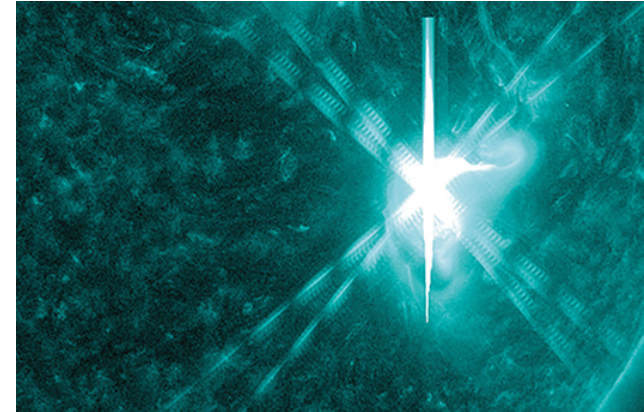
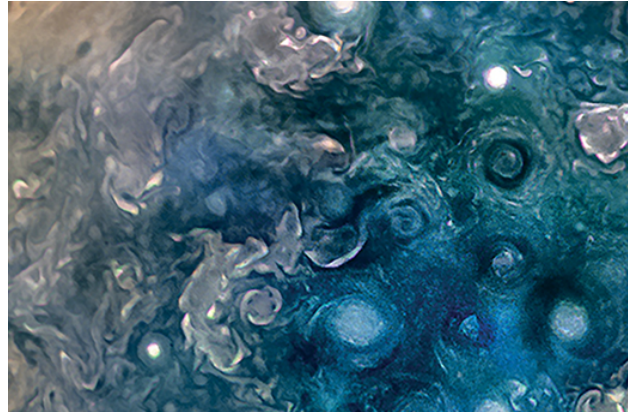
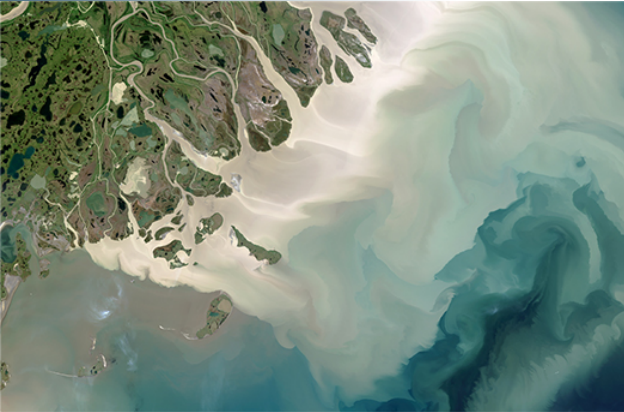


SCIENCE

National Aeronautics and
Space Administration



JOINT NAC SC/HEO COMMITTEE MEETING

SMD Cislunar Activities Overview

Thomas H. Zurbuchen, Associate Administrator

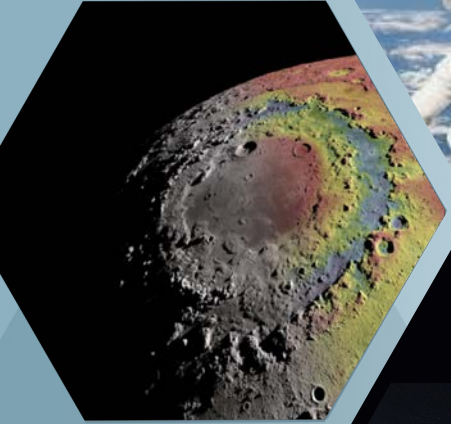
 @Dr_ThomasZ

Steven Clarke, Deputy Associate Administrator for Exploration
Science Mission Directorate, NASA

August 28, 2018

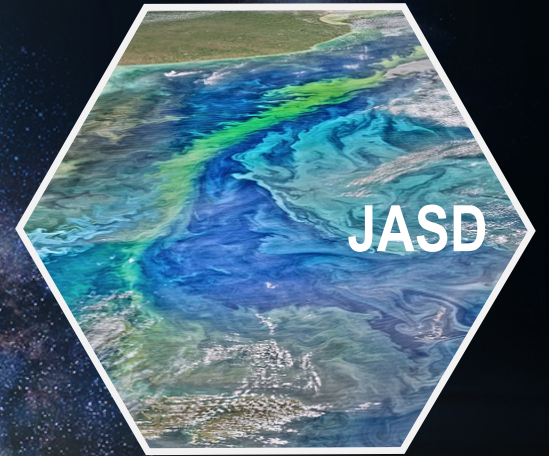
NASA SCIENCE & CISLUNAR ACTIVITIES

- NASA Science Mission Update
- Lunar Focus
- Integrated Exploration Strategy



NASA Science Mission Directorate

An Integrated Program
Enabling Great Science



Science by the NUMBERS



TECHNOLOGY INNOVATION

~\$400M Invested Annually



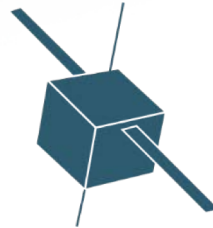
RESEARCH

~10,000 U.S. Scientists Funded
~3,000 Competitively Selected Awards
~\$600M Awarded Annually



