

National Aeronautics and Space Administration



Exploration Campaign

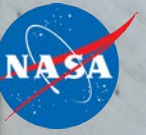
Aeronautics and Space Engineering Board

Mark Geyer

Deputy Associate Administrator (Acting)
Human Exploration & Operations Mission Directorate

May 1, 2018





SPACE POLICY DIRECTIVE-1

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.



STRATEGIC PRINCIPLES OF HUMAN SPACE EXPLORATION

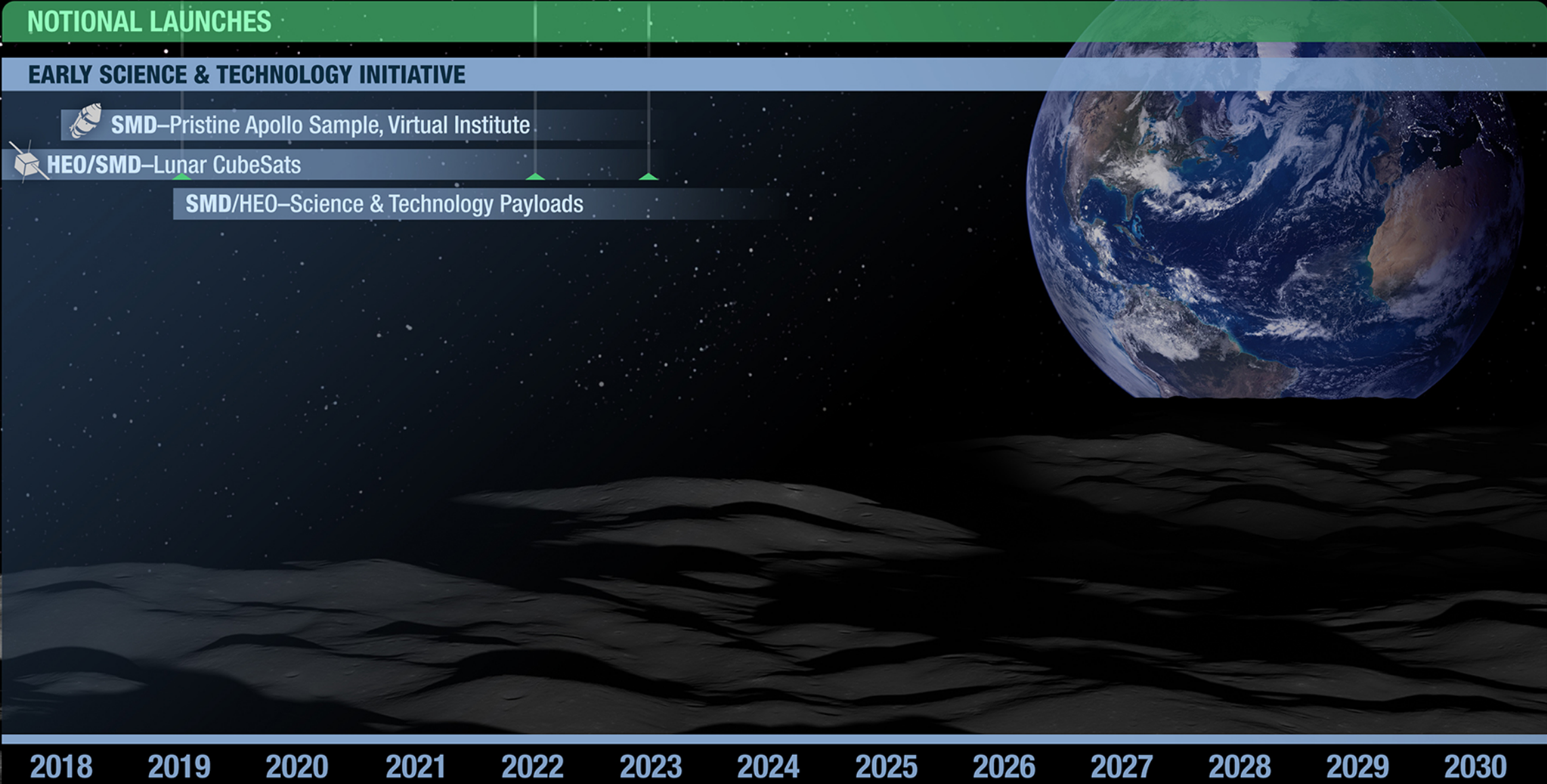
Fiscal Realism | Commercial Partnerships | Scientific Exploration
Technology Pull And Push | Gradual Buildup Of Capability
Architecture Openness And Resilience
Global Collaboration And Leadership | Continuity Of Human Spaceflight

INTERNATIONAL INTEROPERABILITY STANDARDS



- Avionics
- Communications
- Environmental Control and Life Support
- Power
- Rendezvous
- External Robotics
- Thermal
- Docking

