for near term missions, while focusing sustained investments on ***technologies and capabilities*** to address challenges of future missions;
- ***Near-term mission opportunities*** with a defined cadence of compelling and integrated human and robotic missions providing for an incremental buildup of capabilities for more complex missions over time;
- Opportunities for ***U.S. commercial business*** to further enhance the experience and business base;
- ***Multi-use, evolvable*** space infrastructure, minimizing unique major developments, with each mission leaving something behind to support subsequent missions; and
- Substantial ***international and commercial participation***, leveraging current International Space Station and other partnerships.

Mars Vicinity Options Provide the "Pull"



Mars Orbit

- Opportunities for integrated human-robotic missions:
  - Real time tele-operation on Martian surface
  - Mars sample return
  - Other science objectives
  - Technology demonstrations
- Demonstrate sustainable human exploration split-mission Mars concept
- Validate transportation and long-duration human systems
- Validate human stay capability in zero/micro-g



Mars Moons

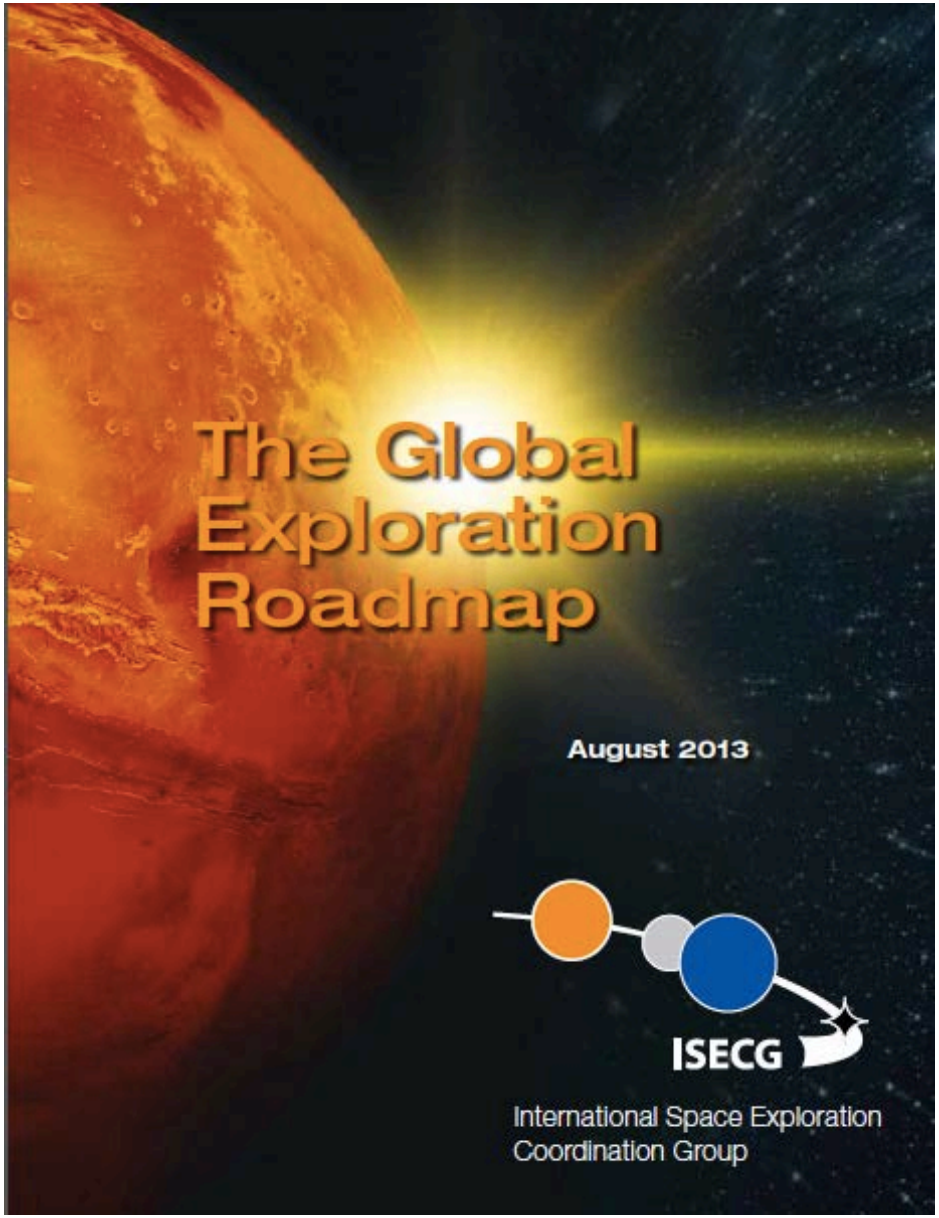
- Opportunities for integrated human-robotic missions:
  - Real time tele-operation on Martian surface
  - Mars & moons sample return
  - Other science objectives
  - Technology demonstrations
- Demonstrate sustainable human exploration split-mission Mars concept
- Moons provides additional radiation protection
- In-situ resource utilization
- Validate human stay capability in low-g

