National Aeronautics and Space Administration

HEOMD Update
NRC Aeronautics and Space Engineering Board
Oct. 16, 2014

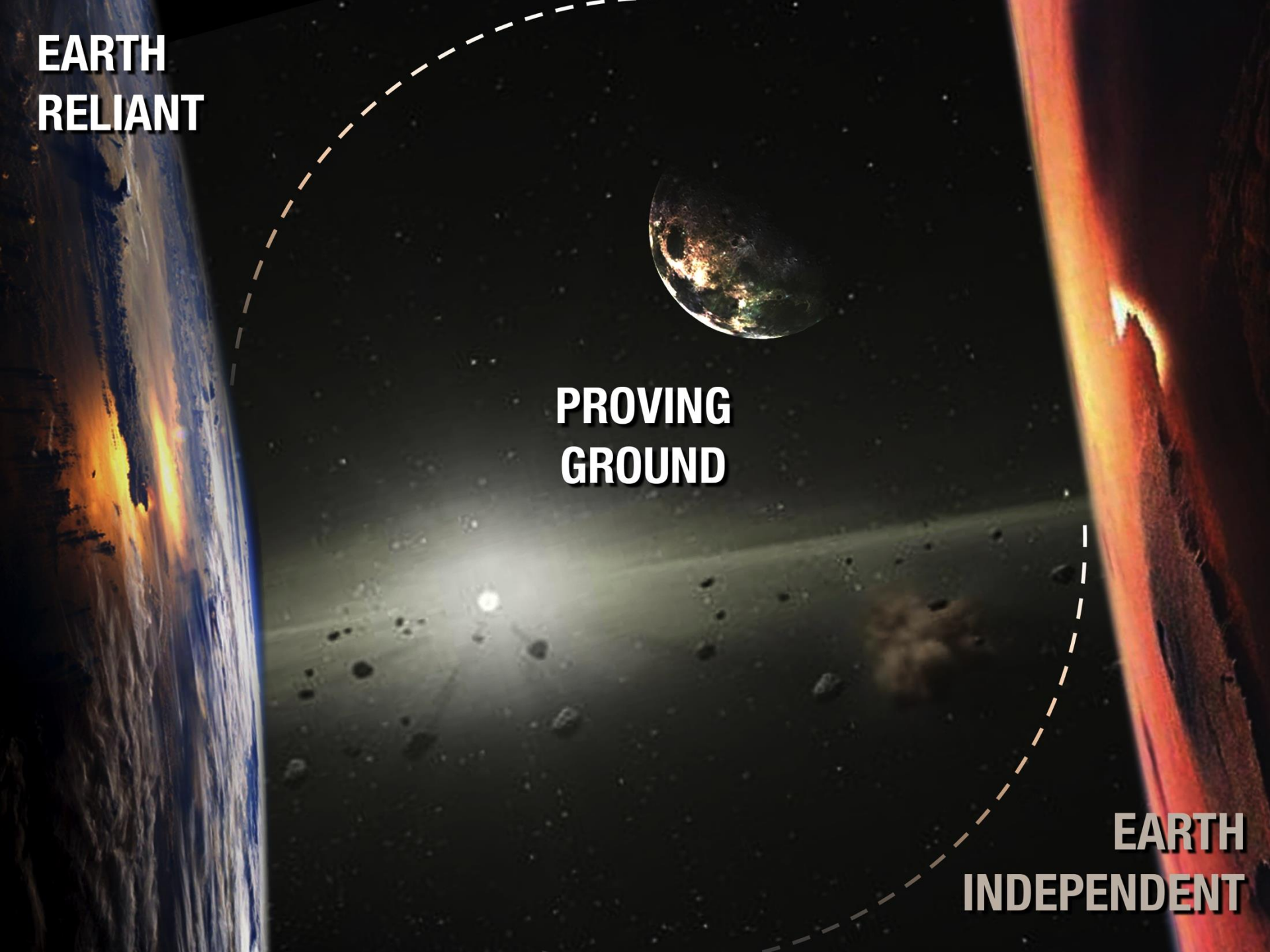
Greg Williams

DAA for Policy and Plans

Human Exploration and Operations Mission Directorate

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***;*
- 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 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 learned from the ISS logistics and crew market;
- ***Multi-use, evolvable*** space infrastructure;
- Substantial ***international and commercial participation***, leveraging current International Space Station partnerships.