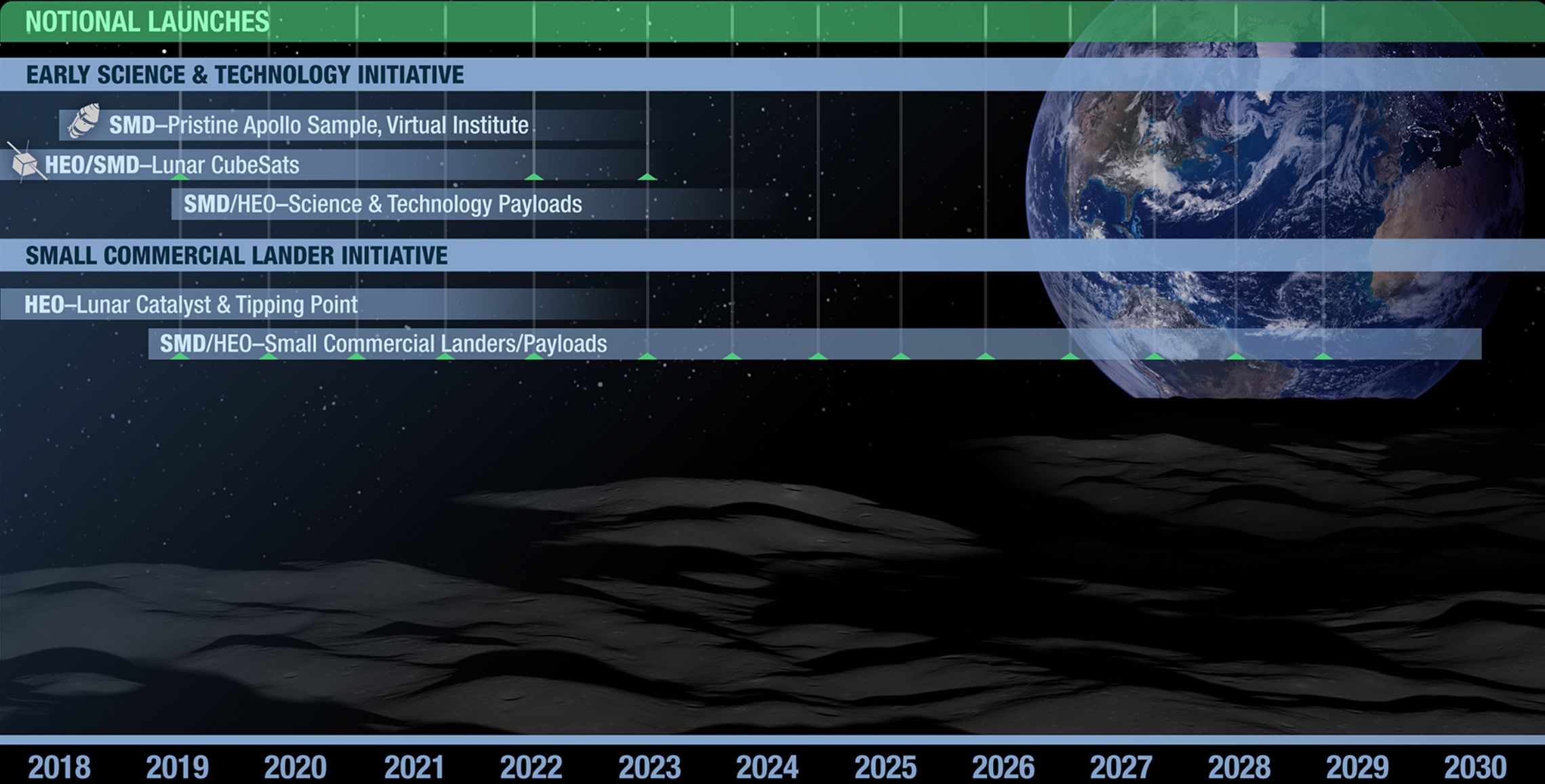
NASA LUNAR EXPLORATION



Timelines are tentative and will be developed further in FY 2019

