



National Aeronautics and Space Administration



The State of Human Exploration and Operations for Mars Exploration

A Very Brief Overview

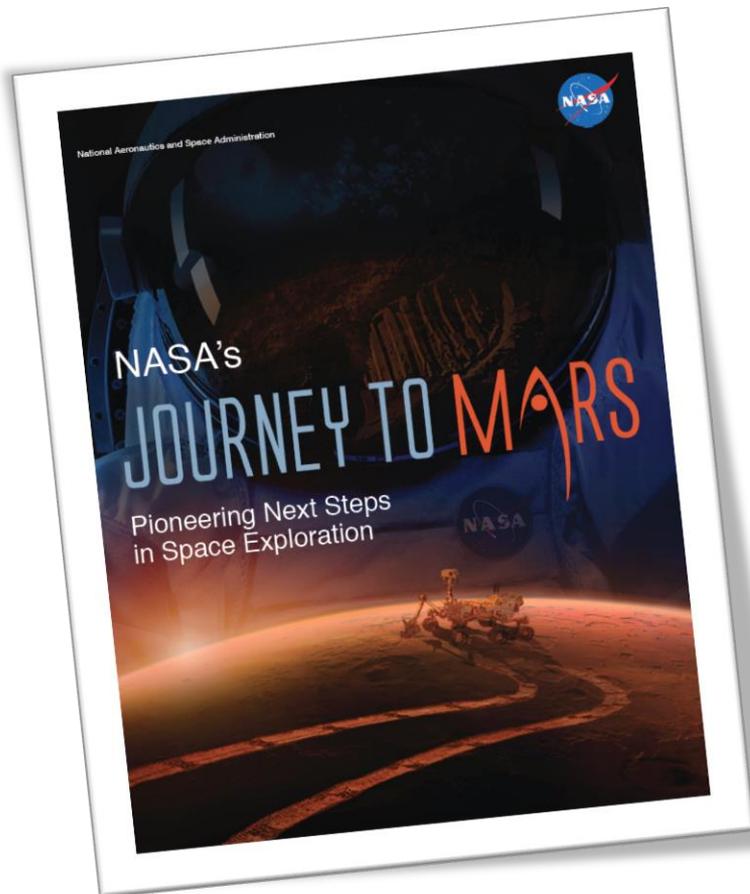
Future Exploration and Science Working Group
NASA GSFC
January 14, 2016

NASA Exploration Systems Projects, GSFC / 455
Advanced Exploration Systems, Habitation, and Architectures

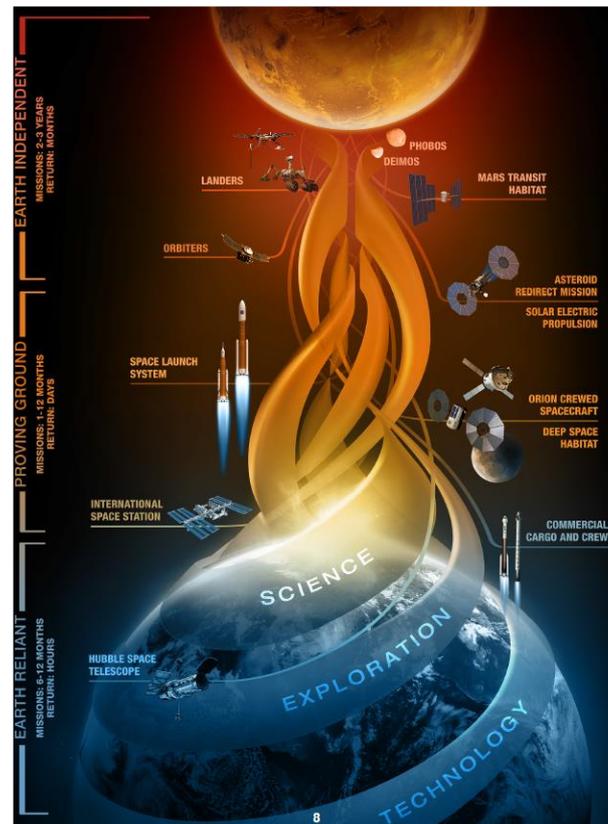
Ruthan Lewis, Ph.D.
ruthan.lewis@nasa.gov, (c) 301-442-9058

