

# PSDS 2013-2022 White Papers

## Community Input Received by Planetary Science Decadal Survey

| Authors         | Title                                                                | Summary                                                                                                                                                                                                                                                                                                     | Panel Selection                                                                           |
|-----------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| David E. Smith  | A budget phasing approach to Europa Jupiter System Mission Science   | Due to budget constraints, the proposed Europa Jupiter System Mission is unlikely to occur as planned. We propose to split EJSM into three small, more affordable and less risky missions that return science earlier (about the same time as the launch date of ELSM) and in easier to accomodate budgets. | Satellites:<br>Galilean satellites, Titan, and the other satellites of the giant planets. |
| Robert M. Kelso | A commercially-leveraged, science-focused, lunar exploration program | Summarizes the NASA work in assessing use of commercially-demonstrated landers and comm systems to enable early access to the lunar surface for science and exploration.                                                                                                                                    | Inner Planets:<br>Mercury, Venus, and the Moon.                                           |

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| <p>Lars Borg</p> <p><b>Co-Authors:</b> Carl Allen, Dave Beaty, Karen Buxbaum, Joy Crisp, Dave Des Marais, Danny Glavin, Monica Grady, Ken Herkenhoff, Richard Mattingly, Scott McLennan, Denis Moura, John Mustard, Lisa Pratt, Steve Symes, Meenakshi Wadhwa</p> | <p>A Consensus Vision for Mars Sample Return</p>                                    | <p>A consensus vision of a Mars Sample Return (MSR) mission concept is presented, reflecting the integration of multiple recent community-based planning discussions. It summarizes the current state of thought regarding the science goals that would be best addressed by samples returned from Mars.</p> | <p>Mars: Not Phobos and Deimos.</p>                                                                                                          |
| <p>William B.C. Crandall</p>                                                                                                                                                                                                                                      | <p>A Decadal Shift: From Space Exploration Science to Space Utilization Science</p> | <p>We urge the Decadal Survey Committee, which is charged with developing “a comprehensive science and mission strategy for planetary science,” to temporarily shift research priorities in the United States from space exploration science to space utilization science.</p>                               | <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |

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A dedicated space observatory for time-domain solar system science

The specific requirements for time-domain solar system science are adequate sampling rates and campaign durations. The observatory must be spaceborne both to satisfy the time-domain requirements as well as to maintain access to the dynamically significant ultraviolet spectral range.

Inner Planets: Mercury, Venus, and the Moon.  
Mars: Not Phobos and Deimos.  
Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.  
Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.  
Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.

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| <p>E. Robert Kursinski</p> <p><b>Co-Authors:</b><br/>James Lyons,<br/>Claire Newman,<br/>Mark Richardson</p>                                                                                                                                                                   | <p>A Dual Satellite Mission Concept for Martian Climate and Chemistry</p>                                 | <p>mm-wavelength satellite to satellite occultations combined with solar occultation and thermal IR emission aerosol measurements will tightly and uniquely constrain processes to answer key open questions about the chemistry and climate of Mars.</p>                                       | <p>Mars: Not Phobos and Deimos.</p>                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <p>J. Edmund Riedel</p> <p><b>Co-Authors:</b><br/>MiMi Aung, Paul G. Backes, David S. Bayard, David S. Berry, John R. Brophy, L. Alberto Cangahuala, Steve A. Chien, Christopher A. Grasso, Jeffery W. Levison, Tomas Martin-Mur, William M. Owen, Jr., Stephen P. Synnott</p> | <p>A Survey of the Technologies Necessary for the Next Decade of Small Body and Planetary Exploration</p> | <p>Deep space reconnaissance and sample return missions will require a range of technology developments for maximum science return. These technologies include propulsion; telecommunication; remote sensing; guidance, navigation and control; sampling; onboard processors; and autonomy.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Mars: Not Phobos and Deimos.<br/>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |

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| <p>James D. Walker</p> <p><b>Co-Authors:</b><br/>Walter F. Huebner,<br/>Sidney Chocron,<br/>Walt Gray, Daniel<br/>Boice</p>                                                                                                                                                                                                                                                                                                                              | <p>Active Seismology<br/>of Asteroids<br/>through Impact<br/>and/or Blast<br/>Loading</p> | <p>We have no direct data on the interior structure of primitive bodies. The interior structure of asteroids is relevant to most solar system formation and evolution theories. Seismology is the only method for determining the interior structure for a range of sizes of asteroids to address.</p> | <p>Primitive Bodies:<br/>Asteroids,<br/>comets, Phobos,<br/>Deimos,<br/>Pluto/Charon and<br/>other Kuiper belt<br/>objects,<br/>meteorites, and<br/>interplanetary<br/>dust.</p> |
| <p>Julian Nott</p> <p><b>Co-Authors:</b> Kim<br/>Reh, Jonathan<br/>Lunine, David L.<br/>Pierce, Patricia<br/>Beauchamp, Tim<br/>Colonus, R.C.<br/>Downs, Jerrold<br/>Marsden, Carl F.<br/>Braun, Don Day,<br/>Michael Arnold,<br/>Wade Allmon,<br/>Dick Bohannon,<br/>Alberto Elfes, John<br/>Elliot, Debora<br/>Fairbrother, Jack<br/>Jones, Jeff Hall,<br/>Greg Mungas,<br/>Michael Pauken,<br/>Rob Sinclair, Luke<br/>Brooke, David<br/>Wakefield</p> | <p>Advanced Titan<br/>Balloon Design<br/>Concepts</p>                                     | <p>Numerous studies agree that Titan is of outstanding scientific interest and Montgolfiere balloons ideal for its exploration. This paper examines balloon operations, weather and steering. It suggests novel concepts that may encourage radical thinking about Titan balloon designs.</p>          | <p>Satellites:<br/>Galilean satellites,<br/>Titan, and the<br/>other satellites of<br/>the giant planets.</p>                                                                    |

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| <p>Carl Pilcher</p> <p><b>Co-Authors:</b><br/> Kevin P. Hand,<br/> Patricia M.<br/> Beauchamp, David<br/> Des Marais, David<br/> Grinspoon, Karen<br/> J. Meech, Sean N.<br/> Raymond</p> | <p>An Astrobiological<br/> Lens on Planetary<br/> System Science</p> | <p>Astrobiology provides a lens through which all of planetary science and solar system exploration, as well as life on Earth, can be viewed. Astrobiology, like planetary science, is a systems-level science. In planetary science, one must understand connections be<br/> [CHARACTERS NOT ACCEPTED BEYOND THIS</p> | <p>Inner Planets:<br/> Mercury, Venus,<br/> and the Moon.<br/> Mars: Not Phobos<br/> and Deimos.<br/> Giant Planets:<br/> Jupiter, Saturn,<br/> Uranus, Neptune,<br/> and exoplanets,<br/> including rings<br/> and magnetic<br/> fields, but not<br/> their satellites.<br/> Satellites:<br/> Galilean satellites,<br/> Titan, and the<br/> other satellites of<br/> the giant planets.<br/> Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p> |
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| <p>Olga Prieto<br/> Ballesteros</p> <p><b>Co-Authors:</b><br/> Kevin P. Hand,<br/> Ariel Anbar, Felipe<br/> Gómez-Gómez,<br/> Oleg Korablev,<br/> Ralph Lorenz,<br/> Ralph Milliken,<br/> Daniel Prieur,<br/> Francois Raulin,<br/> Steve Vance,<br/> Michel Viso</p> | <p>Astrobiology in<br/> Europa and Jupiter<br/> System Mission<br/> (EJSM)</p> | <p>This paper describe the Astrobiology science in EJSM and the opportunities of having in situ elements in future missions.</p>                                                                                                                                                                                | <p>Giant Planets:<br/> Jupiter, Saturn,<br/> Uranus, Neptune,<br/> and exoplanets,<br/> including rings<br/> and magnetic<br/> fields, but not<br/> their satellites.</p> |

