National Aeronautics and Space Administration

Deep Space Gateway and Journey To Mars Update

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Oct. 11, 2017

EXPANDING HUMAN PRESENCE IN PARTNERSHIP

CREATING ECONOMIC OPPORTUNITIES, ADVANCING TECHNOLOGIES, AND ENABLING DISCOVERY

Now

Using the International Space Station

2020s

Operating in the Lunar Vicinity (proving ground)

After 2030

Leaving the Earth-Moon System and Reaching Mars Orbit

Phase 0

Continue research and testing on ISS to solve exploration challenges. Evaluate potential for lunar resources. Develop standards.

Phase 1

Begin missions in cislunar space. Build Deep Space Gateway. Initiate assembly of Deep Space Transport.

Phase 2

Complete Deep Space Transport and conduct yearlong Mars simulation mission.

Phases 3 and 4

Begin sustained crew expeditions to Martian system and surface of Mars.

STRATEGIC PRINCIPLES FOR SUSTAINABLE EXPLORATION

- **FISCAL REALISM**
  Implementable in the near-term with the buying power of current budgets and in the longer term with budgets commensurate with economic growth;

- **SCIENTIFIC EXPLORATION**
  Exploration enables science and science enables exploration; leveraging scientific expertise for human exploration of the solar system.

- **TECHNOLOGY PULL AND PUSH**
  Application of high Technology Readiness Level (TRL) technologies for near term missions, while focusing sustained investments on technologies and capabilities to address the challenges of future missions;

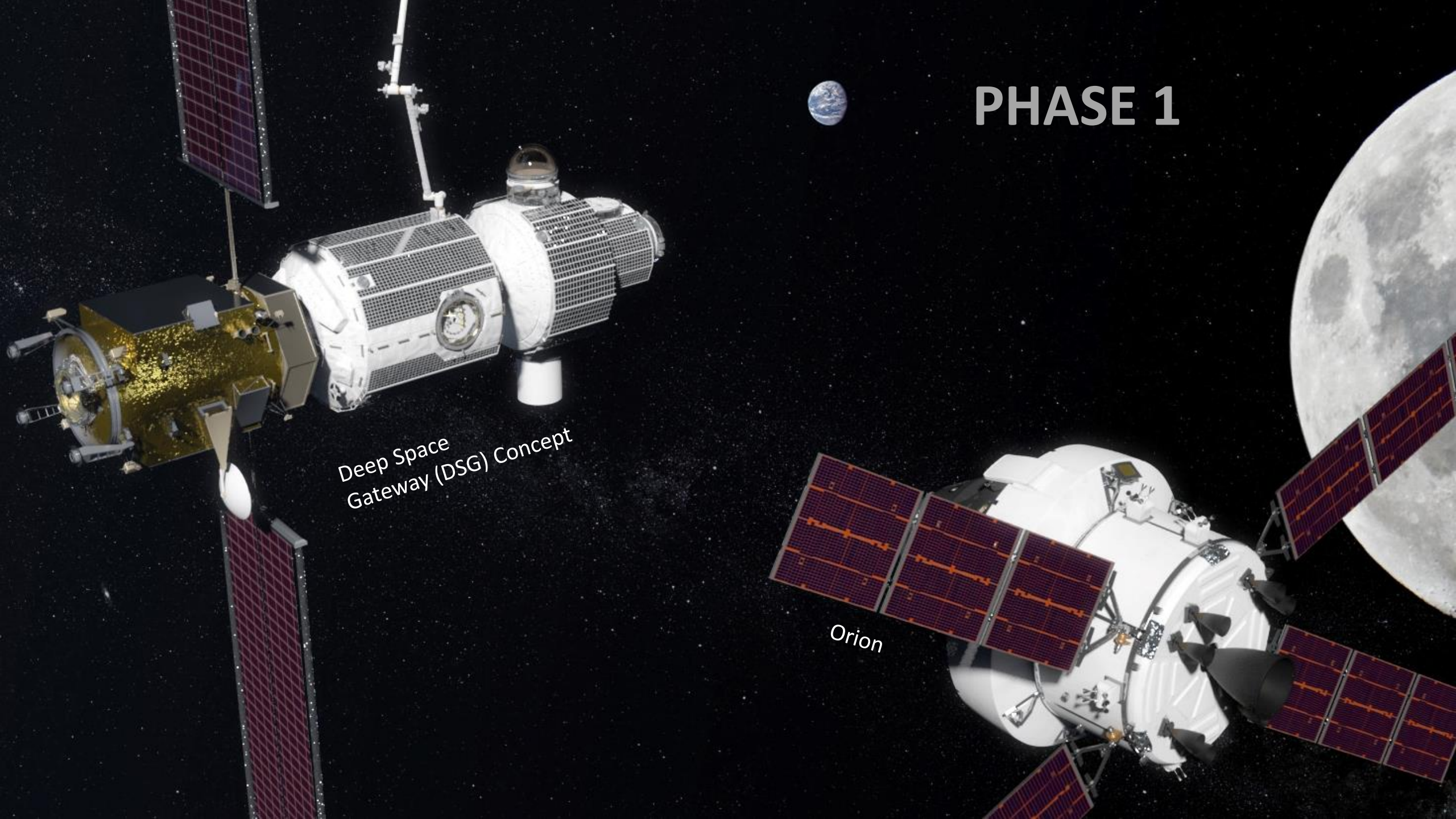
- **GRADUAL BUILD UP OF CAPABILITY**
  Near-term mission opportunities with a defined cadence of compelling and integrated human and robotic missions, providing for an incremental buildup of capabilities for more complex missions over time;

