



NASA's Plans for going Forward to the Moon

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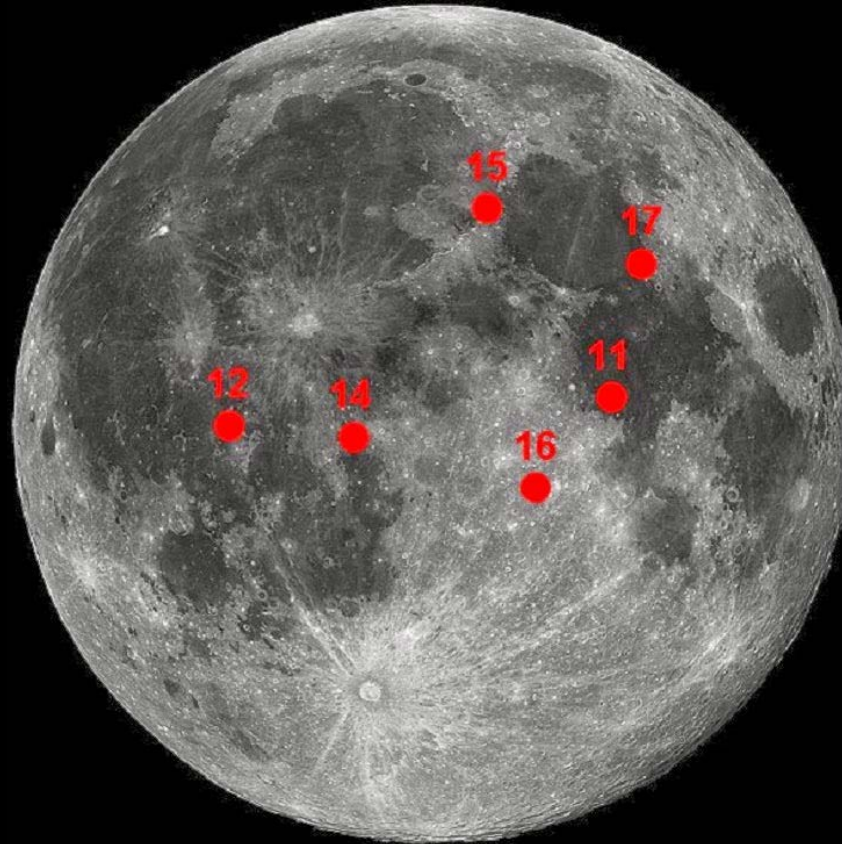
<http://oiir.hq.nasa.gov/europe/>



NASA 60th Anniversary



Apollo Lunar Exploration Program





Spinoffs

- Since 1976, *Spinoff* has highlighted NASA technologies that benefit life on Earth in the form of commercial products – nearly 2,000 in total.