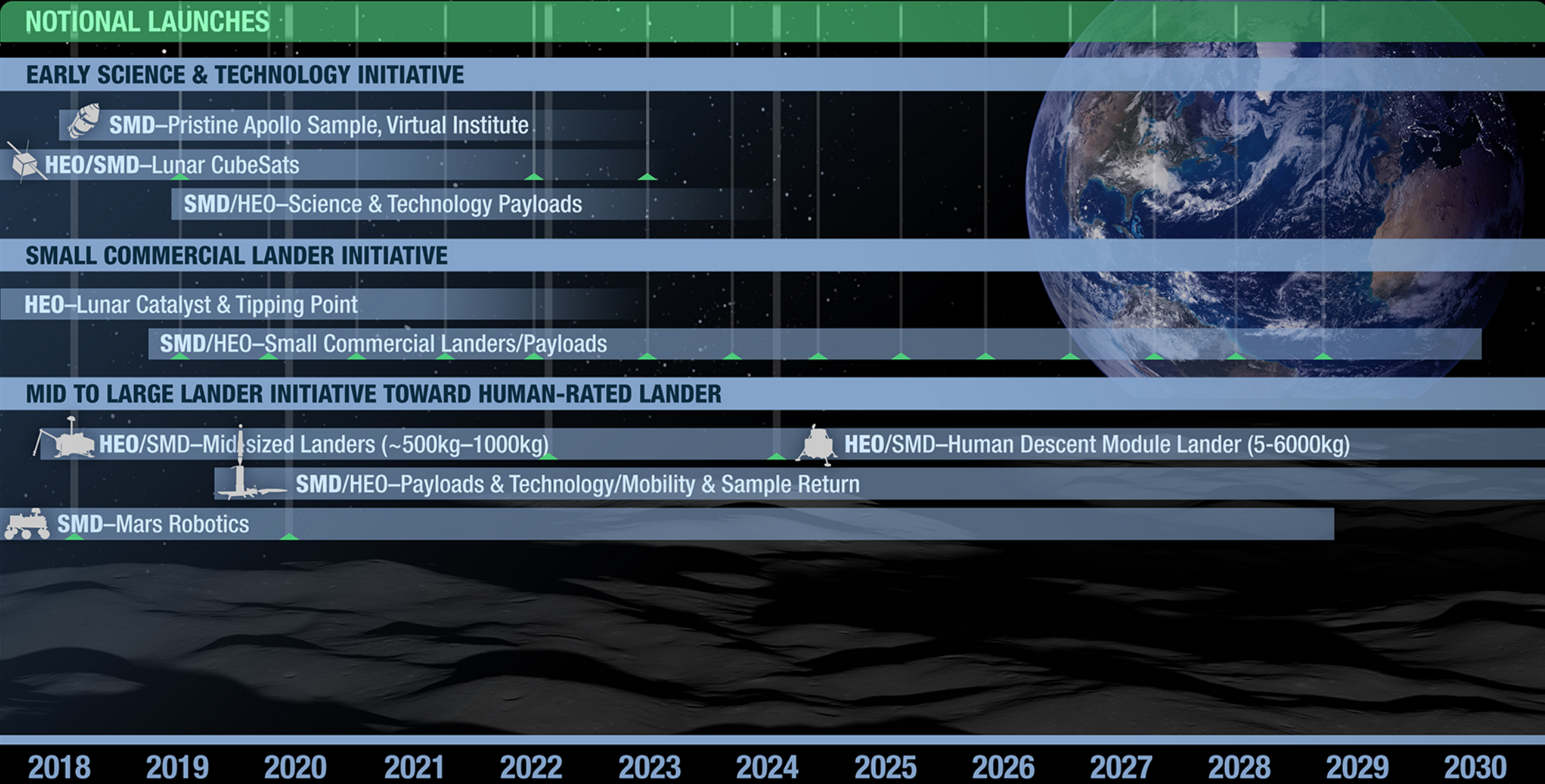
MARCH 2018

NASA LUNAR EXPLORATION



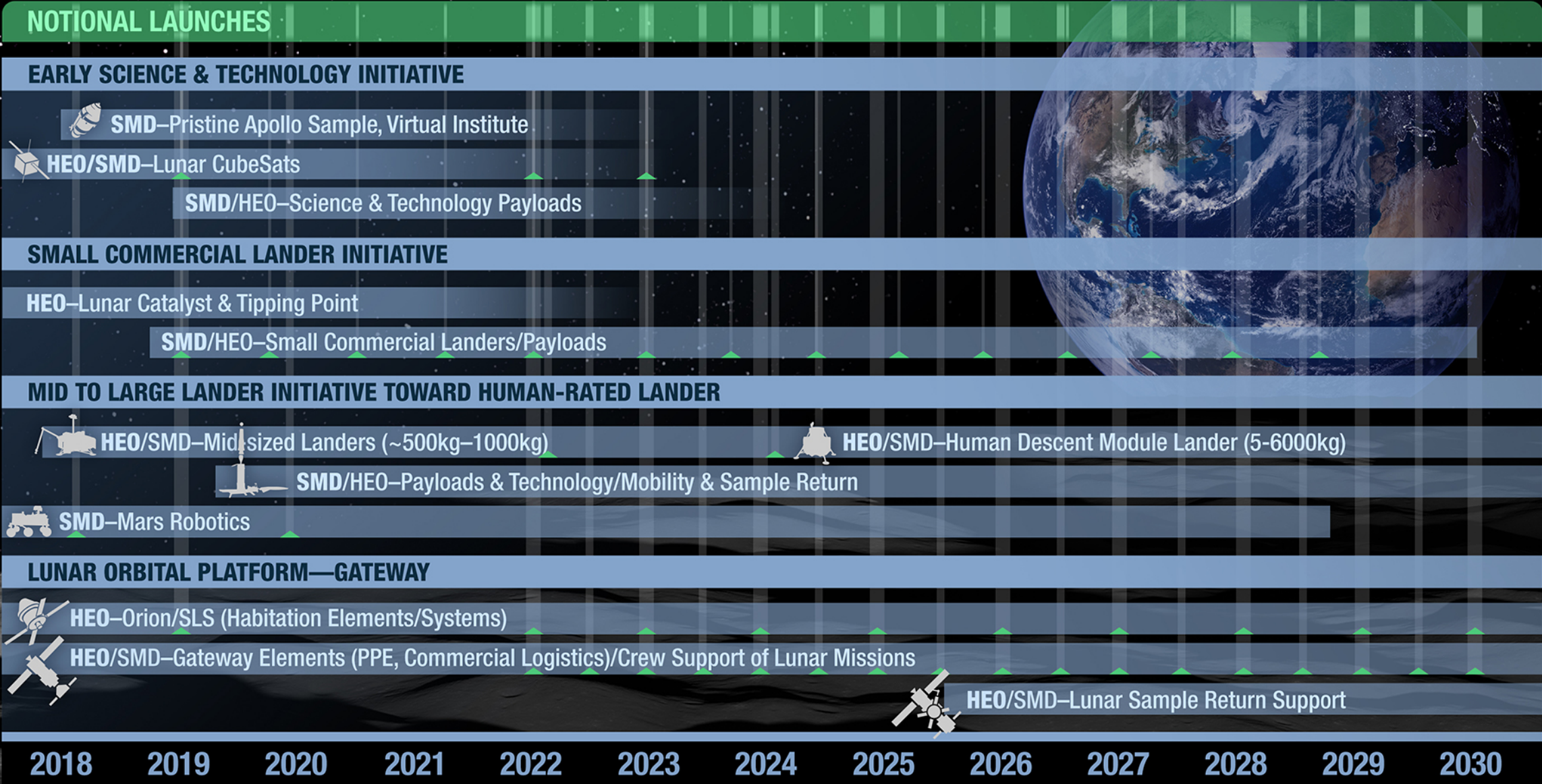
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NASA