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| <p>Carl Pilcher</p> <p><b>Co-Authors:</b> Kevin P. Hand, Patricia M. Beauchamp, David Des Marais, David Grinspoon, Karen J. Meech, Sean N. Raymond</p> | <p>Astrobiology<br/>Priorities for<br/>Planetary Science<br/>Flight Missions</p> | <p>We have posited in another white paper that all of Planetary System Science can be seen through an astrobiological lens. In this paper we present priorities for flight mission investigations derived by applying that lens to the Planetary Science flight mission program.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Mars: Not Phobos and Deimos.<br/>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Jack D. Farmer</p> <p><b>Co-Authors:</b> Mark Allen, Tori Hoehler, Michael Mischna</p>                                                              | <p>Astrobiology<br/>Research and<br/>Technology<br/>Priorities for Mars</p>      | <p>This white paper provides a broad overview of the major science and technology drivers for the next decade of Mars exploration.</p>                                                                                                                                               | <p>Mars: Not Phobos and Deimos.</p>                                                                                                                                                                                                                                                                                                                                                                                                                           |



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| <p>Alan P. Boss</p> <p><b>Co-Authors:</b><br/>Edward Young,<br/>Victoria Meadows,<br/>Nader<br/>Haghighipour</p>                                                                                                                                                                                                                                                                                                                                                                                       | <p>Astrobiology<br/>Research Priorities<br/>for Exoplanets</p>                       | <p>We recommend that the Decadal Survey place a high priority on continued, even expanded, support of the Research &amp; Analysis programs that fund the efforts of exoplanet theorists, laboratory workers, and observers through NASA's and NSF's research programs.</p> | <p>Giant Planets:<br/>Jupiter, Saturn,<br/>Uranus, Neptune,<br/>and exoplanets,<br/>including rings<br/>and magnetic<br/>fields, but not<br/>their satellites.</p> |
| <p>Ariel D. Anbar</p> <p><b>Co-Authors:</b><br/>David Grinspoon,<br/>Sean C. Solomon,<br/>G. Jeffrey Taylor</p>                                                                                                                                                                                                                                                                                                                                                                                        | <p>Astrobiology<br/>Research Priorities<br/>for Mercury, Venus,<br/>and the Moon</p> | <p>This paper describes the value of exploration of Mercury, Venus and the Moon for the field of astrobiology and specifies high priority goals.</p>                                                                                                                       | <p>Inner Planets:<br/>Mercury, Venus,<br/>and the Moon.</p>                                                                                                        |
| <p>Dante S. Lauretta</p> <p><b>Co-Authors:</b> Paul<br/>Abell, Carlton<br/>Allen, Ariel Anbar,<br/>Olivier Barnouin-<br/>Jha, M. Antonella<br/>Barucci, E. Beau<br/>Bierhaus, Richard<br/>P. Binzel, William<br/>F. Bottke, Steven<br/>R. Chesley, Beth E.<br/>Clark, Edward<br/>Cloutis, Harold C.<br/>Connolly, Jr.,<br/>Michael J. Drake,<br/>Jason P. Dworkin,<br/>M. Darby Dyar,<br/>Jack Farmer,<br/>Rebecca Ghent,<br/>Daniel P. Glavin,<br/>Nader<br/>Haghighipour,<br/>Vicky E. Hamilton,</p> | <p>Astrobiology</p>                                                                  | <p>Study of primitive asteroids is fundamental to understanding the origin, distribution, and evolution of volatile and organic</p>                                                                                                                                        | <p>Primitive Bodies:<br/>Asteroids,<br/>comets, Phobos,<br/>Deimos,</p>                                                                                            |