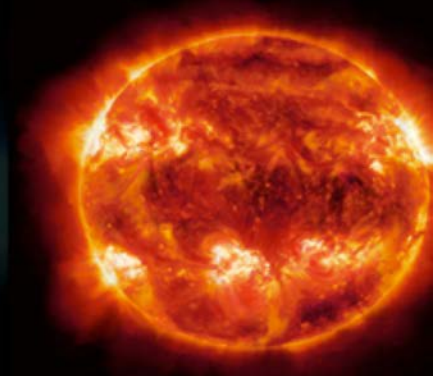




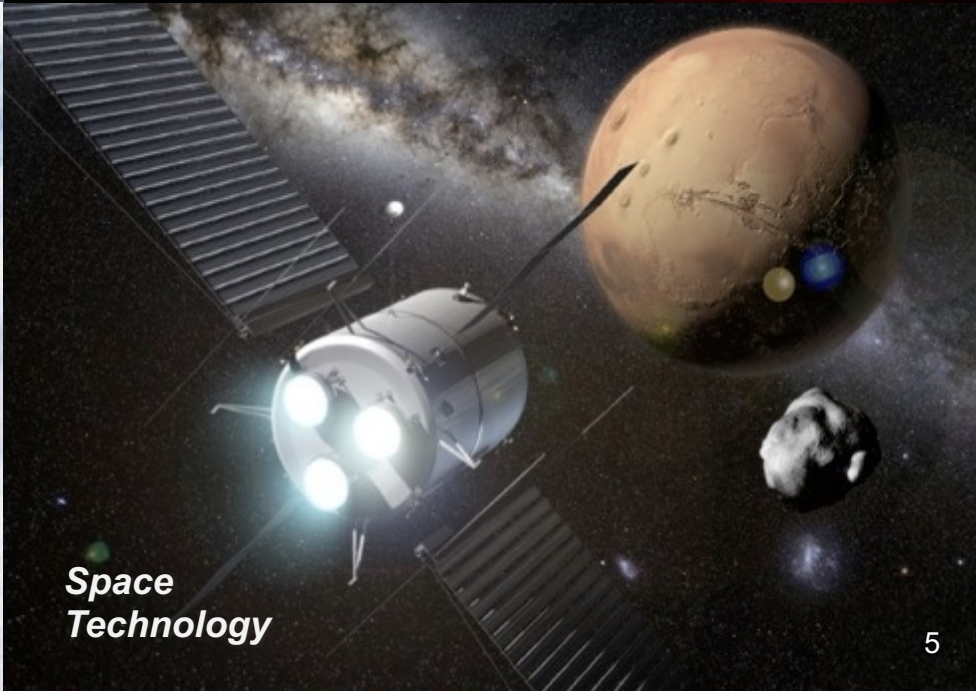
Aeronautics



Science



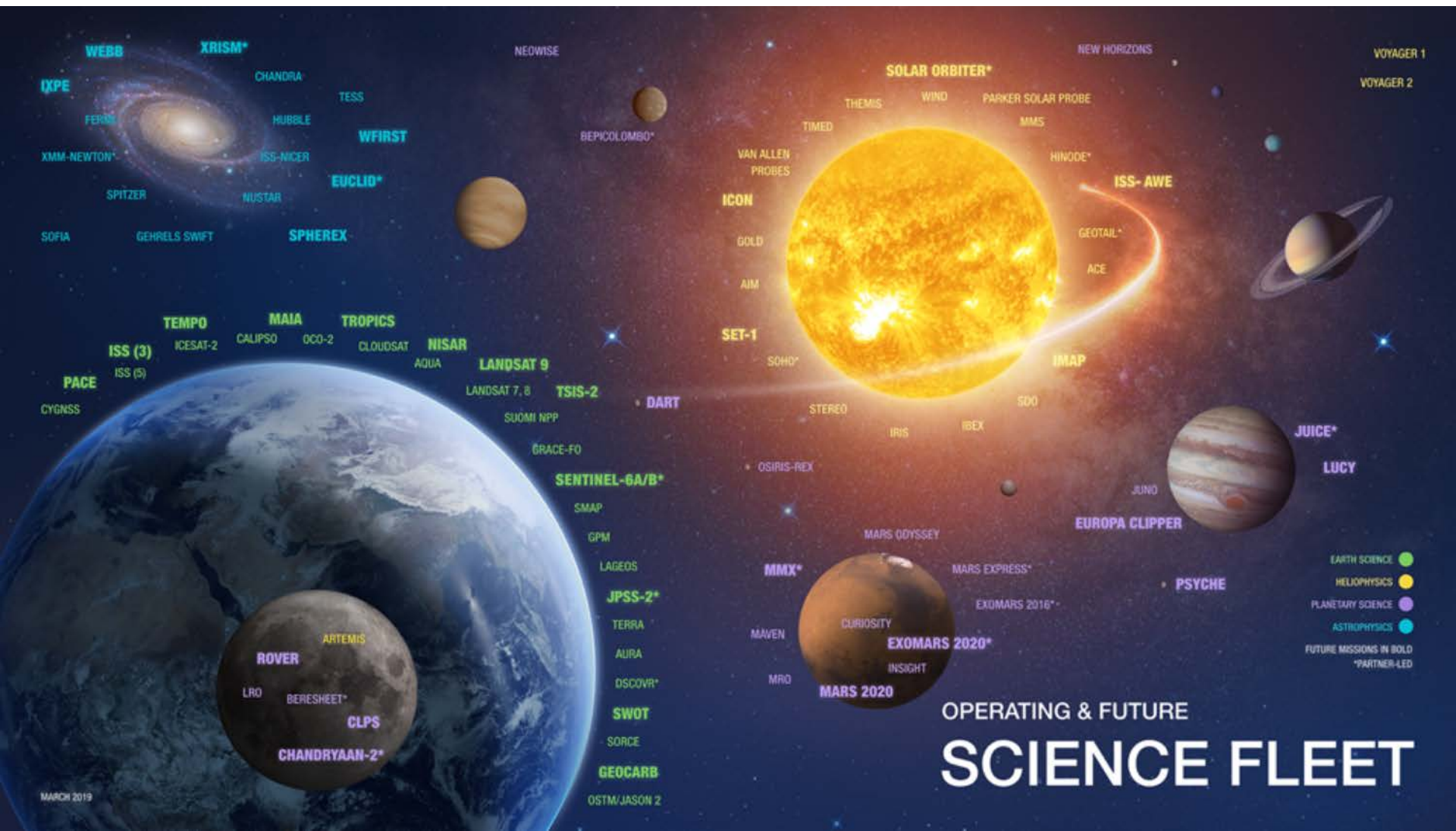
Human Exploration and Operations



Space Technology



NASA's Science Program



MARCH 2019

Space Policy Directive-1

Reinvigorating America's Human Space Exploration Program



“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.”

FY 2020 Budget Request (\$M)