SPACECRAFT

105 Missions
85 Spacecraft



SMALLSATS/CUBESATS

30 Science Missions
23 Technology Demos



SOUNDING ROCKETS

16 Science Missions
3 Tech/Student Missions



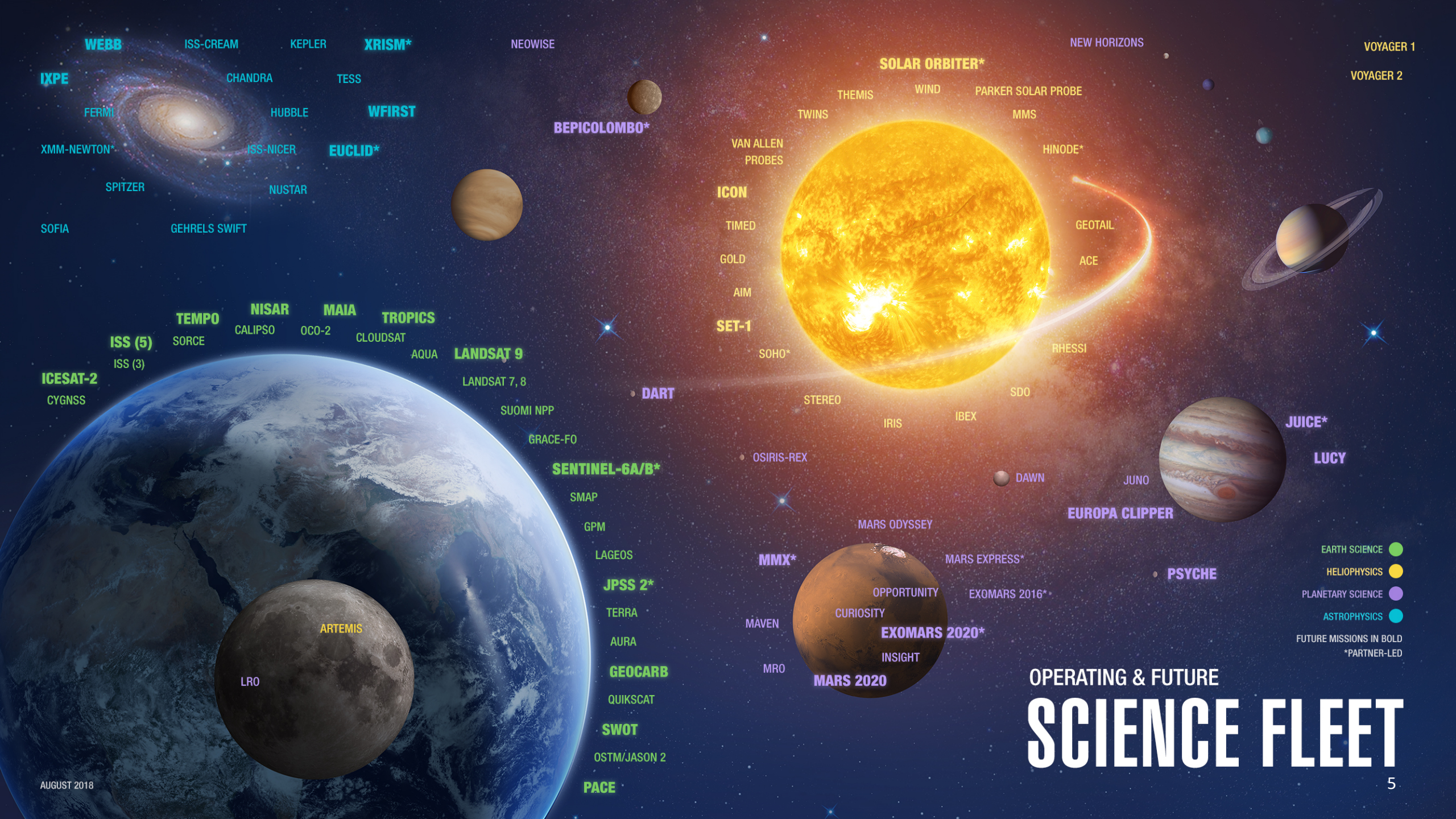
EARTH-BASED INVESTIGATIONS

25 Major Airborne Missions
8 Global Networks



BALLOONS

13 Science Payloads
1 HASP with up to
12 student experiments



WEBB ISS-CREAM KEPLER **XRISM*** NEOWISE

IXPE CHANDRA TESS

FERMI HUBBLE **WFIRST**

XMM-NEWTON* ISS-NICER **EUCLID***

SPITZER NUSTAR

SOFIA GEHRELS SWIFT

TEMPO **NISAR** **MAIA** **TROPICS**

ISS (5) SORCE CALIPSO OCO-2 CLOUDSAT

ICESAT-2 ISS (3) AQUA **LANDSAT 9**

CYGNSS LANDSAT 7, 8

SENTINEL-6A/B*

GRACE-FO

SMAP

GPM

LAGEOS

JPSS 2*

TERRA

AURA

GEOCARB

QUIKSCAT

SWOT

OSTM/JASON 2

PACE

BEPICOLOMBO*

DART

OSIRIS-REX

MMX*

MAVEN

MRO

MARS 2020

EXOMARS 2020*

INSIGHT

SOLAR ORBITER*

THEMIS WIND PARKER SOLAR PROBE

TWINS MMS

VAN ALLEN PROBES

ICON

TIMED

GOLD

AIM

SET-1

SOHO*

STEREO

IRIS

IBEX

SDO

HINODE*

GEOTAIL

ACE

RHESSI

EUROPA CLIPPER

DAWN

JUNO

PSYCHE

JUICE*

LUCY

NEW HORIZONS

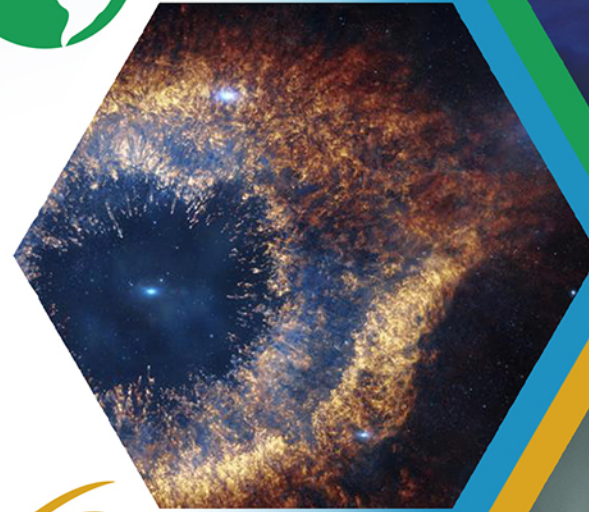
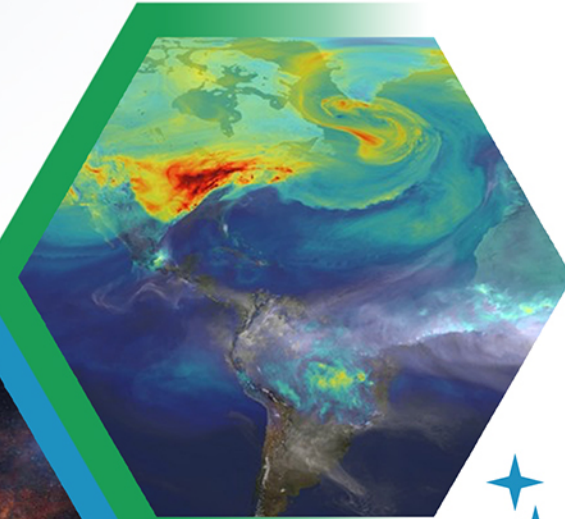
VOYAGER 1

