NOTE ADDED BY JPL WEBMASTER: This content has not been approved or adopted by JPL or the California Institute of Technology. This document is being made available for information purposes only, and any views and opinions expressed herein do not necessarily state or reflect those of JPL or the California Institute of Technology.

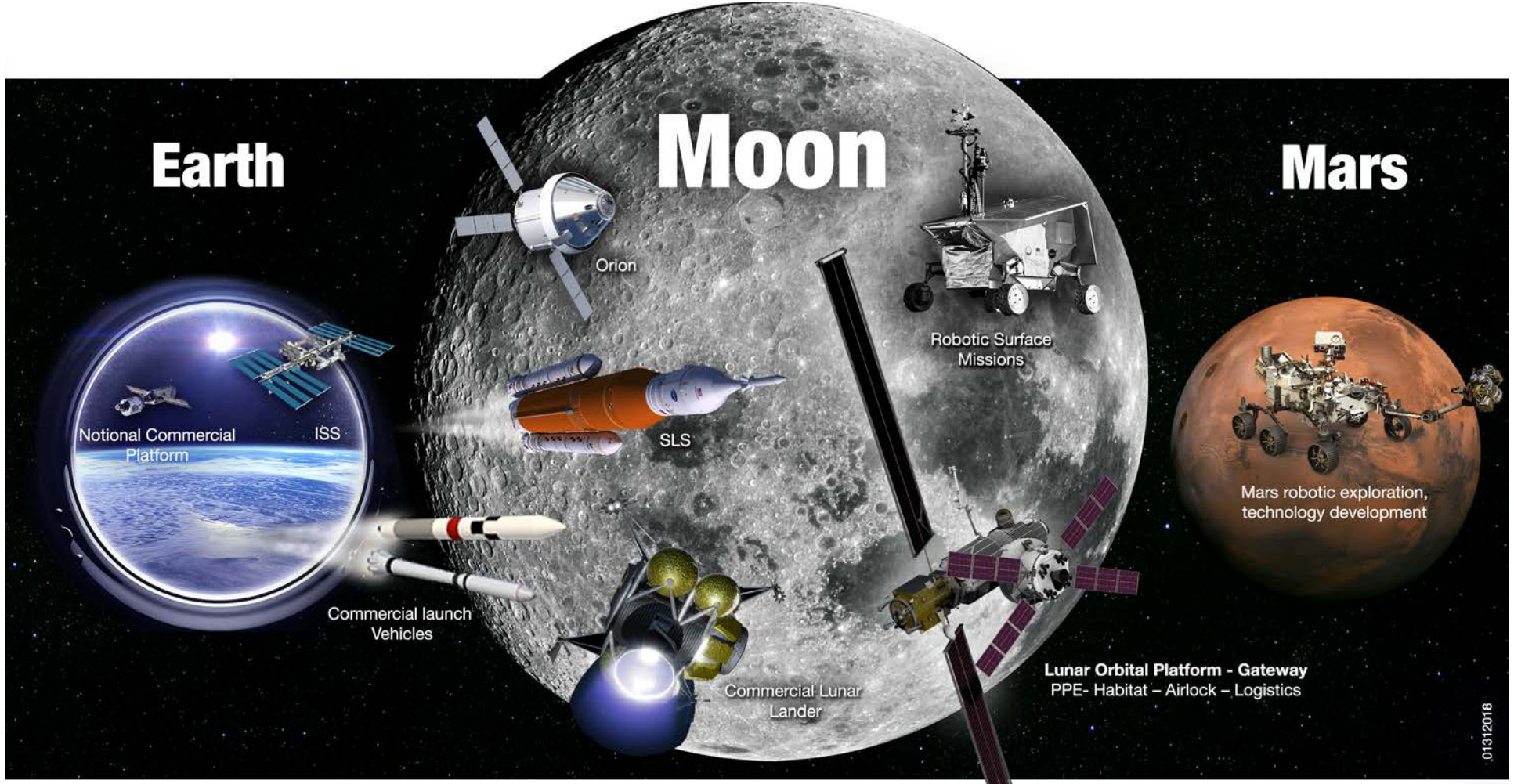
NASA Human Exploration and Operations Mission Directorate Status for MEPAG

NANTEL SUZUKI, ADVANCED EXPLORATION SYSTEMS
HEOMD, NASA HQ
April 5, 2018

Space Policy Directive-1 (Dec 11, 2017)

NASA shall:
"'Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations.''

