NASA's Human Spaceflight Plans and the CCMC

The 8th Community Coordinated Modeling Center Workshop Community Workshop

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Crew Health and Safety
HEOMD
NASA Headquarters

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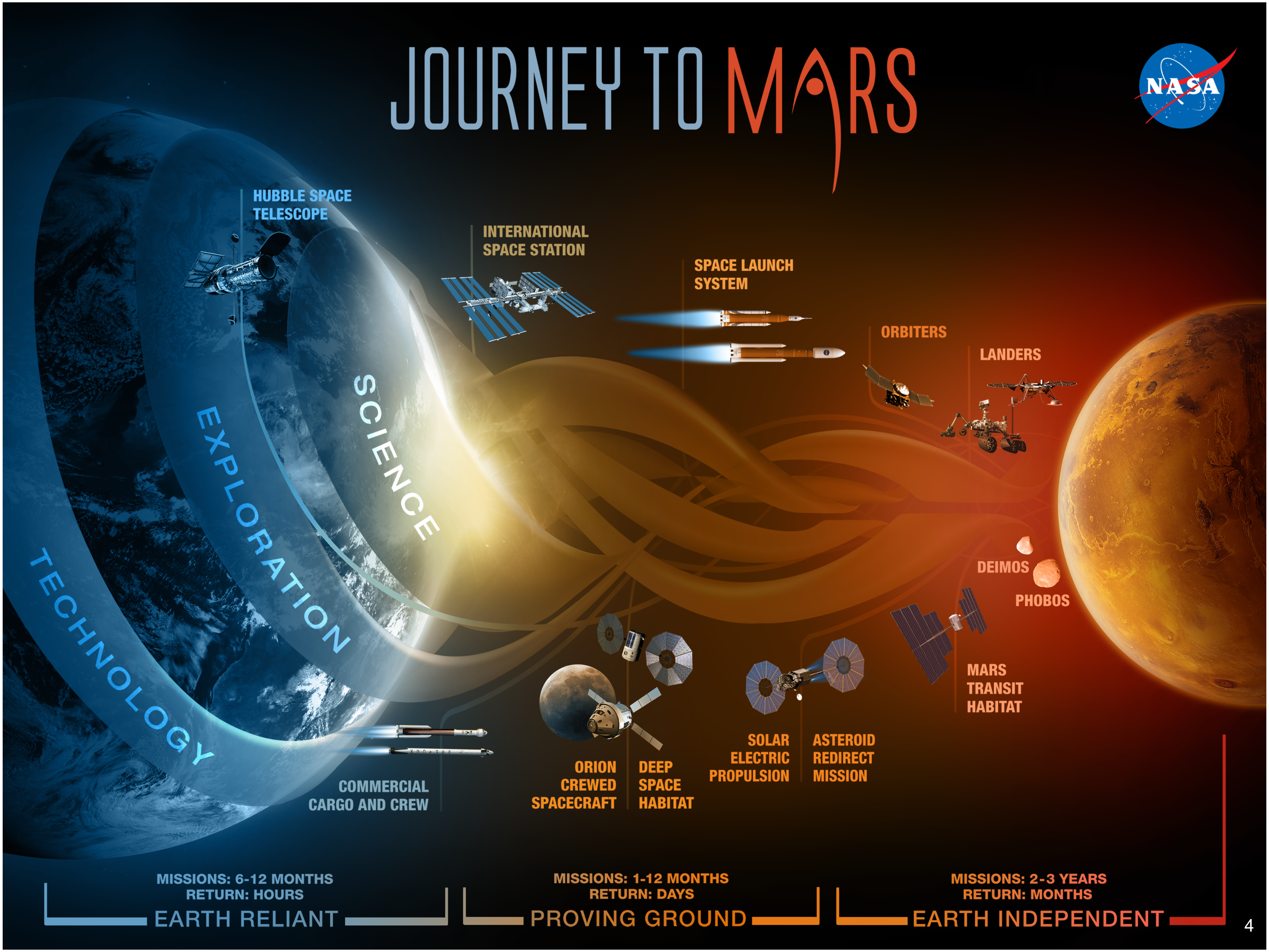
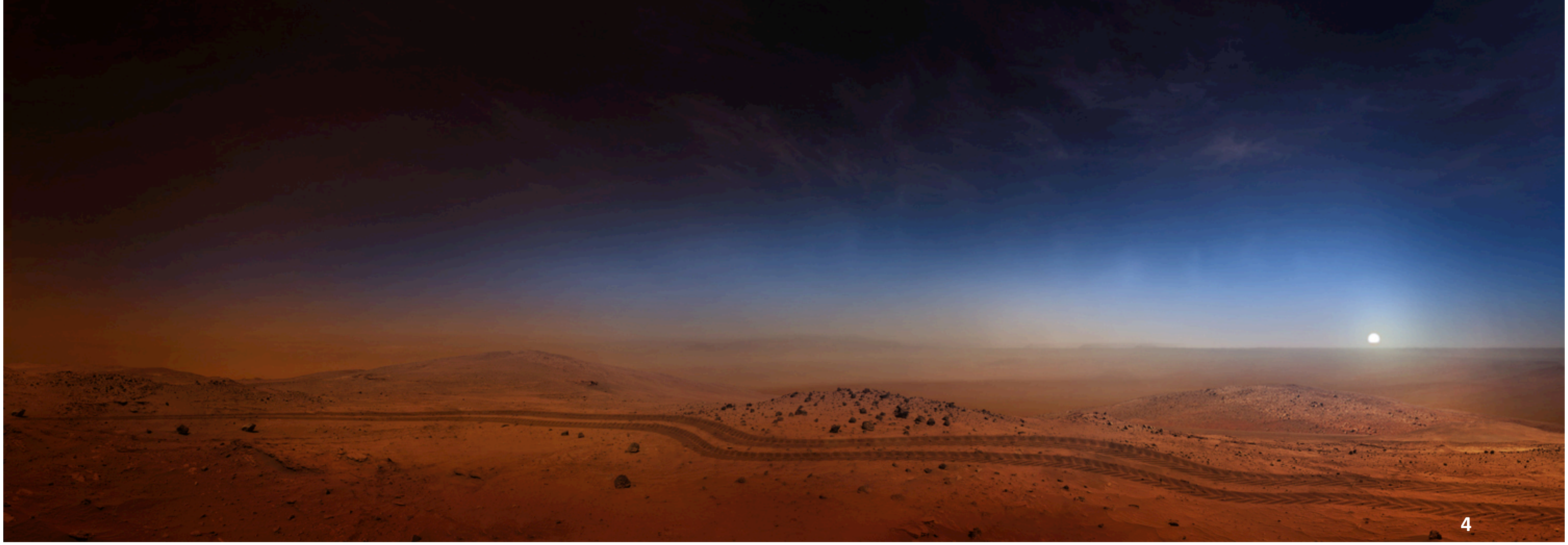
Our Purpose – NASA Strategic Goal 1.1

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


JOURNEY TO MARS
NASA
HUBBLE SPACE TELESCOPE
INTERNATIONAL SPACE STATION
SPACE LAUNCH SYSTEM
ORBITERS
LANDERS
SCIENCE
EXPLORATION
TECHNOLOGY
DEIMOS
PHOBOS
MARS TRANSIT HABITAT
COMMERCIAL CARGO AND CREW
ORION CREWED SPACECRAFT
DEEP SPACE HABITAT
SOLAR ELECTRIC PROPULSION
ASTEROID REDIRECT MISSION
MISSIONS: 6-12 MONTHS
RETURN: HOURS
EARTH RELIANT
MISSIONS: 1-12 MONTHS
RETURN: DAYS
PROVING GROUND
MISSIONS: 2-3 YEARS
RETURN: MONTHS
EARTH INDEPENDENT

Evolvable Mars Campaign
- planning for human spaceflight



Strategic Principles for Sustainable Exploration

- Implementable in the *near-term with the buying power of current budgets*
- *Exploration enables science* and science enables exploration
- Application of *high Technology Readiness Level* (TRL) technologies for near term missions
  - Focus on sustained investments on *technologies and capabilities* to address challenges of future missions
- *Near-term mission opportunities*
  - Defined cadence of integrated human and robotic