Budget Authority (\$ in Millions)	Fiscal Year						
	2018	2019	2020	2021	2022	2023	2024
Deep Space Exploration Systems	\$4,790.0	\$5,050.8	\$5,021.7	\$5,295.5	\$5,481.4	\$6,639.0	\$7,042.3
Exploration Systems Development	\$4,395.0	\$4,092.8	\$3,441.7	\$3,441.0	\$3,468.4	\$3,788.5	\$3,654.7
Exploration Research & Development	\$395.0	\$958.0	\$1,580.0	\$1,854.5	\$2,013.0	\$2,850.4	\$3,387.6
Exploration Technology	\$760.0	\$926.9	\$1,014.3	\$976.1	\$995.4	\$964.4	\$943.1
LEO and Spaceflight Operations	\$4,749.2	\$4,639.1	\$4,285.7	\$4,369.5	\$4,369.5	\$4,235.5	\$4,182.3
International Space Station	\$1,493.0		\$1,458.2	\$1,448.5	\$1,449.4	\$1,352.6	\$1,315.7
Space Transportation	\$2,345.8		\$1,828.6	\$1,854.1	\$1,814.5	\$1,746.2	\$1,727.2
Space and Flight Support (SFS)	\$910.3		\$848.9	\$891.9	\$905.7	\$911.8	\$914.5
Commercial LEO Development	\$0.0	\$40.0	\$150.0	\$175.0	\$200.0	\$225.0	\$225.0
Science	\$6,211.5	\$6,905.7	\$6,303.7	\$6,319.0	\$6,319.0	\$5,846.5	\$5,815.0
Earth Science	\$1,921.0	\$1,931.0	\$1,779.8	\$1,785.6	\$1,779.7	\$1,666.5	\$1,674.6
Planetary Science	\$2,217.9	\$2,758.5	\$2,622.1	\$2,577.3	\$2,629.4	\$2,402.4	\$2,350.9
Astrophysics	\$850.4	\$1,191.6	\$844.8	\$902.4	\$965.2	\$913.5	\$907.7
Heliophysics	\$688.5	\$720.0	\$704.5	\$638.6	\$769.3	\$692.0	\$709.8
James Webb Space Telescope (JWST)	\$533.7	\$304.6	\$352.6	\$415.1	\$175.4	\$172.0	\$172.0
Aeronautics	\$690.0	\$725.0	\$666.9	\$673.6	\$680.3	\$587.1	\$587.0
STEM Engagement	\$100.0	\$110.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Safety, Security, and Mission Services	\$2,826.9	\$2,755.0	\$3,084.6	\$3,084.6	\$3,084.6	\$2,871.6	\$2,871.6
Center Management and Operations	\$1,983.4		\$2,065.0	\$2,058.4	\$2,052.9	\$1,906.0	\$1,905.8
Agency Management and Operations	\$843.5		\$1,019.6	\$1,026.2	\$1,031.7	\$965.6	\$965.8
Construction & Envrmtl Compl Restoration	\$569.5	\$348.2	\$600.4	\$468.8	\$468.8	\$468.8	\$387.8
Construction of Facilities	\$483.1		\$517.5	\$385.9	\$385.9	\$385.9	\$304.9
Environmental Compliance and Restoration	\$86.4		\$82.9	\$82.9	\$82.9	\$82.9	\$82.9
Inspector General	\$39.0	\$39.3	\$41.7	\$42.1	\$42.5	\$43.0	\$43.4
NASA Total	\$20,736.1	\$21,500.0	\$21,019.0	\$21,229.2	\$21,441.5	\$21,655.9	\$21,872.5

FY 2018 reflects funding amounts specified in Public Law 115-41, Consolidated Appropriations Act, 2018, as adjusted by NASA's FY 2018 Operating Plan. Table does not reflect emergency supplemental funds also appropriated in FY 2018, totaling \$81.3 million.

FY 2019 reflects funding as enacted under Public Law 116-06.