Mars Surface

- Opportunities for integrated human-robotic missions:
  - Search for signs of life
  - Comparative planetology
  - Understanding Mars climate changes
  - Geology/geophysics
- Planet provides radiation protection
- Entry, descent, landing
- EVA surface suits
- In-situ resource utilization
- Validate human stay capability in partial-g

Global Exploration Roadmap

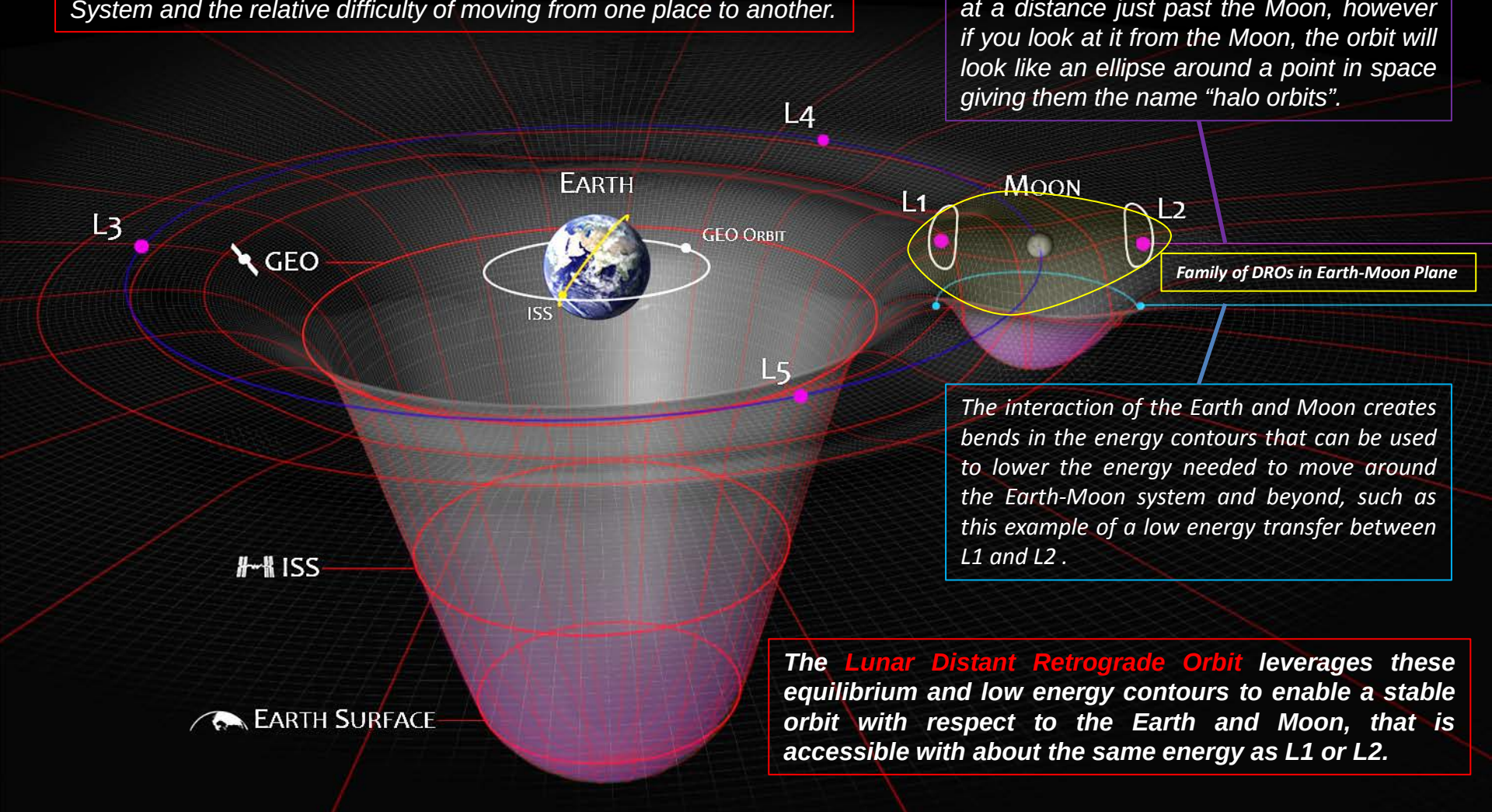
- **Global Exploration Roadmap (GER) outlines multi-agency roadmap for human exploration**
  - Includes consensus principles, notional mission scenarios, preparatory activities
- **All agencies agree on value of cislunar as next step for human exploration**



