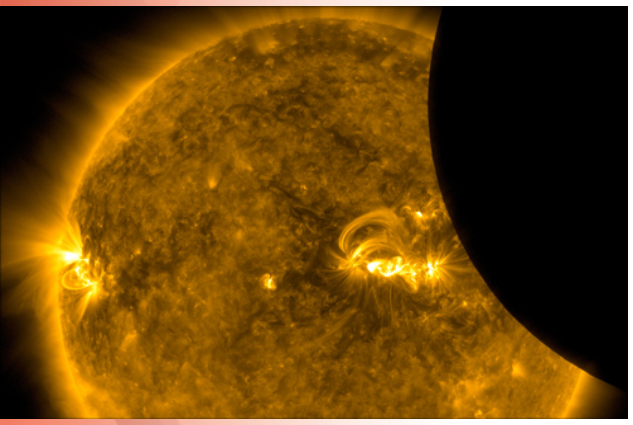
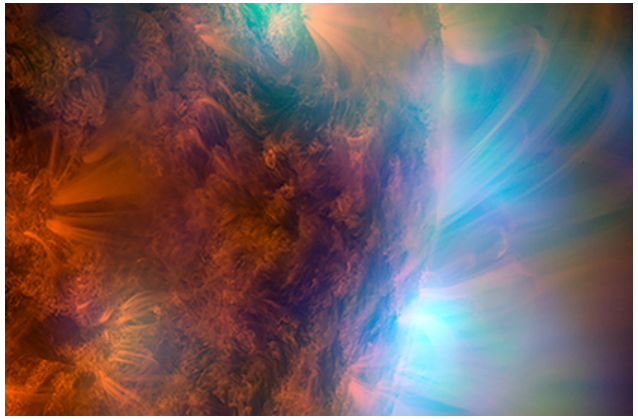
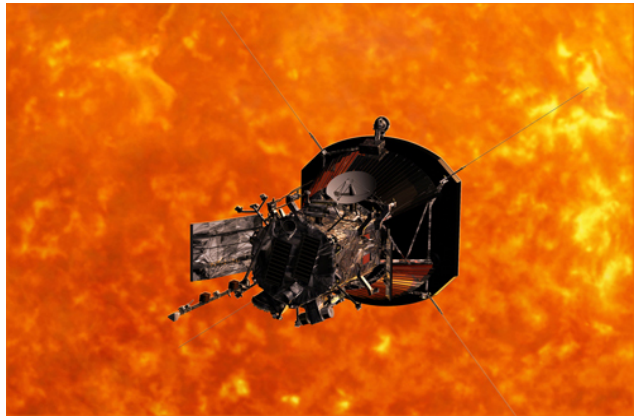
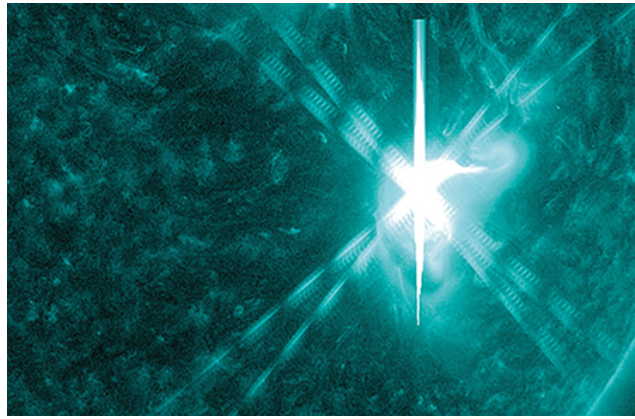
SCIENCE