LUNAR EXPLORATION



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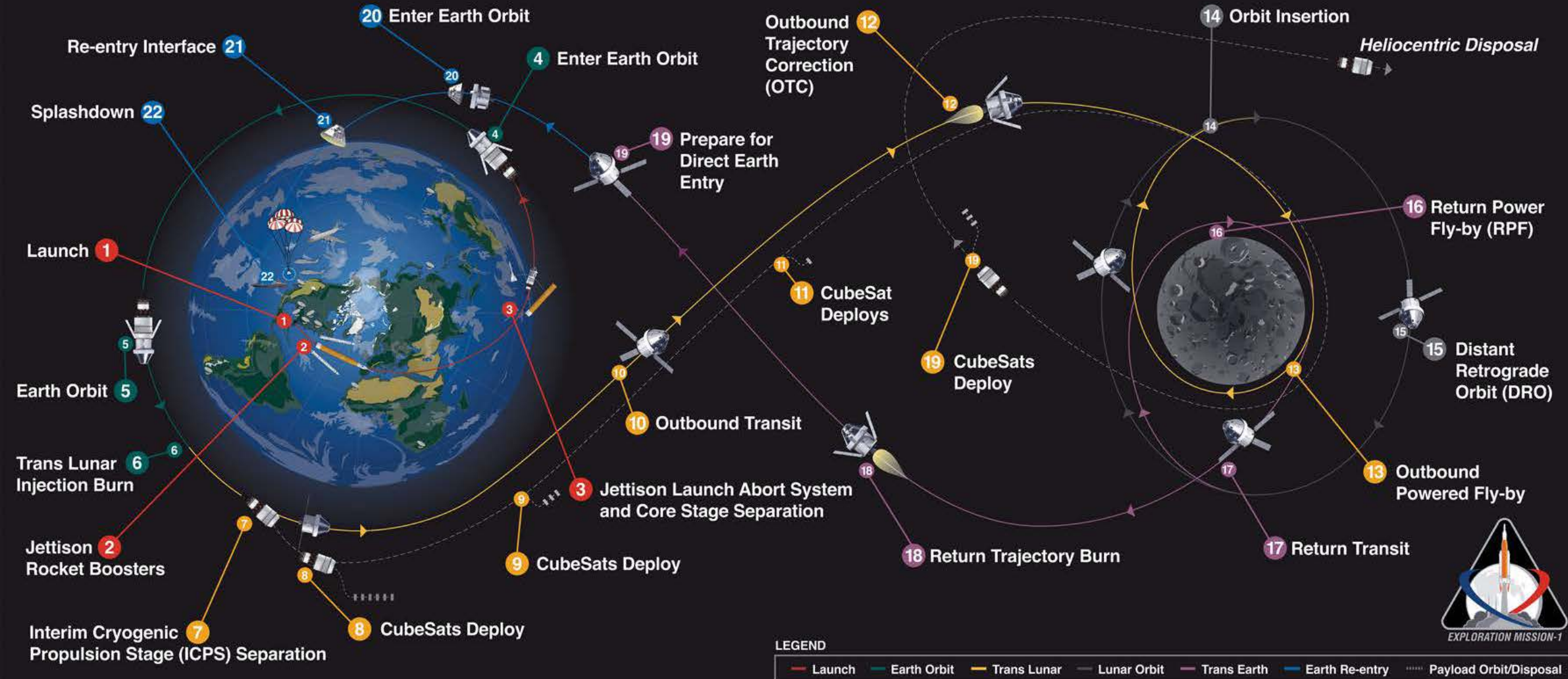
NASA LUNAR EXPLORATION