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| <p>Carl W. Hergenrother, Kip Hodges, Lindsay P. Keller, Detlef Koschny, John Marshall, Scott Messenger, Steven Mielke, Keiko Nakamura-Messenger, Joseph A. Nuth, Dennis Reuter, Frans J. M. Rietmeijer, Kevin Righter, Waddell Robey, Michal Rozyczka, Nicolaus Copernicus, Farid Salama, Scott A. Sandford, Daniel J. Scheeres, Everett Shock, Steve Vance, Brian D. Wade, Kosei E. Yamaguchi</p> | <p>Research Priorities for Primitive Asteroids</p>                 | <p>compounds in the early Solar System. This paper outlines six major research focus areas and recommends three mission concepts, which are listed in priority order.</p>                                                                                                                                    | <p>Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>       |
| <p>Dirk Schulze-Makuch</p> <p><b>Co-Authors:</b><br/>Francois Raulin, Cynthia Phillips, Kevin Hand, Susanne Neuer, Brad Dalton</p>                                                                                                                                                                                                                                                                 | <p>Astrobiology Research Priorities for the Outer Solar System</p> | <p>The outer solar system provides a rewarding assortment of planetary diversity of high interest to astrobiology. This White Paper for the 2009-2011 Planetary Science Decadal Survey evaluates the planetary bodies in the outer solar system and their value to the search for life and astrobiology.</p> | <p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p> |
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Astrobiology  
Sample Acquisition  
and Return

This paper outlines an Astrobiology Sample Acquisition and Return mission based on the MEPAG Mid Range Rover concept mission for Mars exploration.

Mars: Not Phobos  
and Deimos.

Nathan J. Strange

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Astrodynamics  
Research and  
Analysis Funding

Funding for astrodynamics research has been largely limited to the development and operations phases of missions. Early funding for astrodynamics research would produce new techniques prior to formulation of missions, which could lead to novel and exciting concepts.

Inner Planets:  
Mercury, Venus,  
and the Moon.  
Mars: Not Phobos  
and Deimos.  
Giant Planets:  
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Uranus, Neptune,  
and exoplanets,  
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Primitive Bodies:  
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Pluto/Charon and  
other Kuiper belt  
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meteorites, and  
interplanetary  
dust.

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| <p>Oleksandr Potashko</p>                                                                                  | <p>Atmosphere as Sign of Life</p>                       | <p>Is there a feature of presence of life on a macro-level? Could we say something about life on Neptune or on Halley’s Comet or on an exoplanet? Let’s consider that sign of life is an atmosphere. Let's consider crustal planet. Whether planet has an atmosphere we may say that it is alive in geologi</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/> Mars: Not Phobos and Deimos.<br/> Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/> Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/> Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Michael Mischna</p> <p><b>Co-Authors:</b><br/> Michael Smith,<br/> Rob Kursinski,<br/> Don Banfield</p> | <p>Atmospheric Science Research Priorities for Mars</p> | <p>This paper addresses the exploration of the martian atmosphere, and focuses on broad atmospheric science goals that can be obtained from orbit. It presents the key questions in atmospheric science that remain unanswered, and what progress can be made towards answering them in the coming decade.</p>  | <p>Mars: Not Phobos and Deimos.</p>                                                                                                                                                                                                                                                                                                                                                                                                                               |

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| <p>Eliot F. Young</p> <p><b>Co-Authors:</b><br/> Charles Hibbitts,<br/> Joshua Emery,<br/> Amanda Hendrix,<br/> William Merline,<br/> William Grundy,<br/> Kurt Retherford</p>                                                                    | <p>Balloon-Borne<br/> Telescopes for<br/> Planetary Science:<br/> Imaging and<br/> Photometry</p> | <p>This white paper advocates the use of balloon-borne telescopes for diffraction-limited imaging in visible wavelengths by demonstrating their technical readiness and low cost relative to space- and ground-based facilities.</p>                                                                       | <p>Inner Planets:<br/> Mercury, Venus,<br/> and the Moon.<br/> Mars: Not Phobos<br/> and Deimos.<br/> Giant Planets:<br/> Jupiter, Saturn,<br/> Uranus, Neptune,<br/> and exoplanets,<br/> including rings<br/> and magnetic<br/> fields, but not<br/> their satellites.<br/> Satellites:<br/> Galilean satellites,<br/> Titan, and the<br/> other satellites of<br/> the giant planets.<br/> Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p> |
| <p>Andrew F. Cheng</p> <p><b>Co-Authors:</b><br/> Andrew Rivkin,<br/> Patrick Michel,<br/> Carey Lisse, Kevin<br/> Walsh, Keith Noll,<br/> Darin Ragozzine,<br/> Clark Chapman,<br/> William Merline,<br/> Lance Benner,<br/> Daniel Scheeres</p> | <p>Binary and Multiple<br/> Systems</p>                                                           | <p>A sizable fraction of small bodies is found in binary or multiple systems. Understanding the formation processes of such systems is critical to understanding collisional and dynamical evolution. Missions can offer enhanced science return if they target binaries or multiples. [FINAL version]</p> | <p>Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p>                                                                                                                                                                                                                                                                                                                                                                                            |