5

Strategic Principles for Sustainable Exploration

- Opportunities for *U.S. commercial business*
  - Further enhance the experience and business base
- *Resilient architecture featuring multi-use, evolvable space infrastructure*,
  - Minimize unique major developments
  - Each mission leaving something behind to support subsequent missions
- Substantial *New International and Commercial Partnerships*
  - Leveraging International Space Station partnership
  - Building new cooperative ventures

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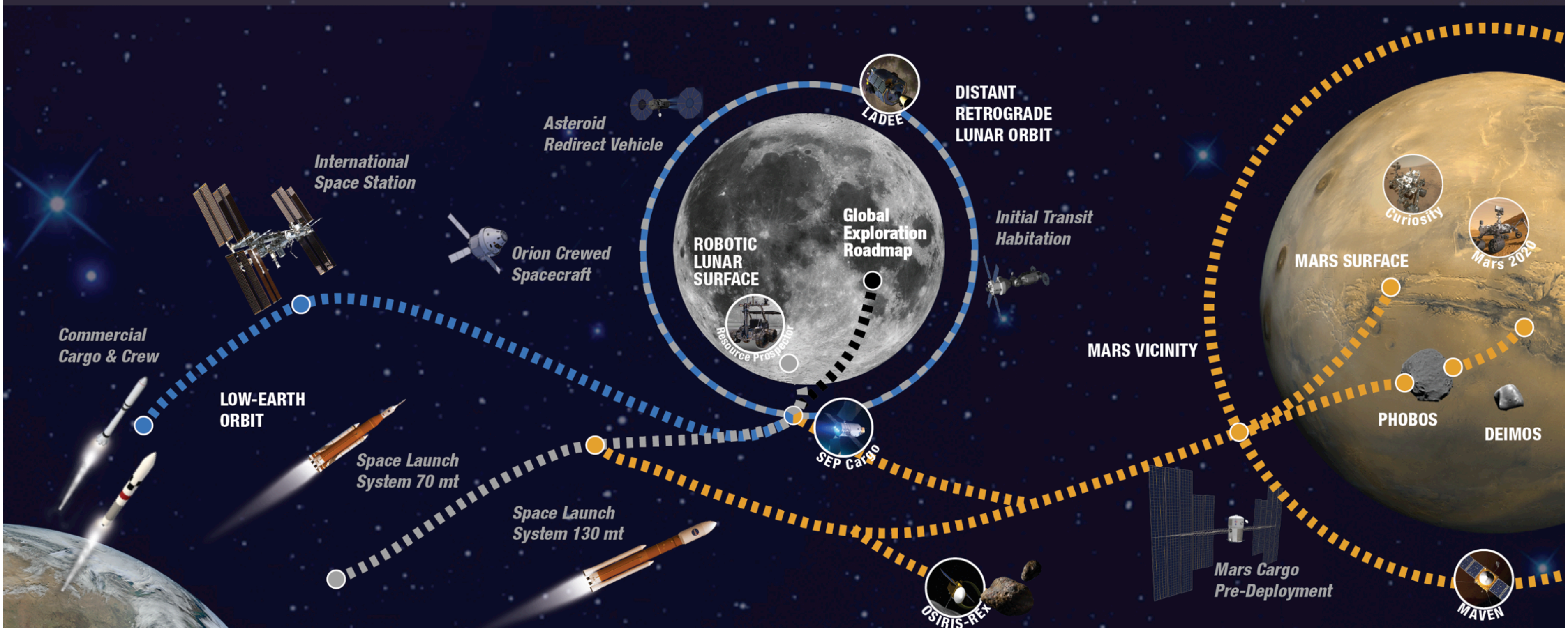
EVOLVABLE MARS CAMPAIGN

A Pioneering Approach to Exploration

EARTH RELIANT | **PROVING GROUND** | **EARTH INDEPENDENT**



THE TRADE SPACE

Across the Board | Solar Electric Propulsion • In-Situ Resource Utilization (ISRU) • Robotic Precursors • Human/Robotic Interactions • Partnership Coordination • Exploration and Science Activities

Cislunar Trades
- Deep-space testing and autonomous operations
- Extensibility to Mars
- Mars system staging/refurbishment point and trajectory analyses

Mars Vicinity Trades
- Split versus monolithic habitat
- Cargo pre-deployment
- Mars vicinity activities
- Entry descent and landing concepts
- Transportation technologies/trajectory analyses

Earth Reliant Objectives

Earth Reliant Objectives

Near-Term Objectives in Low Earth Orbit

National Aeronautics and Space Administration

VALIDATE EXPLORATION CAPABILITIES IN AN IN-SPACE ENVIRONMENT

- Long-duration, deep space habitation systems
- Next-generation spacesuit
- Autonomous operations
- Communications with increased delay
- Human and robotic mission operations
- Operations with reduced logistics capability
- Integrated exploration hardware testing

LONG-DURATION HUMAN HEALTH EVALUATION

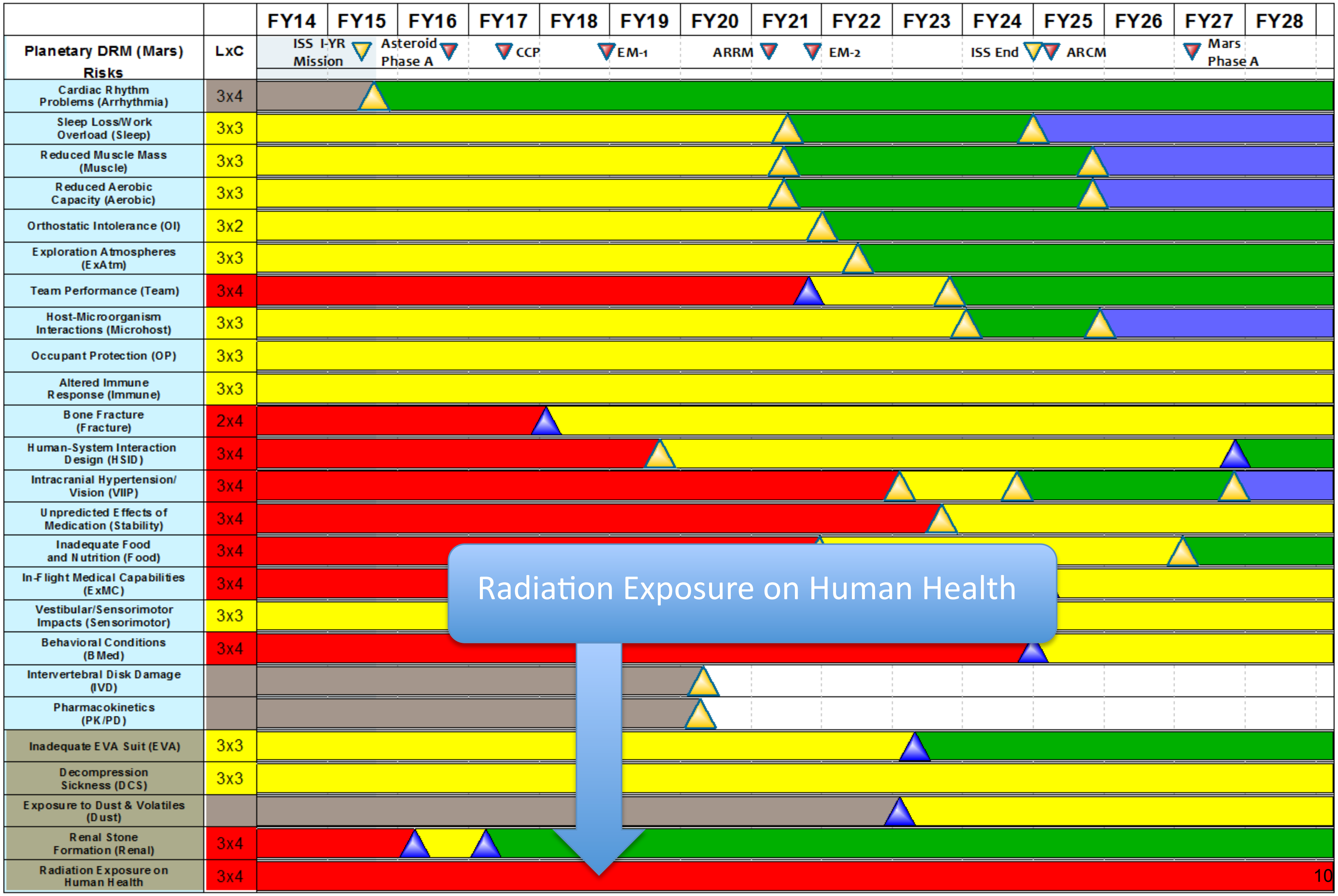
- Evaluate mitigation techniques for crew health and performance in micro-g space environment
- Acclimation from zero-g to low-g

