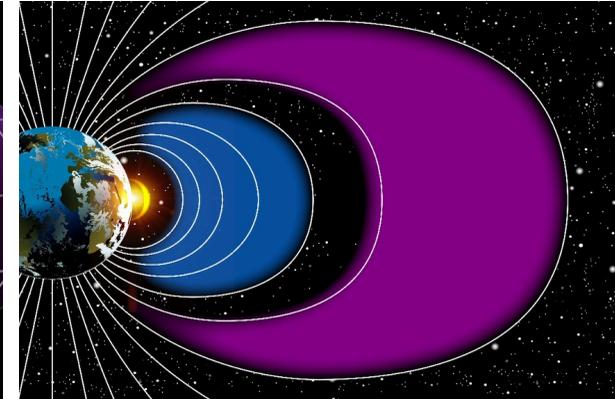
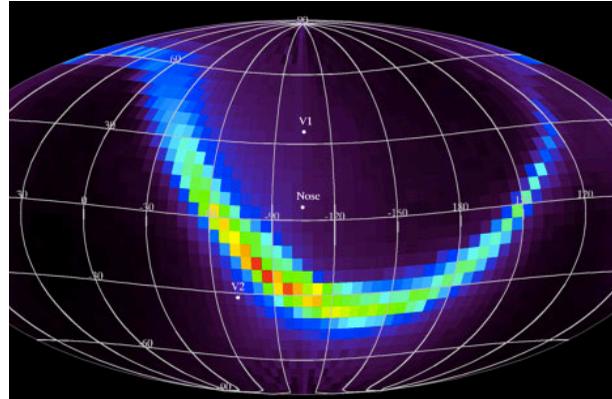
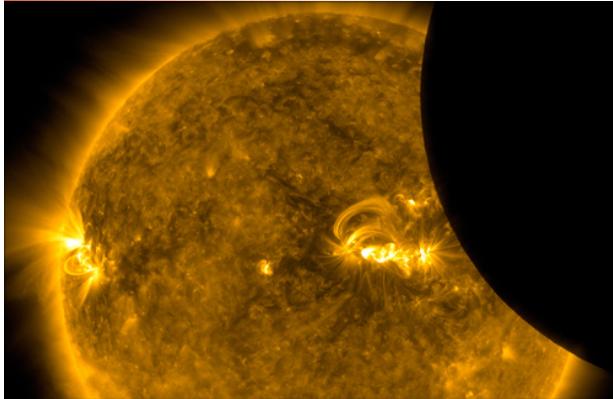