- **ECONOMIC OPPORTUNITY**
  Opportunities for U.S. commercial business to further enhance their experience and business base;

- **ARCHITECTURE OPENNESS AND RESILIENCE**
  Resilient architecture featuring multi-use, evolvable space infrastructure, minimizing unique developments, with each mission leaving something behind to support subsequent missions;

- **GLOBAL COLLABORATION AND LEADERSHIP**
  Substantial new international and commercial partnerships, leveraging current International Space Station partnerships and building new cooperative ventures for exploration; and

- **CONTINUITY OF HUMAN SPACEFLIGHT**
  Uninterrupted expansion of human presence into the solar system by establishing a regular cadence of crewed missions to cis-lunar space during ISS lifetime.


PHASE 1
Deep Space
Gateway (DSG) Concept
Orion

Phase 1 Plan

Establishing deep-space leadership and preparing for Deep Space Transport development

		Deep Space Gateway Buildup			
EM-1	**Europa Clipper**	**EM-2**	**EM-3**	**EM-4**	**EM-5**
2019 - 2025					**2026**
SLS Block 1 Crew: 0	SLS Block 1B Cargo Europa Clipper (subject to approval)	SLS Block 1B Crew: 4 CMP Capability: 8-9T 40kW Power/Prop Bus	SLS Block 1B Crew: 4 CMP Capability: 10mT Habitation	SLS Block 1B Crew: 4 CMP Capability: 10mT Logistics	SLS Block 1B Crew: 4 CPL Capability: 10mT Airlock
Distant Retrograde Orbit (DRO) 26-40 days	Jupiter Direct	Multi-TLI Lunar Free Return 8-21 days	Near Rectilinear Halo Orbit (NRHO) 16-26 days	NRHO, w/ ability to translate to/from other cislunar orbits 26-42 days	NRHO, w/ ability to translate to/from other cislunar orbits 26-42 days
Gateway (blue) Configuration (Orion in grey)			Cislunar Support Flight	Cislunar Support Flight	

These essential Gateway elements can support multiple U.S. and international partner objectives in Phase 1 and beyond