COMMERCIAL CREW TRANSPORTATION

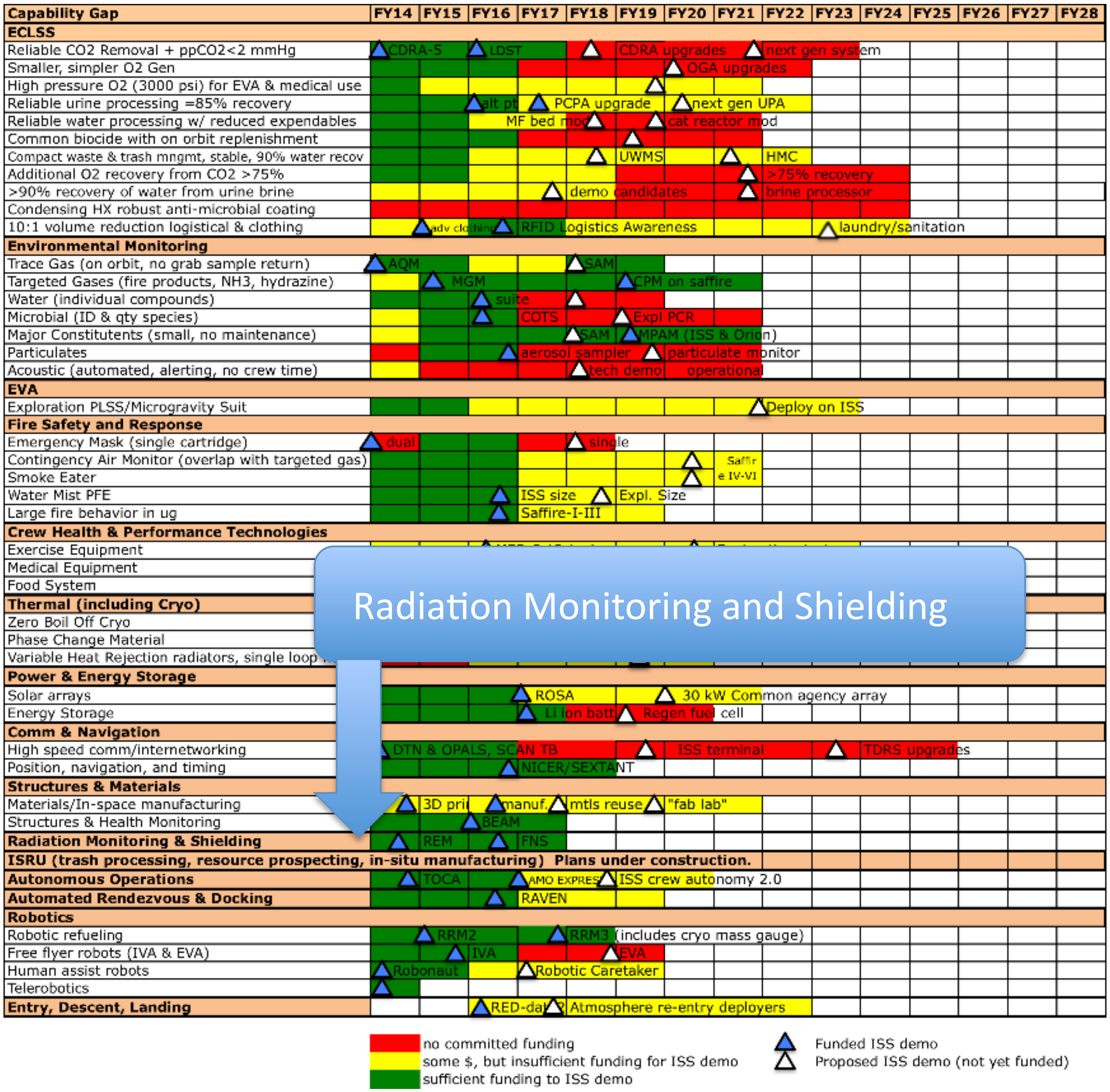
- Acquire routine U.S. crew transportation to LEO

#JOURNEYTOMARS

Human Research Program: Path to Risk Reduction

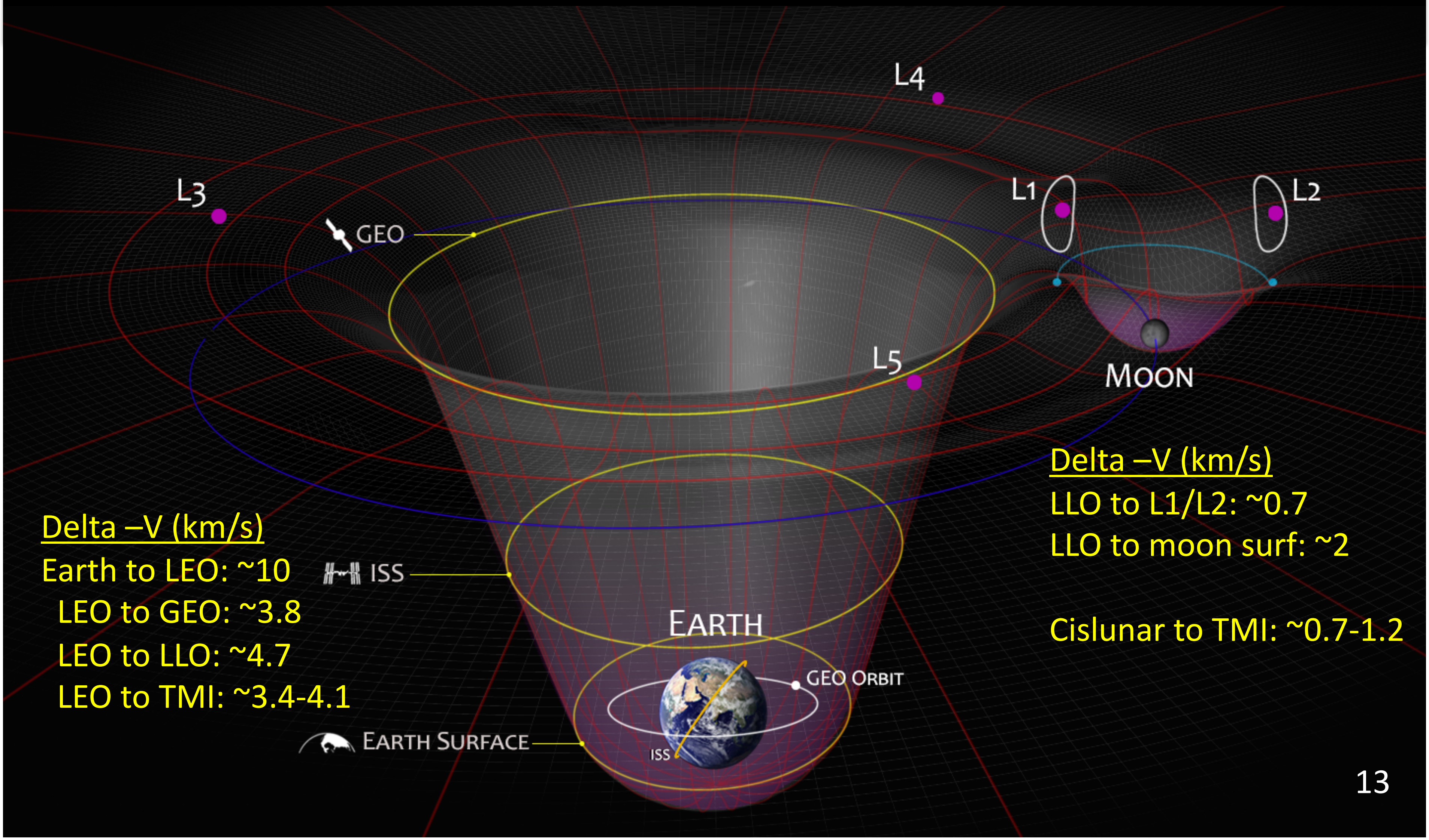


ISS Technology Demonstration Plan



Proving Ground – Cislunar Space Objectives

Why Cislunar Space?
The 'Gravity Well' Advantage



Proving Ground Objectives

Using Cislunar Resources to Enable Human Missions to Mars

TRANSPORTATION

- **Heavy Launch Capability**: beyond low-Earth orbit launch capabilities for crew, co-manifested payloads, large cargo
- **Crew**: transport at least four crew to cislunar space
- **In-Space Propulsion**: send crew and cargo on Mars-class mission durations and distances