National Aeronautics and Space Administration

Heliophysics Science and the Lunar Orbital Platform-Gateway

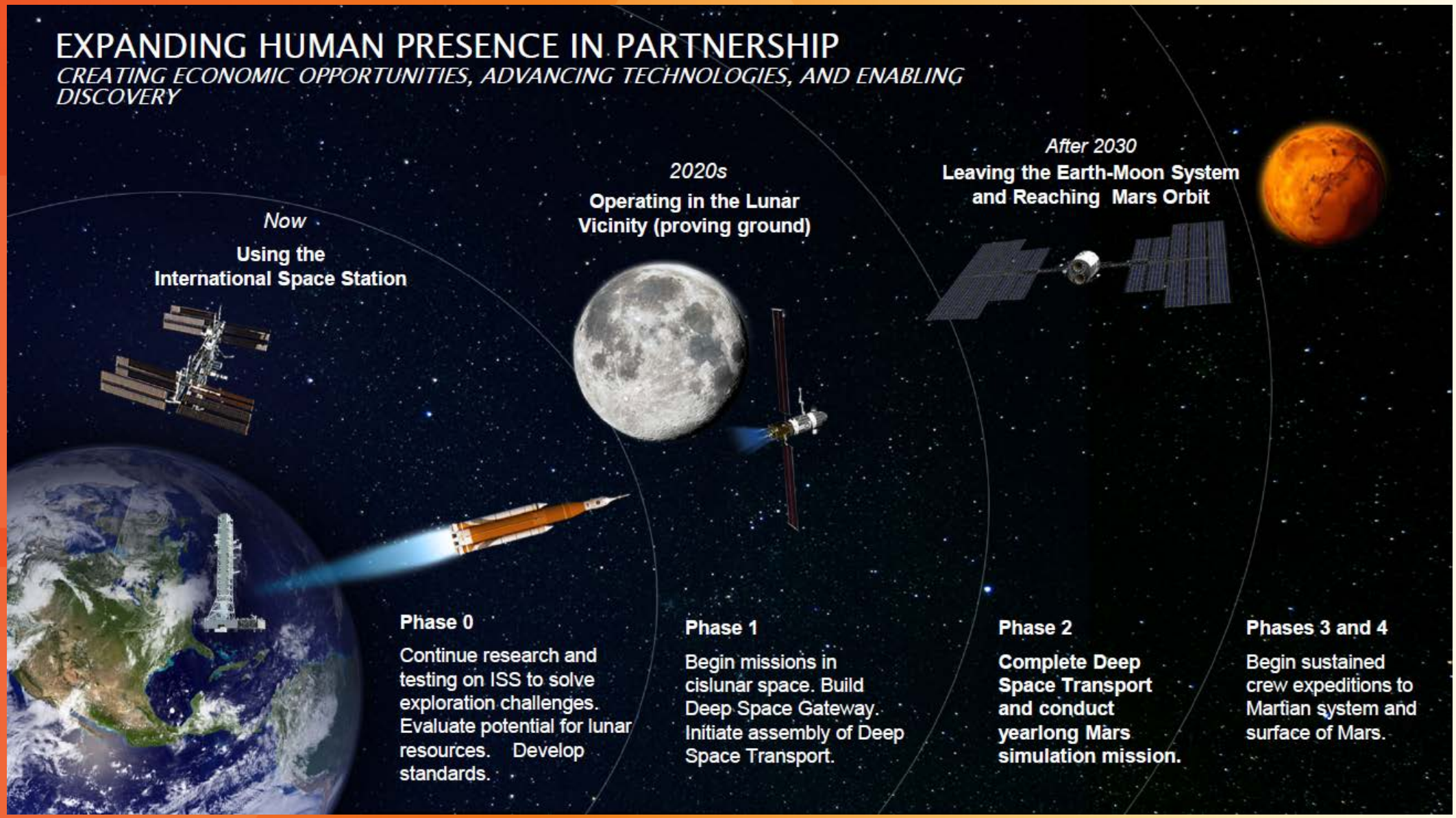
Committee on Solar and Space Physics

Jim Spann

Acting Chief Scientist
Heliophysics Division

28 MARCH 2018

Human Exploration Path Pre-NASA Space Council

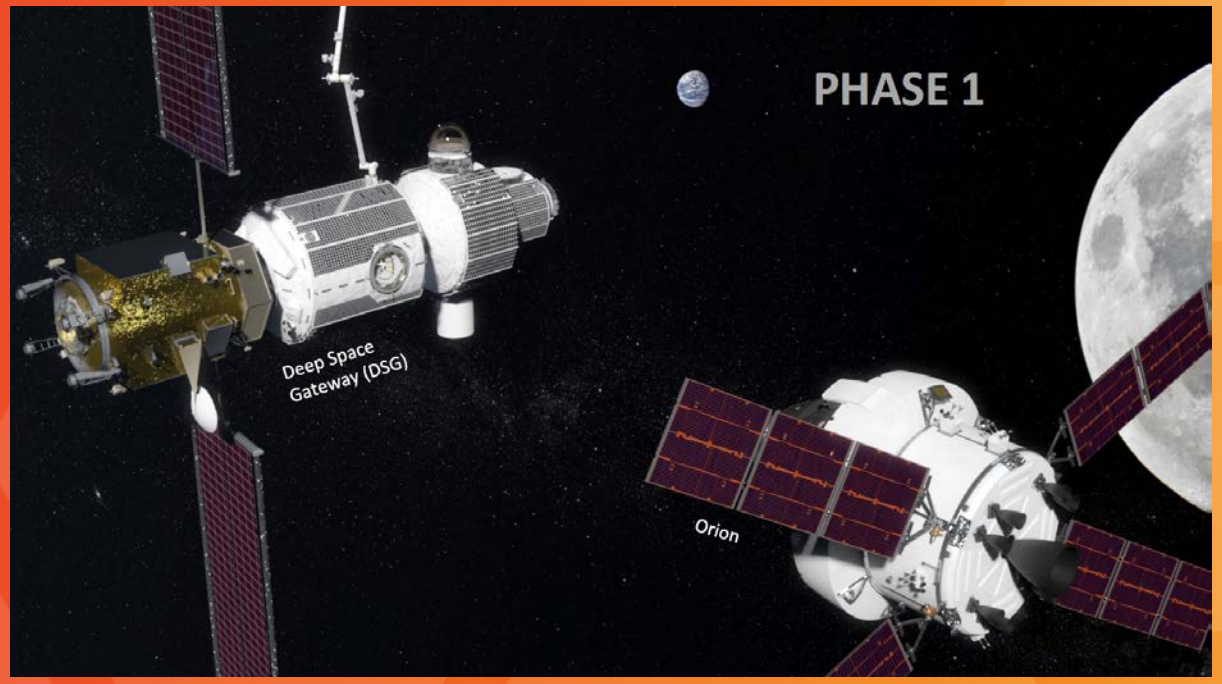


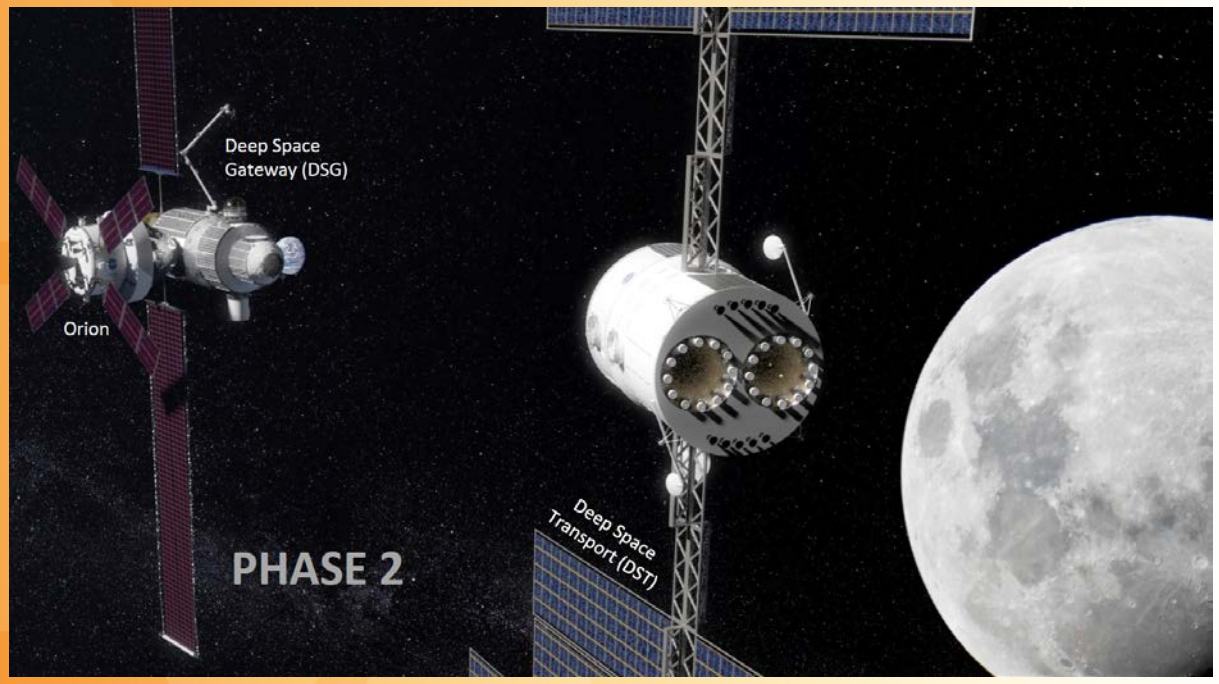
Using a Lunar Orbital Platform-Gateway