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| <p>Linda Spilker</p> <p><b>Co-Authors:</b><br/> Robert Pappalardo,<br/> Robert Mitchell,<br/> Michel Blanc,<br/> Robert Brown, Jeff<br/> Cuzzi, Michele<br/> Dougherty, Charles<br/> Elachi, Larry<br/> Esposito, Michael<br/> Flasar, Daniel<br/> Gautier, Tamas<br/> Gombosi, Donald<br/> Gurnett, Arvydas<br/> Kliore, Stamatios<br/> Krimigis, Jonathan<br/> Lunine, Tobias<br/> Owen, Carolyn<br/> Porco, Francois<br/> Raulin, Laurence<br/> Soderblom, Ralf<br/> Srama, Darrell<br/> Strobel, Hunter<br/> Waite, David<br/> Young</p> | <p>Cassini-Huygens<br/> Solstice Mission</p> | <p>Understanding the Saturn system has been greatly enhanced by the Cassini-Huygens mission. The proposed 7-year Cassini Solstice Mission would address new questions that have arisen during the mission, and observe seasonal and temporal change in the Saturn system to prepare for future missions.</p> | <p>Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p> |
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David Grinspoon

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Comparative  
Planetary Climate  
Studies

It is the purpose of this White Paper to draw attention to, and summarize, the important role that planetary exploration, and research with a comparative planetology focus, have played and should continue to play in our understanding of climate, and climate change, on Earth.

Inner Planets:  
Mercury, Venus,  
and the Moon.  
Mars: Not Phobos  
and Deimos.



Brad Jolliff

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Constraining Solar System impact history and evolution of the terrestrial planets with exploration of and samples from the Moon's South Pole-Aitken Basin

A fundamental issue of Solar System science is determining the early history of the terrestrial planets, including giant impact bombardment and the evolution of differentiated crust. Exploration and sampling of the Moon's South Pole–Aitken Basin can illuminate these formative planetary processes.

Inner Planets:  
Mercury, Venus,  
and the Moon.

Reta F. Beebe

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Data Management,  
Preservation and the  
Future of PDS

This paper summarizes the history, evolution and current status of analysis and archiving of planetary science data. It presents goals for PDS 2010, a revised PDS, and addresses conditions needed to achieve those goals.

Inner Planets:  
Mercury, Venus,  
and the Moon.  
Mars: Not Phobos  
and Deimos.  
Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.  
Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.  
Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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| <p>Jasper Halekas</p> <p><b>Co-Authors:</b> M. Fuller, I. Garrick-Bethell, L. L. Hood, C. L. Johnson, K. Lawrence, R. J. Lillis, R. P. Lin, M. Manga, M. E. Purucker, B. P. Weiss</p> | <p>Determining the origins of lunar remanent crustal magnetism</p>                    | <p>The discovery of lunar magnetic fields of crustal origin was a major scientific surprise of the Apollo program. Solving the enigma of lunar remanent crustal magnetization will provide fundamental insights into the thermal history of the lunar core/dynamo, mantle, and crust, and into the processes by which crustal magnetization is acquired on airless bodies - for instance, large basin-forming impacts. Determining the origin and history of lunar crustal magnetism will require the return of oriented samples...</p> | <p>Inner Planets: Mercury, Venus, and the Moon.</p>                                                                                                                                                                            |
| <p>Clive R. Neal</p> <p><b>Co-Authors:</b> Charles K. Shearer, Meenakshi Wadwha, Lars Borg, Bradley Jolliff, Allan Treiman</p>                                                        | <p>Developing Sample Return Technology using the Earth's Moon as a Testing Ground</p> | <p>Lowering cost and risk through development of sample return technologies that can be used on various sample return mission styles is emphasized, as is using the Moon as a testing ground for such technologies.</p>                                                                                                                                                                                                                                                                                                                 | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Mars: Not Phobos and Deimos.<br/>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |

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| <p>Andrew M. Davis</p> <p><b>Co-Authors:</b><br/> Meenakshi Wadhwa, Christine Floss, Bradley L. Jolliff, Scott Messenger, Dimitri A. Papanastassiou, Allan Treiman, Andrew J. Westphal</p>                                                                                       | <p>Development of Capabilities and Instrumentation for Curation and Analysis of Returned Samples</p> | <p>The purpose of this white paper is to emphasize the importance of investments in sample curation and analytical instrument development for the full realization of the science objectives of any sample return missions in the coming decade.</p>                                                  | <p>Inner Planets: Mercury, Venus, and the Moon.<br/> Mars: Not Phobos and Deimos.<br/> Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Glenn Orton</p> <p><b>Co-Authors:</b><br/> Glenn Orton, Padma Yanamandra-Fisher, Leigh Fletcher, Kevin Baines, Imke de Pater, Olivier Mousis, Jean-Pierre Lebreton, Steve Miller<sup>5</sup>, Sang-Joon Kim, Makenzie Lystrup, Kunio Sayanagi, Tom Stallard, Paul Steffes</p> | <p>Earth-Based Observational Support for Spacecraft Exploration of Outer-Planet Atmospheres</p>      | <p>This white paper advocates continued robust Earth-based observational support for spacecraft missions, addressing in particular investigations of Giant Planet atmospheres. Recommendations include upgrades to the NASA IRTF as well as cooperative investments in large or giant telescopes.</p> | <p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.</p>                                                                                           |

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| <p>Saumitra Mukherjee</p> | <p>Effect of Star-burst on Sun-Earth environment</p> | <p>Starbursts produces extragalactic cosmic rays which initiate the Sun to develop low Planetary Indices (Kp) and low Electron flux (E-flux) condition of Sun-Earth Environment which leads to snowfall on earth and some changes in other plants of the solar system</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/> Mars: Not Phobos and Deimos.<br/> Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/> Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/> Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
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| <p>Robert Grimm</p>                                                                                                                                 | <p>Electromagnetic Sounding of Solid Planets and Satellites</p>               | <p>EM methods can sense subsurface structure from meters to a thousand kilometers. This white paper gives a tutorial on material sensitivities, exploration depths, sources, and particularly what measurements must be made for different target bodies, without specific mission endorsements.</p>              | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Mars: Not Phobos and Deimos.<br/>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Peter Tsou</p> <p><b>Co-Authors:</b><br/>Donald E. Brownlee, Isik Kanic, Christophe Sotin, Linda J. Spilker, Nathan Strange, Joseph Vellinga</p> | <p>Enceladus Flyby Sample Return, LIFE (Life Investigation For Enceladus)</p> | <p>One of the most significant discoveries made by the Cassini Mission was finding water ice particles containing organic compounds in the plume emanating from the south pole of Enceladus. Several theories for the origin of life on Earth would also apply to Enceladus. Therefore, it should be of utmos</p> | <p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p>                                                                                                                                                                                                                             |