EARTH
RELIANT
PROVING
GROUND
EARTH
INDEPENDENT

Human Exploration Pathways

Mastering the Fundamentals

- Extended Habitation Capability (ISS)
  - High Reliability Life Support
- Deep-space Transportation (SLS and Orion)
- Exploration EVA
- Automated Rendezvous & Docking
- Docking System

Land on Mars

On to Mars

Toward Earth Independent

Crewed Orbit of Mars or Phobos/Deimos

To Moon And Beyond
(International and/or Industry Partners)

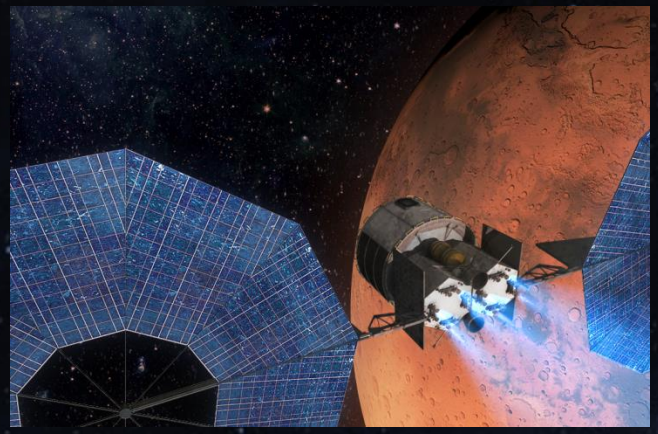
To Mars

Bringing the moon within Earth's economic sphere.

Pushing the Boundaries

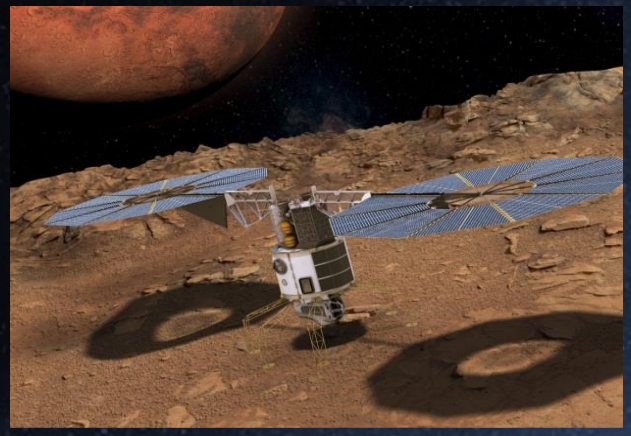
- Deep Space Operations
  - Deep Space Trajectories
  - Deep Space Radiation Environment
  - Integrated Human/Robotic Vehicle
- Advanced In-Space Propulsion (SEP)
  - Moving Large Objects
- Exploration of Solar System Bodies

Mars Vicinity Options Provide the "Pull"



Mars Orbit

- Opportunities for integrated crewed/robotic missions, such as:
  - Real time tele-operation on Martian surface
  - Mars sample return
  - Other science objectives
  - Technology demonstrations
- Demonstration of sustainable human exploration split-mission Mars concept
- Test transportation and long duration human systems



Mars Moons

- Exploration of Phobos and/or Deimos
- Human stay capability in low-G environment
- Enables a variety of science missions, such as:
  - Sample return
- Demonstration of sustainable human exploration split-mission Mars concept
- Moon provides additional radiation protection
- In-situ resources

Mars Surface

- Extending Human Presence Leveraging Marian resources for future human exploration
- Provides radiation protection
- Search for Signs of Life
- Comparative Planetology
- Understanding Mars Climate Changes
- Geology/Geophysics

For Human Exploration - What's Left to Know?