The vicinity of the Moon is the next step in a sustainable human exploration endeavor building on the ISS and leading to exploration of the Moon, asteroids, and Mars

- Advance human space flight operations and techniques
- Test technologies and subsystems
- Characterize human health and performance
- Conduct **high priority** science

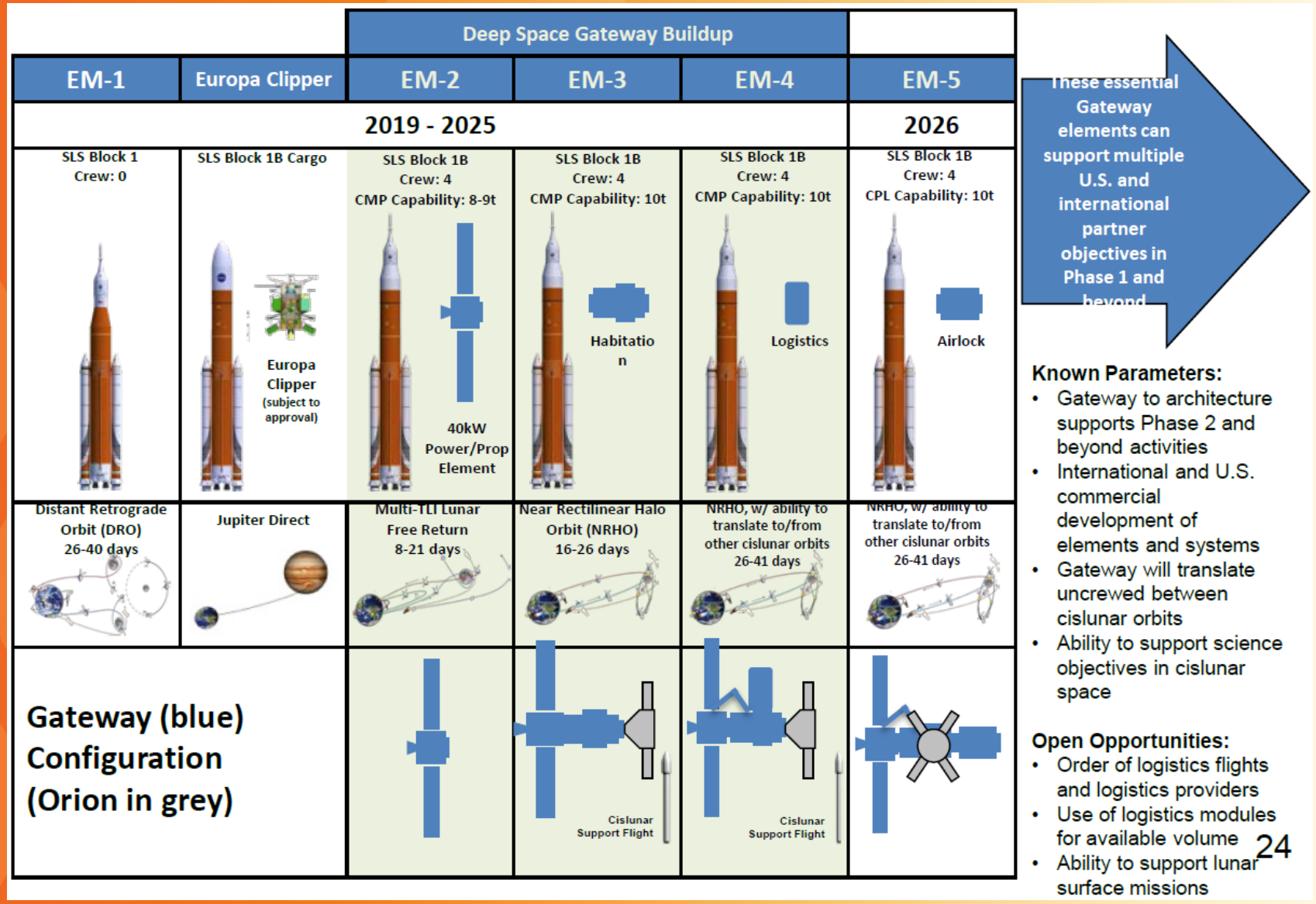
Lunar Orbital Platform-Gateway: Cislunar Stepping Stone