WORKING IN SPACE

- **ISRU**: Understand the nature and distribution of volatiles and extraction techniques and decide on their potential use in human exploration architecture.
- **Deep-space operations capabilities**: EVA, Staging, Logistics, Human-robotic integration, Autonomous operations
- **Science**: enable science community objectives

STAYING HEALTHY

- **Deep-Space Habitation**: beyond low-Earth orbit habitation systems sufficient to support at least four crew on Mars-class mission durations and dormancy
- **Crew Health**: Validate crew health, performance and mitigation protocols for Mars-class missions

Habitation Systems Goals

System	Includes	Today	Mars Goal
Life Support	Air revitalization, water recovery, waste collection and processing	42% recovery of O2 from CO2; 90% recovery of H2O; <6 mo MTBF for some components	>75% recovery of O2 from CO2; >98% recovery of H2O; >2 yr MTBF
Environmental Monitoring	atmosphere, water, microbial, particulate, and acoustic monitors	Limited, crew-intensive on-board capability; rely on sample return to Earth	On-board analysis capability with no sample return; identify and quantify species and organisms in air & water
Crew Health	exercise equipment, medical treatment and diagnostic equipment, long-duration food storage	Large, cumbersome exercise equipment, limited on-orbit medical capability, food system based on frequent resupply	Small, effective exercise equipment, on-board medical capabilities, long-duration food system
EVA	Exploration suit	ISS EMU's based on Shuttle heritage technology; not extensible to surface ops	Next generation spacesuit with greater mobility, reliability, enhanced life support, operational flexibility
Fire	Non-toxic portable fire extinguisher, emergency mask, combustion products monitor, fire cleanup device	Large CO2 suppressant tanks, 2-cartridge mask, obsolete fire products. No fire cleanup other than depress/repress	Unified fire safety approach that works across small and large architecture elements
Radiation Protection	**Low atomic number materials including polyethylene, water, or any hydrogen-containing materials**	**Node 2 CQ's augmented with polyethylene to reduce the impacts of trapped proton irradiation for ISS crew members**	**Solar particle event storm shelter based on optimized position of on-board materials and CQ's with minimized upmass to eliminate major impact of solar particle event on total mission dose**

Radiation Protection

National Aeronautics and Space Administration

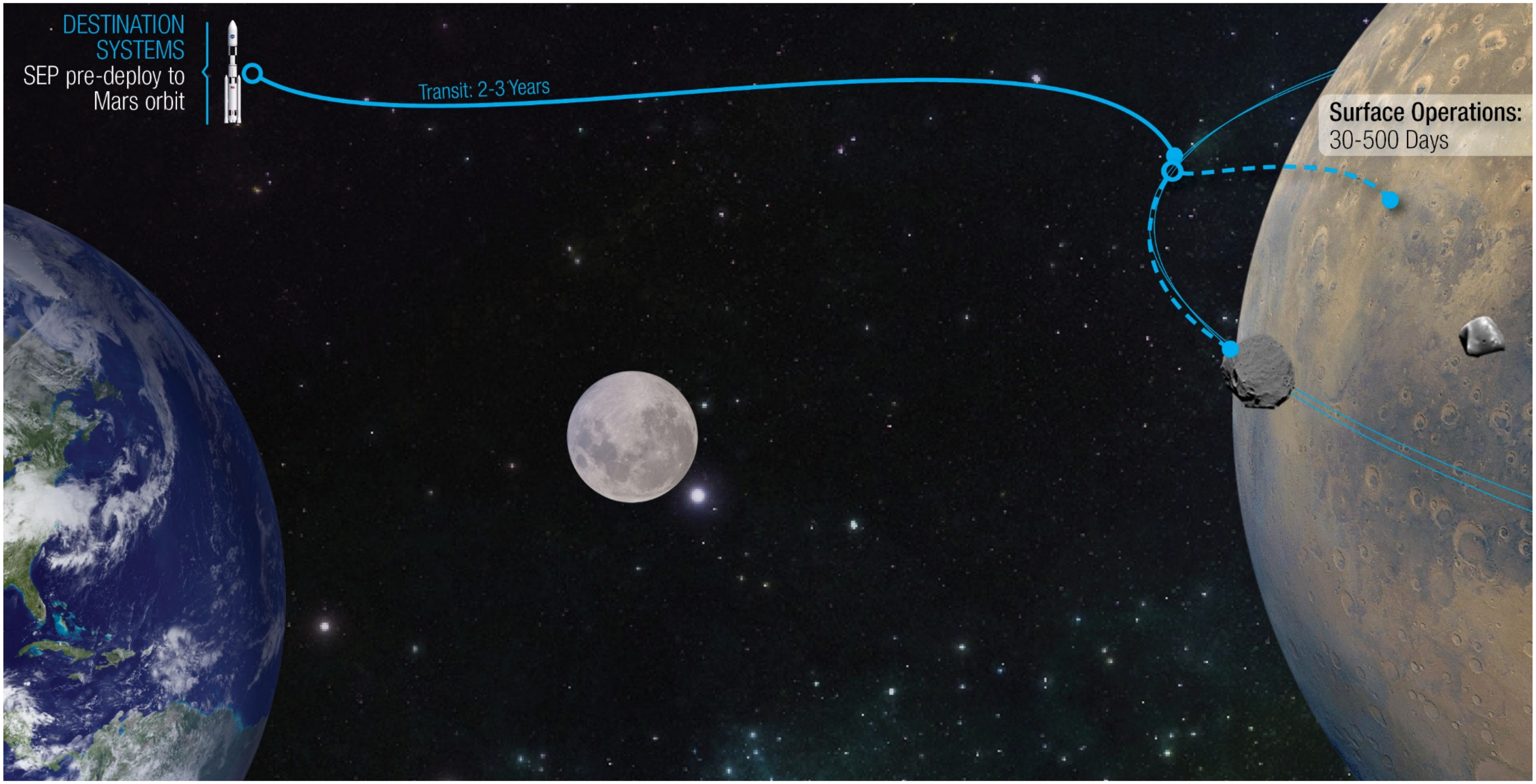
- Includes
  - Low atomic number materials including polyethylene, water, or any hydrogen-containing materials
- Current
  - Node 2 Crew Quarters augmented with polyethylene to reduce the impacts of trapped proton irradiation for ISS crew members
- Mars Goal
  - Solar particle event storm shelter
  - Optimized position of on-board materials and Crew Quarters
  - Minimized upmass to eliminate major impact of on total mission dose