Cis-Lunar Space:
How the Earth and the Moon Interact

The contours on the plot depict energy states in the Earth-Moon System and the relative difficulty of moving from one place to another.

A spacecraft at L2 is actually orbiting Earth at a distance just past the Moon, however if you look at it from the Moon, the orbit will look like an ellipse around a point in space giving them the name "halo orbits".

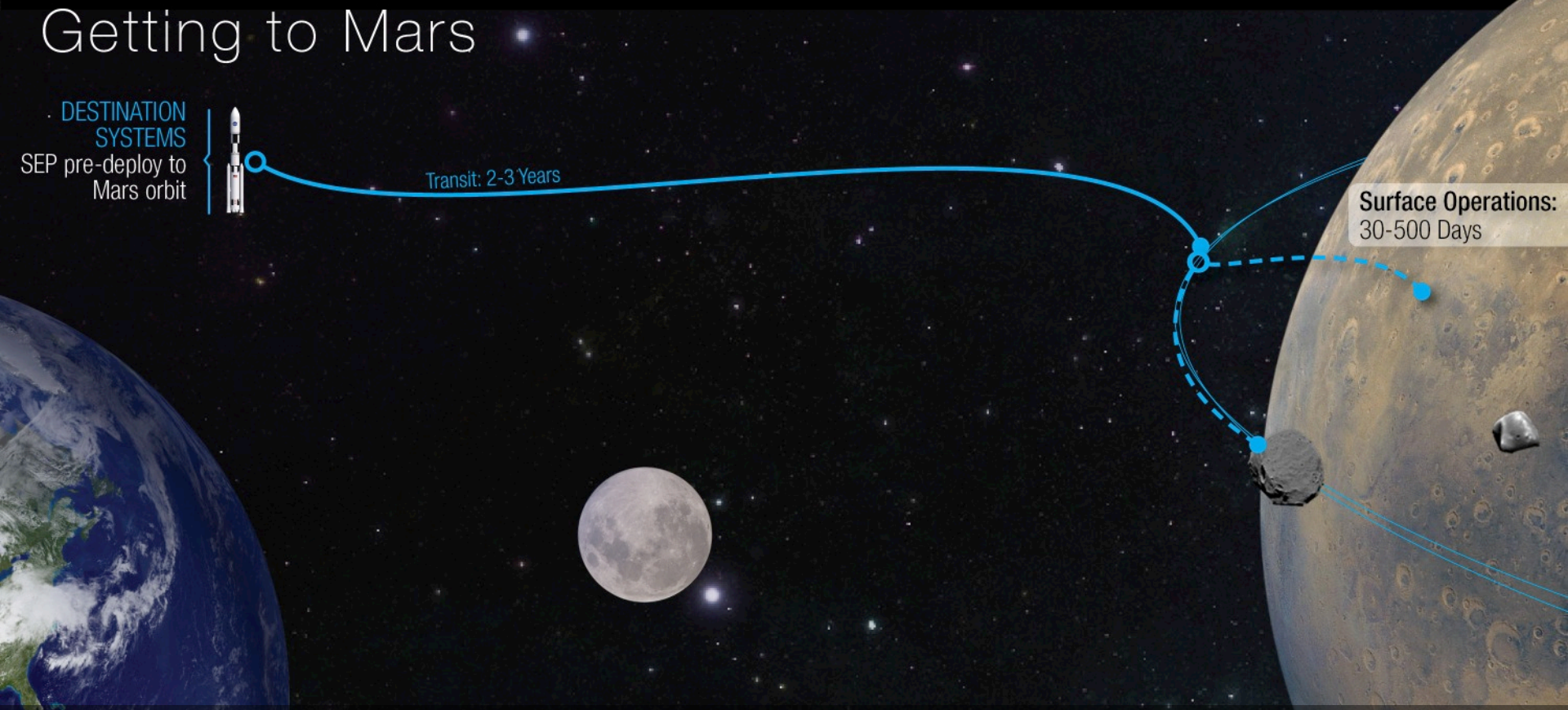


Family of DROs in Earth-Moon Plane

The interaction of the Earth and Moon creates bends in the energy contours that can be used to lower the energy needed to move around the Earth-Moon system and beyond, such as this example of a low energy transfer between L1 and L2 .

The Lunar Distant Retrograde Orbit leverages these equilibrium and low energy contours to enable a stable orbit with respect to the Earth and Moon, that is accessible with about the same energy as L1 or L2.