Lunar Orbital Platform-Gateway: Cislunar Stepping Stone

Phase 1



Known Parameters:

- Gateway to 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

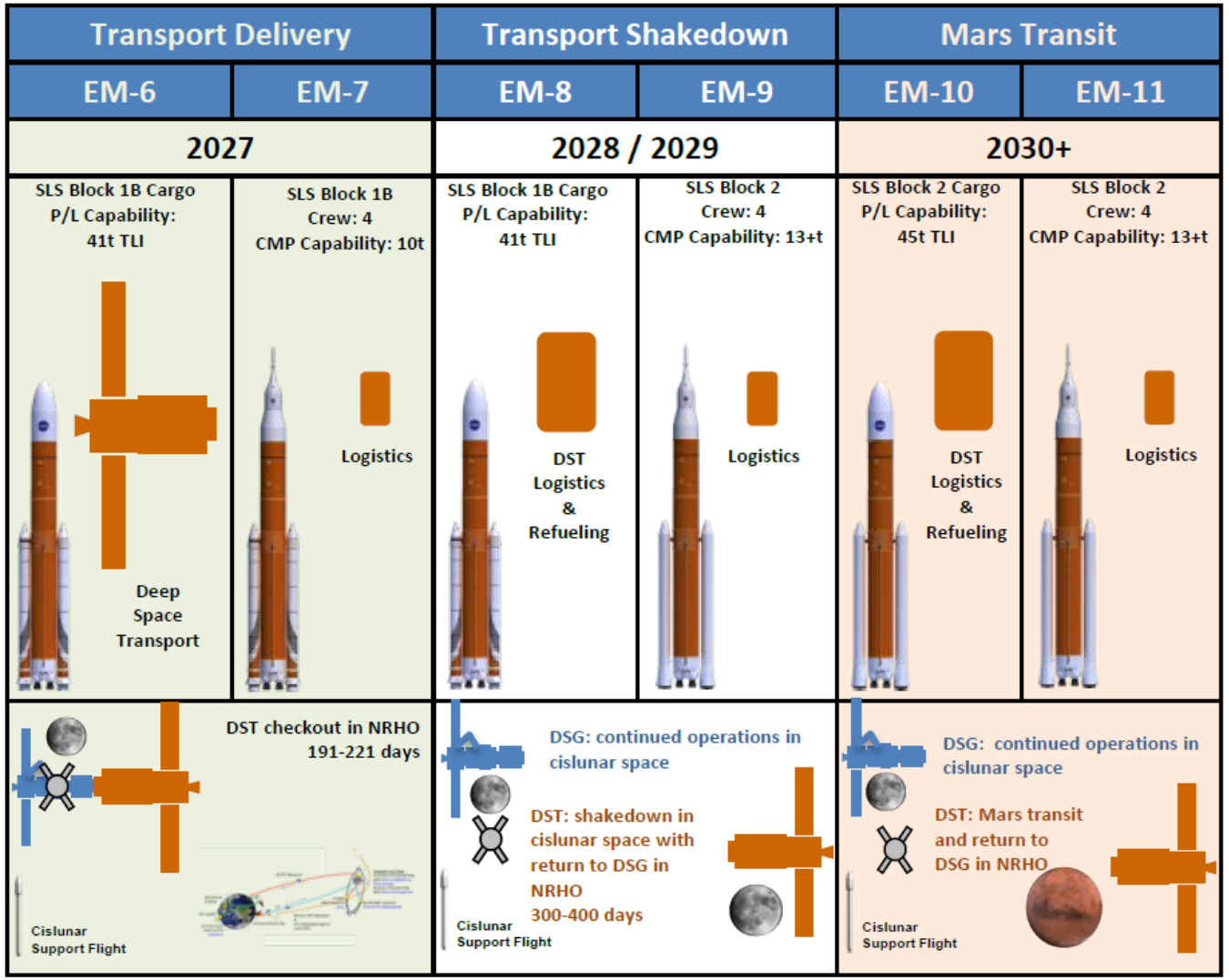
Open Opportunities:

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

24

Lunar Orbital Platform-Gateway: Cislunar Stepping Stone

Phase 2



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:

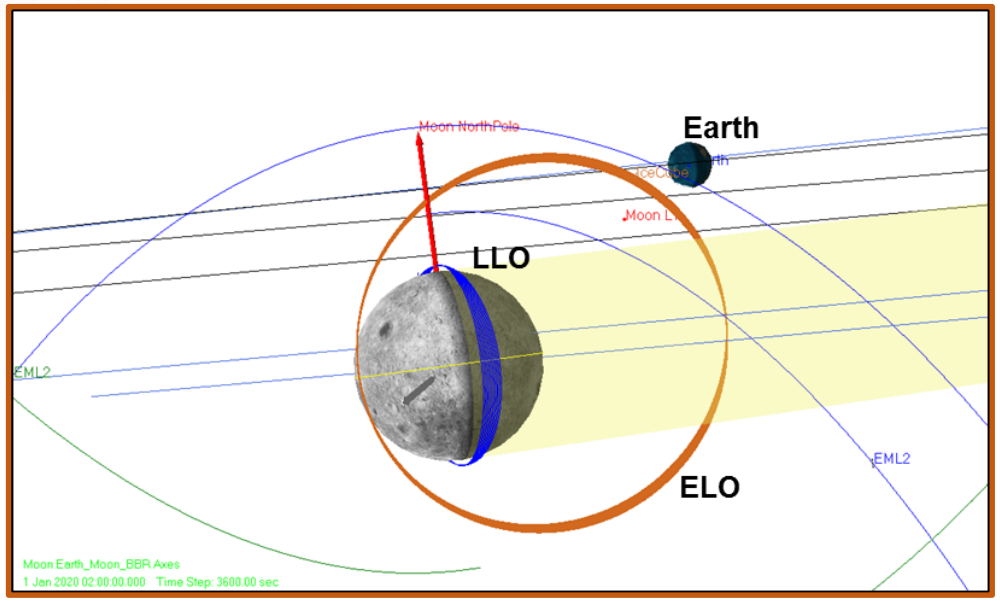
- Order of logistics flights and logistics providers
- Shakedown cruise vehicle configuration and destination/s
- Ability to support lunar surface missions

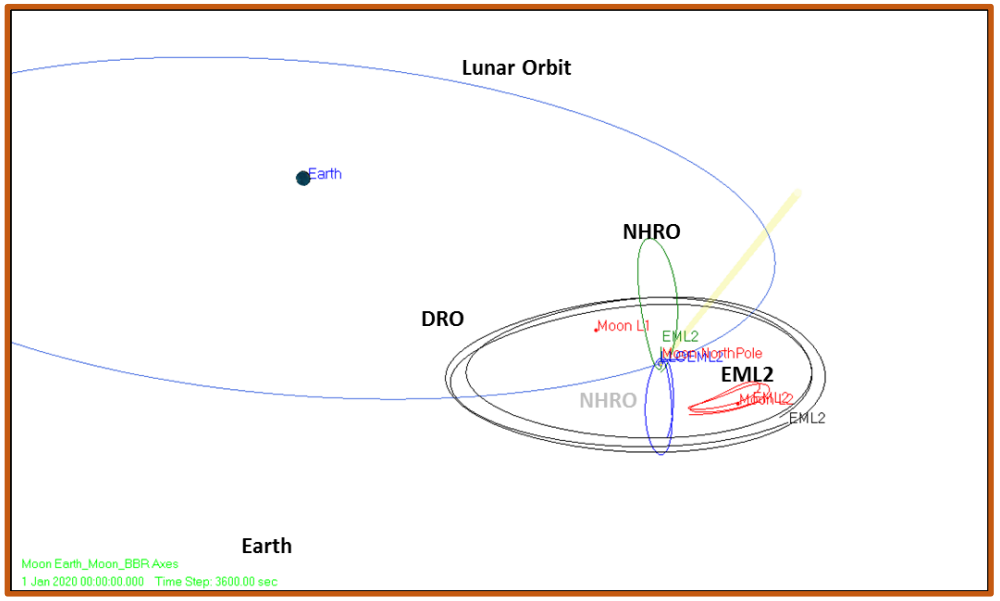
NASA Pre-Decisional

26

Available Modeled Views from Lunar Orbits*

- Low Lunar Orbit (LLO)
- Elliptical Lunar Orbit (ELO)
- Earth-Moon L2 Libration Orbit (EML2)
- Earth-Moon Near Rectilinear Orbit (NHRO)
- Earth-Moon Distant Retrograde Orbit (EMDRO)