Timelines are tentative and will be developed further in FY 2019

EXPLORATION MISSION-1 SUMMARY

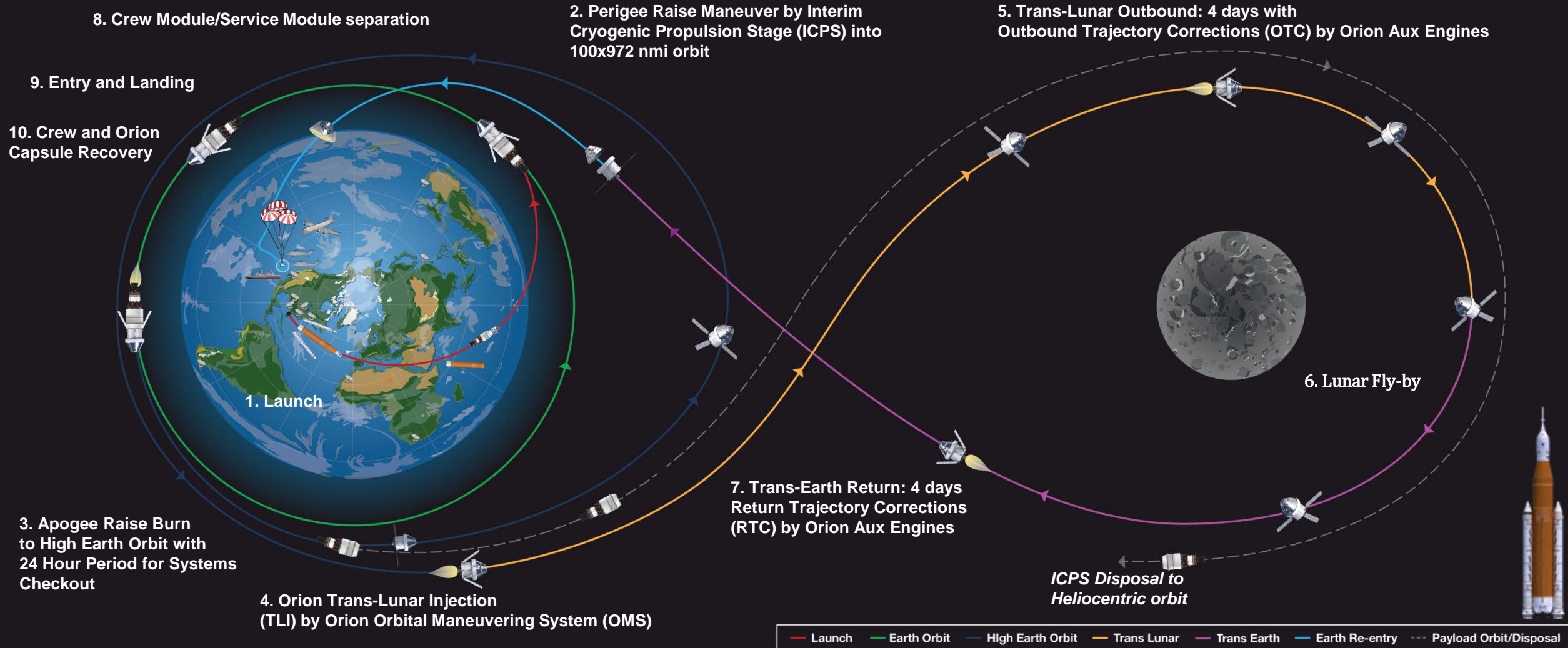
The first uncrewed, integrated flight test of NASA's Orion spacecraft and Space Launch System rocket, launching from a modernized Kennedy spaceport