VOYAGER 2

OPERATING & FUTURE SCIENCE FLEET

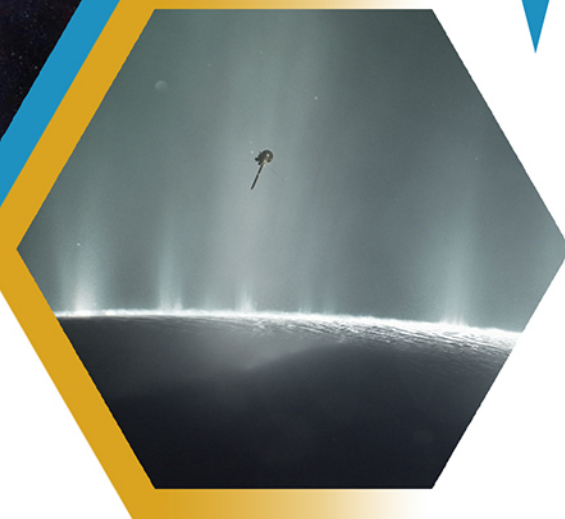
Key Science THEMES

Protect & Improve
Life on Earth

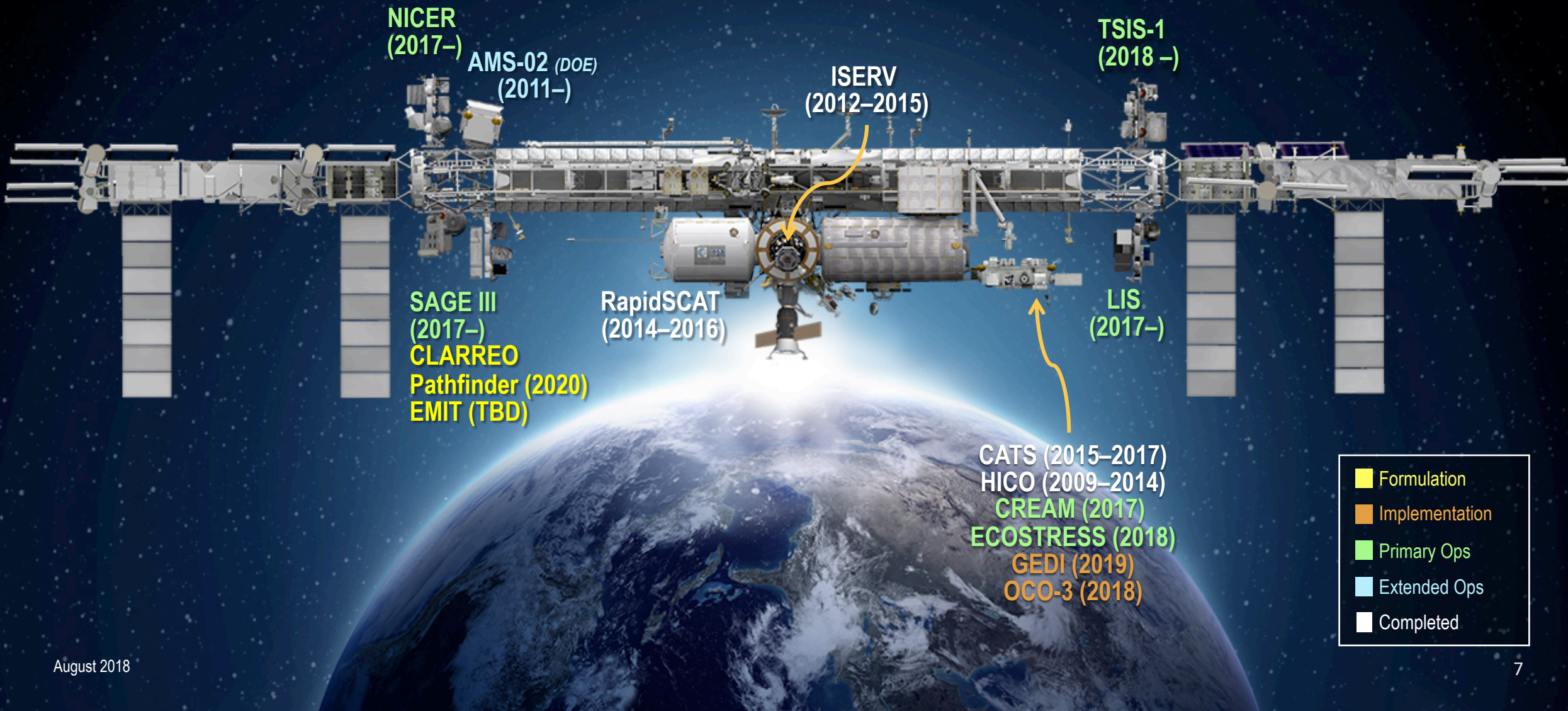


Discover Secrets
of the Universe

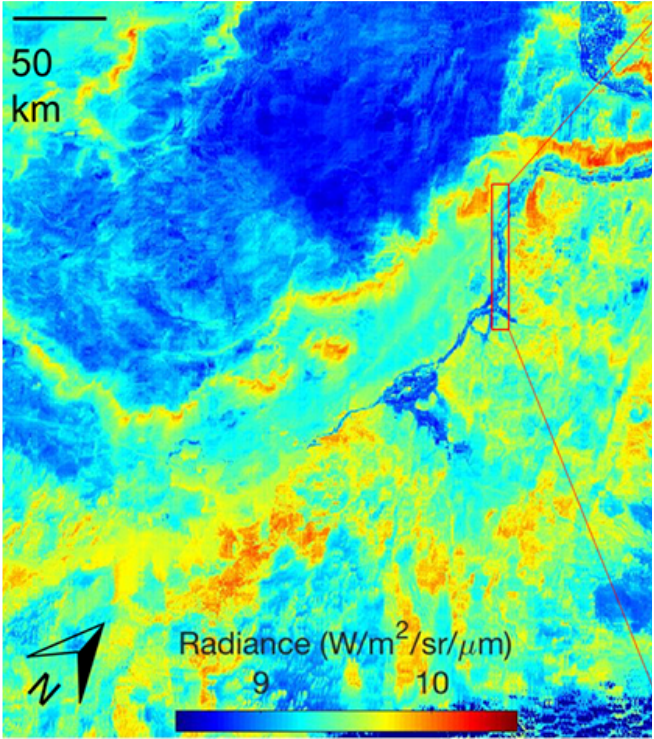
Search for
Life Elsewhere



International Space Station Science Instruments

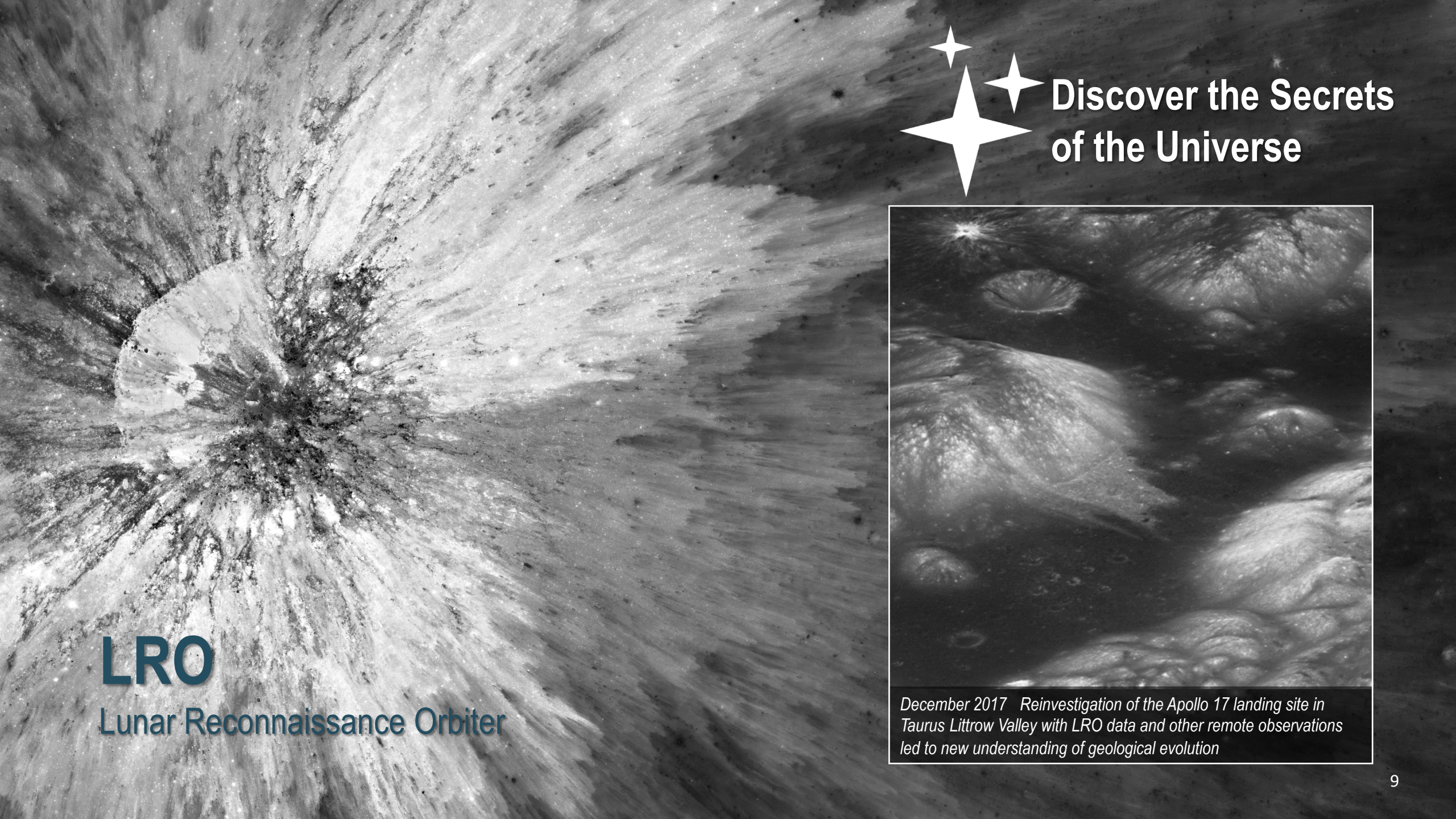


Protect & Improve
Life on Earth