**Models available from NASA Goddard Space Flight Center, D. Folta, Code 595, Flight Dynamics*

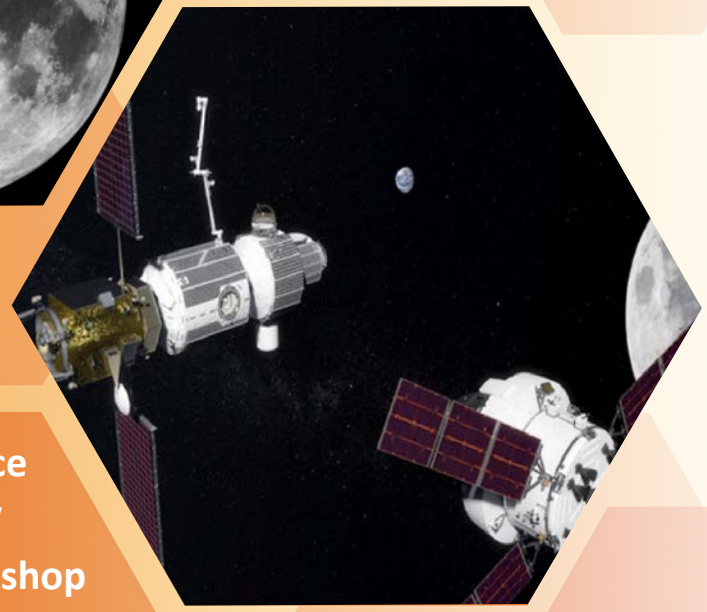
Example: View of Earth and Moon from Elliptical Orbit

Lunar Orbital Platform-Gateway: Concept of Operations

Camera on Curiosity's Arm as Seen by Camera on Mast

- Internal and External workstations and platforms
- Fixed/attached, deployment, retrieval systems
- Pressurized and unpressurized systems
- Science airlock: external/internal exchange/deployment
- Robotic and camera assistance
- Remote control/command: ground, telerobotics
- Crew assistance

Lunar Orbital Platform-Gateway Science/Research Workshop



Deep Space Gateway

Science Workshop

February 27-March 1, 2018

Denver, Colorado

NASA sponsored a three-day workshop in February that engaged the scientific/research communities in Lunar Gateway formulation and determine the best ways the it can be used in its early phases to facilitate science and research

- Purpose
  - discuss science and research that may be leveraged using the DSG
  - provide first-order determination of instruments required to acquire the scientific data
- Based on the successful Tempe Lunar Science Workshop held in 2007
- Over 180 abstracts were presented and 300 Scientists/researchers, engineers, program managers, and decision/policy makers from NASA, academia, industry, and international organizations
- Plenary, discipline-focused, and cross-cutting sessions
- Program with links to all extended abstracts

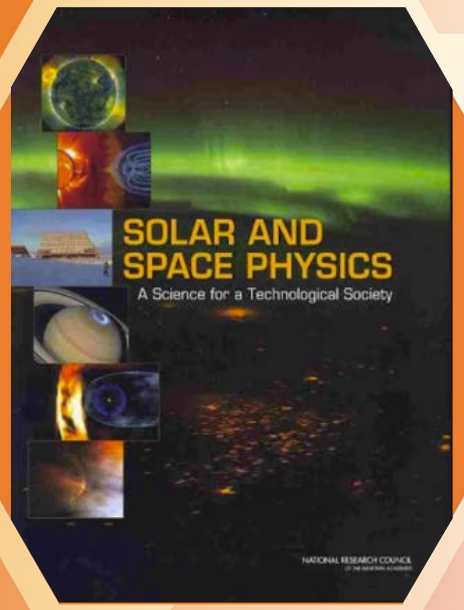
https://www.hou.usra.edu/meetings/deepspace2018/pdf/program.pdf

Lunar Orbital Platform-Gateway Science/Research Workshop

Executive Committee	
NASA HQ	Ben Bussey, HEOMD Chief Scientist
	Michael New, Dep. AA SMD
JSC	Eileen Stansberry, Chief Scientist
	Paul Niles, Executive Secretary
GSFC	Jim Garvin, Chief Scientist
	Sasha Marshak, DSCOVR Deputy PI
MSFC	Jim Spann, Chief Scientist

Advisory Group	
NASA HQ	Brad Carpenter, SLPSRA
JSC	Jennifer Fogarty
	Sam Lawrence
	Bobbie Gail Swan
	Julie Robinson
GSFC	Barbara Giles
	Jake Bleacher
	Ruthan Lewis
MSFC	Caleb Fassett
	Debra Hurwitz Needham
NGO	Dana Hurley, JHU/APL
	Jack Burns, UC-Boulder
	Paul Neitzel, Georgia Tech
	Clive Neal, Univ. of Notre Dame
	Mike Ramsey, Univ. Pittsburgh
ESA	James Carpenter

Heliophysics Lunar Orbital Platform-Gateway Team	
Stuart Bale - UCB	Harlan Spence - UNH
Edward Deluca - SAO	Bill Farrell – GSFC
Sarah Gibson – UCAR	Mihaly Horanyi – LASP
Janet Luhmann - UCB	Lazio, Joseph – JPL
Marit Oieroset - UCB	Rumi Nakamura – AAS
Todd Hoeksema - Stanford	Jeff Newmark – GSFC
Vassilis Angelopoulos - UCLA	Sabrina Savage – MSFC
Nathan A. Schwadron – UNH	Antii Pulkkinen – GSFC
Daniel Winterhalter – JPL	Jerry Goldstein – SwRI
Larry Paxton – APL	Jasper Halekas – Iowa
Lynn Kistler – UNH	Merav Opher - BU