Mark Lupisella, Ph.D.
mark.l.lupisella@nasa.gov, 202-281-0801

www.nasa.gov



- Released October 2015
- Strategy and progress
- Discussion with stakeholders, partners
- Current plans and activities
- Challenges



Planning

Tactical

- Future Capabilities Team
- System Maturation Team
- Evolvable Mars Campaign

Strategic

- Future Capabilities Team
- System Maturation Team
- Evolvable Mars Campaign



Orion and Space Launch System



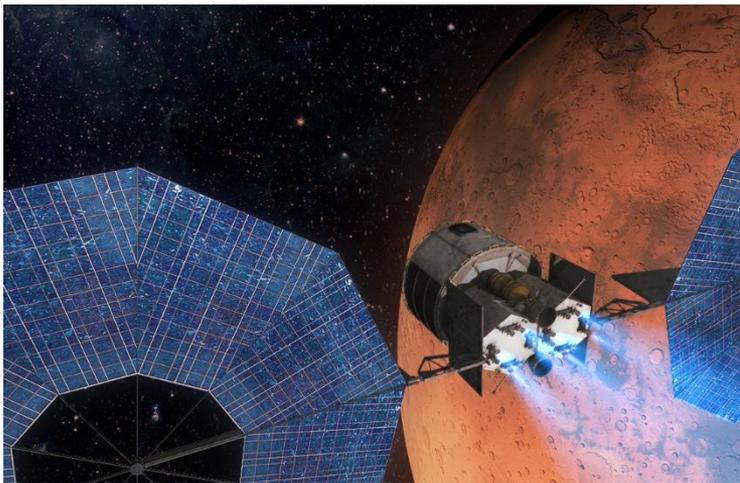
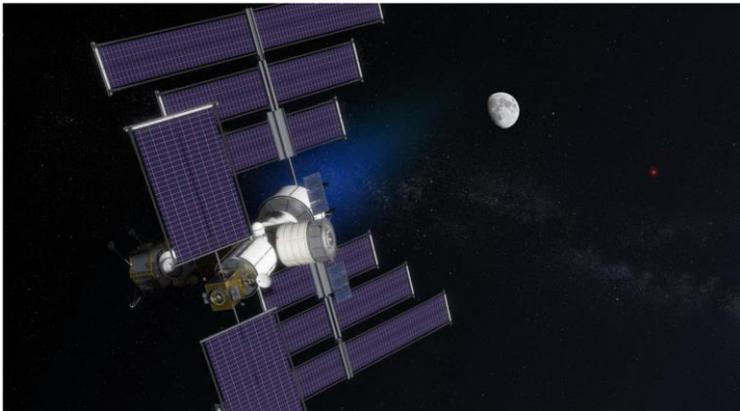
Orion

- FY2015
 - Commitment to technical, cost, schedule baseline
 - Launch Abort System tested
 - Primary structure welding
- FY2016
 - Heat shield water impact tests
 - European Service Module tests

Space Launch System

- FY2015
 - Engine firing test
 - Critical Design Review
- FY2016
 - Final qualification booster firing test
 - Flight testing RS-25 engines





- Deriving and detailing Proving Ground plans
 - **Habitation and logistics concept** for cis-lunar space that feeds forward to Mars
 - **System technologies** to be incorporated including roadmaps for improved systems based on technology readiness and operation experience gained
 - **Synergies** with the International Space Station, ARM, and long-term Human Architecture Team architectures
 - **Key assumptions and constraints** sufficient to develop requirements for acquiring the transit habitat capability
 - **Options for obtaining this capability**, considering as a minimum potential public-private partnerships, international contributions, and acquisitions
- FY15: agency documentation review
- FY16: further refinement