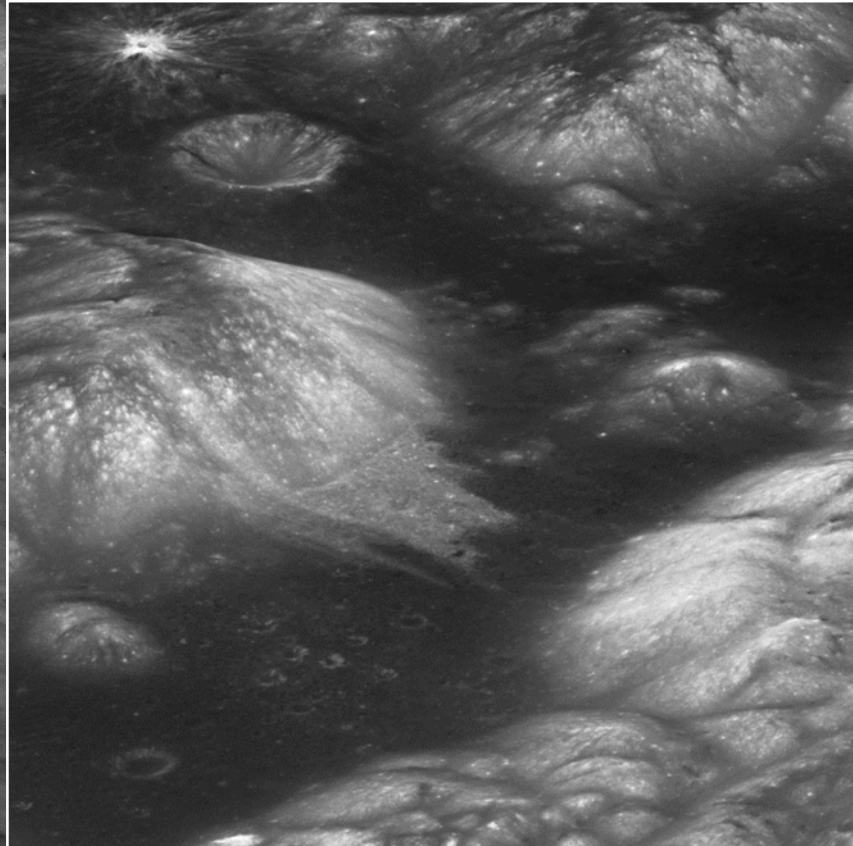


July 9 ECOSTRESS image over Egypt; yellow and red indicate generally higher temperatures

ECOSTRESS



**Discover the Secrets
of the Universe**

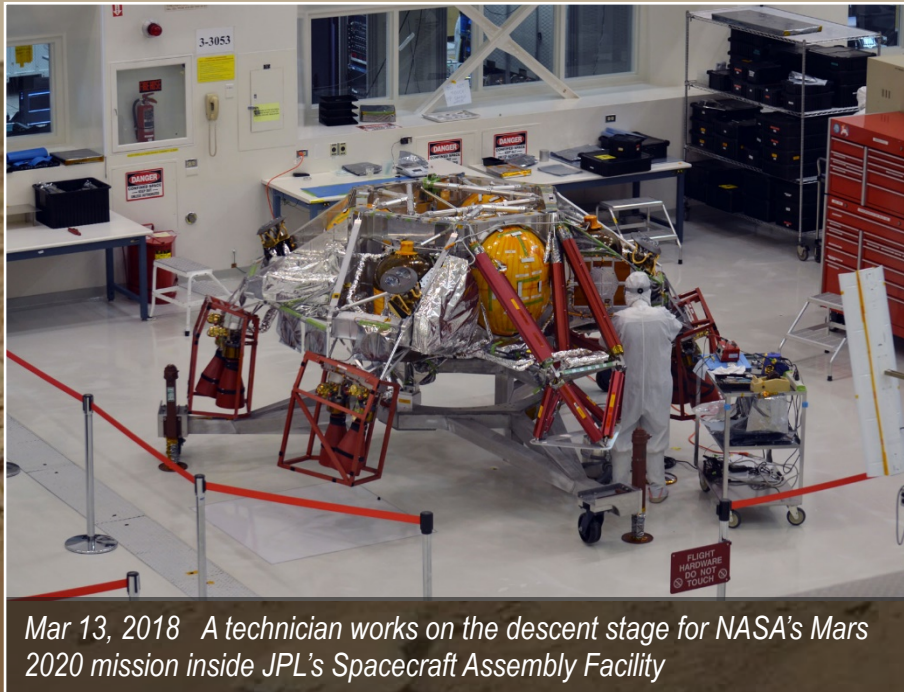


December 2017 Reinvestigation of the Apollo 17 landing site in Taurus Littrow Valley with LRO data and other remote observations led to new understanding of geological evolution