Total distance traveled: 1.3 million miles – Mission duration: 25.5 days – Re-entry speed: 24,500 mph (Mach 32) – 13 CubeSats deployed

EXPLORATION MISSION-2 SUMMARY

Crewed Multi-Trans Lunar Injection (TLI) with Free Return Trajectory, demonstrating crewed flight and spacecraft systems performance beyond Low Earth Orbit (LEO)



SLS Configuration (Block 1) | 5-seg (SRBs and 4 RS-25D) | Human Rated ICPS | 22x975 nmi (40.7x1806 km) insertion orbit | 28.5 deg inclination

4 astronauts | Total distance traveled: 1,090,320 km – Mission duration: 9 Days – Re-entry speed: 24,500 mph (Mach 32)

GATEWAY DEVELOPMENT

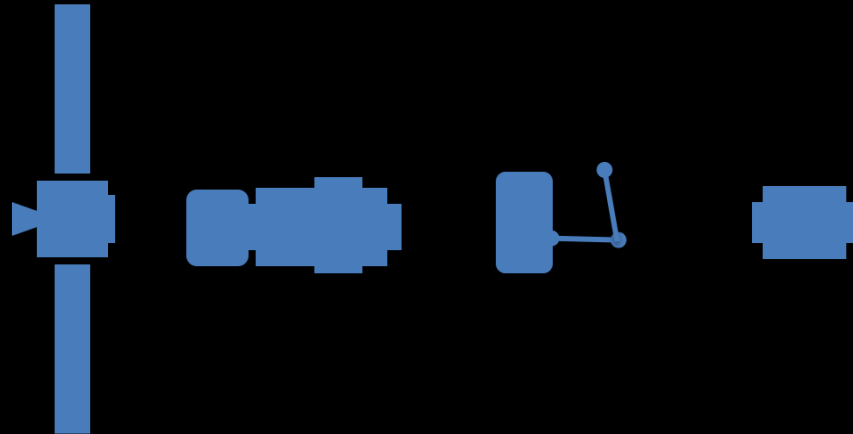
Establishing leadership in deep space and preparing for exploration into the solar system

FOUNDATIONAL GATEWAY CAPABILITIES

2022

2023

2024+



50 kW-class
Power &
Propulsion
Element

Habitation
and
Utilization

Logistics and
Robotic Arm

Airlock

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
- External robotic arm for berthing, science, exterior payloads, and inspections

