Heliophysics Science and the Lunar Orbital Platform-Gateway

Heliophysics Advisory Committee

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Acting Chief Scientist
Heliophysics Division

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Now
Using the International Space Station

EXPANDING HUMAN PRESENCE IN PARTNERSHIP
CREATING ECONOMIC OPPORTUNITIES, ADVANCING TECHNOLOGIES, AND ENABLING DISCOVERY

2020s
Operating in the Lunar Vicinity (proving ground)

Phase 0
Continue research and testing on ISS to solve exploration challenges. Evaluate potential for lunar resources. Develop standards.

Phase 1

Phase 2
Complete Deep Space Transport and conduct yearlong Mars simulation mission.

Phase 3 and 4
Begin sustained crew expeditions to Martian system and surface of Mars.

After 2030
Leaving the Earth-Moon System and Reaching Mars Orbit

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

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<th>EM-1</th>
<th>Europa Clipper</th>
<th>EM-2</th>
<th>EM-3</th>
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<td>CMP Capability: 10t</td>
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<td>Gateway (blue) Configuration (Orion in grey)</td>
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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
### 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 |

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| NASA HQ | Brad Carpenter, SLPSRA  
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|         | Clive Neal, Univ. of Notre Dame  
<p>|         | Mike Ramsey, Univ. Pittsburgh |
| ESA     | James Carpenter |</p>
<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Stuart Bale</td>
<td>UCB</td>
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<td>Harlan Spence</td>
<td>UNH</td>
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<td>Edward Deluca</td>
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<td>Bill Farrell</td>
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<td>Sarah Gibson</td>
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<td>Mihaly Horanyi</td>
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<td>Marit Oieroset</td>
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<td>Rumi Nakamura</td>
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<td>Todd Hoeksema</td>
<td>Stanford</td>
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<td>Jeff Newmark</td>
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<td>Vassilis Angelopoulos</td>
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<td>Sabrina Savage</td>
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<td>Nathan A. Schwadron</td>
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<td>Antii Pulkkinen</td>
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<td>Daniel Winterhalter</td>
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<td>Jerry Goldstein</td>
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<td>Larry Paxton</td>
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<td>Jasper Halekas</td>
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<tr>
<td>Lynn Kistler</td>
<td>UNH</td>
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<td>Merav Opher</td>
<td>BU</td>
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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
• 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

- 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
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