LRO

Lunar Reconnaissance Orbiter

Search for Life Elsewhere



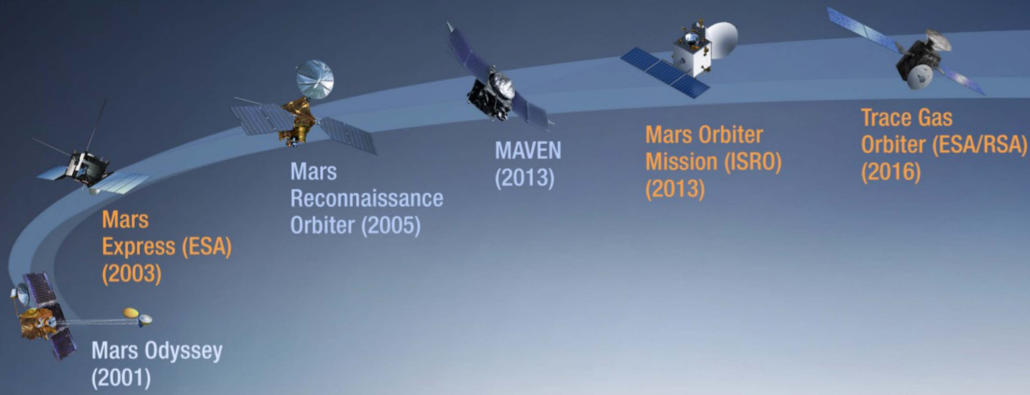
Mar 13, 2018 A technician works on the descent stage for NASA's Mars 2020 mission inside JPL's Spacecraft Assembly Facility

MARS 2020

MARS MISSIONS

OPERATIONAL 2001–2017

2018 AND BEYOND



Opportunity Rover (2003)

Curiosity Rover (2011)

InSight

Mars Lander & Rover (China)

Mars 2020 Rover (NASA)

Mars Sample Return Lander

ExoMars Rover (ESA/RSA)

Mars Sample Return (China)

Follow the Water

Explore Habitability

Seek Signs of Life

Prepare for Future Human Explorers

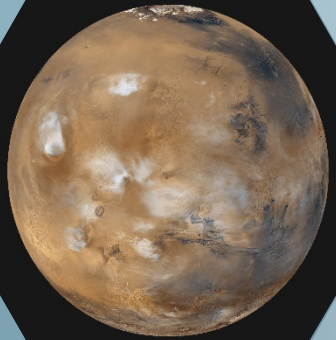
■ U.S. Missions

■ non-U.S. Missions

Key Priorities

Advance National Science and Exploration Goals

- Execute a new **Lunar Discovery and Exploration** program to leverage commercial partnerships and innovative approaches to achieve human and science exploration goals
- Build on extensive past **Lunar** exploration and science experience
- Plan a potential **Mars Sample Return** mission, a decadal survey priority, leveraging international and commercial partnerships



Steve Clarke, SMD Deputy Associate Administrator for Exploration

Role and Responsibilities

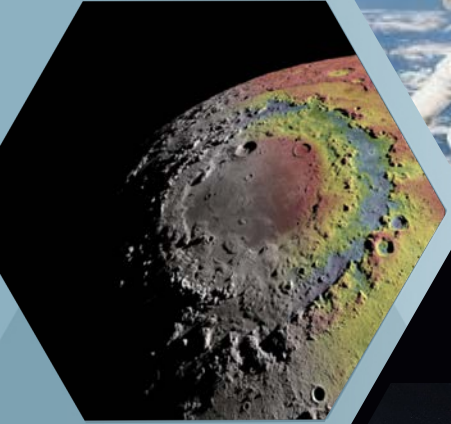
Develop and integrate a strategy to enable Moon and Mars robotic and human exploration

- Formulate and execute an integrated strategy for exploration through cross-Agency collaboration with SMD, HEOMD and STMD, NASA field centers, and interagency and international participation where appropriate
- Coordinate SMD research, technology development, and scientific payload development efforts, including commercial partnerships benefiting SMD science
- Identify potential interdisciplinary research and technology opportunities, including commercial, necessary for NASA's Exploration Campaign
- Reach out to: steven.w.clarke@nasa.gov