In the past 50 years, robotic missions have contributed data that reduces the risks of future human Mars exploration

TODAY

No data,
Most "unknowns"

Complete data sets
Planet completely characterized

There's more to know, but we're well on our way

2. Asteroid Redirect Mission: Into the Proving Ground

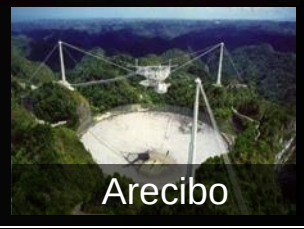
IDENTIFY

Ground and space based assets detect and characterize potential target asteroids


Pan-STARRS


NEOWISE

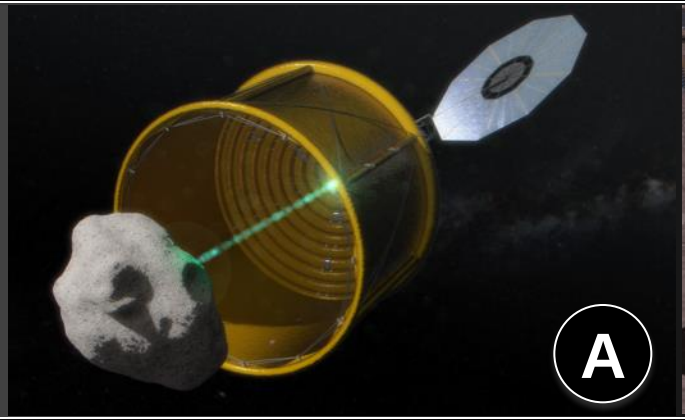

Goldstone

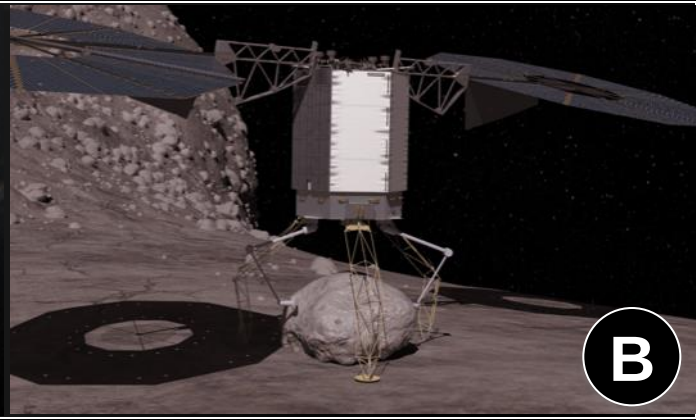

Arecibo


Infrared Telescope Facility

REDIRECT

Solar electric propulsion (SEP) based system redirects asteroid to cis-lunar space (two capture options)





EXPLORE

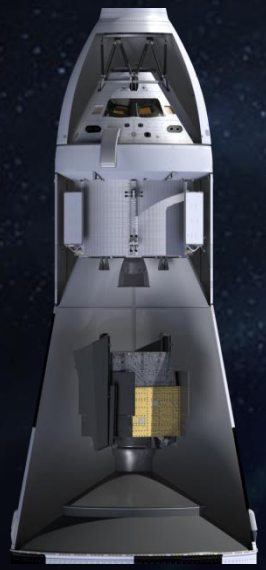
Crews launches aboard SLS rocket, travels to redirected asteroid in Orion spacecraft to rendezvous with redirected asteroid, studies and returns samples to Earth

Cis-Lunar "Proving Ground" Objectives

- **Demonstrate SLS and Orion in deep space**
  - Critical Mission Events
    - Separation Events, Key Maneuvers, Re-entry, Landing and Recovery
  - Co-manifested cargo capability with Orion incl loads, dynamics.
  - Demonstrate integrated vehicle systems in flight
    - Deep space communications (e.g., Optical, DTN), power and thermal systems, in-space maneuvering
  - Validate environments
  - Autonomous operations
- **Demonstrate Solar Electric Propulsion (SEP) systems**
- **Demonstrate long duration, deep space habitation systems**
- **Conduct EVAs in deep space, micro-g environments**
- **Conduct human and robotic mission operations**
- **Evaluate crew health and performance in a deep space environment**
- **Demonstration of In-Situ Resource Utilization**
- **Learn to operate with reduced logistics capability**
- **Demonstrate structures & mechanisms**
  - Inflatable structures
- **Capability Pathfinder and SKG missions**

Exploration Upper Stage Concept Options

- **Co-manifesting large payloads is game changing capability**
- **Proving ground vehicle as SLS with Exploration Upper Stage – Block 1B**
  - Volume between EUS and Orion for large payloads
  - Max 10-15 mt capability (TBR)
  - Flight rate one/year beginning with EM-2
- **Supports development of Mars capabilities and enhances value of early missions**