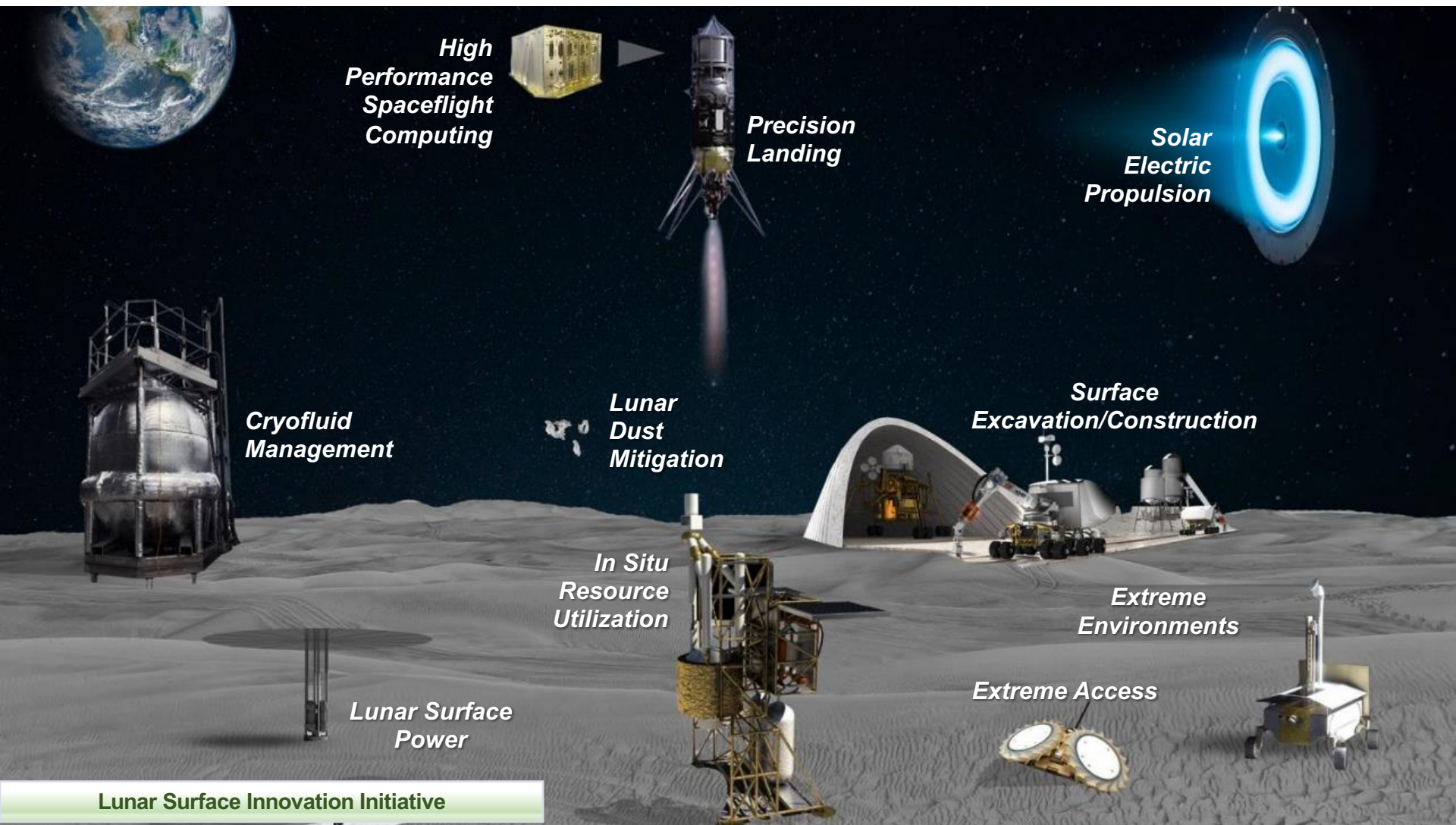
A Budget Increase Towards 2024

This FY 2020 budget amendment provides an increase of \$1.6 billion above the President's initial \$21 billion budget request to accelerate our return to the lunar surface. This additional investment is a down payment on NASA's efforts to land humans on the Moon by 2024, and is required to achieve that bold objective. It's the boost NASA needs to move forward with design, development and exploration.

- ***Human Lunar Landing System: This budget includes \$1 billion to enable NASA to begin supporting the development of commercial human lunar landing systems three years earlier than previously envisioned to bring humans to the Moon's surface by 2024.***
 - ***This acquisition strategy will allow NASA to purchase an integrated commercial lunar lander that will transport astronauts from lunar orbit to the lunar surface and back.***
 - ***Focusing Gateway development on capabilities needed to support a lunar landing of 2024 allowed a scope reduction of \$321 million. This budget amendment shifts potential development of additional Gateway capabilities into the future.***
- ***Space Launch System Rocket and Orion Spacecraft: With an additional \$651 million for SLS and Orion, this budget supports the most powerful rocket in the world and our new spacecraft to ultimately take the astronauts to the staging point for reaching the lunar surface, the Gateway in lunar orbit.***
- ***Exploration Technology: An additional \$132 million for technologies that will support NASA to advance key precursor capabilities on the lunar surface. This includes various exploration technologies like solar electric propulsion and a demonstration converting polar ice to water.***
- ***Science: An augmentation of \$90 million to enable increased robotic exploration of the Moon's polar regions in advance of a human mission.***