NASA SCIENCE & CISLUNAR ACTIVITIES

- NASA Science Mission Update
- Lunar Focus
- Integrated Exploration Strategy

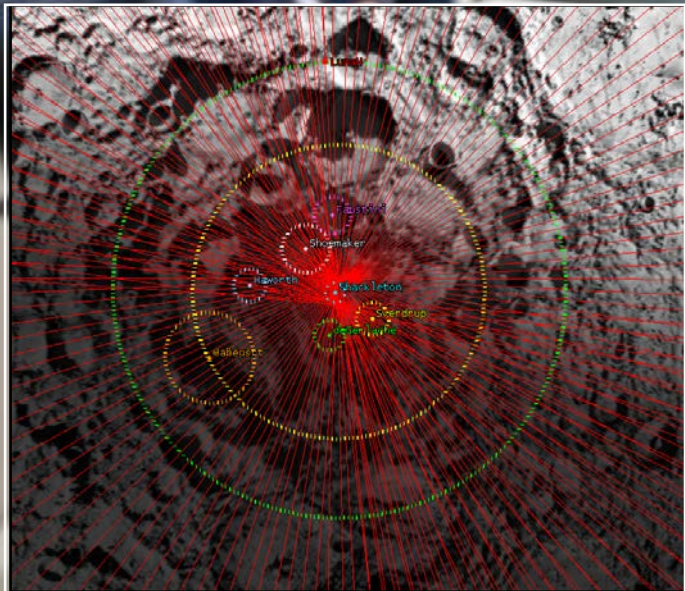
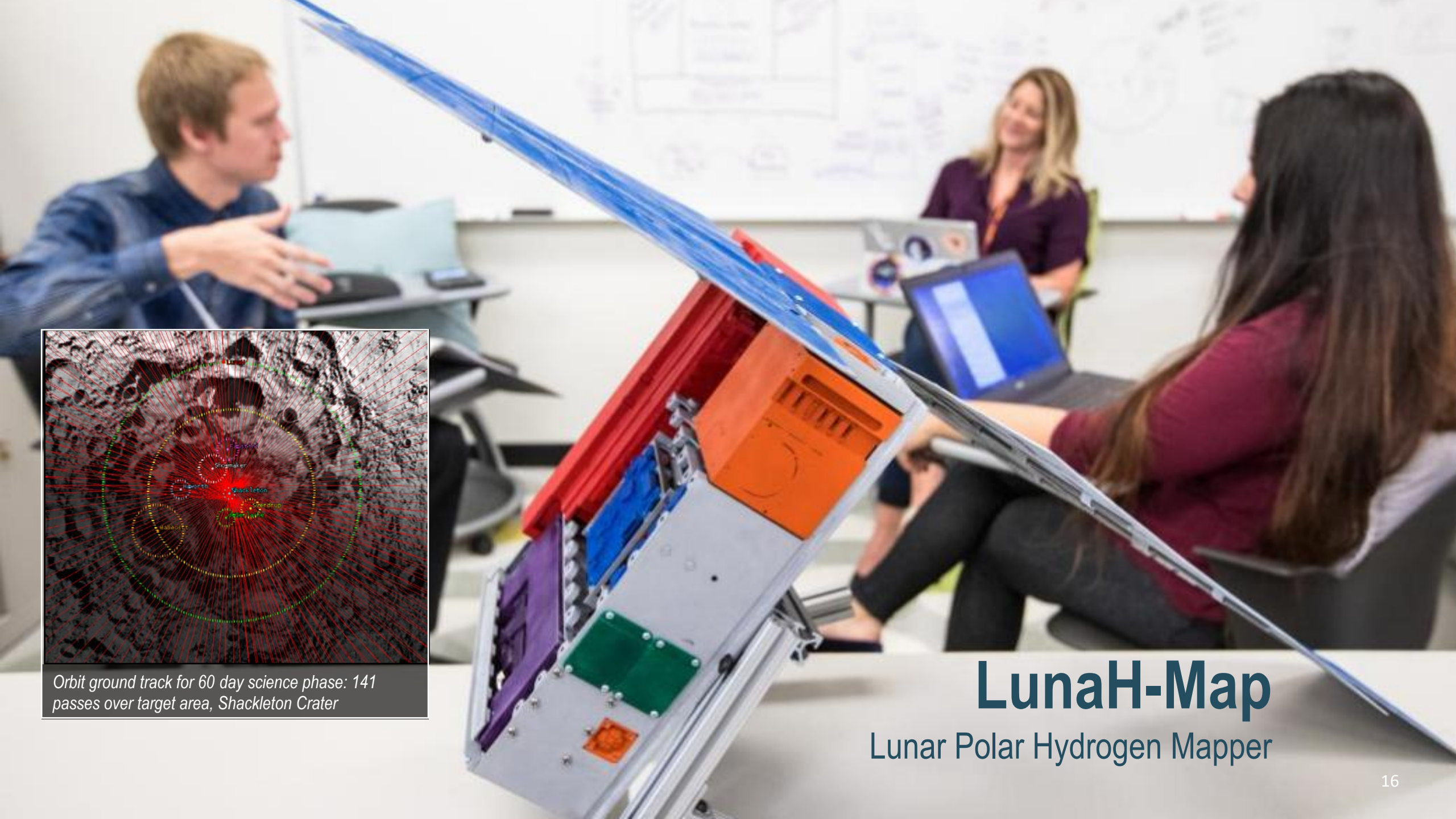




Solar System Exploration Research Virtual Institute

Transformative Lunar Science

- Based on the decadal survey, a SSERVI white paper identified key areas of lunar science, including
 - Establish period of giant planet migration
 - Provide absolute chronology for Solar System events
 - Use accessible vantage from lunar far side to view universe
 - Understand sources of water, and cycles
 - Characterize lunar interior
 - Evaluate plasma interactions w/ surfaces



Orbit ground track for 60 day science phase: 141 passes over target area, Shackleton Crater