EXPLORATION CAMPAIGN



In LEO
Commercial & International partnerships

In Cislunar Space
A return to the moon for long-term exploration

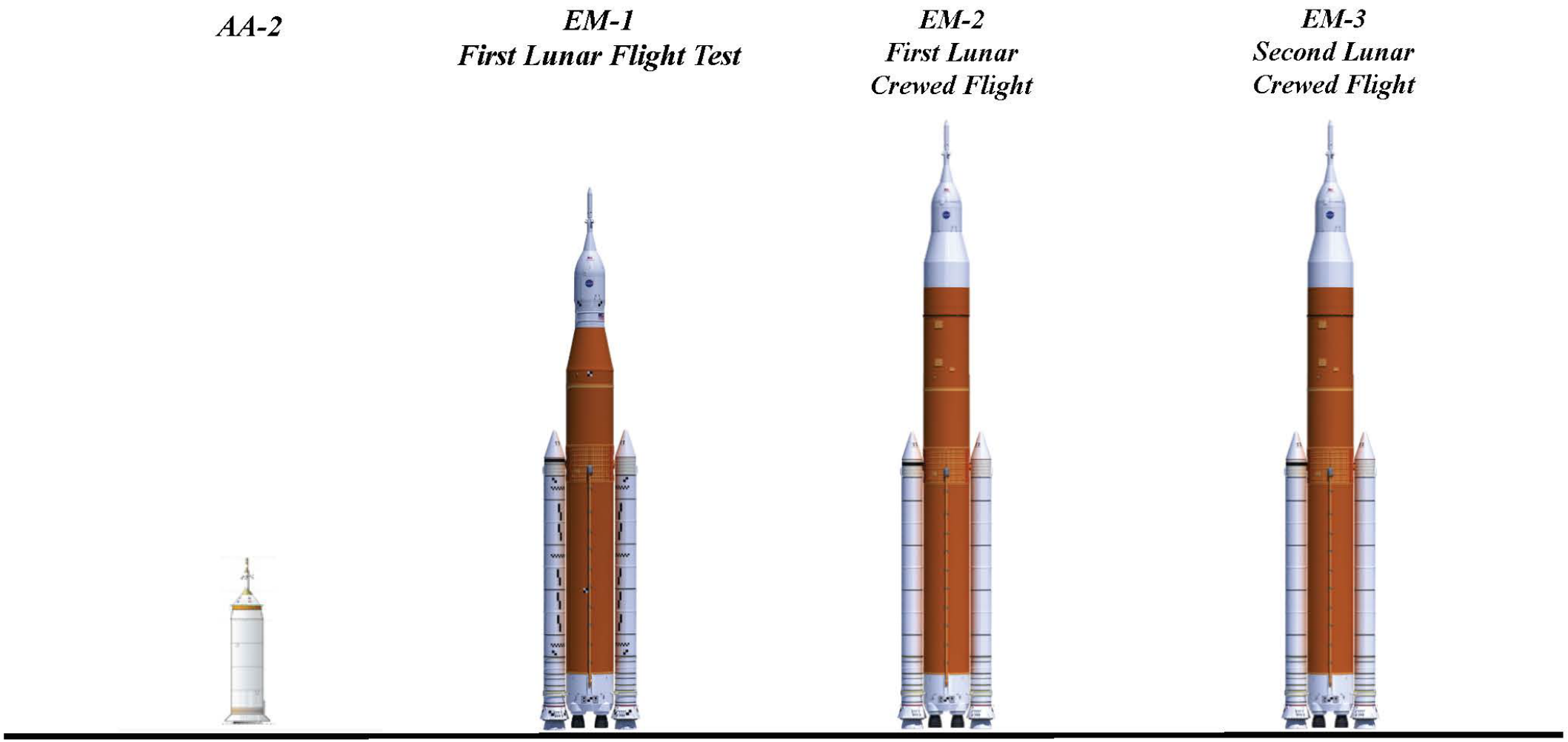
On Mars
Research to inform future crewed missions