EMC Split Mission Concept

- series of missions

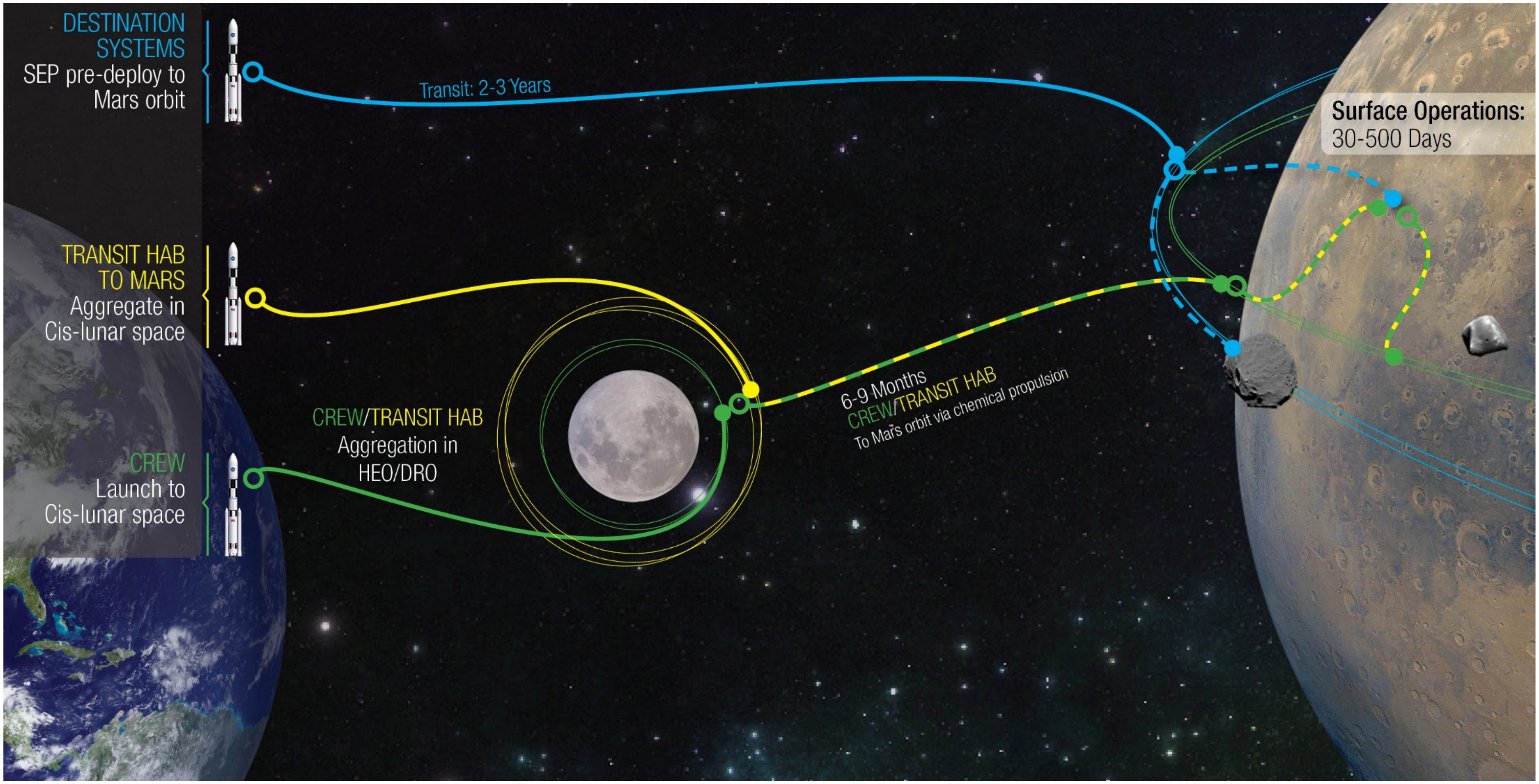
Split Mission Concept

Pre-Deploy Cargo First



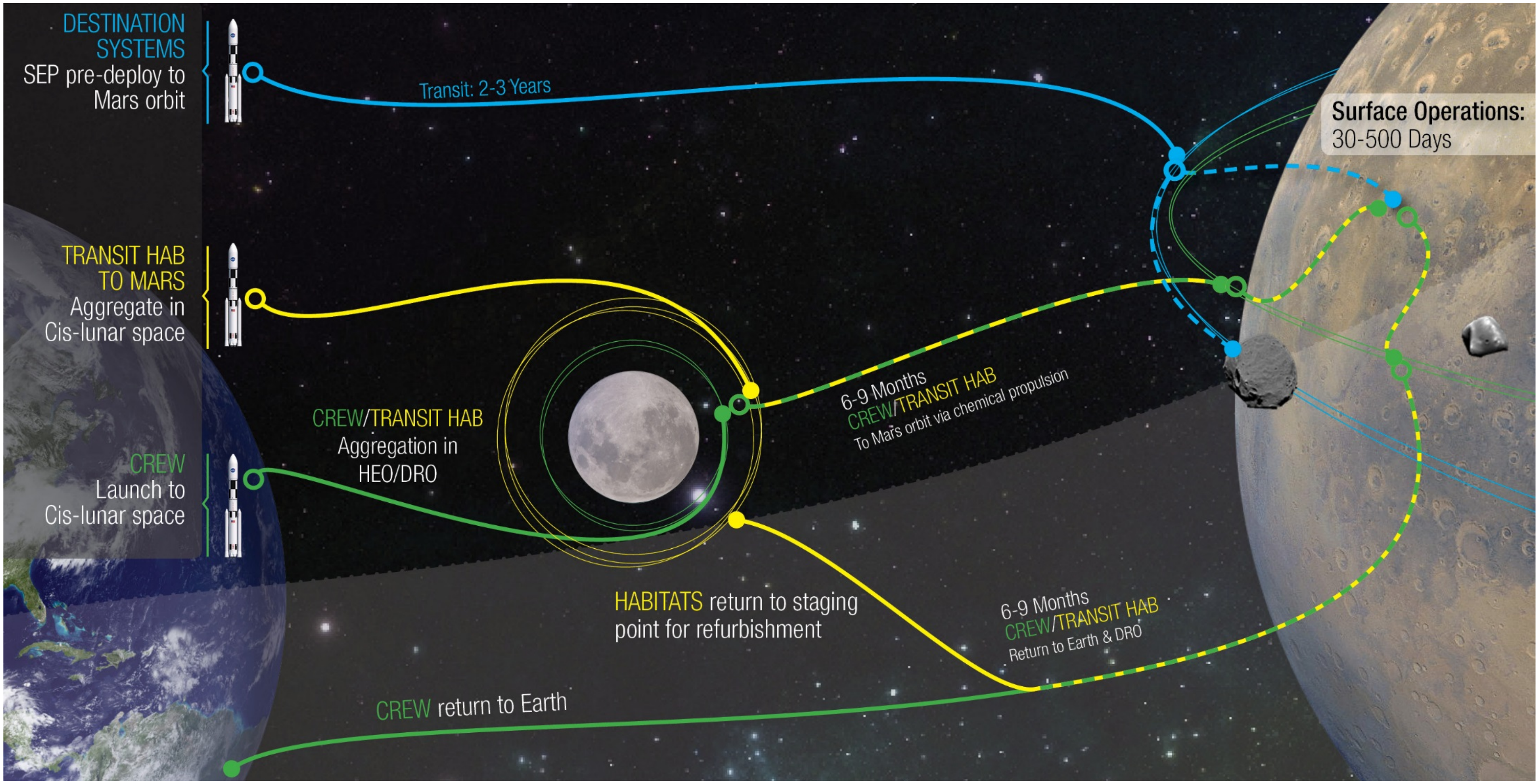
Split Mission Concept

Crew to Mars Orbit

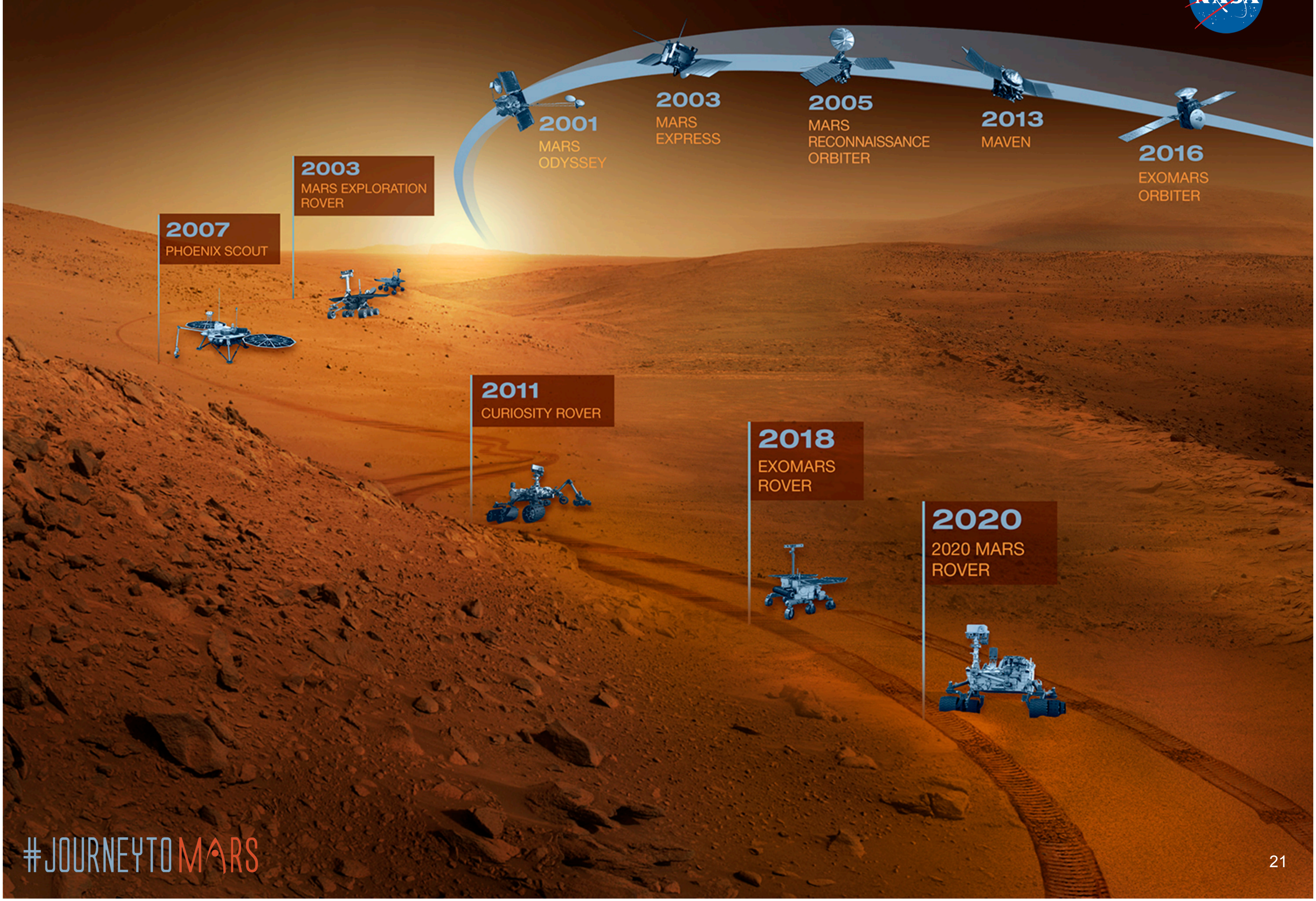


Split Mission Concept

Crew Return to Earth



Journey to Mars - in Progress



International Space Station

The First Step in Exploration

Human Health Research

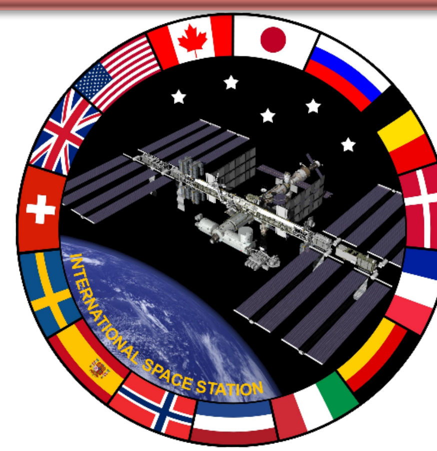
Advanced Life Support

Technology Demonstration

Logistics Management

Maintenance & Repair

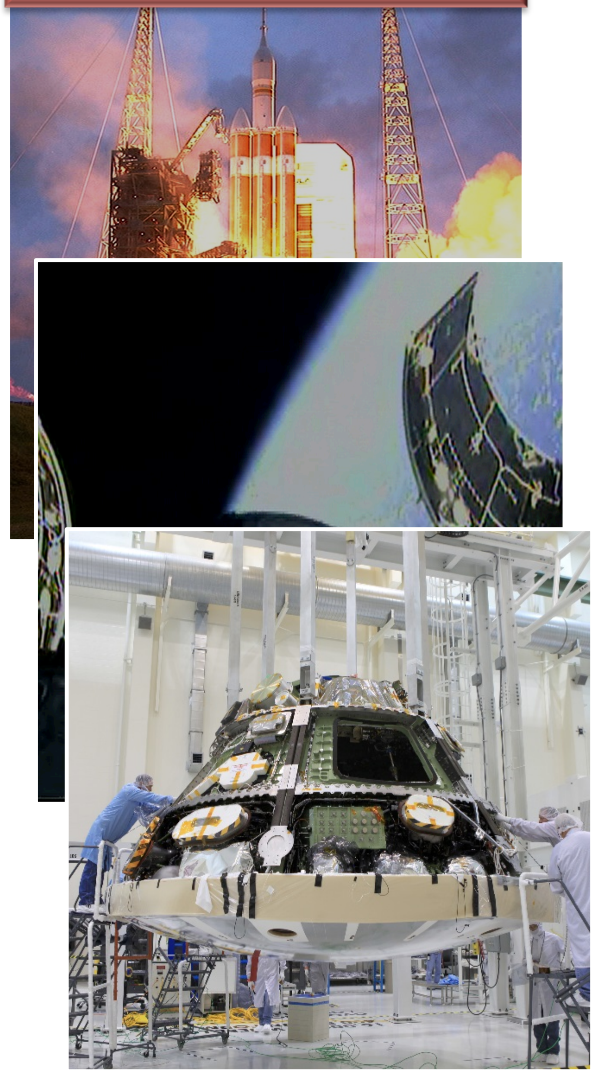
International Collaboration



SLS, Orion, and Ground Operations

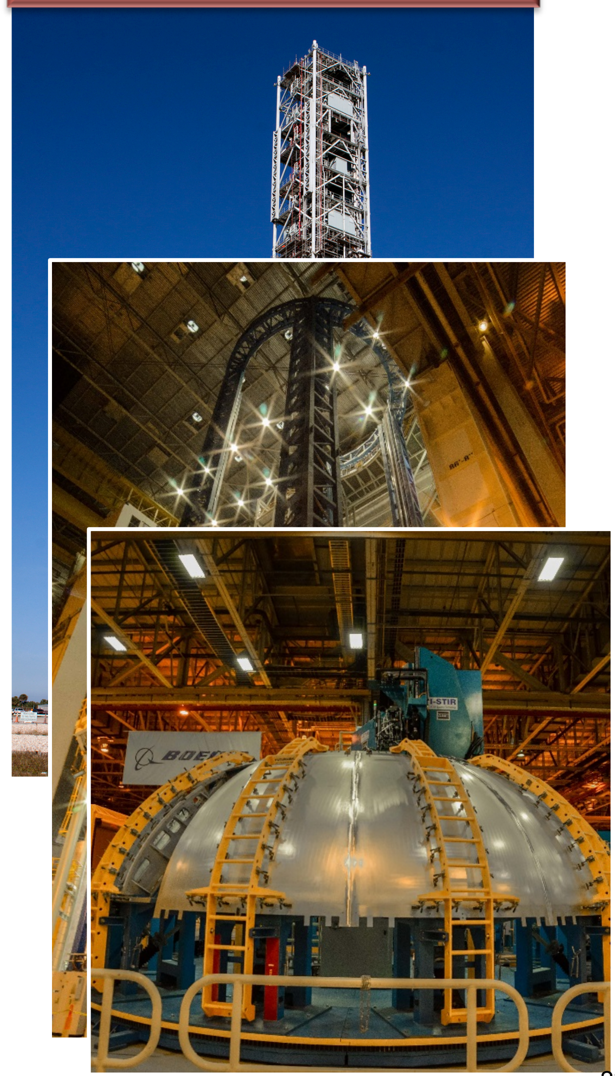
Making Real Progress

Orion