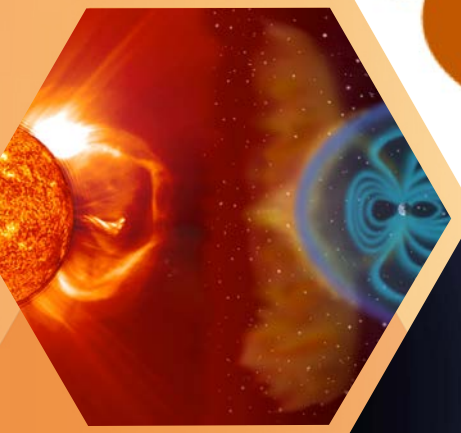


Thinking of Science/Research

- Consider what Decadal science can be achieved by research on the Deep Space Gateway
- Determine what Strategic Knowledge Gaps can be filled
- Determine science/research jointly relevant to human exploration and science/research domains

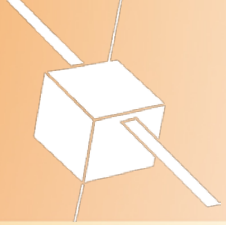
DSG Science Abstracts

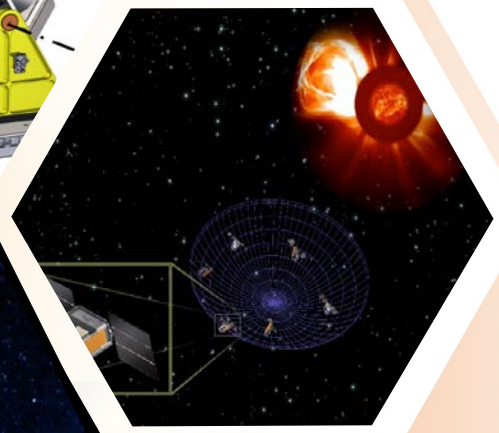
- Over 180 abstracts submitted covering 12 topics:
  - Earth Observation
  - Heliophysics
  - Astrophysics and Fundamental Physics
  - Lunar and Planetary Sciences
  - Human Physiology, Space Biology, and Human Health and Performance
  - Externally Mounted Instrumentation
  - Instruments Inside the Pressurized Modules
  - Receiving and Storing Planetary Samples
  - Science Enabled by Telerobotics
  - Science Enabled by Support/Servicing of Lunar Landers and/or Independent Satellites
  - Use of the Gateway as a Communication Hub for Cubesats
  - Other

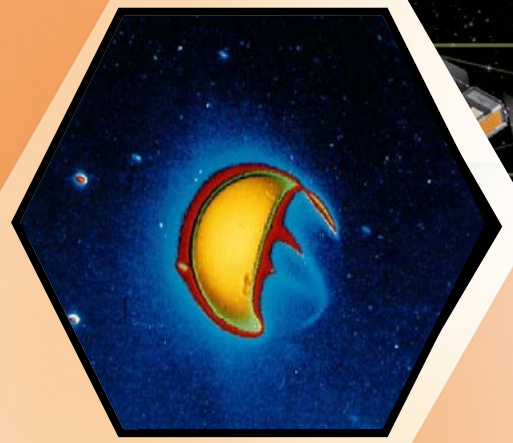


Heliophysics Science and the Deep Space Gateway

- Heliophysics Science of the Moon
  - Characteristics of the near-lunar electromagnetic and plasma environment
  - Magnetotail dynamics at lunar orbit
  - Interaction of plasmas with the moon
  - Characterize and understand the interaction of dust and plasma with the surface of the moon
- Space Weather, Safeguarding the Journey
  - Understand and predict SW impact on robotic and human systems
  - Prototype SW prediction and mitigations for deep space exploration
- The DSG as a Heliophysics Science Platform
- Imaging the heliospheric boundary
- Imaging geospace from lunar orbit
- Analyze the composition of the solar wind
- Potential for a high-energy optical solar observatory







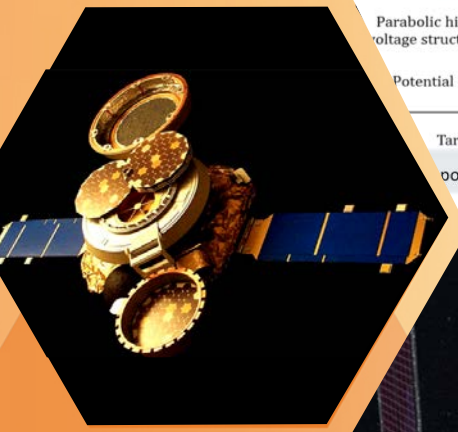
Heliophysics Science and the Deep Space Gateway