Proving Ground Objectives

Proving Ground Objectives		
CATEGORY	TITLE	OBJECTIVE
Transportation	Crew Transportation	Provide ability to transport at least four crew to cislunar space
Transportation	Heavy Launch Capability	Provide beyond LEO launch capabilities to include crew, co-manifested payloads, and large cargo
Transportation	In-Space Propulsion	Provide in-space propulsion capabilities to send crew and cargo on Mars-class mission durations and distances
Transportation	Deep Space Navigation and Communication	Provide and validate cislunar and Mars system navigation and communication
Working in Space	Science	Enable science community objectives
Working in Space	Deep Space Operations	Provide deep-space operations capabilities: <ul style="list-style-type: none">• Extravehicular activity• Staging• Logistics• Human-robotic integration• Autonomous operations
Working in Space	In-Situ Resource Utilization	Understand the nature and distribution of volatiles and extraction techniques, and decide on their potential use in the human exploration architecture
Staying Healthy	Deep Space Habitation	Provide beyond LEO habitation system sufficient to support at least four crew on Mars-class mission durations and dormancy
Staying Healthy	Crew Health	Validate crew health, performance, and mitigation protocols for Mars-class missions

EVOLVABLE MARS CAMPAIGN

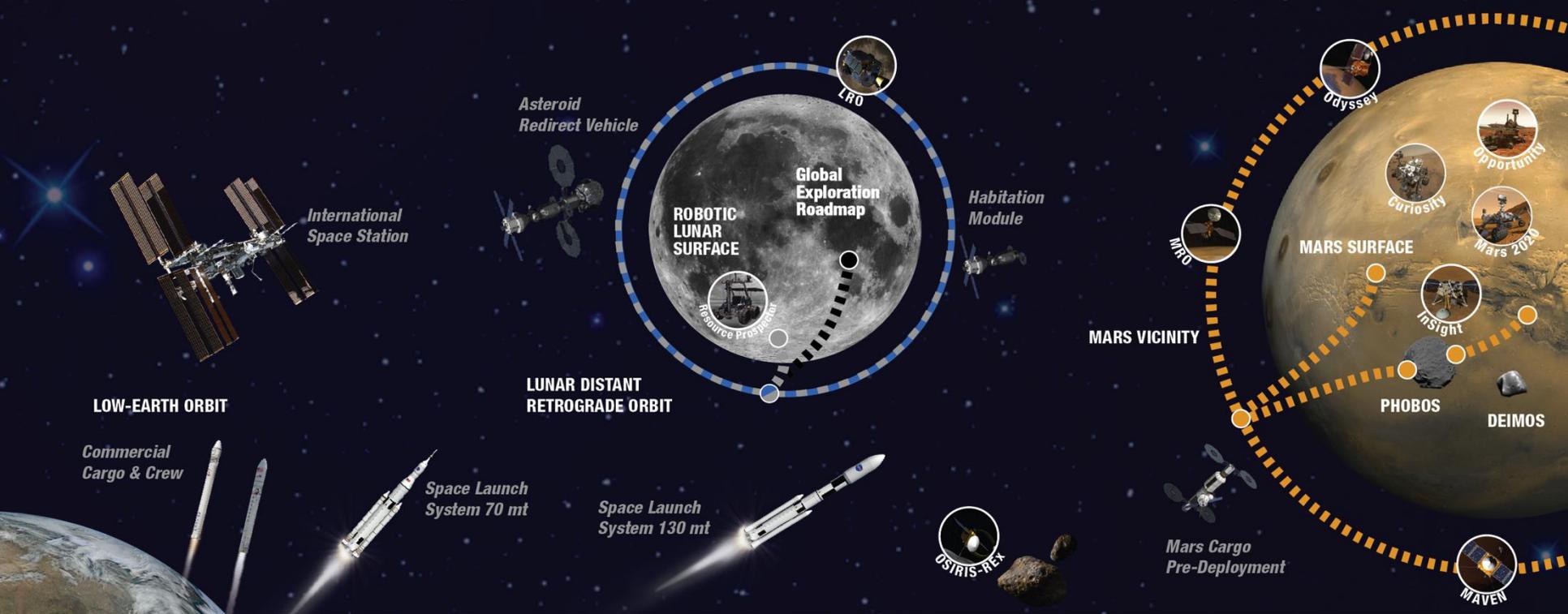
A Pioneering Approach to Exploration



EARTH RELIANT

PROVING GROUND

EARTH INDEPENDENT



THE TRADE SPACE

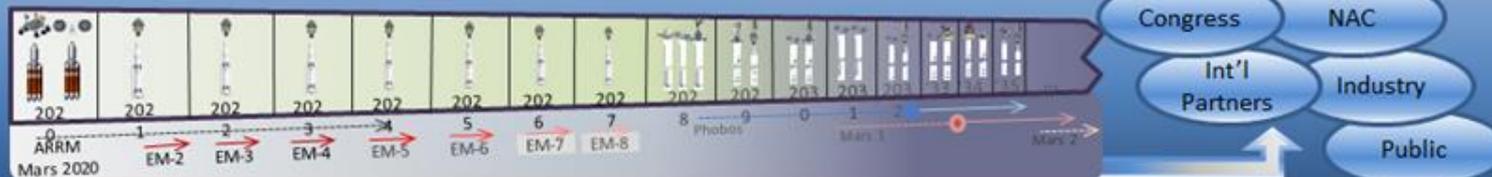
Across the Board | Solar Electric Propulsion • In-Situ Resource Utilization (ISRU) • Robotic Precursors • Human/Robotic Interactions • Partnership Coordination • Exploration and Science Activities

Cis-lunar 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 Phobos/Deimos activities
• Entry descent and landing concepts
• Transportation technologies/trajectory analyses