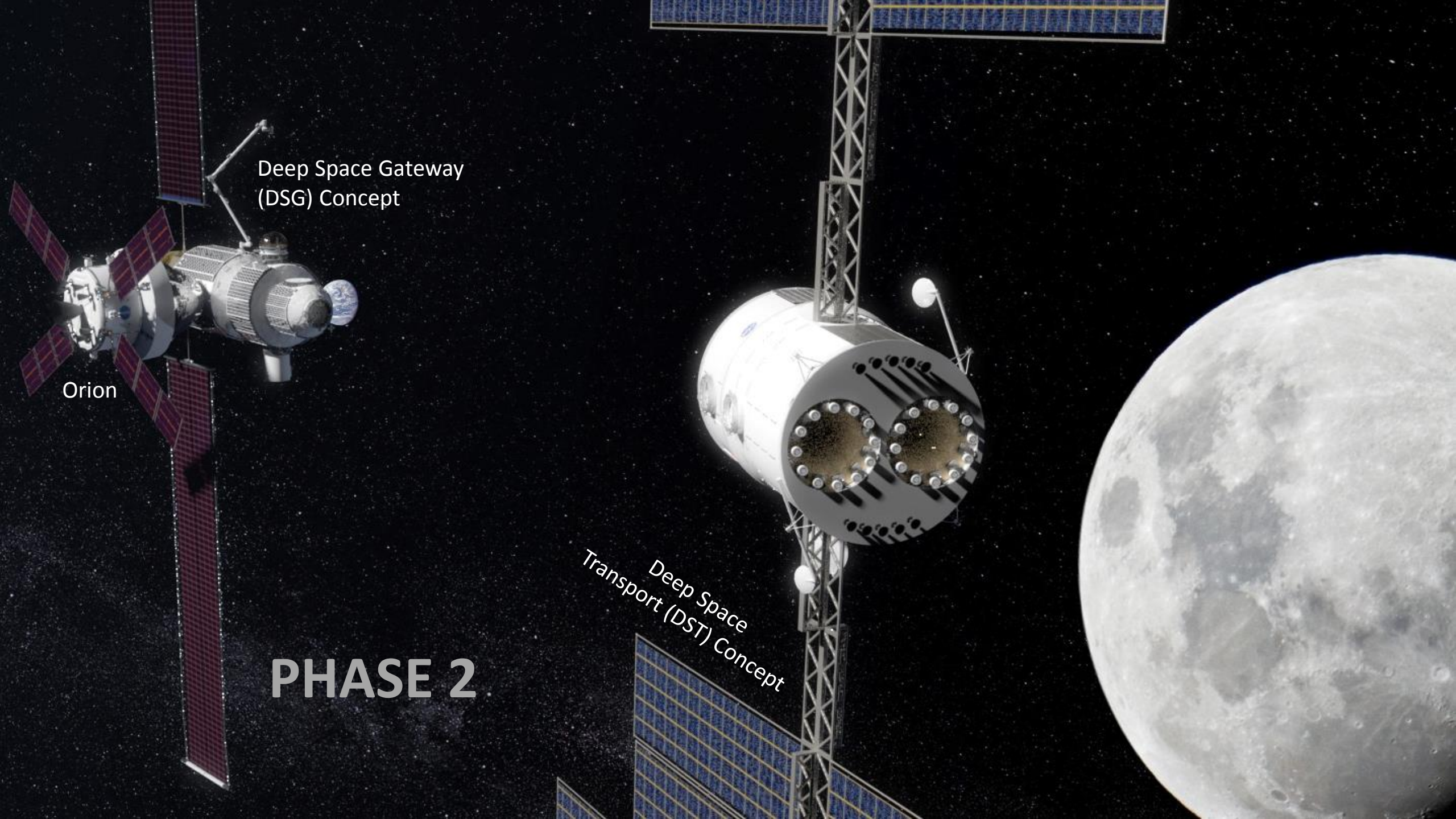
Known Parameters:

- Gateway architecture supports Phase 2 and beyond activities
- International and U.S. commercial development of elements and systems
- Gateway will translate uncrewed between cislunar orbits
- Ability to support science objectives in cislunar space

Open Opportunities:

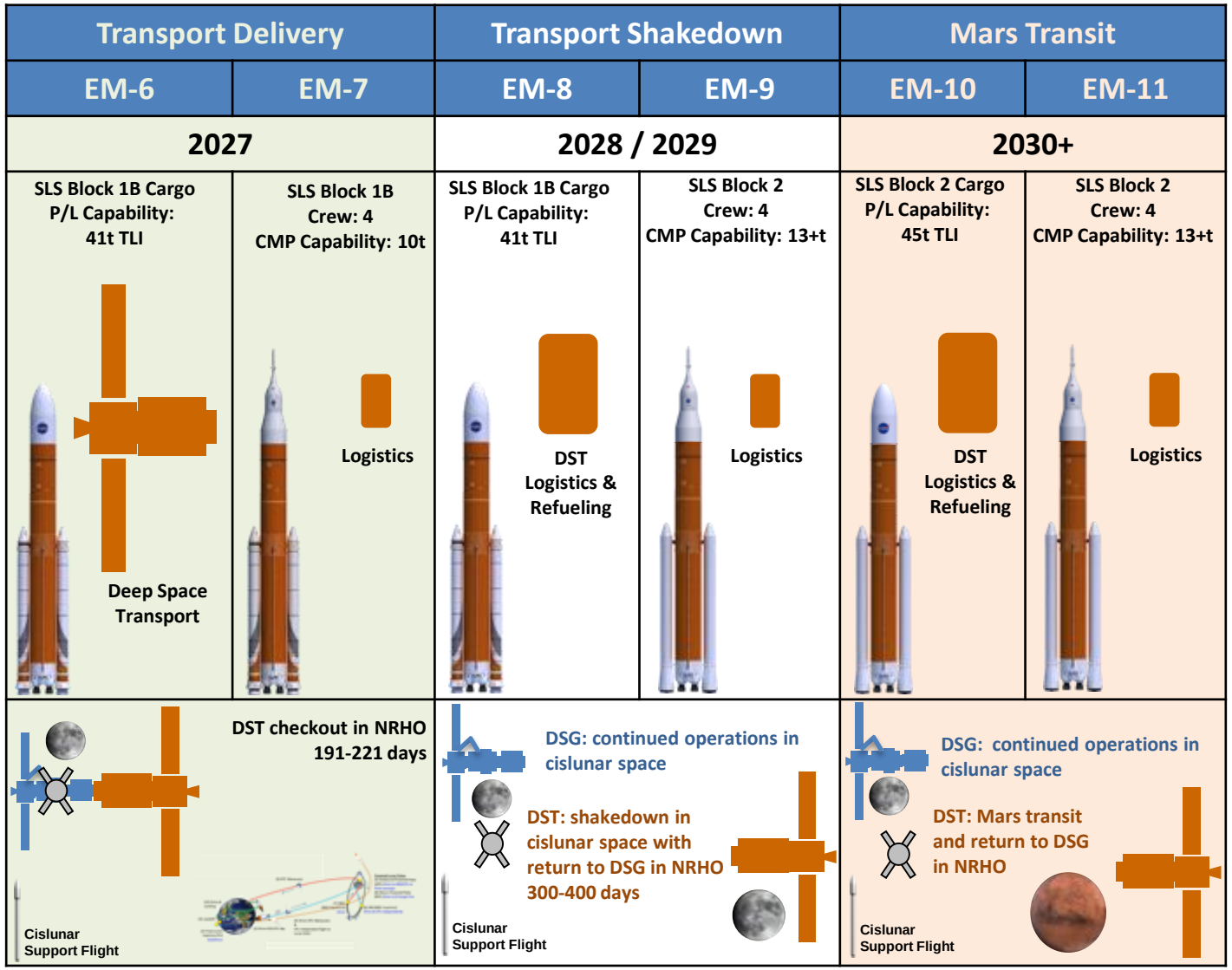
- Order of logistics flights and logistics providers
- Use of logistics modules for available volume
- Ability to support lunar surface missions

- **Assumptions**
  - Deep Space Gateway provides ability to support multiple NASA, U.S. commercial, and international partner objectives in Phase 1 and beyond
  - The Gateway is designed for deep space environments
    - Supports (with Orion docked) crew of 4 for a minimum of 30 days
    - Supports buildup of the Deep Space Transport
- **Emphasis on defining early Phase 1 elements**
  - Gateway Power Propulsion Element
  - Gateway Habitat
  - Logistics Strategy
- **Future work to refine later elements; early feasibility trades complete**
  - Airlock
  - Deep Space Transport


Deep Space Gateway
(DSG) Concept
Orion
Deep Space
Transport (DST) Concept
PHASE 2

(PLANNING REFERENCE) Phase 2 and Phase 3

Looking ahead to the shakedown cruise and the first crewed missions to Mars



Reusable Deep Space Transport supports repeated crewed missions to the Mars vicinity

Known Parameters:

- DST launch on one SLS cargo flight
- DST shakedown cruise by 2029
- DST supported by a mix of logistics flights for both shakedown and transit
- Ability to support science objectives in cislunar space

Open Opportunities:

- Order of logistics flights and logistics providers
- Shakedown cruise vehicle configuration and destination/s
- Ability to support lunar surface missions

DSG&T CONCEPT MATURATION ACTIVITIES

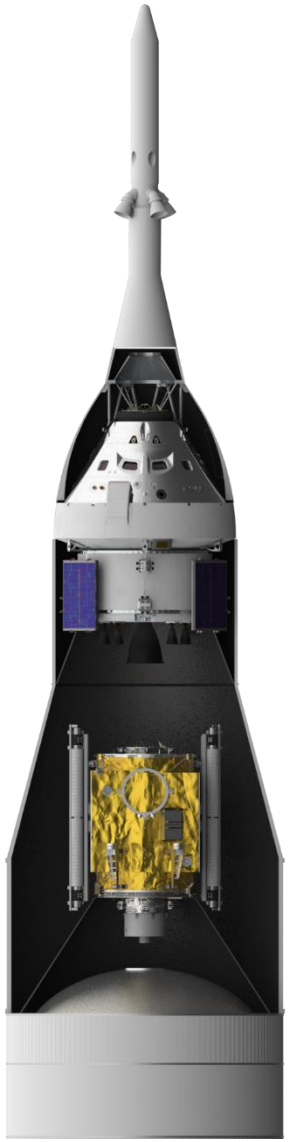
To inform decision making of DSG&T consistent with a delivery of the Power/Propulsion Element (PPE) for launch as a co-manifested payload on EM-2, HEOMD is leading the development and maturation of the following products through the fall/winter of 2017:

- High level **Exploration Objectives**. Initially baselined in September 2016; updated in June 2017. Establishes 60 objectives in phases 0, and 1, and 2 timeframes. Discussions ongoing with international partners for opportunities to align U.S. and partner deep space exploration objectives.
- **Interoperability Standards** that provide a comprehensive set of HEOMD-level requirements necessary to certify the DSG&T for deep space missions.
- **Exploration Requirements** and **Design Concept of Operations** that captures the HEO-level requirements and design conops for the systems we are building to implement Exploration Objectives. Evolving Exploration Systems Development requirements to include DSG&T requirements and reflect SLS and Orion support for DSG&T buildup.
- **Utilization Plan** that defines how and when we will use the systems, mission by mission, and what capabilities and resources are provided to support civilian, commercial, and international partner utilization of the DSG&T.

To ensure consistent coordination and communication across all exploration activities, these products are configuration controlled at the HEOMD level consistent with the **HEOMD configuration management process.**