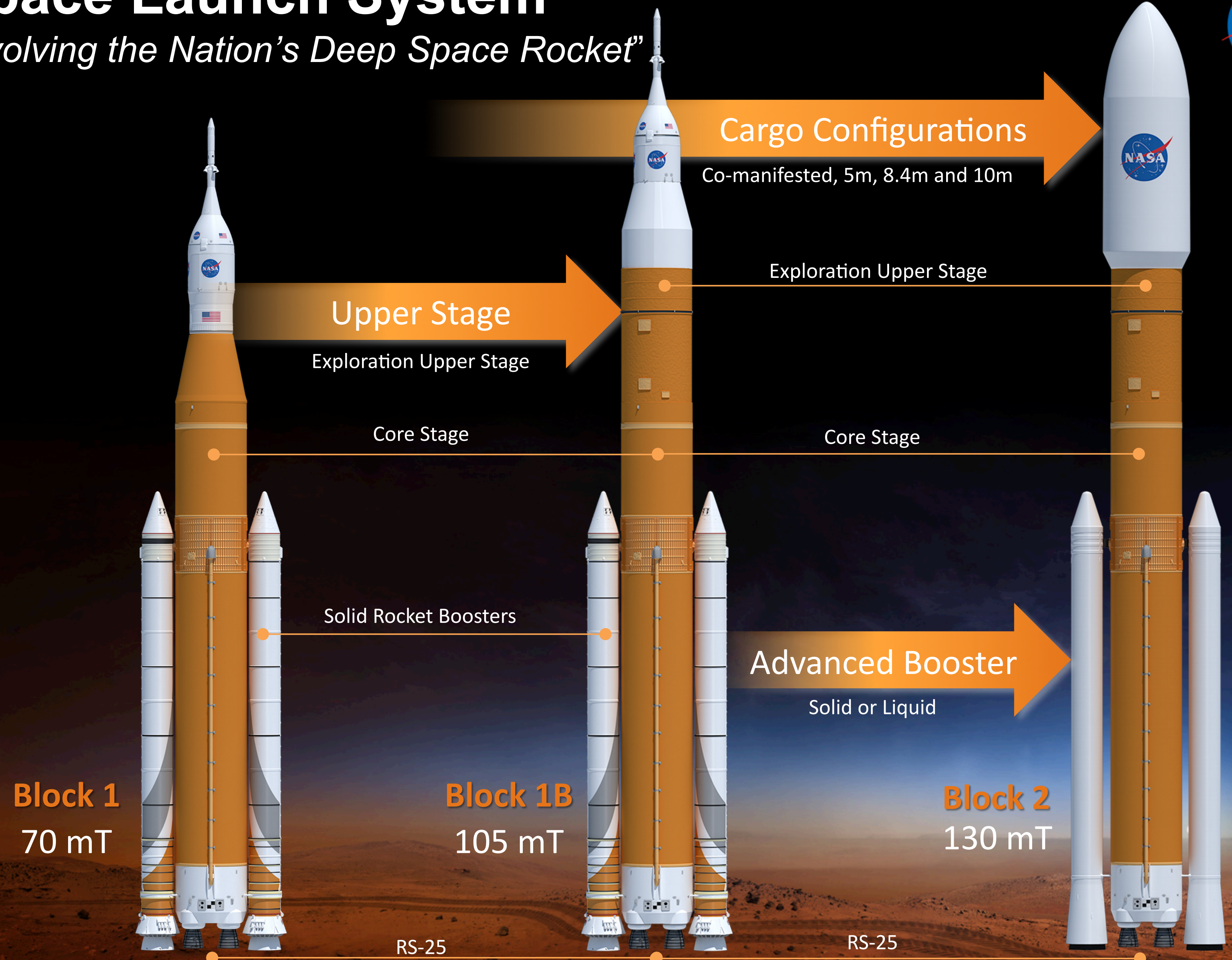
Space Launch System

Ground Operations



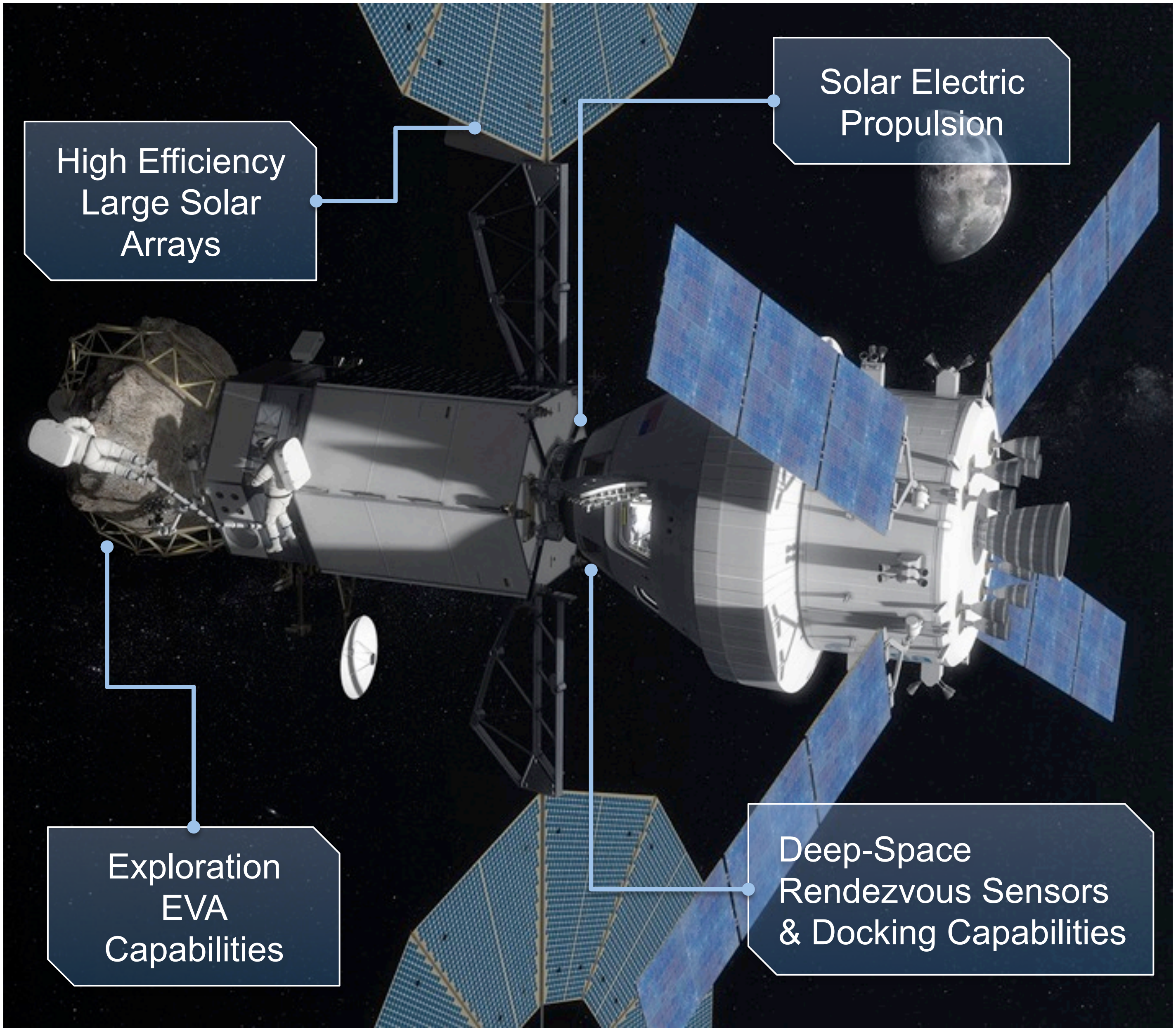
Space Launch System

"Evolving the Nation's Deep Space Rocket"



As documented in "Pioneering Next Steps in Space Exploration"
https://www.nasa.gov/sites/default/files/atoms/files/journey-to-mars-next-steps-20151008_508.pdf

ARM: An Early Mission in the Proving Ground of Cislunar Space



IN-SPACE POWER & PROPULSION:

- High efficiency 40kW SEP extensible to Mars cargo missions
- Power enhancements feed forward to deep-space habitats and transit vehicles

EXTRAVEHICULAR ACTIVITIES:

- Two in-space EVAs of four hours each
- Primary Life Support System design accommodates Mars
- Sample selection, collection, containment, and return

TRANSPORTATION & OPERATIONS:

- Capture and control of non-cooperative objects
- Common rendezvous sensors and docking systems for deep space
- Cislunar operations are proving ground for deep space operations, trajectory, and navigation

What We've Learned Thus Far and Still Need to Learn

Orbital Environment and Operations

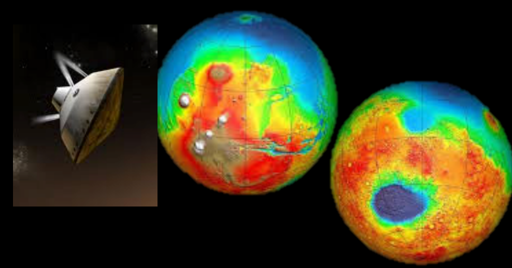
Learned:

- Deep space navigation
- Orbit transfer near low-gravity bodies
- Gravity assist
- Aero-braking
- Gravitational potential
- Mars's moons' characteristics
- ISRU potential

To Learn:

- Return flight from Mars to Earth
- Autonomous rendezvous and docking
- ISRU feasibility
- Resource characterization of Mars's moons
- High-power SEP