FY 2019 President's Budget Request

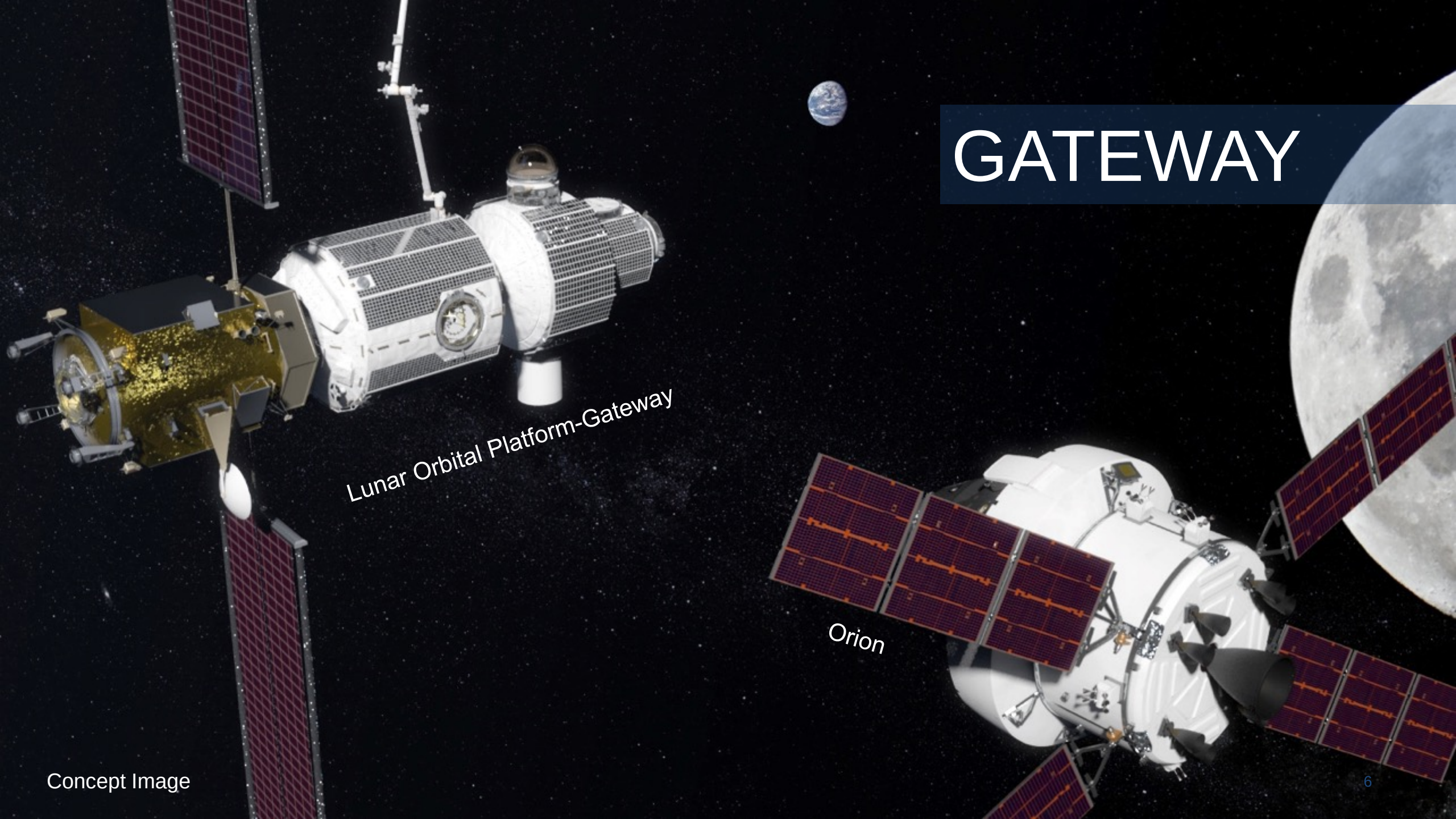
Human Exploration and Operations

Budget Authority ($ in millions)	Actual 2017	CR *2018	Request 2019	Notional 2020	2021	2022	2023
Human Exploration and Operations	**9,126.5**	**9,072.7**	**9,183.4**	**9,132.8**	**9,157.8**	**9,182.8**	**9,207.8**
Deep Space Exploration Systems	**4,184.0**	**4,222.6**	**4,558.8**	**4,859.1**	**4,764.5**	**4,752.5**	**4,769.8**
Exploration Systems Development	**3,929.0**	**3,902.3**	**3,669.8**	**3,790.5**	**3,820.2**	**3,707.5**	**3,845.6**
Orion Program	1,330.0	1,340.8	1,163.5	1,137.7	1,134.2	1,117.8	1,117.8
Space Launch System	2,127.1	2,135.4	2,078.1	2,062.9	2,165.1	2,131.0	2,276.0
Exploration Ground Systems	471.9	426.1	428.2	589.9	520.8	458.7	451.9
****Advanced Exploration Systems**	**255.0**	-	**889.0**	**1,068.6**	**944.4**	**1,045.0**	**924.1**
Adv Cislunar and Surface Capabilities	-	-	116.5	146.0	163.7	300.0	320.3
***Exploration Advanced Systems	255.0	-	268.2	260.7	240.6	186.1	144.7
Lunar Orbital Platform - Gateway	-	-	504.2	662.0	540.1	558.9	459.1
Power and Propulsion Element	-	-	*327.9*	*210.9*	*108.4*	*43.4*	-
Habitation	-	-	*176.3*	*191.5*	*110.7*	*98.0*	*51.0*
Airlock	-	-	-	*89.1*	*124.7*	*221.6*	*267.0*
Logistics	-	-	-	*170.5*	*196.3*	*195.9*	*141.1*
LEO and Spaceflight Operations	**4,942.5**	**4,850.1**	**4,624.6**	**4,273.7**	**4,393.3**	**4,430.3**	**4,438.0**
International Space Station	**1,450.9**	-	**1,462.2**	**1,453.2**	**1,471.2**	**1,466.2**	**1,451.2**
Space Transportation	**2,589.0**	-	**2,108.7**	**1,829.1**	**1,858.9**	**1,829.2**	**1,807.3**
Commercial Crew Program	1,184.8	-	173.1	35.8	36.3	36.3	36.3
Crew and Cargo Program	1,404.2	-	1,935.6	1,793.2	1,822.6	1,792.8	1,771.0
Space and Flight Support	**902.6**	-	**903.7**	**841.4**	**888.2**	**934.9**	**954.6**
21st Century Space Launch Complex	20.0	-	-	-	-	-	-
Space Communications and Navigation	630.1	-	634.1	568.8	615.6	652.9	670.6
Human Space Flight Operations	123.1	-	135.4	136.4	136.4	145.9	147.8
Launch Services	85.7	-	86.6	88.6	88.6	88.6	88.6
Rocket Propulsion Test	43.7	-	47.6	47.6	47.6	47.6	47.6
Commercial LEO Development	-	-	**150.0**	**150.0**	**175.0**	**200.0**	**225.0**