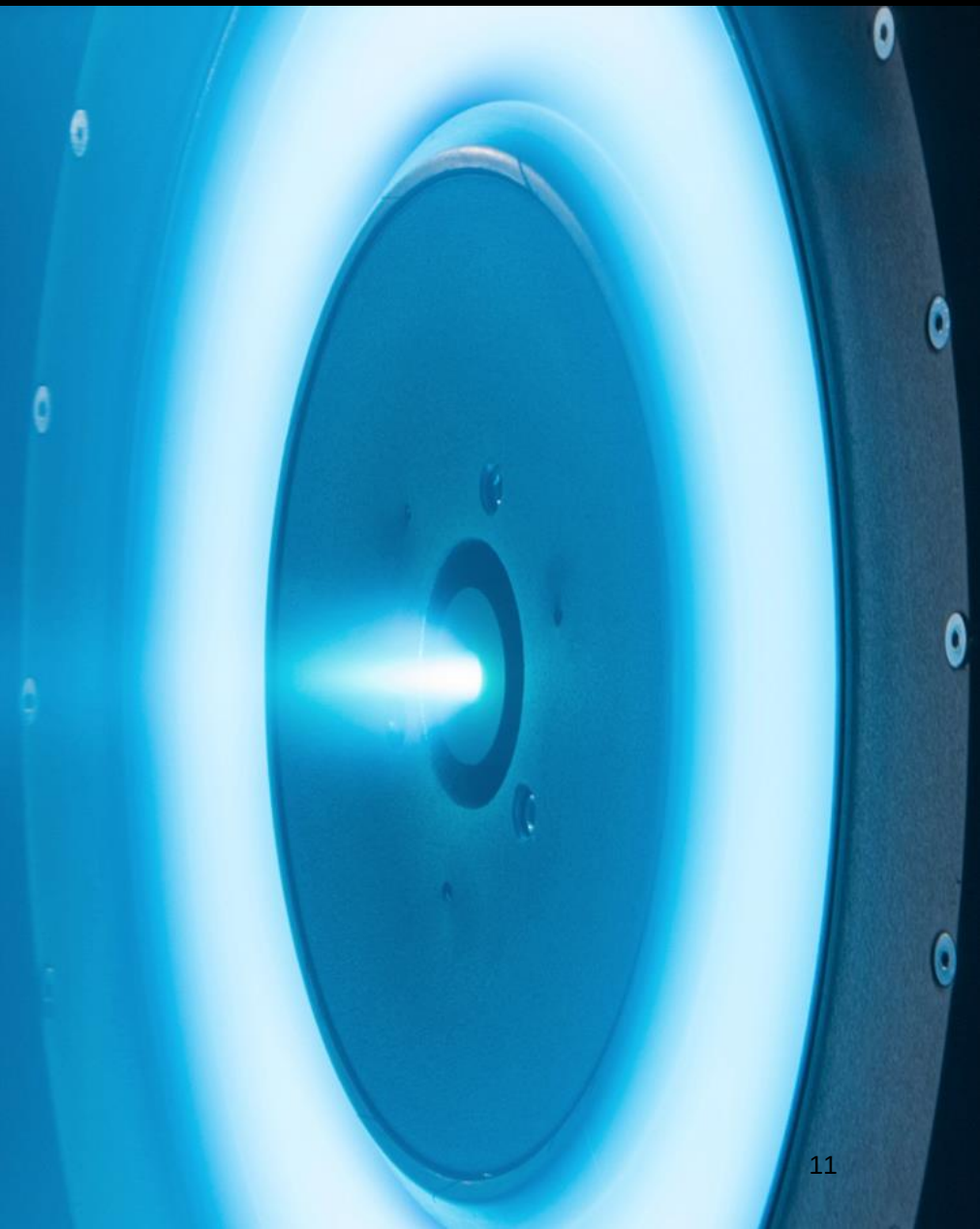
POWER & PROPULSION: 1ST ELEMENT IN DEEP SPACE GATEWAY

- Start deep space gateway when we fly crew to vicinity of the moon
- A power and propulsion element (PPE) would be the first element in a cislunar gateway
- The PPE would provide key functionality for the DSG including
  - Power to DSG and externally accommodated elements
  - Transportation for the DSG between cislunar orbits
  - Orbital maintenance as needed
  - Attitude control for the DSG in multiple configurations with and without visiting vehicles such as Orion
  - Communications with Earth, space to space communications, and radio frequency relay capability in support of extra-vehicular activity (EVA) communications.
- PPE will launch co-manifested with Orion crew vehicle on the Space Launch System for the EM-2 flight



Approach to PPE Development

- **PPE will leverage advanced solar electric propulsion (SEP) technologies developed and matured during Asteroid Redirect Mission activities:**
  - Directly use commercially available U.S. flight hardware
  - Infuse advanced SEP technology developed by NASA's Space Technology Mission Directorate
  - Align with U.S. industry plans for future use of SEP
  - Accommodate international and/or commercial partner provided capabilities