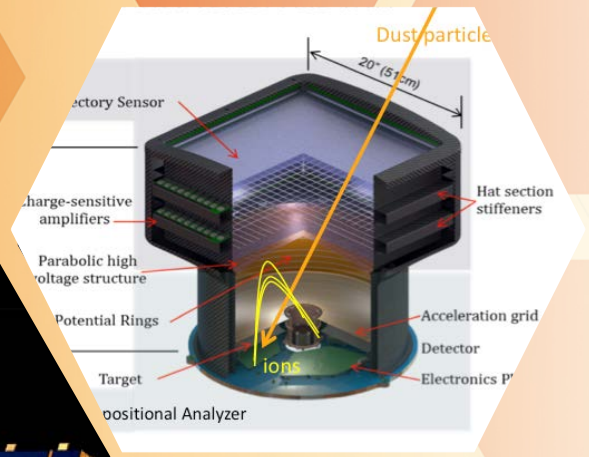
- 33 identified Heliophysics as either primary (25) or secondary (8) focus
  - based on the content of their abstract, more are relevant to Heliophysics
- 38 presentations covered many topics
  - Space weather/radiation - many
  - Remote sensing with external mounted telescopes - several
    - Solar, heliosphere boundary, geospace
  - In situ solar wind & ion outflow observations – a few
  - Lunar surface mounted radio telescope – a few
  - Small satellite concepts (Space weather ensembles and Radio Telescope) – a few
  - Dust experiments (Dust telescope Dust/particle/meteoroid collector) – several

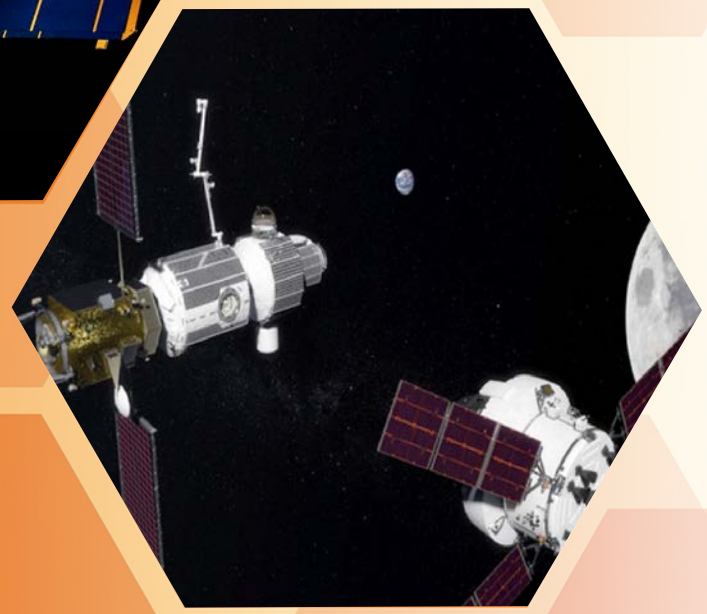
External Payloads Session

- Decadal science with
  - Sun pointing platform
  - Earth pointing platform
  - In situ instrument suite

Dust, Small Particles, and Dusty Plasmas





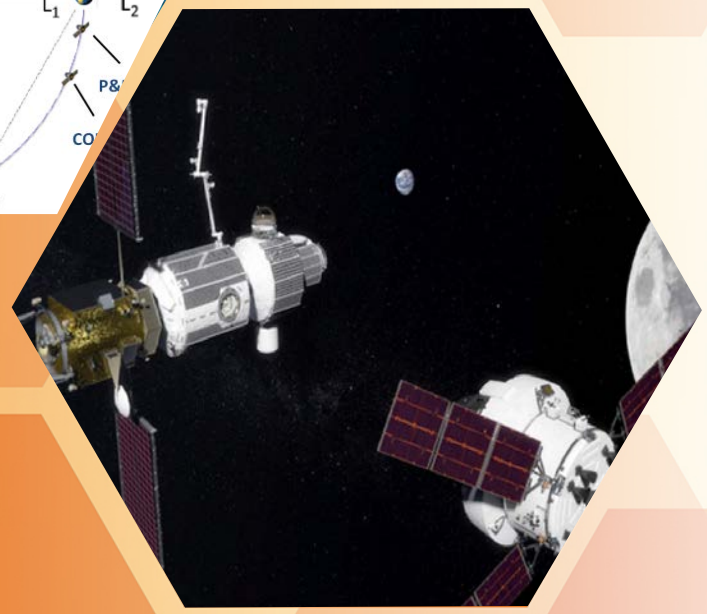


- Fundamental dust/plasma science
- Solar system/planetary origins
- Using
  - Dust telescope
  - Dust/particle/meteoroid collector

Summary Space Weather Session

- Develop, design, test and implement a suite of instruments and associated software tools that will allow astronauts in deep space, off the sun-earth line, to forecast rapidly evolving space weather situations.
- Radiation observations – internal/external to structure

CubeSats and SmallSats



- Provides staging and deployment for small spacecraft
- Lunar vicinity, 1AU
- Using
  - Space weather ensembles
  - Radio Telescope

Summary

- Heliophysics can benefit from the Lunar Obital Platform-Gateway
- Unique perspectives of Geospace
- Development of space weather observatories needed for deep space exploration that cannot rely on Earth connection
- Staging for prototype telescopes and multi-spacecraft mission concepts
- Unique deployment stage for some missions

Heliophysics Science and the Lunar Orbital Platform-Gateway Report ?

- Coordinate Heliophysics community input to the DSG workshop and document that Heliophysics input in the form of a report for later use by Heliophysics strategic planning groups and to inform future Heliophysics technology development efforts. The report is not intended to be advice, nor is it to contain recommendations; rather the report simply consolidates concepts presented at the workshop for later use by SMD and/or HEOMD.

We like the Moon