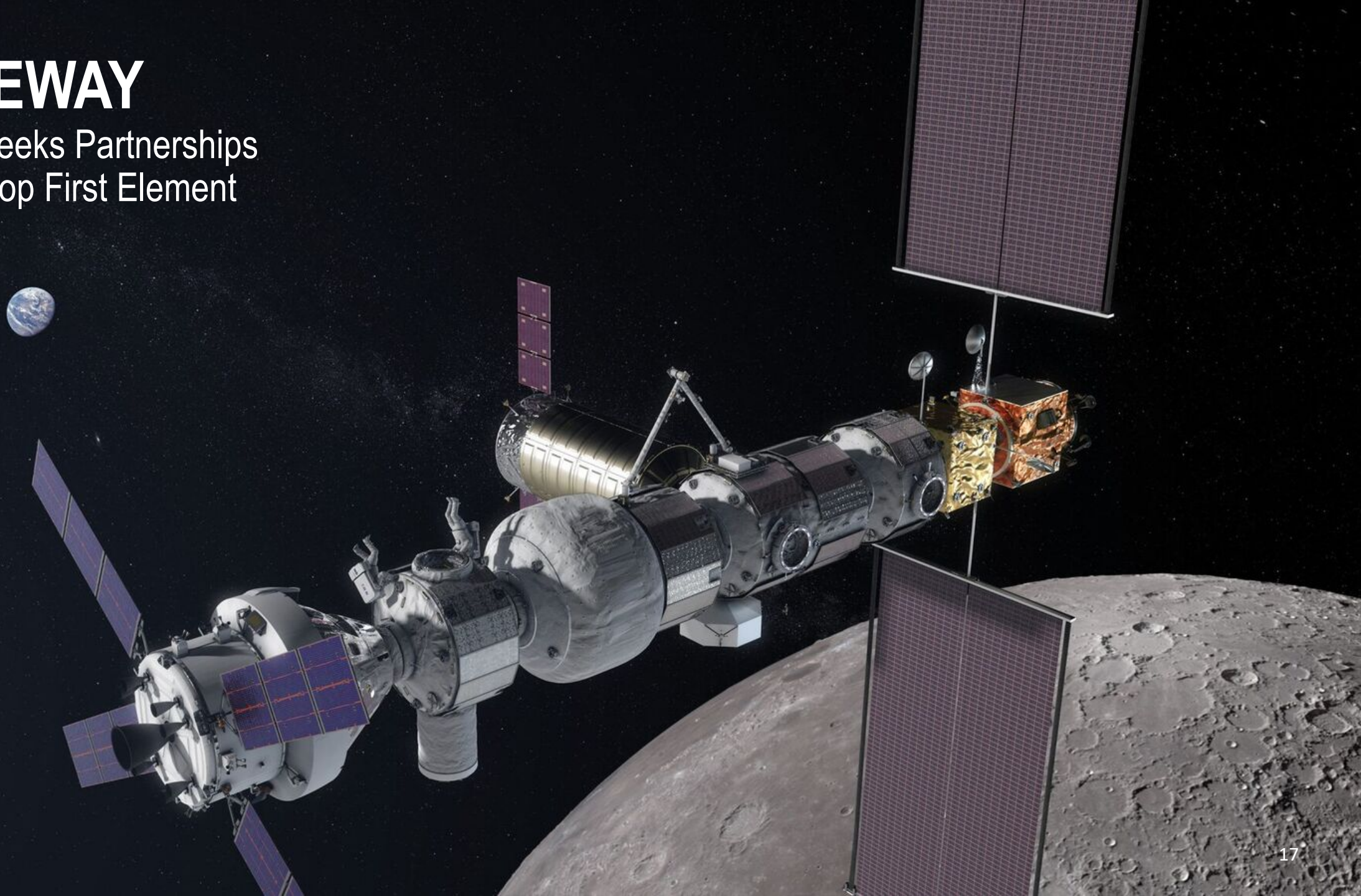


LunaH-Map

Lunar Polar Hydrogen Mapper

GATEWAY

NASA Seeks Partnerships
to Develop First Element



Artistic Rendering

Commercial Lunar Payload Services (CLPS)

- Competition open to US commercial providers of space transportation services, consistent with National Space Transportation Policy and Commercial Space Act
- Multi-vendor catalog, 10-year IDIQ contract, managed through task order competition for specific payload missions
- Structured for NASA as marginal buyer of a commercial service
- Expected release of final RFP August 28, 2018



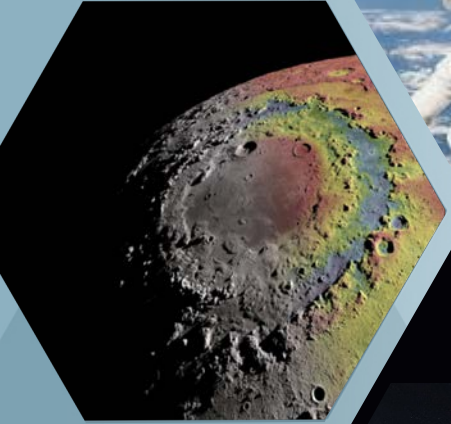
Apollo Next Generation Sample Analysis (ANGSA)

- Maximize science derived from samples returned by Apollo Program in preparation for future lunar missions
- ANGSA solicits research on specially curated materials from Apollo 15, 16, and 17 sample collections
- New research opportunities with current analysis tools
- Research awards in early 2019