Space Launch System



GATEWAY



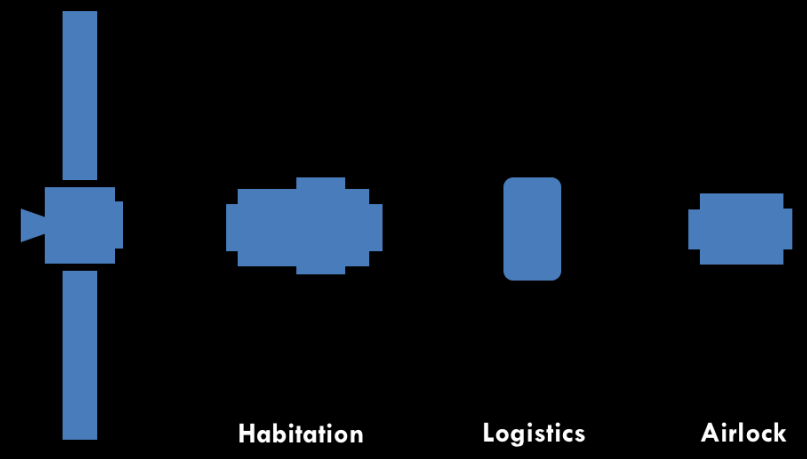
Concept Image

LUNAR ORBITAL PLATFORM-GATEWAY DEVELOPMENT

Establishing leadership in deep space and preparing for exploration into the solar system

FOUNDATIONAL GATEWAY ELEMENTS

2022	2023	2024+



40kW Power/Prop Bus

These foundational gateway capabilities can support multiple U.S. and international partner objectives in cislunar space and beyond.

CAPABILITIES

- Supports exploration, science, and commercial activities in cislunar space and beyond
- Includes international and U.S. commercial development of elements and systems
- Provides options to transfer between cislunar orbits when uncrewed

OPPORTUNITIES

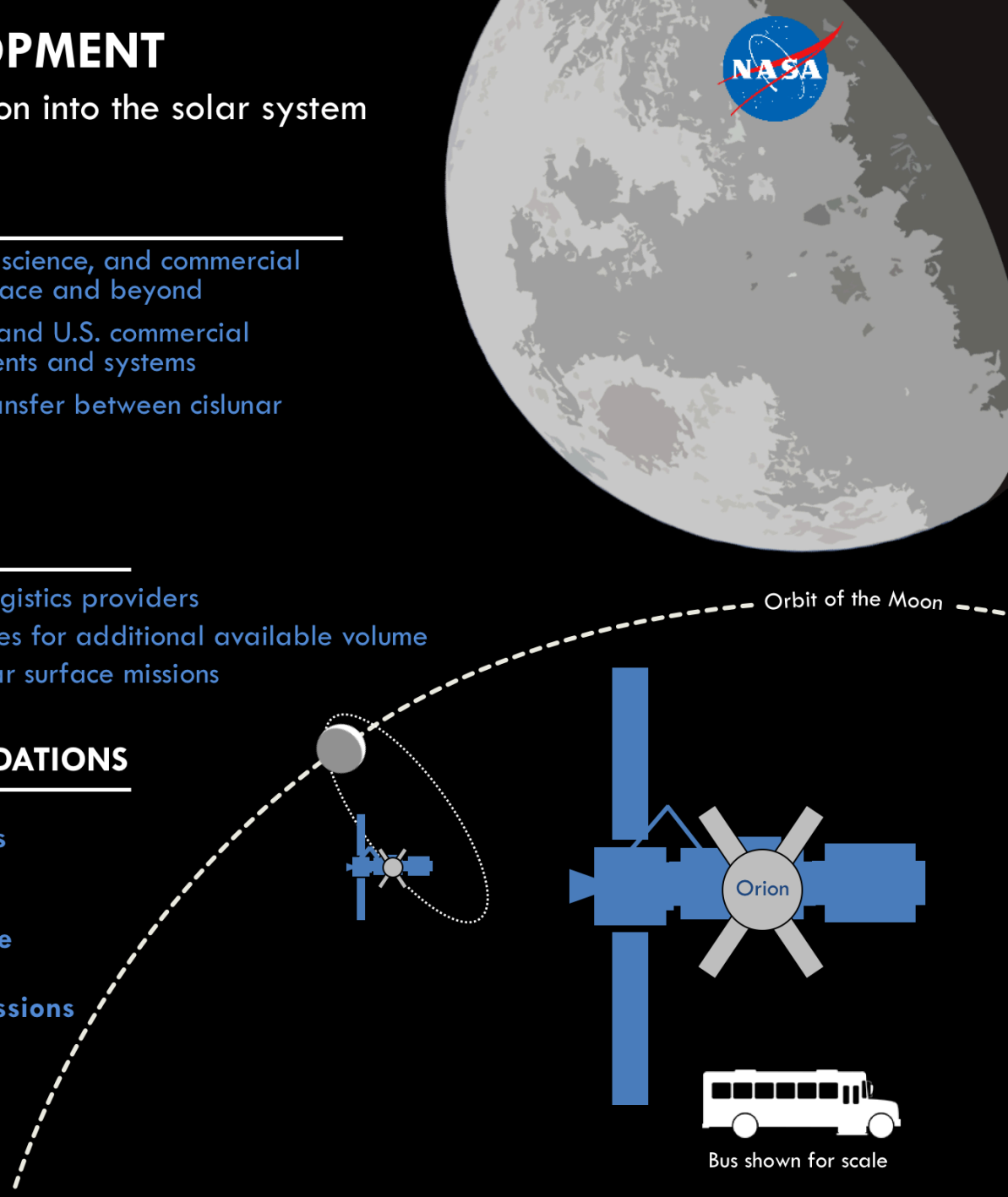
- Logistics flights and logistics providers
- Use of logistics modules for additional available volume
- Ability to support lunar surface missions