Space Technology for 2024 and Beyond



*High
Performance
Spaceflight
Computing*



*Precision
Landing*

*Solar
Electric
Propulsion*

*Cryofluid
Management*

*Lunar
Dust
Mitigation*

*Surface
Excavation/Construction*

*In Situ
Resource
Utilization*

*Extreme
Environments*

*Lunar Surface
Power*

Extreme Access

Lunar Surface Innovation Initiative



Transportation to the Moon



DEEP SPACE EXPLORATION SYSTEM

Recent Accomplishments



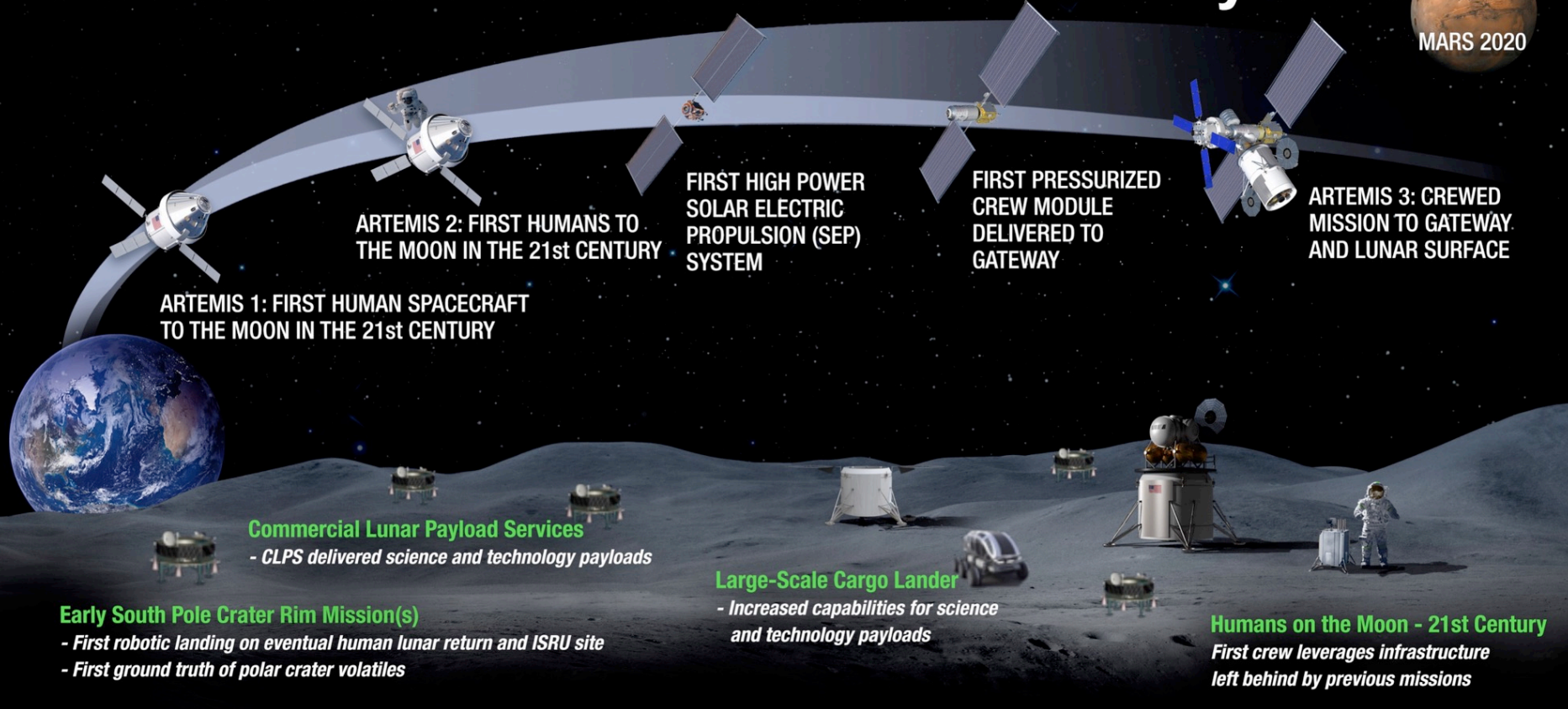


To the Lunar Surface by 2024

Artemis Phase 1: To the Lunar Surface by 2024



MARS 2020



ARTEMIS 1: FIRST HUMAN SPACECRAFT TO THE MOON IN THE 21st CENTURY

ARTEMIS 2: FIRST HUMANS TO THE MOON IN THE 21st CENTURY

FIRST HIGH POWER SOLAR ELECTRIC PROPULSION (SEP) SYSTEM

FIRST PRESSURIZED CREW MODULE DELIVERED TO GATEWAY

ARTEMIS 3: CREWED MISSION TO GATEWAY AND LUNAR SURFACE

Commercial Lunar Payload Services
- CLPS delivered science and technology payloads

Early South Pole Crater Rim Mission(s)
- First robotic landing on eventual human lunar return and ISRU site
- First ground truth of polar crater volatiles

Large-Scale Cargo Lander
- Increased capabilities for science and technology payloads

Humans on the Moon - 21st Century
First crew leverages infrastructure left behind by previous missions

LUNAR SOUTH POLE CRATER TARGET SITE

2019

2024



Gateway Role for 2024 Landing

Gateway is Essential for 2024 Landing

- Initial Gateway focuses on the minimum systems required to support a 2024 human lunar landing while also supporting Phase 2
- Provides command center and aggregation point for 2024 human landing
- Establishes strategic presence around the Moon – US in the leadership role
- Creates resilience and robustness in the lunar architecture
- Provides building block for the future, expanded capabilities on and around the Moon