NASA SCIENCE & CISLUNAR ACTIVITIES

- NASA Science Mission Update
- Lunar Focus
- Integrated Exploration Strategy



SMD LUNAR INTEGRATION

Astrophysics

Planetary Science

Earth Science

Heliophysics

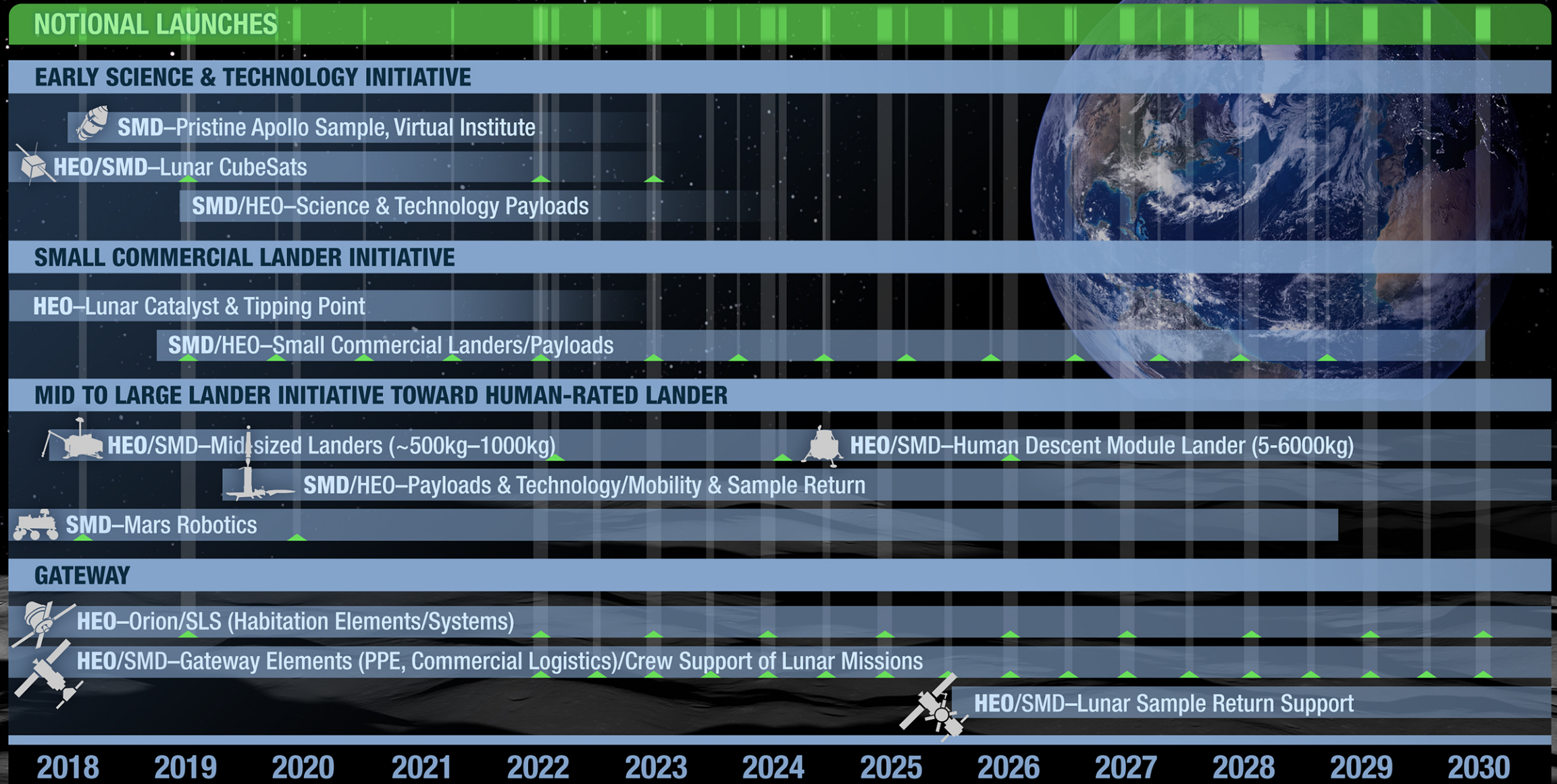




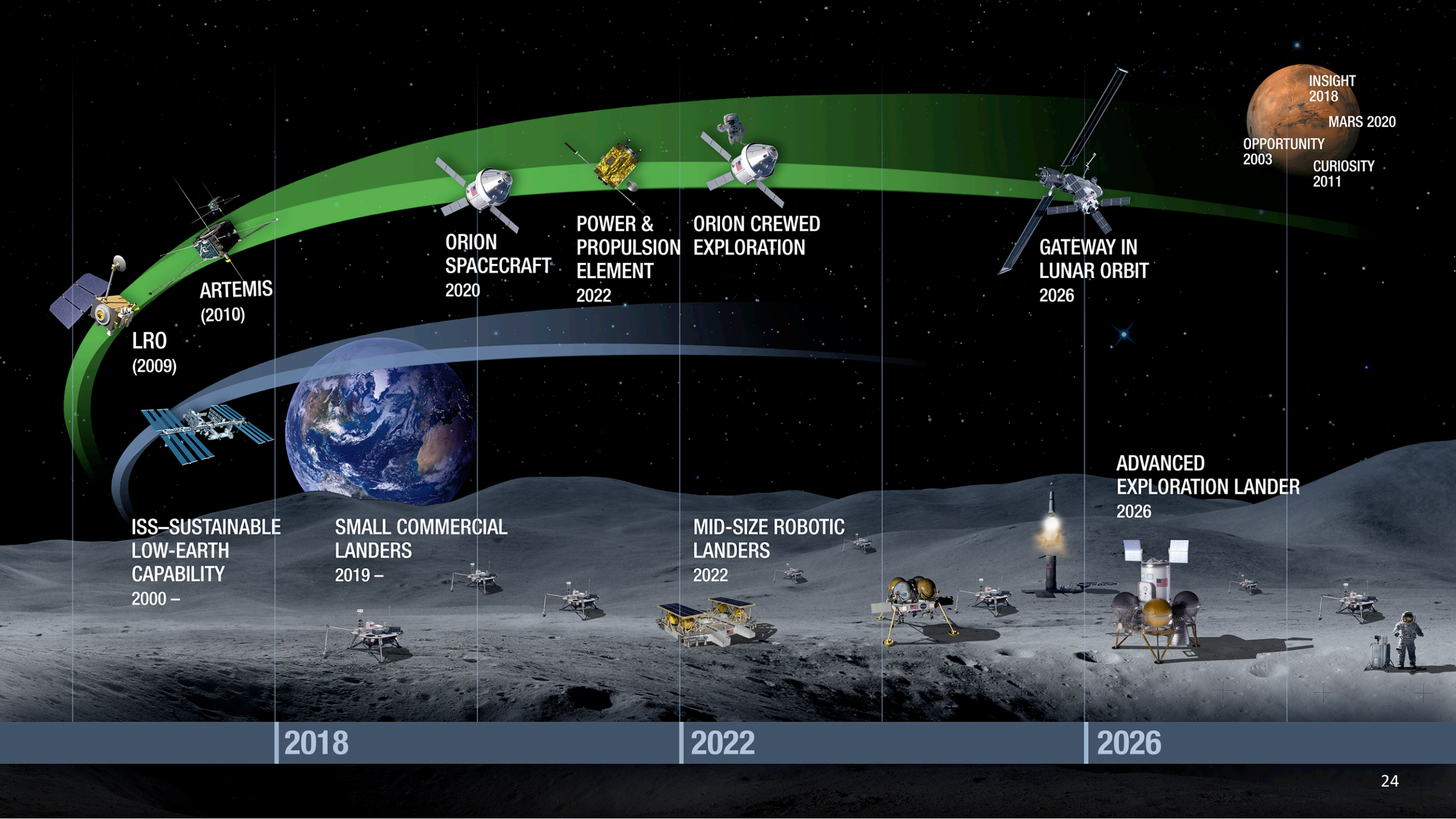
HUMANS AND ROBOTICS

Moon as Human, Robotic Interaction
and Science Platform

NASA Exploration Campaign



Timelines are tentative and will be developed further in FY 2019



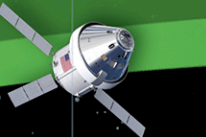
LRO
(2009)

ARTEMIS
(2010)

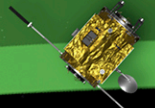
ISS-SUSTAINABLE
LOW-EARTH
CAPABILITY
2000 -



SMALL COMMERCIAL
LANDERS
2019 -



ORION
SPACECRAFT
2020

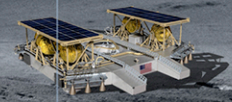


POWER &
PROPULSION
ELEMENT
2022



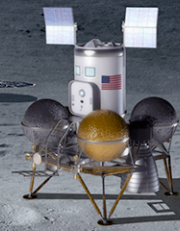
ORION CREWED
EXPLORATION

MID-SIZE ROBOTIC
LANDERS
2022



GATEWAY IN
LUNAR ORBIT
2026

ADVANCED
EXPLORATION LANDER
2026



INSIGHT
2018
MARS 2020
OPPORTUNITY
2003
CURIOSITY
2011




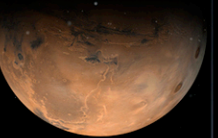



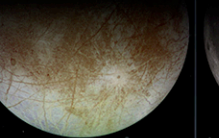








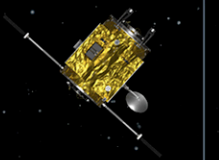

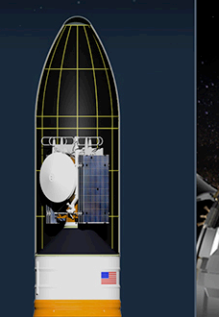
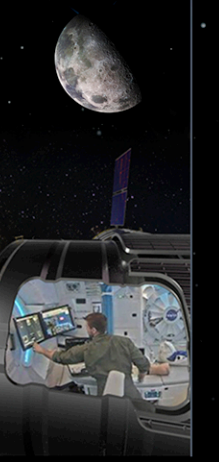
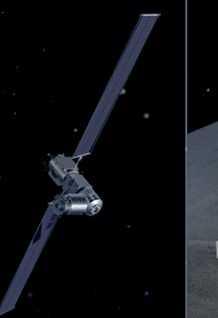
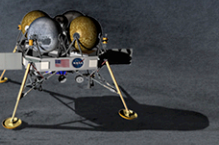


2018

2022

2026

Exploration Firsts

										
CCP Commercial Crew to ISS	CLPS Small Payload Deliveries to the Moon	EM-1 SLS/Orion Flight	MARS 2020 Mars ISRU Test	EM-2 Crewed Mission	GATEWAY PPE Gateway Element	MID-SIZED LANDER Science & Prospecting Lander	EUROPA CLIPPER SLS Cargo	EM-3 Block 1B Crewed Mission to Gateway	GATEWAY LOGISTICS/ARM Deep Space Resupply	LARGE-SIZED LANDER Human Class Demonstration
										
2019	2020		2022			2023	2024			

< 2018 Mars InSight Lander

										
--	---	---	---	---	---	---	---	---	---	---

Lunar/Mars Sample Return 2026 >