INITIAL ACCOMMODATIONS

4 Crew Members

At least 55 m^3 Habitable Volume

30 Day Crew Missions



20180327

Gateway Core Functionality

- **Power and Propulsion Element**
  - First gateway capability targeted for launch readiness in 2022
  - Spaceflight demonstration of advanced solar electric propulsion spacecraft for industry and NASA objectives; developed through public-private partnership
  - Power to gateway and externally accommodated elements
  - Orbital maintenance and potential to transport the uncrewed gateway between cislunar orbits
  - Attitude control for the gateway in multiple configurations
  - Communications with Earth, space-to-space communications, and radio frequency relay capability in support of extra-vehicular activity (EVA) communications; accommodations for an optical communications demonstration in the future
- **Habitation**
  - Provides habitable volume and short-duration life support functions for crew in cislunar space
  - Docking ports allow for attachment to the PPE, other Gateway elements and visiting vehicles
  - Offers attach points for external robotics, external science and technology payloads or rendezvous sensors
  - Provide accommodations for crew exercise, science/utilization and stowage
- **Airlock**
  - Provides capability to enable astronaut EVAs as well as the potential to accommodate docking of additional elements, observation ports, or a science utilization airlock
- **Logistics**
  - Deliver cargo to enable extended crew mission durations, science utilization, exploration technology demonstrations, potential commercial utilization, and other supplies

Power & Propulsion: First Element in the Gateway

Boeing

Orbital ATK

Lockheed Martin

Sierra Nevada Corporation, Aerojet Rocketdyne, Draper

SSL, DSS, Draper, University of Illinois-Urbana Champaign

Power and propulsion element industry engagement

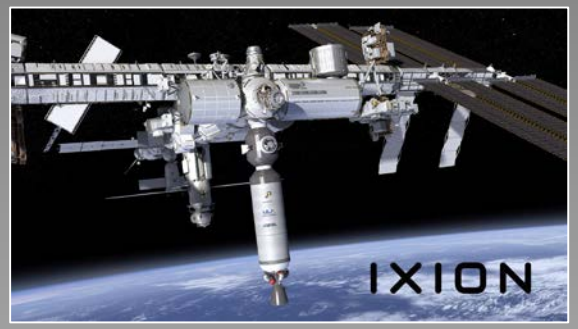
- **July 2017:** NASA issued a request for information to capture U.S. industry's capabilities and plans for spacecraft concepts that potentially could be advanced to power an advanced SEP system for the gateway.
- **August 2017:** NASA issued NextSTEP Appendix C, Power and Propulsion Studies seeking U.S. industry-led studies on leveraging commercial spacecraft, plans, and risk reduction for 50 kW-class SEP vehicle capabilities. Five companies began four-month studies in late November 2017.
- **February 2018:** NASA issued synopsis for a Spaceflight Demonstration of a Power and Propulsion Element. Draft BAA to be issued April 2018.

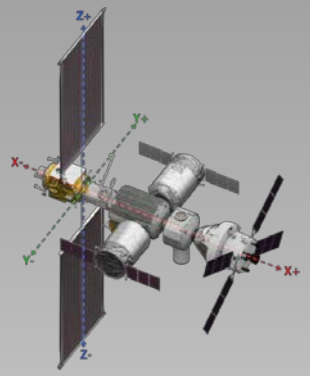
Gateway Concept Investigations

U.S. Industry:

Five full-scale prototypes in development for ground testing across the U.S.