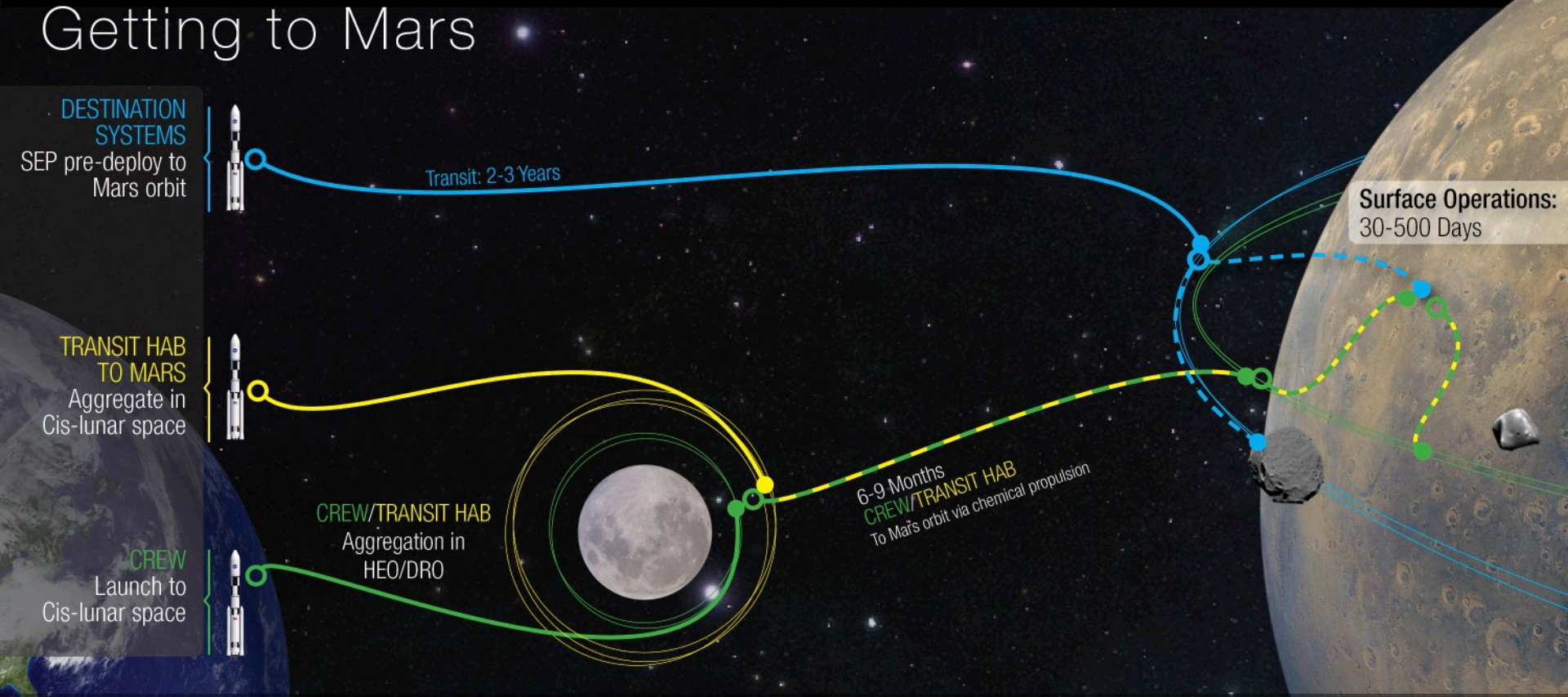
Split Mission Concept



Using SEP for pre-emplacement of cargo and destination systems enables sustainable Mars campaign

- Minimizes the cargo needed to be transported with the crew on future launches
- Enables a more sustainable launch cadence
- Pre-positions assets for crew missions allows for system checkout in the Mars vicinity prior to committing to crew portion of mission