OPPORTUNITIES

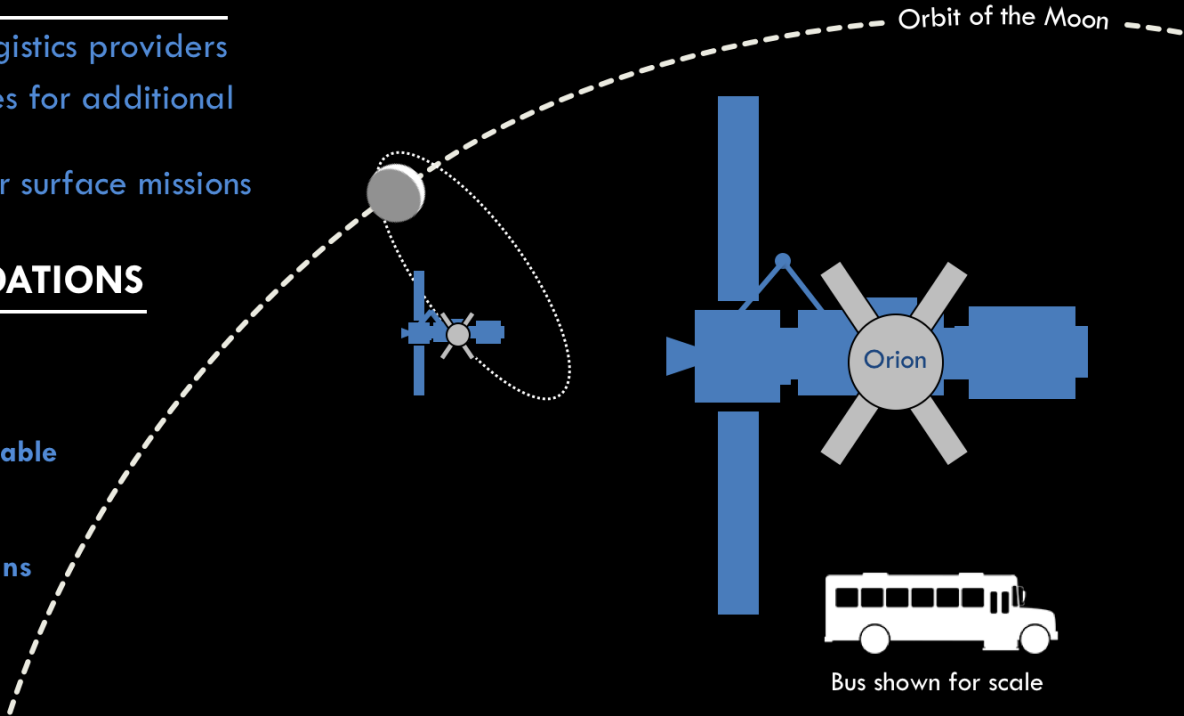
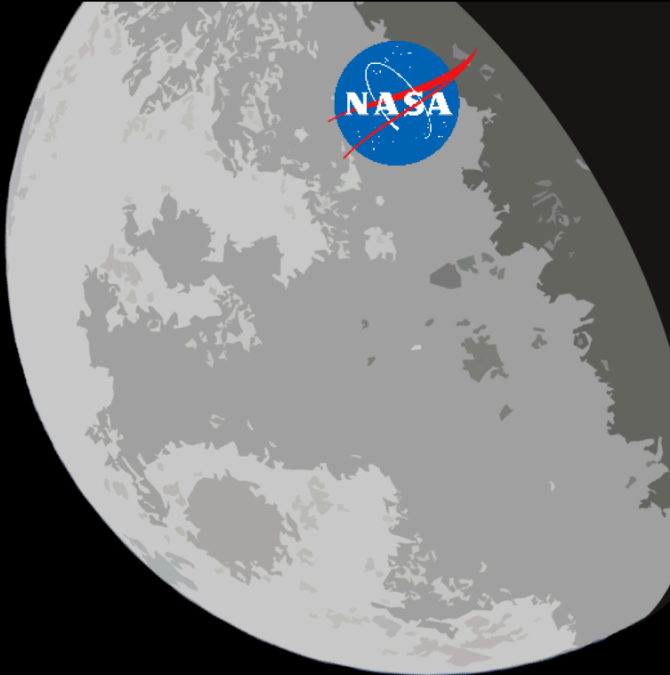
- Logistics flights and logistics providers
- Use of logistics modules for additional available volume
- Ability to support lunar surface missions

INITIAL ACCOMMODATIONS

 4 Crew Members

 At least 55 m³ Habitable Volume

 30 Day Crew Missions



GATEWAY SUPPORT OF LUNAR ACTIVITIES



Sample return

Externally mounted
Science and Tech
Demos



Teleoperations of
surface assets



Landers and Robotic Vehicles
including Aggregation,
refueling and staging of
reusable elements

**NASA Orion
Human Spacecraft**

Communication relay for
surface & orbital robotic
missions



Commercial
Cargo

Operations support for
human surface missions



APPROACH TO POWER AND PROPULSION ELEMENT DEVELOPMENT



PPE leverages advanced solar electric propulsion (SEP) technologies developed and matured during Asteroid Redirect Mission activities:

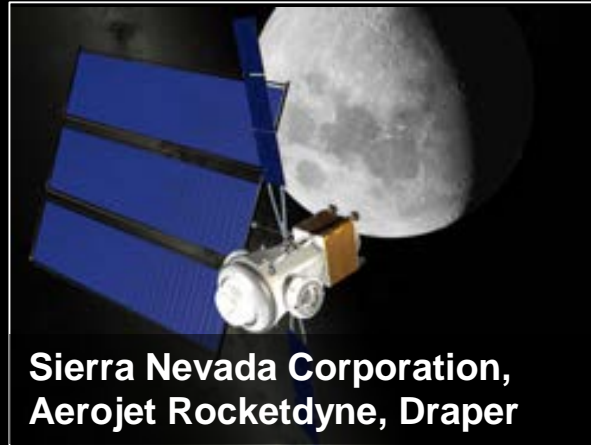
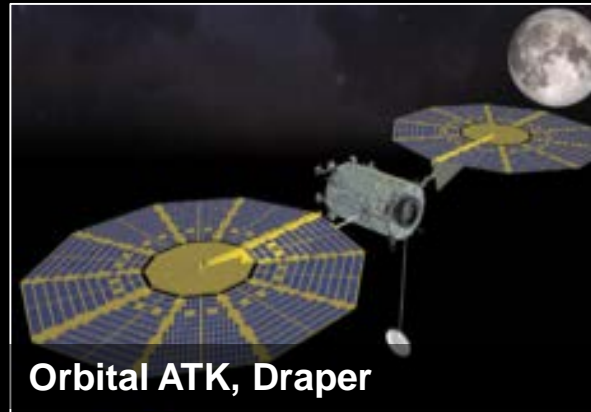
- First gateway element capability targeted for launch readiness in 2022
- Spaceflight demonstration of advanced solar electric propulsion spacecraft for industry and NASA objectives; developed through public-private partnership
- Leverage with U.S. industry current capabilities and future plans for future use of SEP
- Will provide transportation and controls for lunar orbital operations, power to future lunar orbiting elements, and communications