Gateway Phase One

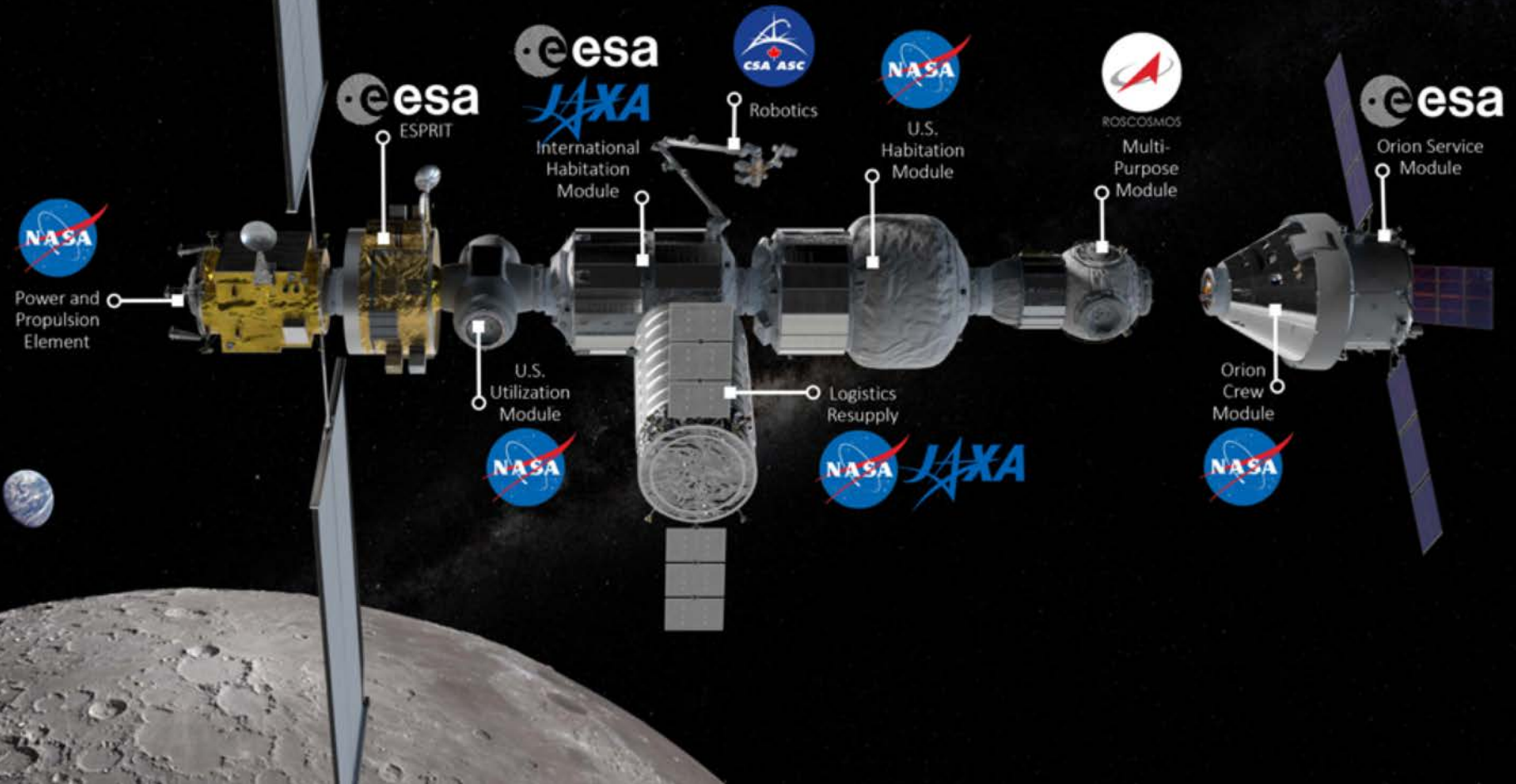
Lunar Landing System (Ascent, Descent, Transfer)

Orion/European Service Module



MCB Concept – March 2019

GATEWAY CONFIGURATION CONCEPT





Transformative Lunar Science



- **Based on the decadal survey, a SSERVI white paper identified top areas of lunar science, including**
 - Establish the period of giant planet migration
 - Provide absolute chronology for Solar System events
 - Use the vantage from lunar far side to view universe at key wavelengths
 - Understand sources of water and the water cycle on the Moon
 - Characterize the lunar interior (core, mantle, crust)
 - Evaluate solar wind interactions with the lunar surface and extend the record of extreme space weather events of the past



Commercial Lunar Payload Services (CLPS)