One feasibility study on converting a spent rocket stage.

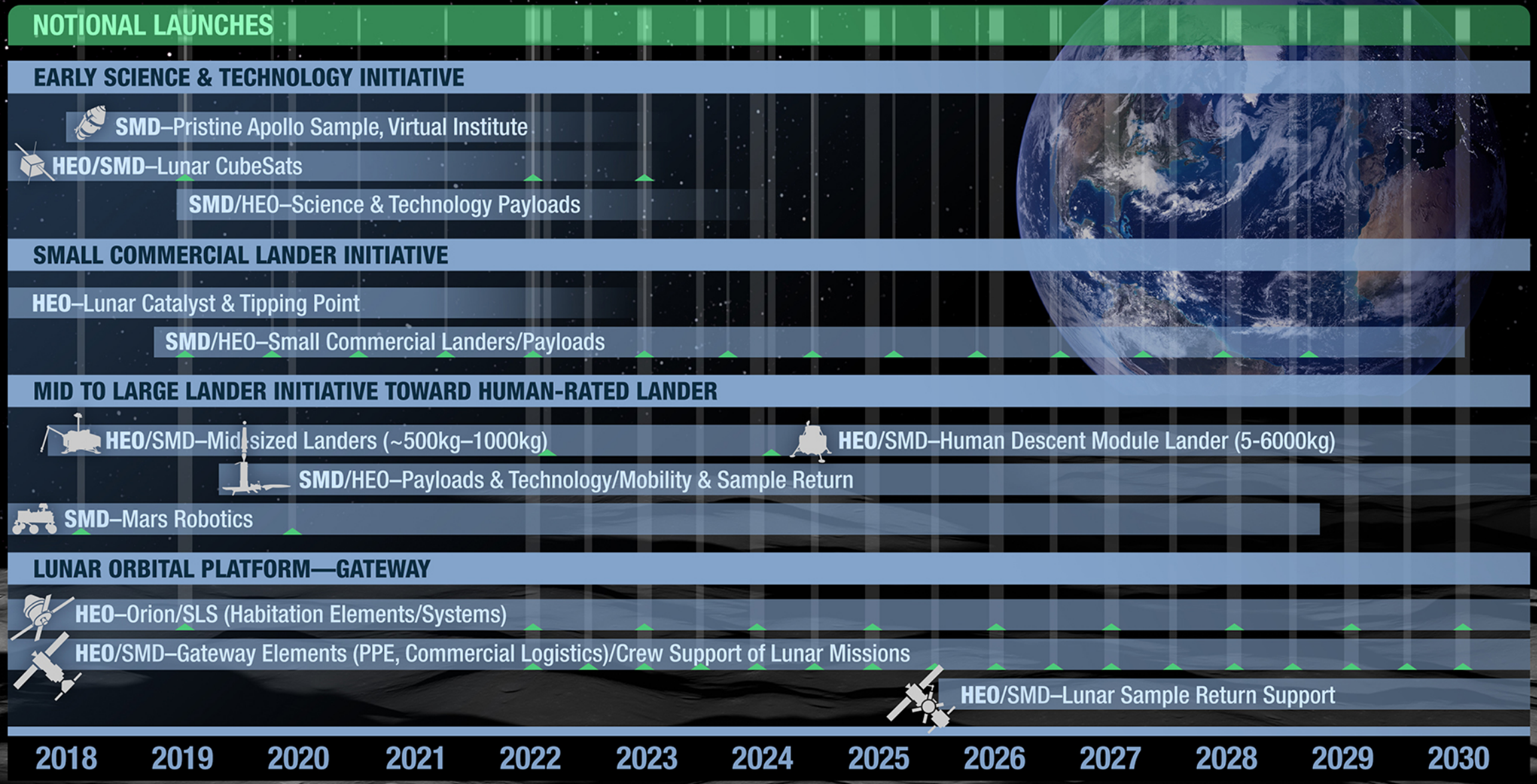




International Partners:

Concepts for contributions and utilization for gateway buildup in cislunar space

NASA Exploration Campaign



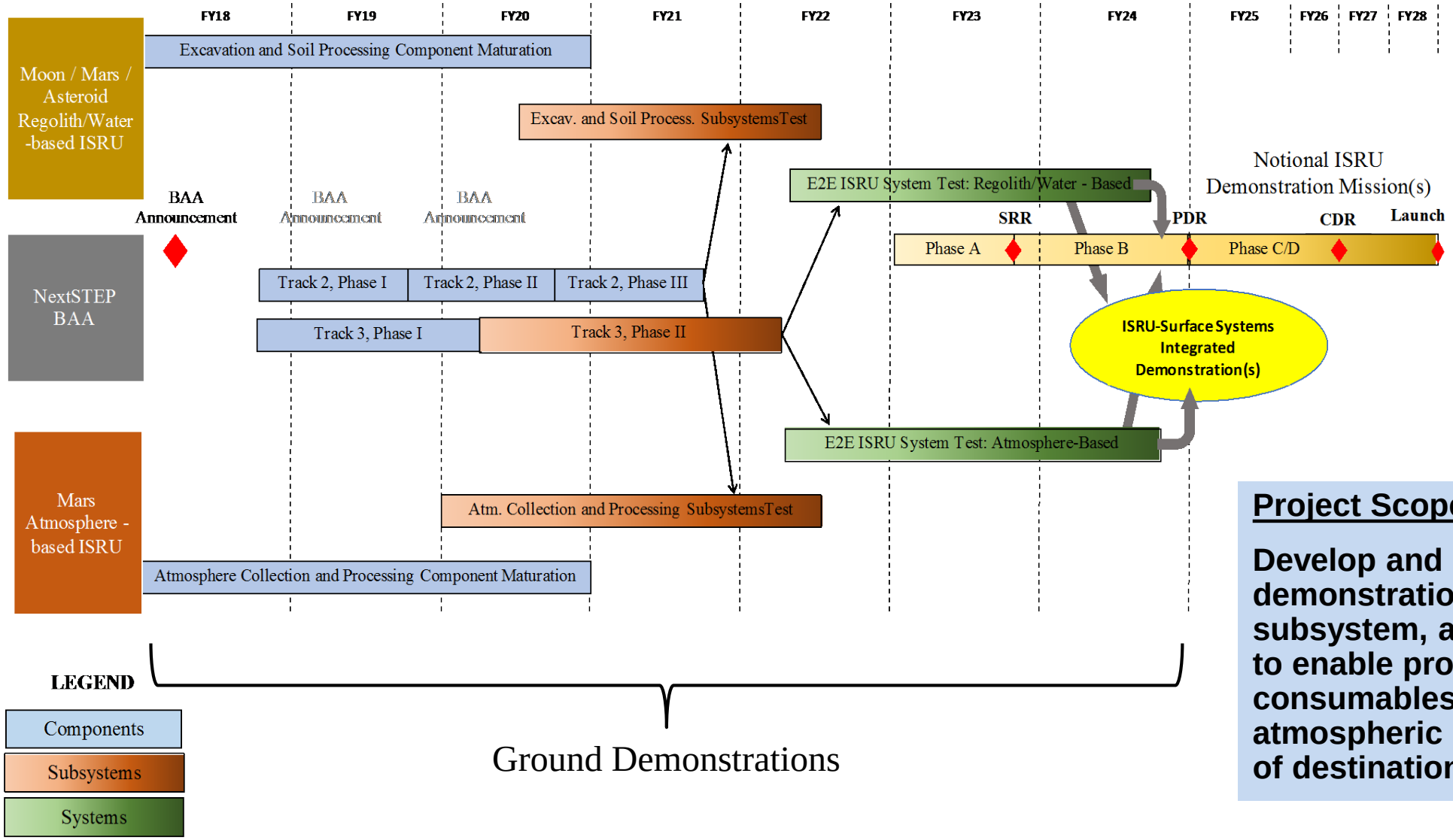
Timelines are tentative and will be developed further in FY 2019

MARCH 2018

Advanced Exploration Systems (AES) ISRU Technology Project

Notional Schedule

All dates are subject to evolving agency policy and funding priorities



Project Scope

Develop and demonstrate, in ground demonstrations, the component, subsystem, and system technology to enable production of mission consumables from regolith and atmospheric resources at a variety of destinations

NextSTEP-2 Appendix D (ISRU Technology) BAA

Overview

- **NASA is soliciting proposals for firm fixed price contracts for trade studies and design, fabrication, and testing of critical components and subsystems for acquisition and processing of extraterrestrial resources into water, oxygen, and fuel**
  - Track 1 – Trade Studies: provide guidance and rationale on critical open questions that need to be addressed for ISRU development and incorporation into mission architecture plans
  - Track 2 – Component Development: development and testing, in a relevant environment, critical components whose operation within an ISRU system requires unique capabilities not available in state-of-the-art hardware
  - Track 3 – Component and Subsystem Development: fast-paced development of a critical component(s), followed by development and testing of the subsystem in which the critical component(s) resides.
- **Technologies and processes that leverage and support space or terrestrial commercial activities**
  - Terrestrial technologies and capabilities that can be spun-in to space ISRU needs
  - Components and subsystems developed under this BAA can be commercialized or spun-out into terrestrial markets