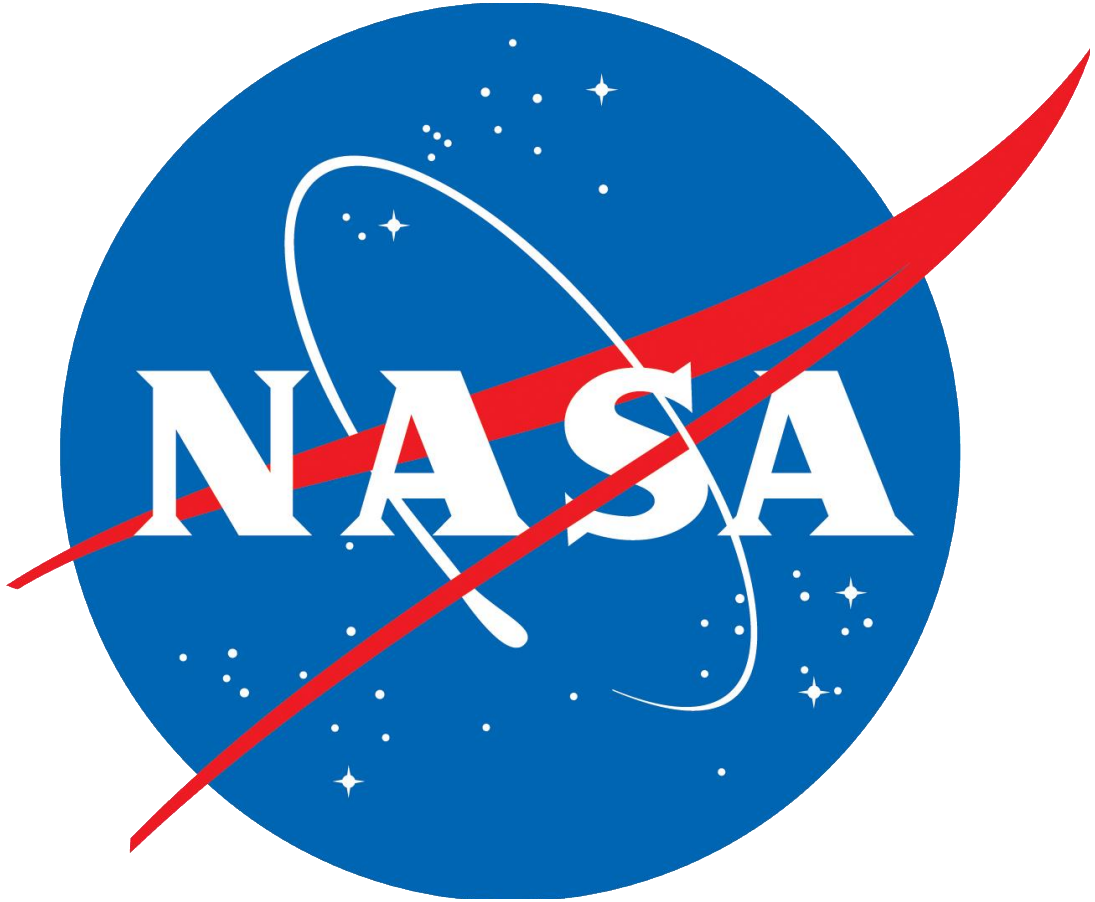


Advanced Electric Propulsion Development

- Led by Glenn Research Center with JPL support
- Developed 13 kW Hall thruster
  - with magnetic shielding to extend lifetime
  - Isp: 2000-3000 sec
- Three test development units (TDU's) fabricated and tested (TDU-1 shown here)
- Integrated power testbed being assembled at GRC
- Vendor for engineering development and flight unit delivery under contract - Aerojet Rocketdyne
- Development to be completed by end of 2018
- Flight unit delivery by 2019

POWER AND PROPULSION ELEMENT MILESTONES

✓ Update stakeholders on Asteroid Redirect Mission transition and potential plan for solar electric propulsion	Jul2017
✓ Release of PPE Request for Information (RFI)	Jul 17, 2017
✓ Synopsis for Studies through NextSTEP BAA Appendix C	Jul 17, 2017
✓ RFI Responses Due	Jul 28, 2017
✓ STMD Electric Propulsion System Preliminary Design Review	Aug 1-3, 2017
✓ Draft PPE Industry Studies Solicitation Release	Aug 11, 2017
✓ PPE virtual industry day	Aug 17, 2017
✓ Discussions with industry	Aug 17-18, 2017
✓ Last day for written questions and comments on the draft release	Aug 22, 2017
✓ PPE Control Board: Establish Reference Requirements	Aug 24, 2017
✓ Deep Space Gateway Control Board: PPE Top Level Reference Requirements	Aug 28, 2017
✓ Final Release, NextSTEP BAA Appendix C: Power & Propulsion Studies	Aug 30, 2017
• Study Proposals Due	Sep 26, 2017


NASA