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| <p>Ian Garrick-Bethell</p> <p><b>Co-Authors:</b><br/>Cassandra Runyon,<br/>Carle Pieters,<br/>Michael Wyatt,<br/>Peter Isaacson,<br/>Linda Elkins-Tanton</p>                                                                                                                                                                                                                                                                                                                                                                                             | <p>Ensuring United States Competitiveness in the 21st Century Global Economy with a Long-Term Lunar Exploration Program</p> | <p>A focused Lunar Exploration Program can help retain United States economic and strategic leadership in the 21st century.</p>                                                                                                                                                                                     | <p>Inner Planets: Mercury, Venus, and the Moon.</p>                                                                                    |
| <p>David H. Atkinson</p> <p><b>Co-Authors:</b><br/>Thomas R. Spilker,<br/>Linda Spilker,<br/>Tony Colaprete,<br/>Tibor Balint,<br/>Robert Frampton,<br/>Sushil Atreya,<br/>Athena Coustenis,<br/>Jeff Cuzzi, Kim Reh, Ethiraj Venkatapathy, Y. Alibert, N. K. Alonge, S. Asmar, G. Bampasidis, K.H. Baines, D. Banfield, J. Barnes, R. Beebe , B. Bezar, G. Bjoraker, B. Buffington, E. Chester, A. Christou, P. DeSai, M.W. Evans, L.N. Fletcher, J. Fortney, R. Gladstone, T. Guillot, M. Hedman, G. Herdrich, M. Hofstadter, A. Howard, R. Hueso,</p> | <p>Entry Probe Missions to the Giant Planets</p>                                                                            | <p>It is recommended that probe missions to the giant planets be performed to help constrain models of solar system formation and the origin and evolution of atmospheres, to provide a basis for comparative studies of the gas and ice giants, and to provide a valuable link to extrasolar planetary systems</p> | <p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.</p> |

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| <p>Karla B. Clark</p>                                                                                                                                                                                                                                                                                                                 | <p>Europa Jupiter System Mission</p> | <p>The baseline EJSM architecture consists the NASA-led Jupiter Europa Orbiter (JEO), and the ESA-led Jupiter Ganymede Orbiter (JGO). Complementary instruments monitor dynamic phenomena, map the Jovian magnetosphere and its interactions with the Galilean satellites, and characterize water oceans beneath</p> | <p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites. Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p> |



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| <p>Wesley A. Traub</p> <p><b>Co-Authors:</b><br/> Charles Beichman,<br/> Ruslan Belikov,<br/> Geoff Bryden,<br/> Mark Clampin and<br/> William Danchi,<br/> Imke de Pater,<br/> Thomas Greene,<br/> Olivier Guyon,<br/> Sara Heap, John<br/> Johnson, Lisa<br/> Kaltenegger,<br/> Jeremy Kasdin,<br/> James Kasting,<br/> Douglas Lin, Jack<br/> Lissauer, Carey<br/> Lisse, Jonathan<br/> Lunine, Bruce<br/> Macintosh, Geoff<br/> Marcy, Mark<br/> Marley, Michael<br/> Meyer, Matt<br/> Mountain, Ben<br/> Oppenheimer,<br/> Glenn Orton, Marc<br/> Postman, Aki<br/> Roberge, Sara<br/> Seager, Eugene<br/> Serabyn and<br/> Christophe Sotin,<br/> Remi Soummer,<br/> Karl Stapelfeldt,<br/> John Trauger,<br/> Stephen Unwin,<br/> Michael Werner</p> | <p>Exoplanets and<br/> Solar System<br/> Exploration</p> | <p>The purpose of this White Paper is to highlight areas of knowledge of our Solar System that will be important in interpreting future observations of exoplanets, especially giant exoplanets, and also how the diversity of exoplanets can inform our understanding of the Solar System.</p> | <p>Giant Planets:<br/> Jupiter, Saturn,<br/> Uranus, Neptune,<br/> and exoplanets,<br/> including rings<br/> and magnetic<br/> fields, but not<br/> their satellites.<br/> Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p> |
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Exploration of  
Europa

Europa's icy surface may hide an ocean of liquid water. We summarize the unanswered questions pertaining to Europa following the Galileo mission, and address how those questions will be answered by suggested missions such as EJSM and a lander, as well as new telescopic and laboratory measurements.

Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.

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| <p>William B. McKinnon</p> <p><b>Co-Authors:</b> S.K. Atreya, K.H. Baines, P.M. Beauchamp, J. Clarke, G.C. Collins, J.E. Connerney, C.J. Hansen, M.D. Hofstadter, T.V. Johnson, R.D. Lorenz, R.T. Pappalardo, C.B. Phillips, J. Radebaugh, P.M. Schenk, L.J. Spilker, T. Spilker, H. Throop, E.P. Turtle, D.A. Williams, T. Balint, A. Coustenis, T. Hurford, J.-P. Lebreton, D.L. Matson, M. McGrath</p> | <p>Exploration Strategy for the Outer Planets 2013-2022: Goals and Priorities</p> | <p>Outer Planets Assessment Group (OPAG) recommends that the DS support 1) the JEO and ESJM flagship, 2) Cassini Solstice Mission, and 3) Technology to permit next Outer Planets flagship to Titan/Enceladus, and assess the feasibility of 4) "small flagship" mission class and 5) a set of NF candidates.</p> | <p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites. Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p> |
| <p>William F. Bottke</p>                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                   |                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                               |