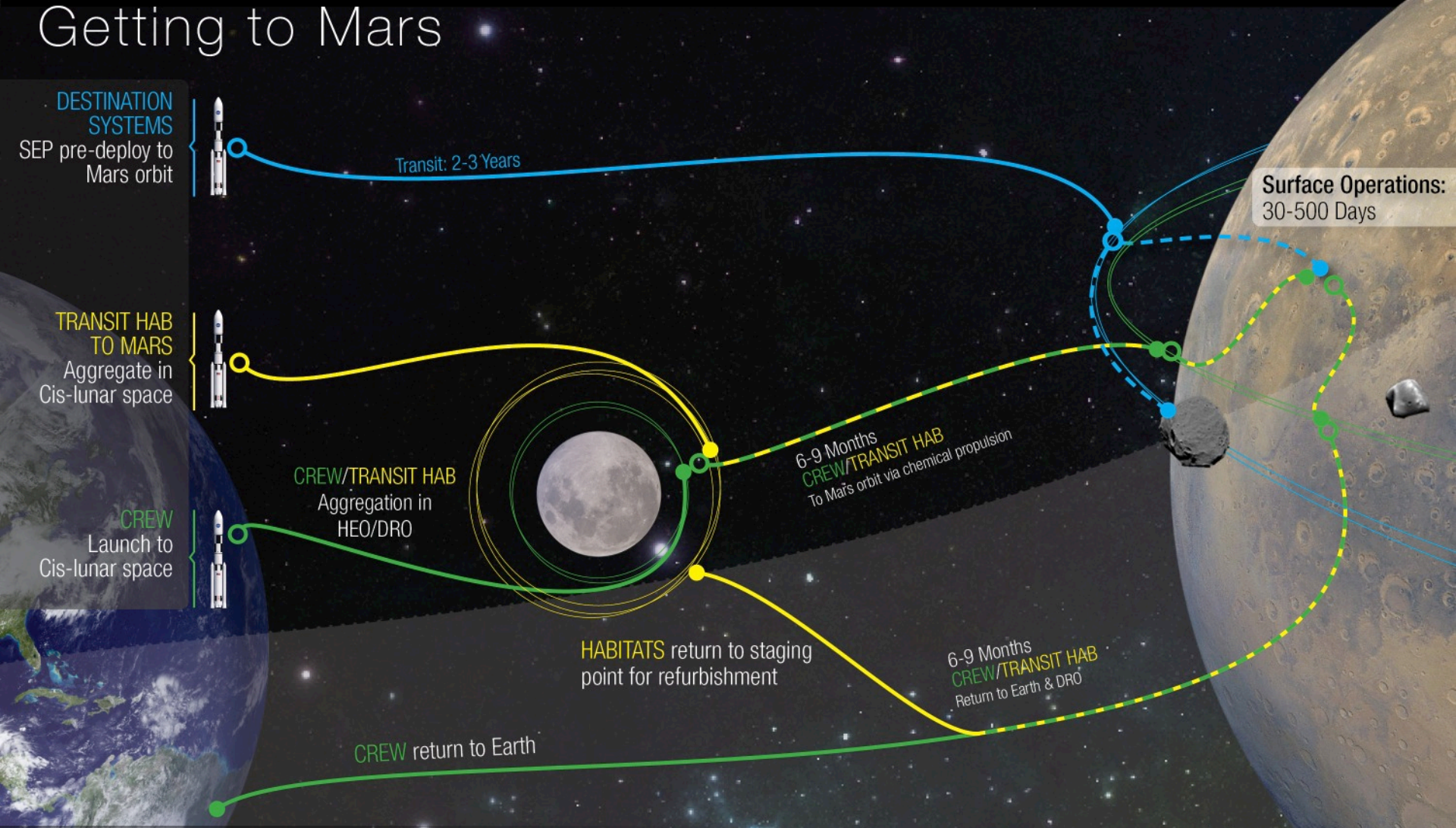
Split Mission Concept



DRO as an aggregation point for Mars habitation systems

- Provides a stable environment and ease of access for testing Proving Ground capabilities
- Allows for Mars transit vehicle build-up and checkout in the deep-space environment prior to crew departure
- Able to transfer Mars Transit Vehicle from DRO to High Earth Orbit with small amount of propellant to rendezvous with crew in Orion – HEO is more efficient location to leave Earth-moon system for Mars vicinity

Split Mission Concept



- Returning from Mars, the crew will return to Earth in Orion and the Mars Transit Habitat will return to the staging point in cis-lunar space for refurbishment for future missions

PROVING GROUND OBJECTIVES

Enabling Human Missions to Mars

VALIDATE

- Advanced Solar Electric Propulsion (SEP) systems to move large masses in interplanetary space
- LDRO as a staging point for large cargo masses en route to Mars