National Aeronautics and
Space Administration



SCIENCE

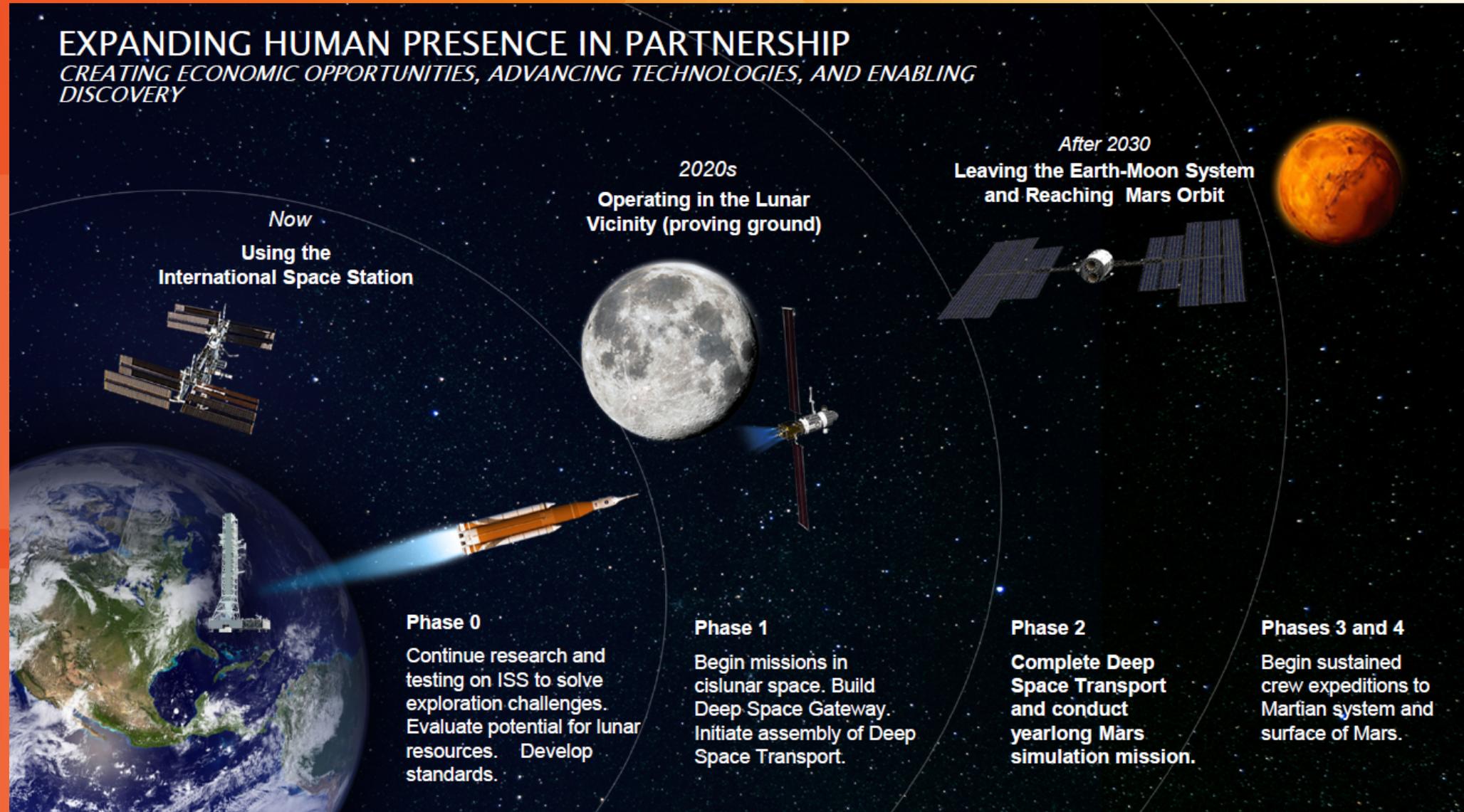


Heliophysics Science and the Lunar Orbital Platform-Gateway *Heliophysics Advisory Committee*

Jim Spann
Acting Chief Scientist
Heliophysics Division

6 April 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

Phase 1

		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 Element	SLS Block 1B Crew: 4 CMP Capability: 10t Habitation	SLS Block 1B Crew: 4 CMP Capability: 10t Logistics	SLS Block 1B Crew: 4 CPL Capability: 10t 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 26-41 days	NRHO, w/ ability to translate to/from other cislunar orbits 26-41 days	
Gateway (blue) Configuration (Orion in grey)			Cislunar Support Flight	Cislunar Support Flight		