Capture, EDL, and Ascent at Mars



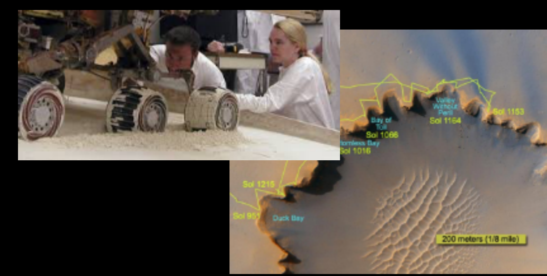
Learned:

- Spatial/temporal temperature variability
- Density and composition variability
- Storm structure, duration, and intensity
- 1 mT payload
- ~10 km accuracy

To Learn:

- Ascent from Mars
- Large-mass EDL
- Precision EDL
- Aero-capture
- Site topography and roughness
- Long-term atmospheric variability

Surface Operations at Mars



Learned:

- Water once flowed and was stable
- Global topography: elevation and boulder distributions
- Remnant magnetic field
- Dust impacts on solar power/ mechanisms
- Radiation dose
- Global resource distribution
- Relay strategies, operations cadence

To Learn:

- Landing site resource survey
- Dust effects on human health, suits, and seals
- Rad/ECLSS in Mars in environment
- Power sufficient for ISRU
- Surface navigation

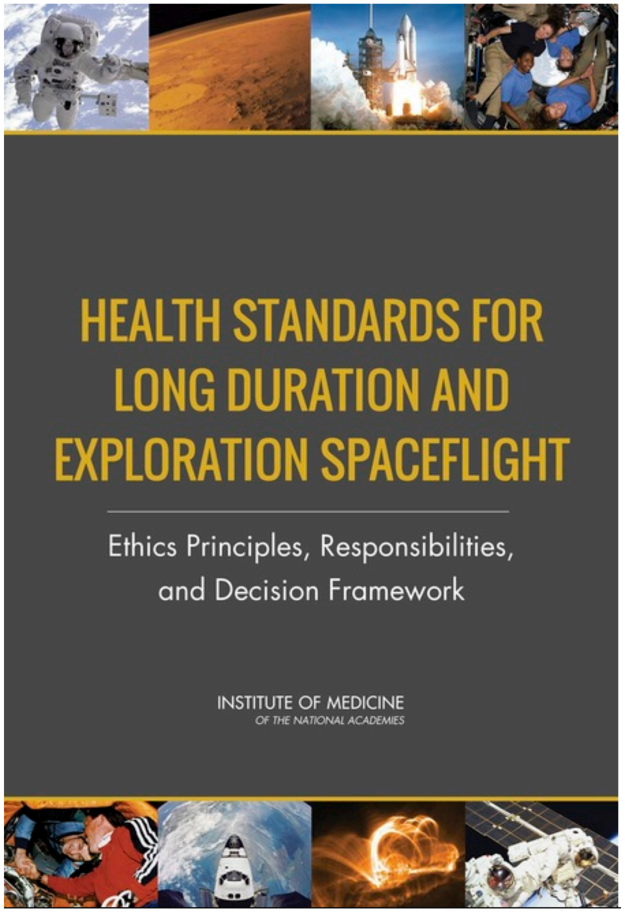
IOM Report

"Health Standards for Long Duration and Exploration Spaceflight: Ethics Principles, Responsibilities, and Decision Framework" (April, 2014)

The report makes 4 recommendations:

- The first 3 recommendations are directed at how OCHMO develops and implements health and medical standards.

- The fourth recommendation provides a tri-level decision-making framework based on the ethical principles and responsibilities that can be used when a health/medical standard(s) cannot be met, or when there are health/medical risks that are not fully understood for a proposed long duration or space exploration mission.



HEOMD view of CCMC??

National Aeronautics and Space Administration

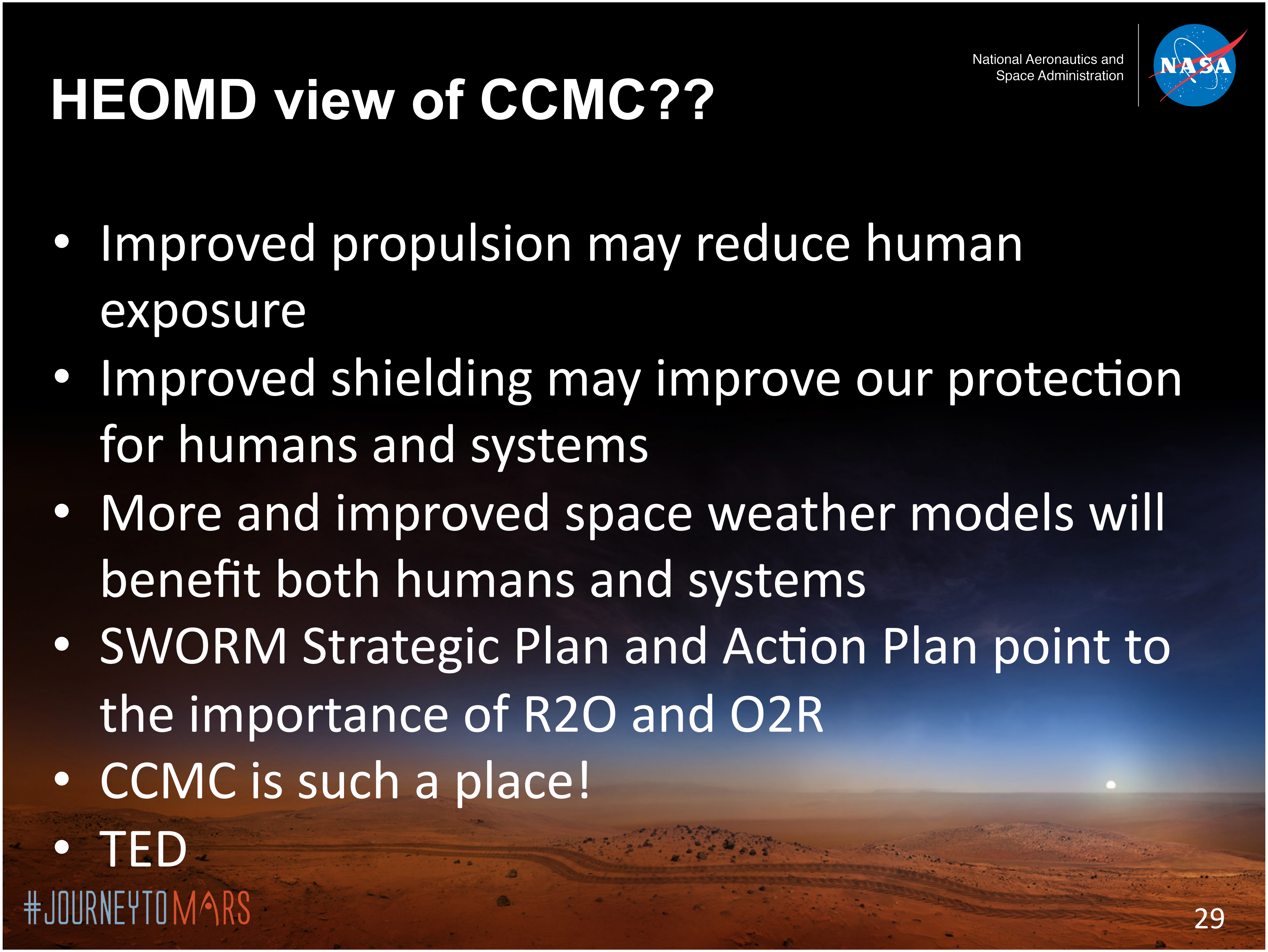
WE WANT IT ALL, AND WE WANT IT NOW…

- We want to know
  - When we can safely launch
  - When we can safely operate
  - When will an event happen
  - How big will it be
  - How long will it last
  - Will it adversely impact humans
  - Will it adversely impact space-based and/or ground-based systems

National Aeronautics and
Space Administration

HEOMD view of CCMC??

- Improved propulsion may reduce human exposure
- Improved shielding may improve our protection for humans and systems
- More and improved space weather models will benefit both humans and systems
- SWORM Strategic Plan and Action Plan point to the importance of R2O and O2R
- CCMC is such a place!
- TED



#JOURNEYTOMARS


QUESTIONS?
MARS
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