POWER AND PROPULSION ELEMENT INDUSTRY STUDIES

NextSTEP Appendix C: Issued Aug 11, 2017 | Selections announced Nov. 1, 2017

- U.S. industry-led studies for an advanced solar electric propulsion (SEP) vehicle capability
- Four-month studies commenced late Nov 2017



PPE NEAR TERM MILESTONES FROM PREVIOUS UPDATE TO NAC HEOC

as of Mar 6, 2018



✓ International interactions on potential hosted system	Aug 2017 – Feb 2018
✓ PPE Industry Study Contracts Awarded	Nov 17, 2017
✓ Kickoff Review of Interoperability Standards	Nov 17, 2017
✓ Orbital ATK PPE study kickoff	Nov 27, 2017
✓ PPE rqmts/con ops synthesis cycle 1 close	Nov 28, 2017
✓ Space Systems Loral PPE study kickoff	Nov 29, 2017
✓ Sources sought public release	Nov 30, 2017
✓ Sierra Nevada Corp PPE study kickoff	Nov 30, 2017
✓ Boeing PPE study kickoff	Dec 4, 2017
✓ Lockheed Martin PPE study kickoff	Dec 5, 2017
✓ PPE rqmts/con ops synthesis cycle 2 close	Dec 13, 2017
✓ PPE rqmts/con ops synthesis cycle 3 close	Jan 10, 2017
✓ Industry study 45 day reports completed	Jan 2018
✓ Synopsis public release	Feb 20, 2018
✓ Industry study final briefings completed	Mar 23, 2018



- **Use innovative approaches for Advanced Cislunar and Surface Capabilities (ACSC) to combine lunar robotics, a cislunar presence, and lunar landing capabilities**
 - Involve commercial and international participation to enhance U.S. leadership and establish U.S. preeminence to, around, and on the Moon
 - Use Mid to large class lander activity to allow NASA workforce to understand and develop human rated lander requirements
- **Partner with SMD's new Lunar Discovery and Exploration Program to build and launch instruments that serve lunar science, long-term exploration and utilization needs**
- **Develop commercial lunar landing capabilities to support future NASA mission needs, reduce risk, and stimulate commercial investments and activities in cislunar space**
 - Validate commercial capabilities and explore business cases for lunar payload delivery by purchasing instrument delivery services and technology demonstrations as soon commercially available
 - Partner with industry to evolve capabilities for mid-size (500-1000 kg of payload) landers, and could deliver payloads such as lunar resource prospecting, ascent stages for sample return missions, and infrastructure to support future missions
 - Advance capabilities to continue support for developing a human class lander (5000-6000 kg of payload) to enable progress towards landing humans on the Moon

HEO PROGRAM FINANCIAL PLAN (FY 2019 PBR)



Budget Authority (\$ in millions)	Actuals	P.L. 115-141	Request	Notional			
	2017	*2018	2019	2020	2021	2022	2023
Human Exploration and Operations	9,266.5	9,541.5	9,183.4	9,132.8	9,157.8	9,182.8	9,207.8
Deep Space Exploration Systems	4,324.0	4,790.0	4,558.8	4,859.1	4,764.5	4,752.5	4,769.8
Exploration Systems Development	3,929.0	4,395.0	3,669.8	3,790.5	3,820.2	3,707.5	3,845.6
Orion Program	1,330.0	1,350.0	1,163.5	1,137.7	1,134.2	1,117.8	1,117.8
Space Launch System	2,127.1	2,150.0	2,078.1	2,062.9	2,165.1	2,131.0	2,276.0
Exploration Ground Systems	471.9	895.0	428.2	589.9	520.8	458.7	451.9
**Exploration Research and Tech	395.0	395.0	-	-	-	-	-
Human Research Program	140.0	-	-	-	-	-	-
Advanced Exploration Systems	255.0	-	-	-	-	-	-
Advanced Exploration Systems	-	-	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	-	-	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	4,751.5	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
Construction and Environment Compliance	45.5	112.5	44.8	-	-	-	-
Deep Space Exploration Systems	8.8	95.9	25.9	-	-	-	-
LEO and Spaceflight Operations	36.7	16.6	18.9	-	-	-	-

* FY2018 reflects amounts appropriated by Public Law 115-141; details due to Congress in the Initial Operating Plan, early May 2018

** In the FY 2019 PBR, ERD was transferred to the Exploration Research and Technology account but will continue to be executed in FY 2018 under the Exploration account and managed by HEO

Totals may not add due to rounding



QUESTIONS?