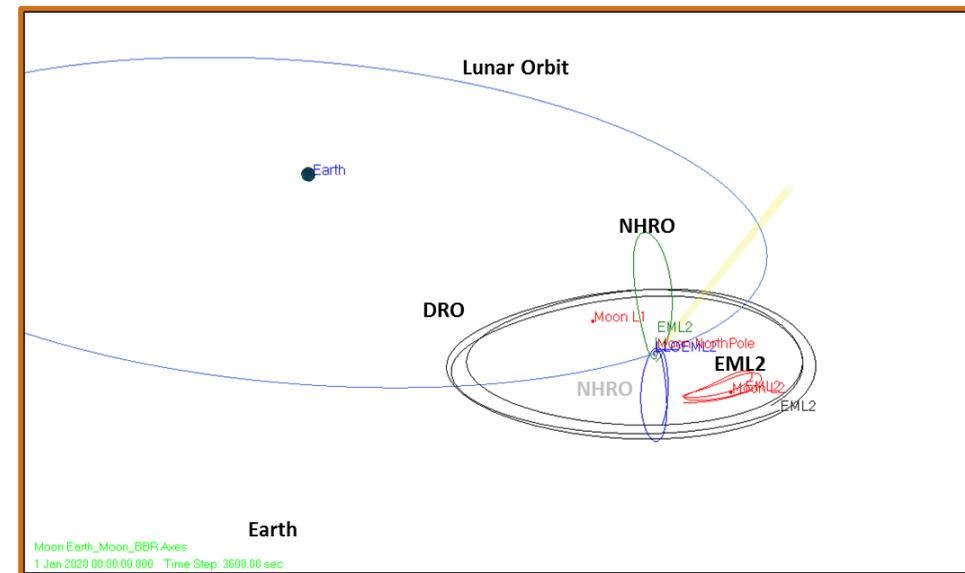
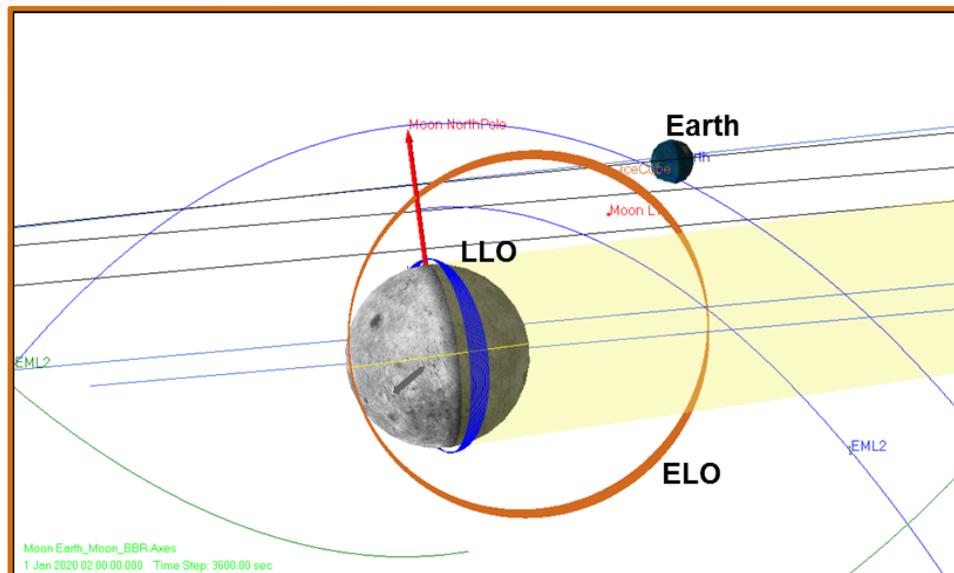
These essential Gateway elements can support multiple U.S. and international partner objectives in Phase 1 and beyond.

- Known Parameters:**
- Gateway 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

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

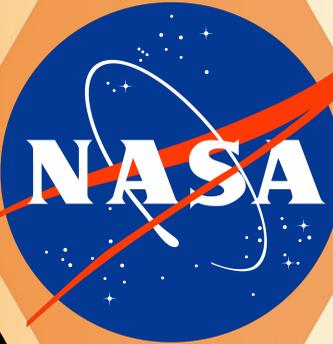


Lunar Orbital Platform-Gateway Science/Research Workshop

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>



Deep Space
Gateway
Science Workshop
February 27-
March 1, 2018
Denver, Colorado

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, DSCOVN Deputy PI
MSFC	Jim Spann, Chief Scientist