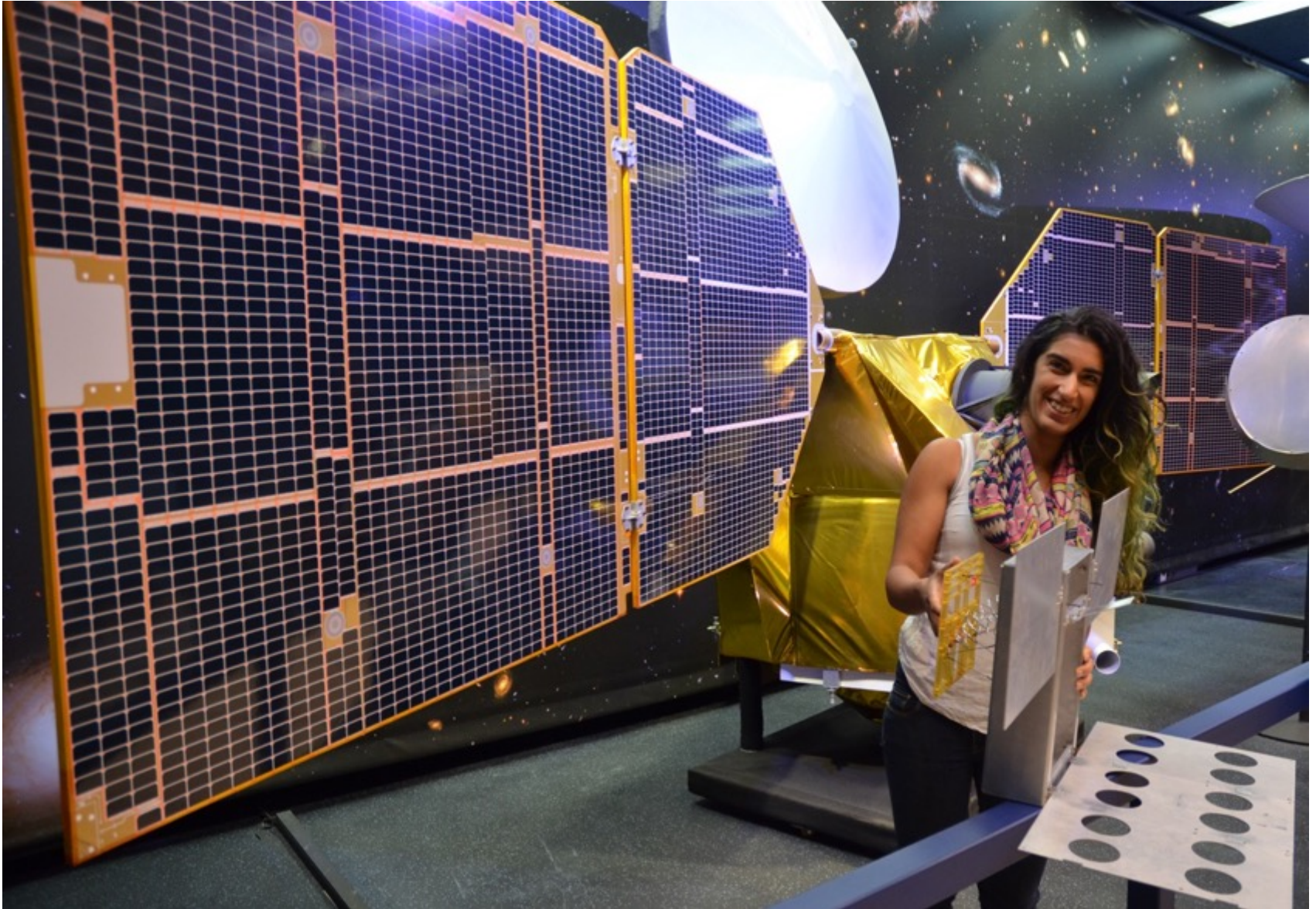
Commercial Lunar Payload Services

- US commercial providers of space transportation services,
- 10-year multi-vendor catalog for payload missions