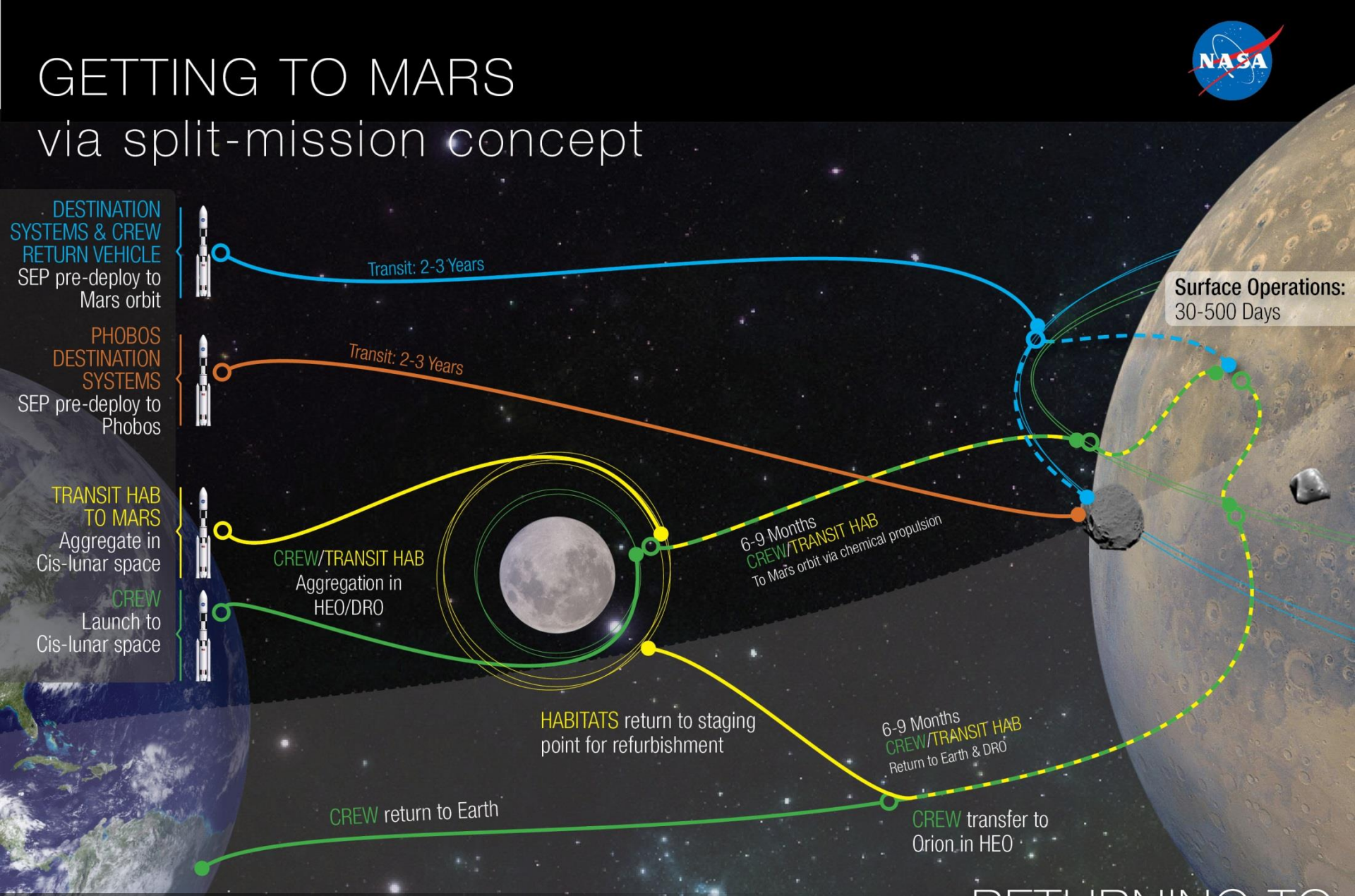


Orion w/Asteroid Redirect Vehicle

Orion w/ Habitation or Cargo Element

Orion w/ Robotic Landers

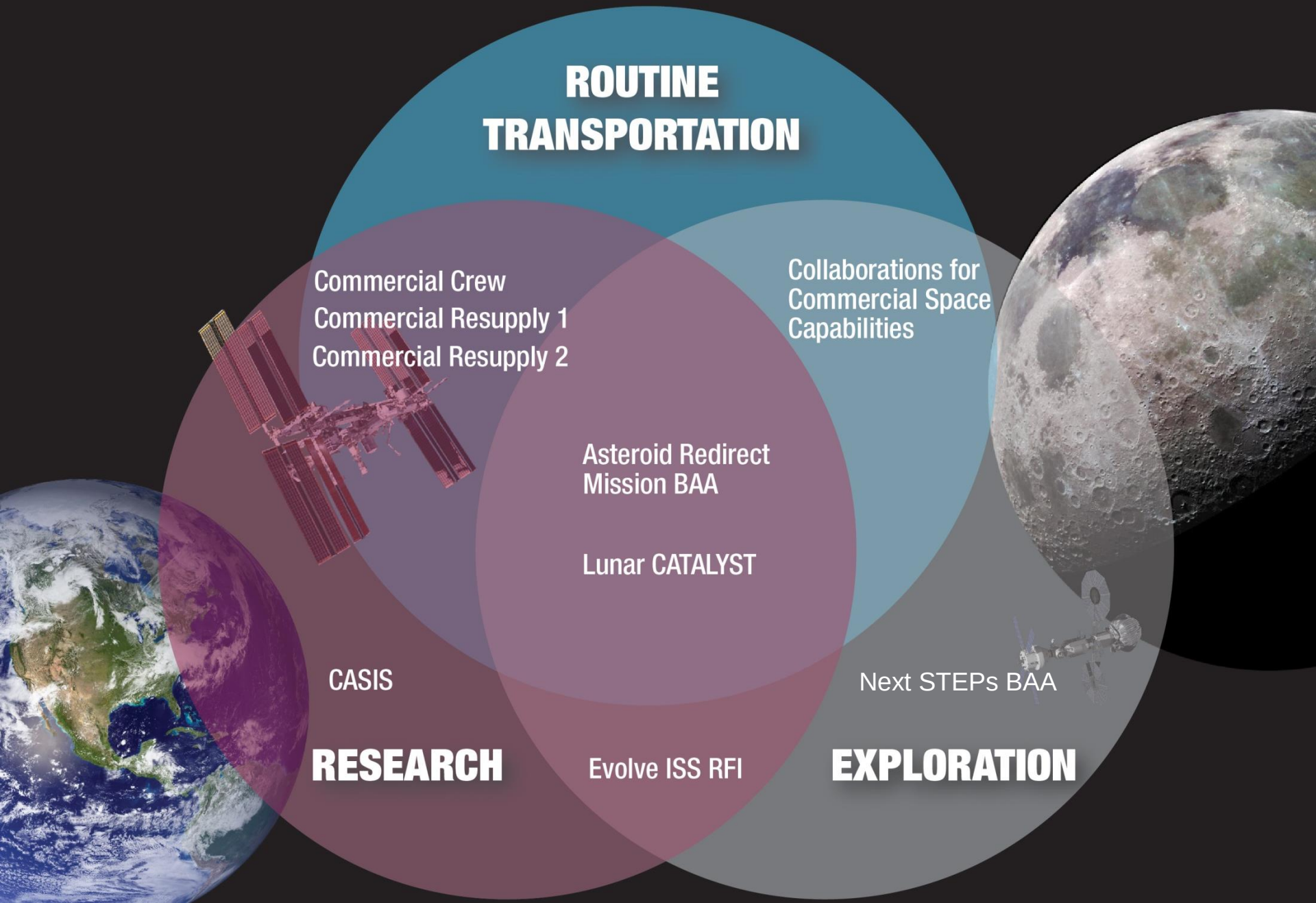
GETTING TO MARS
via split-mission concept



- 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

RETURNING TO EARTH

Commercial Opportunities in Space Enabled by NASA



Pioneering Space

"Fifty years after the creation of NASA, our goal is no longer just a destination to reach. Our goal is the capacity for people to work and learn and operate and live safely beyond the Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite. And in fulfilling this task, we will not only extend humanity's reach in space -- we will strengthen America's leadership here on Earth."

- President Obama -- April 2010