- SLS and Orion in deep space
- Long duration, deep space habitation systems
- Crew health and performance in a deep space environment
- In-Situ Resource Utilization
- Operations with reduced logistics capability
- Structures and mechanisms

CONDUCT

- EVAs in deep space with sample handling in micro-g
- Integrated human and robotic mission operations
- Capability Pathfinder and SKG missions

Exploration Upper Stage & Payload Accommodation Variations

Mission Elements

Exploration Upper Stage

Core Stage / Boosters

Mission concepts with 5m fairing

Inter-Planetary Mission
total mission volume = ~ 300m3

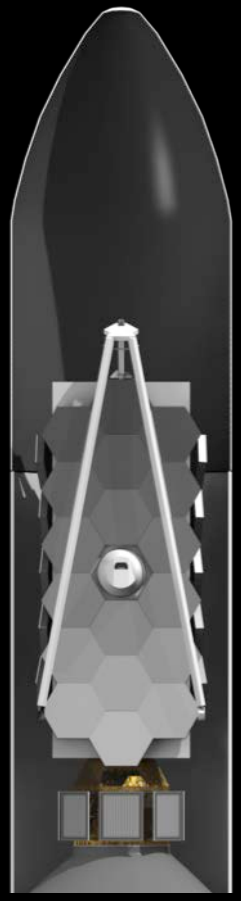
Mission concepts with Universal Stage Adaptor (includes additional payload capability)

Orion with short-duration hab module
total mission volume = ~ 400m3

Orion with ARV
total mission volume = ~ 400m3

5m fairing w/Robotic Lunar Lander & short-duration hab
total mission volume = ~ 600m3