Advisory Group

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



University of Colorado
Boulder



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY



University of Pittsburgh



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

Antti Pulkkinen – GSFC

Daniel Winterhalter – JPL

Jerry Goldstein – SwRI

Larry Paxton – APL

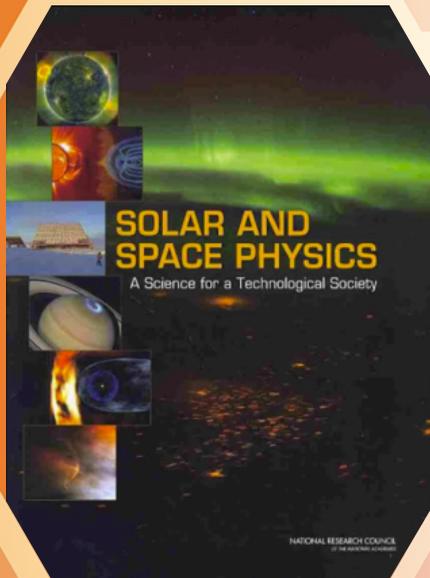
Jasper Halekas – Iowa

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

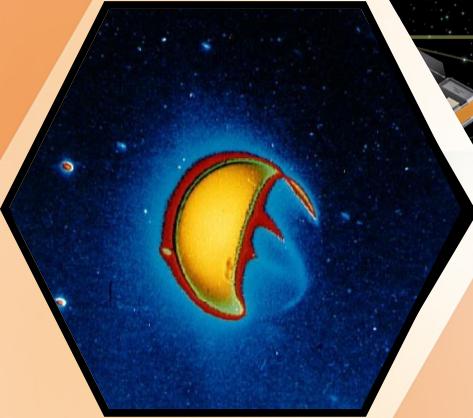
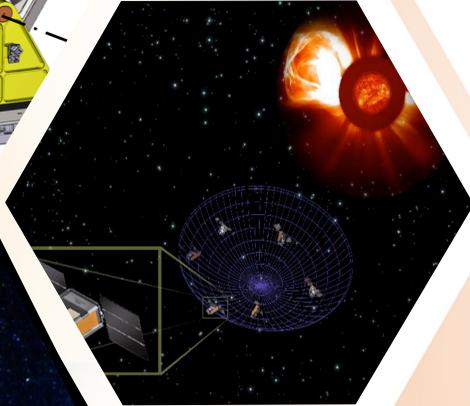
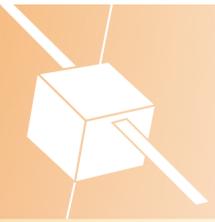


DSG Science Abstracts

- 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/Service 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

- 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



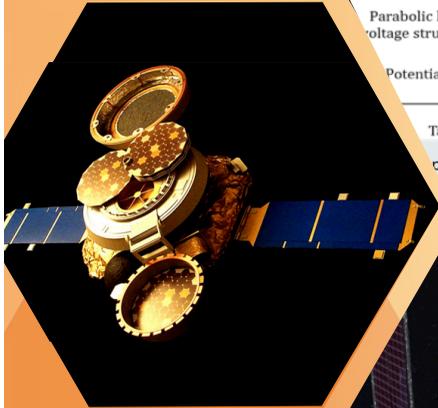
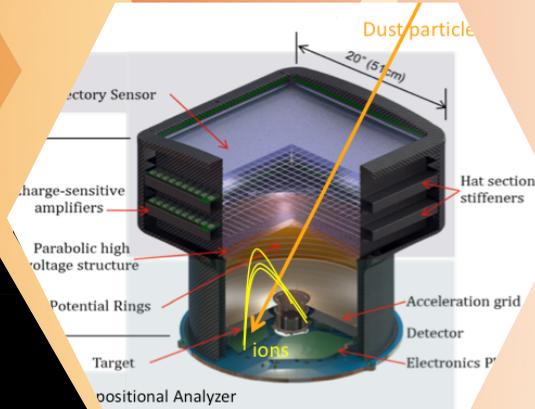
External Payloads Session

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



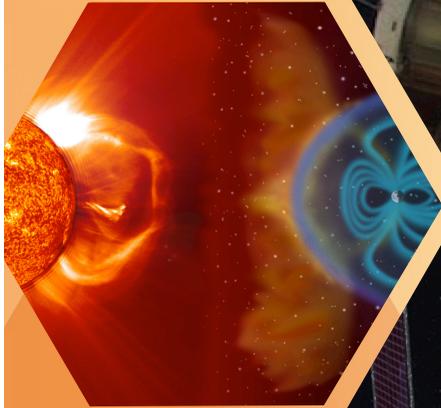
Dust, Small Particles, and Dusty Plasmas