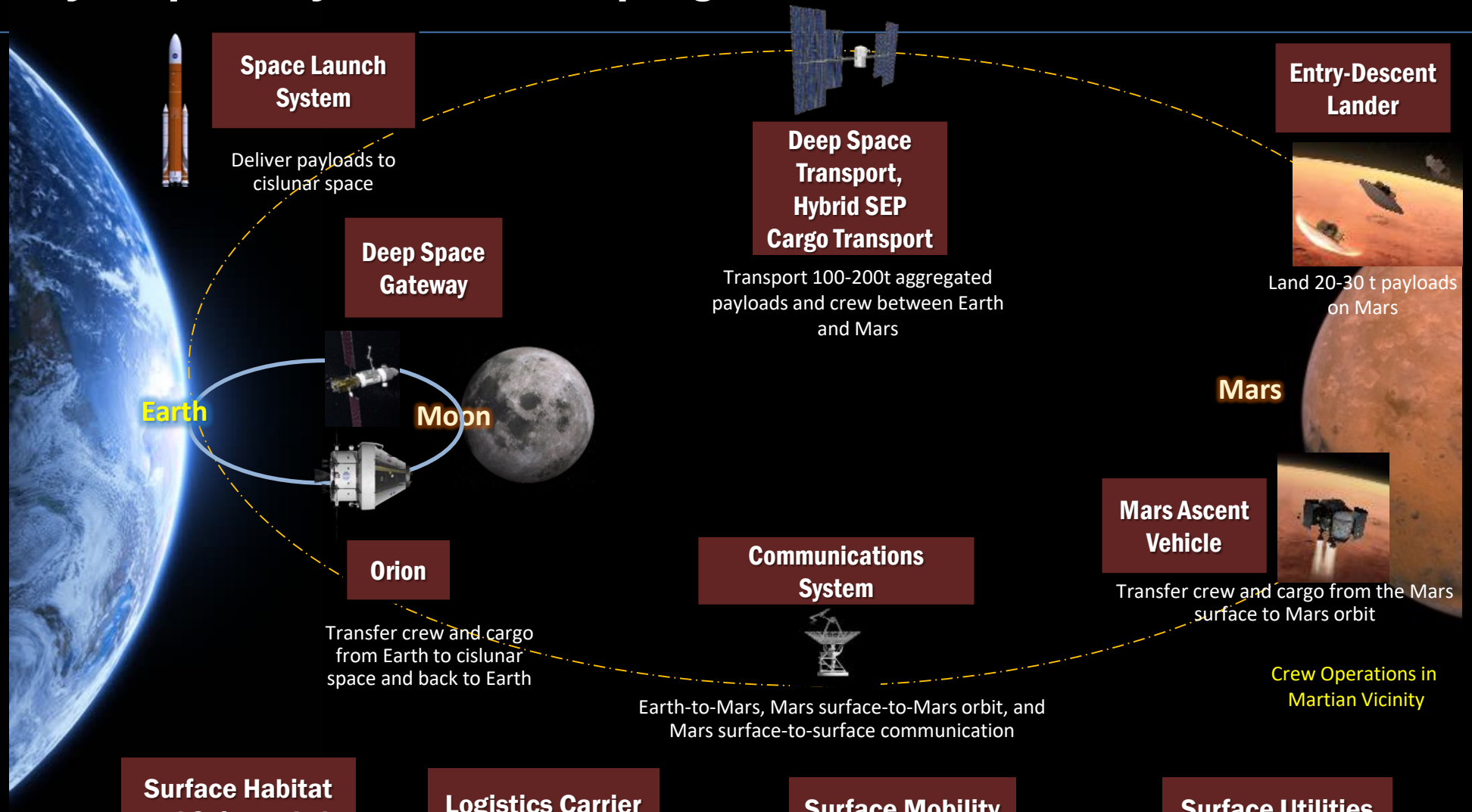
- **Solicitation Released:** **12/4/17**
- **Industry Forum** **12/11/17**
- **Proposals Due:** **3/12/18**
- **Awardee Selections:** **Early May, 2018 (approximate)**
- **Contract Awards:** **Early August, 2018 (approximate)**

Draft Deep Space Interoperability System Standards – Posted for Feedback on March 1, 2018

- **NASA, in collaboration with International Space Station partners, has developed a draft set of deep space interoperability system standards in seven prioritized domain areas:**
  - Avionics
  - Communications
  - Environmental Control and Life Support Systems
  - Power
  - Rendezvous
  - Robotics
  - Thermal
- **The draft standards were released for public comment on March 1, 2018, with the goals of:**
  - enabling industry and international entities to **independently develop systems and elements** for deep space that would be compatible aboard any spacecraft, irrelevant of the spacecraft developer;
  - defining interfaces and environments to **facilitate cooperative deep space exploration endeavors**; and
  - engaging the wide-ranging global spaceflight industry, and encourage feedback on the standards **from all potential stakeholder audiences**.

www.internationaldeepspacestandards.com

Mars Study Capability Team – Keeping a Focus on Mars



Surface Habitat and Science Lab

Sustain 4 crew for up to 500 days per Expedition

Logistics Carrier

Deliver equipment and consumables

Surface Mobility

Planetary Space Suits and robotic or pressurized rovers

Surface Utilities

Power, In Situ Resource Utilization

NASA