Mission concepts with 8m and 10m fairings

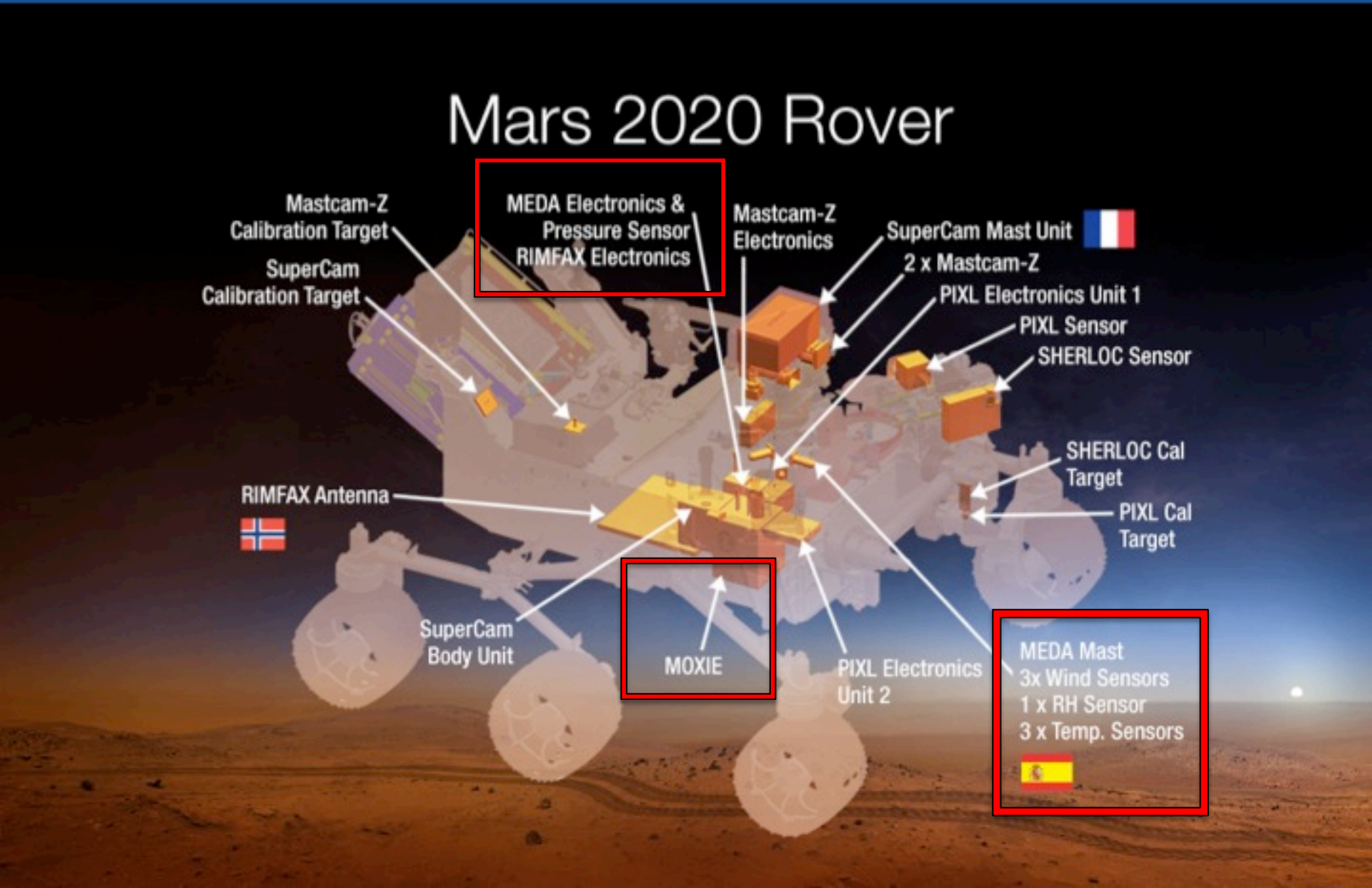


8m fairing with Telescope
total mission volume = ~ 1200m3

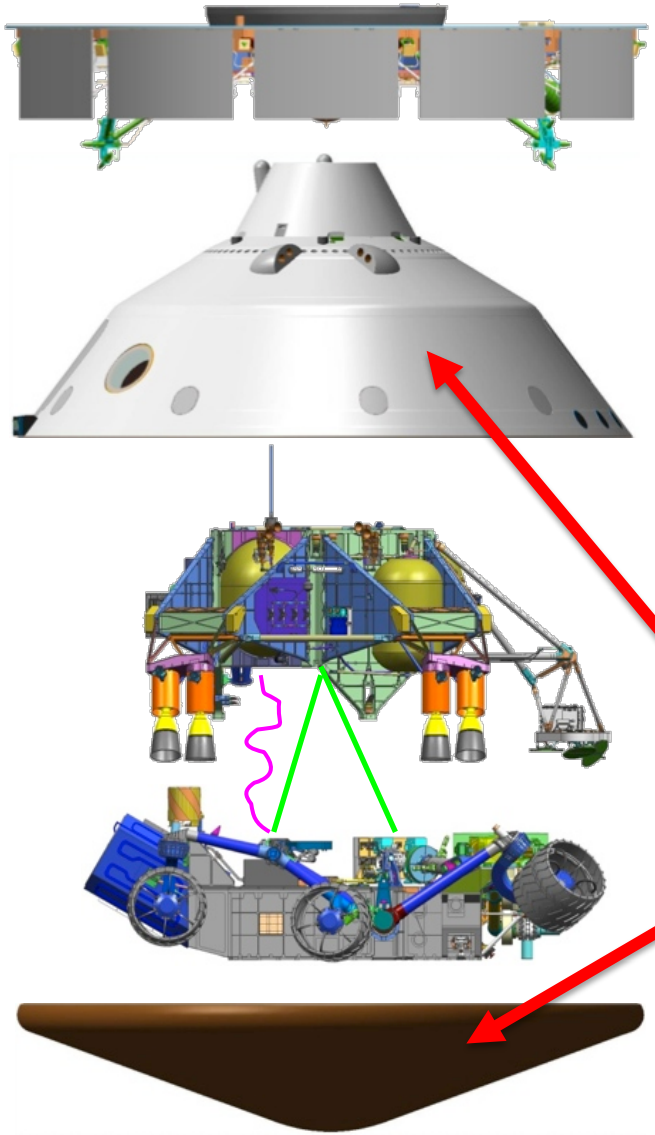
10m fairing w/notional Mars payload
total mission volume = ~ 1800m3

8335_SLS_JPL.11

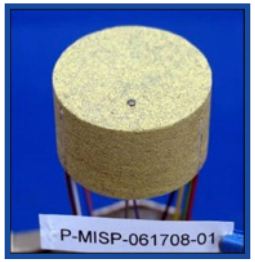
Mars 2020 Selected Payload Suite



Mars Entry, Descent, and Landing Instrumentation 2 (MEDLI2)

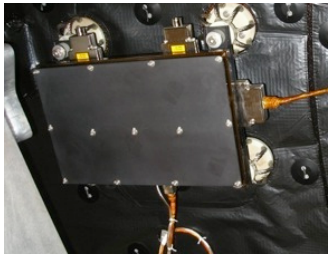


MEDLI2 will provide critical environmental and system performance data for entry vehicles during the entry and descent phases of Mars entry, descent, and landing (EDL).



MEDLI Instrumented Sensor Plug (MISP)

Mars Entry Atmospheric Data System (MEADS)



Sensor Support Electronics

New for Mars 2020, MEDLI2 includes pressure transducers and thermal plugs on <u>both</u> the heatshield and backshell

Resource Prospector

Get there…

- Launch
- Lunar Transfer
- Lunar Orbit
- Descent & Landing
- Quick Checkout
- Roll-off Lander
- Quick Checkout
- Begin Surface Ops

Find & Excavate Volatiles…

Map surface — Use the Neutron Spec & Near-IR Spec to look for Hydrogen-rich materials

Enter permanent shadows — Go to the areas with highest concentrations of volatiles, Permanently Shadowed Regions (PSRs)

Expose regolith — Use the Drill Subsystem to bring material from up to 1 [m] depth to examine with Near-IR Spec

Collect and Process the volatiles…

Capture regolith — Use the Drill to capture samples from up to 1 [m] depth

Heat regolith — Heat samples (150-450 degC) in the OVEN Subsystem

Identify Volatiles — Determine type and quantity of volatiles in the LAVA Subsystem, (H_2, He, CO, CO_2, CH_4, H_2O, N_2, NH_3, H_2S, SO_2)

Show me the water! — Image and quantify the water created using the LAVA Subsystem

WE NEED (& VALUE) YOUR HELP!

HEOMD often calls upon the expertise of the planetary community

- E.g. recent LEAG-led lunar volatiles study & ongoing human Mars landing site study

These studies results in benefits to the community as they help HEOMD shape potential opportunities

- They are worth your time!

The types of opportunities include

- HEOMD-funded instrument on SMD missions (e.g. Mars 2020)
- HEOMD-funded instruments on foreign missions (e.g. Mini-RF)
- Focused HEOMD missions (e,g, RP)