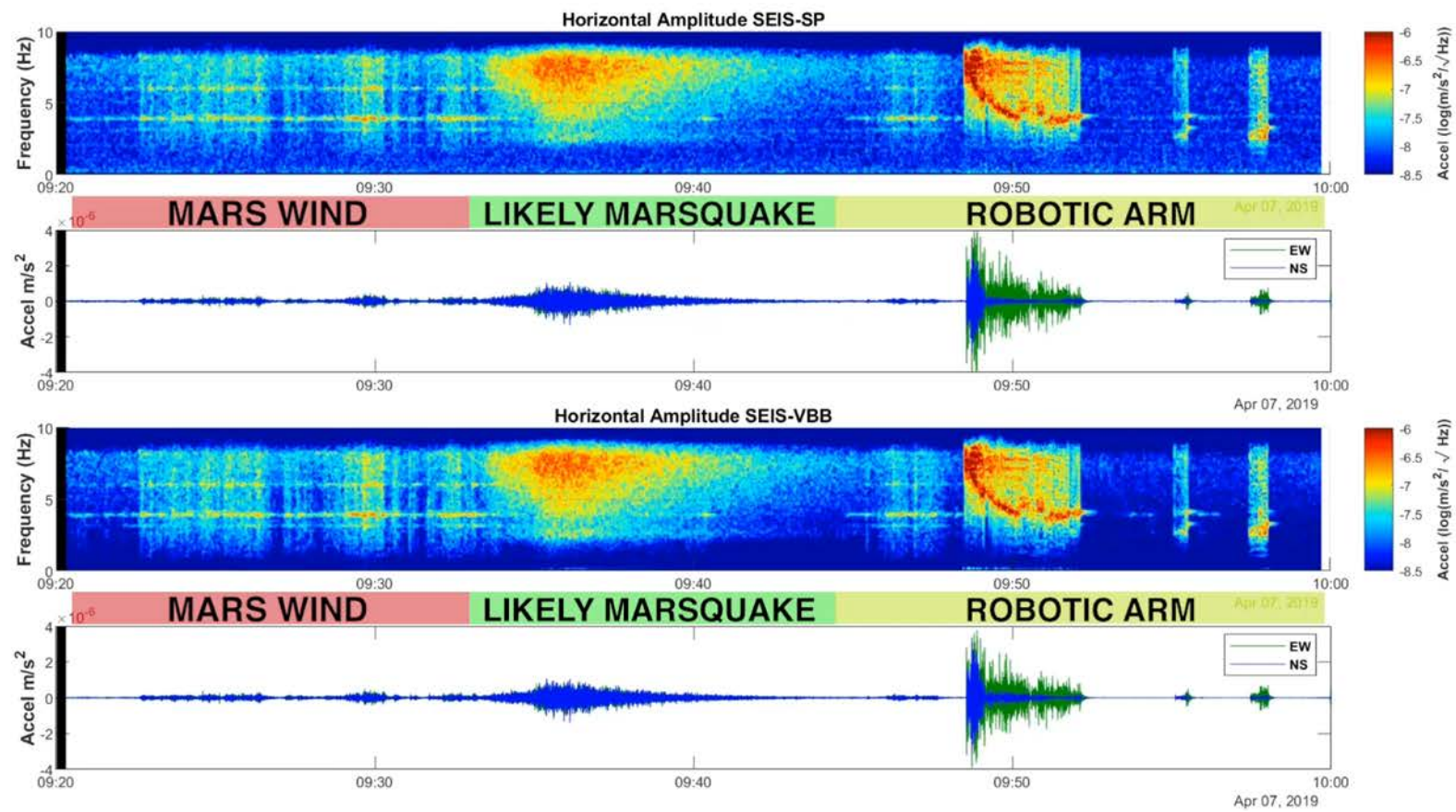


CubeSats





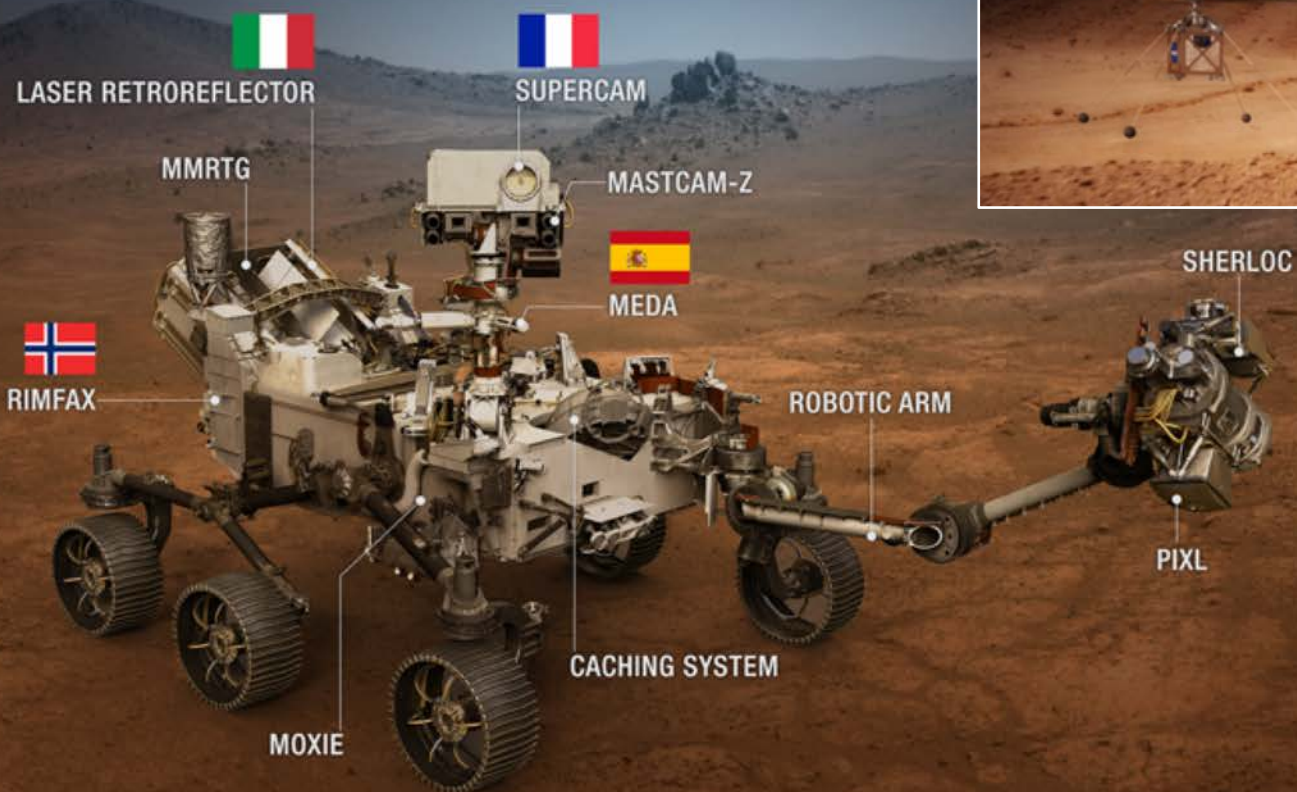
InSight Results





Mars 2020

Seeking Signs of Life: Mars 2020 Rover



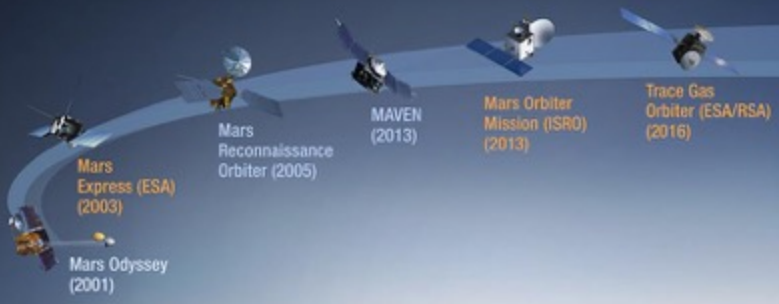


Missions to Mars

MARS MISSIONS

OPERATIONAL 2001-2019

2020 AND BEYOND



Follow the Water

Explore Habitability

Seek Signs of Life


Prepare for Future Human Explorers

U.S. Missions

non-U.S. Missions

Mars

Vistas of opportunity and discovery



Earth