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



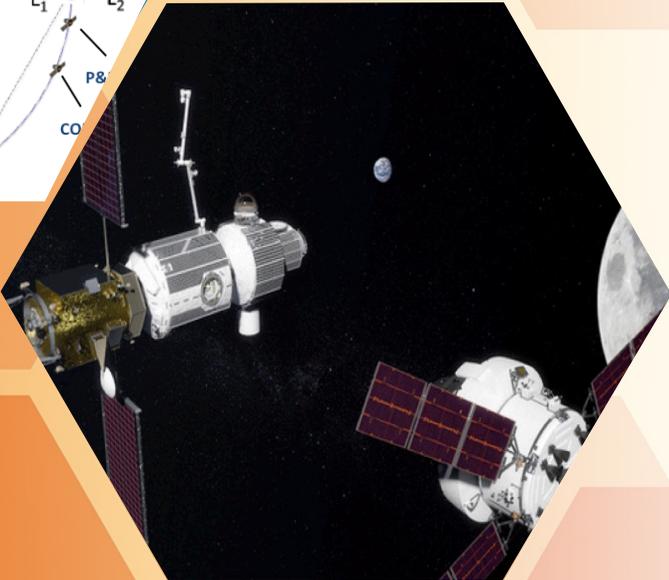
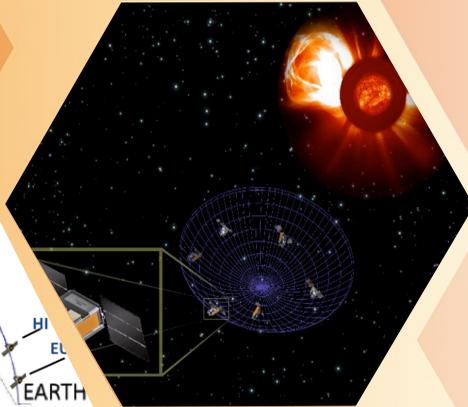
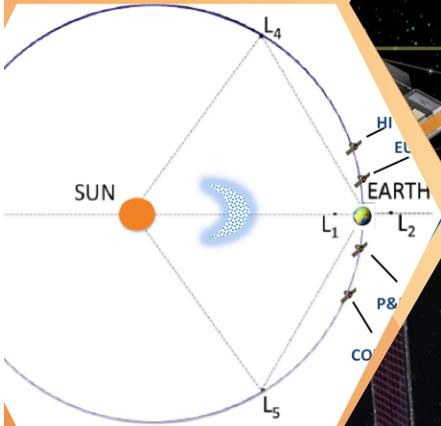
Summary Space Weather Session

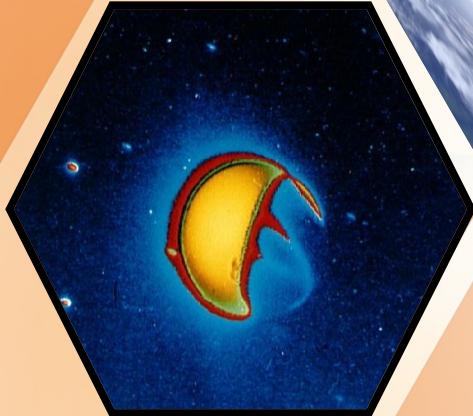
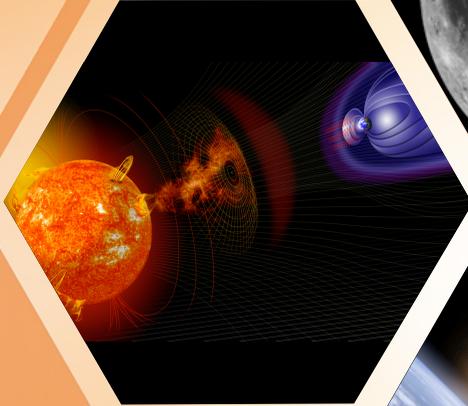
- Develop, design, test and implement a suite of instruments and associated software tools that will allow astronauts in deep space, off the sun-earth line, to forecast rapidly evolving space weather situations.
- Radiation observations – internal/ external to structure



CubeSats and SmallSats

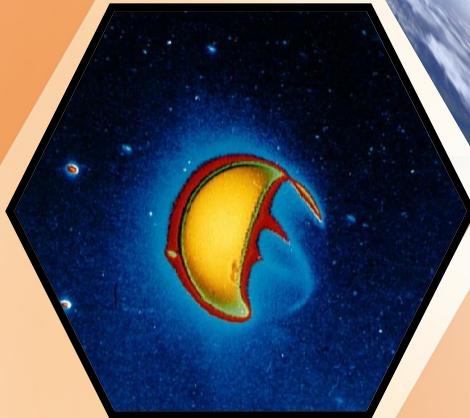
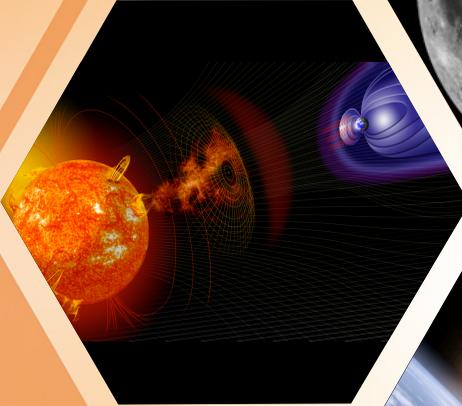
- Provides staging and deployment for small spacecraft
- Lunar vicinity, 1AU
- Using
 - Space weather ensembles
 - Radio Telescope





Summary

- Heliophysics can benefit from the Lunar Orbital 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