Evolvable Mars Campaign Goes Broad and Deep

Campaign Analysis, Timelines and Decision Needs



Mission Operations Development



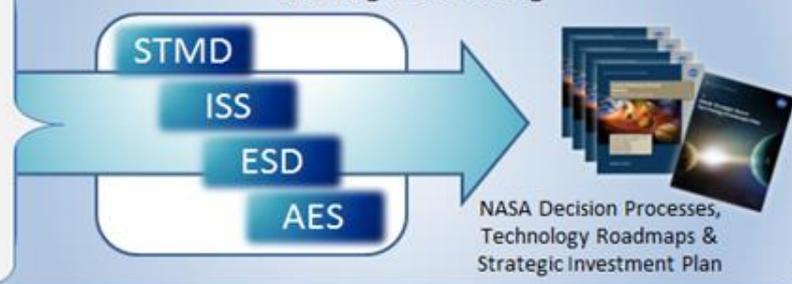
Element Conceptualization and Design



Capability Needs Analysis



Strategic Planning



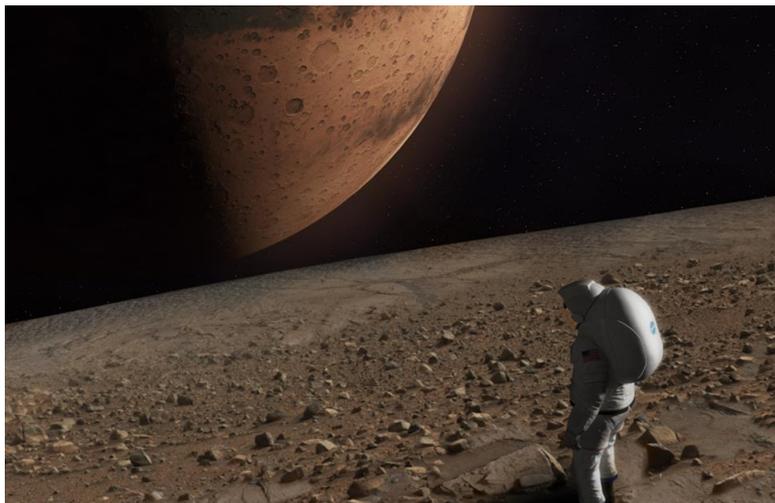


Evolvable Mars Campaign Efforts

1. **Notional campaigns**
2. **Diet EMC**
3. **Lander trades**
4. **Updated Surface Strategy**
5. **Habitat Refinement**
6. **Cislunar In-Situ Resource Utilization (ISRU)**
7. **Proving Ground Satisfaction Criteria**
8. **Water Rich Point of Departure (POD)**
9. **Modularity and Standards**
10. **NextSTEP Broad Area Announcement (BAA) Studies**
11. **Entry-Descent-Landing (EDL) Pathfinder**
12. **Mars Surface Power trades**
13. **Long-Term Human Presence**
14. **Mars Moons Analysis**
15. **In-Situ Resource Utilization**
16. **Technology Development**
17. **Modeling and Simulation**

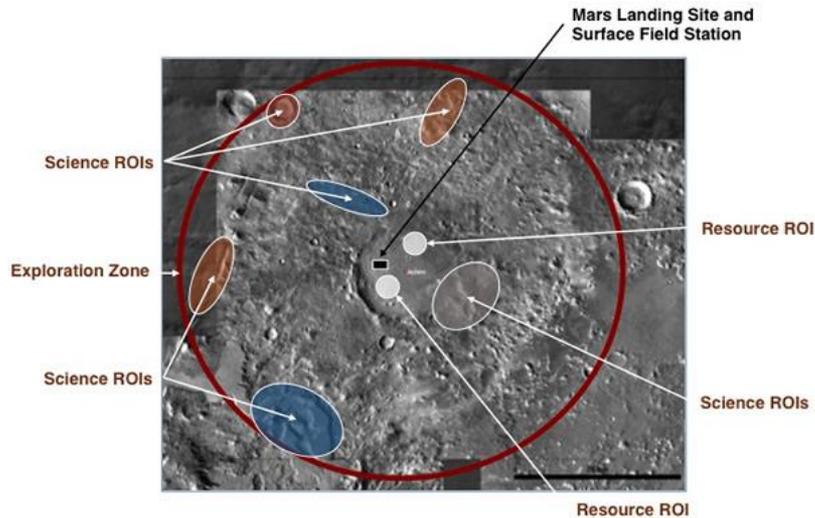


Additional Architectural Considerations



- Mars Moons first?
- Human Robotic Interactions
- Low-Latency Telerobotics
- Where and how do we explore with planetary protection boundaries?
- Site(s) design and configuration





- Identified and discussed candidate locations (“Exploration Zones”, EZ) where humans could land, live, and work on the martian surface
- An EZ is a collection of Regions of Interest (ROIs) located within approximately 100 kilometers of a centralized landing site
- ROIs are areas relevant for scientific investigation and/or development/maturation of capabilities and resources necessary for a sustainable human presence
- An EZ contains a landing site and a habitation site that will be used by multiple human crews during missions to explore and utilize the ROIs within the EZ





- Exploration Systems Projects and Partners
 - Evolvable Mars Campaign: architecture, habitation, research systems integration, low latency telerobotics
 - Future Capabilities Team: research systems integration
 - Advanced Exploration Systems projects
 - Delay Tolerant Networks
 - Avionics and Software
 - Lunar IceCube
 - Lunar Lander Technology / Lunar CATALYST
 - KaBOOM
 - Mars Environmental Dynamic Analyzer
 - NEA Scout
 - Commercial Crew
- Crew training – field geology
- Space Launch System composites
- Asteroid redirection
- Radiation mitigation

**The Human Exploration and Operations State of the Union is...
dynamic, hopeful, and full of potential opportunities**