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Exploring the  
Bombardment  
History of the Moon

We discuss our priorities for exploring the Moon's bombardment history: (1) Test the idea of a massive impactor spike 3.8-4.0 billion years ago. (2) Anchor the early Earth-Moon impact flux curve by determining the age of South Pole-Aitken Basin. (3) Establish a precise absolute chronology.

Inner Planets:  
Mercury, Venus,  
and the Moon.

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| Wieczorek, Nicolle<br>Zellner, Maria<br>Zuber                                                                                                                                                                                                            |                                                                                                         |                                                                                                                                                                                                                                                                                                           |                                              |
| Bruce A. Campbell<br><br><b>Co-Authors:</b> John A. Grant, Ted Maxwell, Jeffrey J. Plaut, Anthony Freeman                                                                                                                                                | Exploring the Shallow Subsurface of Mars with Imaging Radar: Scientific Promise and Technical Rationale | Global information on martian near-surface features and physical properties represents a great untapped aspect of the search for habitable zones and evidence of past climate. Imaging radar measurements can penetrate several meters of mantling material and 10's of meters into ice.                  | Mars: Not Phobos and Deimos.                 |
| Marc Fries<br><br><b>Co-Authors:</b> John Armstrong, James Ashley, Luther Beegle, Timothy Jull, Glenn Sellar                                                                                                                                             | Extralunar Materials in Lunar Regolith                                                                  | This paper describes the scientific rationale for locating and studying extralunar material found in lunar regolith. The extreme age and lack of weathering of lunar regolith make it a natural repository for samples from a wide range of parent bodies and across a vast span of solar system history. | Inner Planets: Mercury, Venus, and the Moon. |
| Athena Coustenis<br><br><b>Co-Authors:</b> J. Lunine, D. Matson, K. Reh, P. Beauchamp, J.-M. Charbonnier, L. Bruzzone, M.-T. Capria, A. Coates, C. Hansen, R. Jaumann, J.-P. Lebreton, R. Lopes, R. Lorenz, I. Mueller-Wodarg, F. Raulin, E. Sittler, J. |                                                                                                         |                                                                                                                                                                                                                                                                                                           |                                              |

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Future in situ  
balloon exploration  
of Titan's  
atmosphere and  
surface

Many of the questions  
remaining to be addressed  
after the Cassini-Huygens  
mission require both remote  
and in situ exploration. Our  
understanding of the lower  
atmosphere, surface and  
interior of Titan will benefit  
greatly from detailed  
investigations by a  
montgolfiere, reaching a  
variety of locations

Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.

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| <p>D. Williams, E. Wilson, M. Wright, V. Zivkovic</p>                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                     |                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                               |
| <p>David A. Williams</p> <p><b>Co-Authors:</b> Jani Radebaugh, Rosaly M.C. Lopes, Imke de Pater, Nicholas M. Schneider, Frank Marchis, Julianne Moses, Ashley G. Davies, Jason Perry, Jeffrey S. Kargel, Laszlo P. Keszthelyi, Chris Paranicas, Alfred S. McEwen, Kandis Lea Jessup, David Goldstein, Melissa Bunte, Julie Rathbun, Melissa McGrath, Krishan Khurana, Sébastien Rodriguez, Terry A. Hurford, Amanda R. Hendrix, Michelle Kirchoff, Elizabeth Turtle</p> | <p>Future Io Exploration for 2013-2022 and Beyond, Part 1: Justification and Science Objectives</p> | <p>This white paper (revised draft) summarizes the current scientific questions regarding Jupiter's volcanic moon Io, and the scientific objectives and measurements that need to be accomplished by future exploration. (Final version with additional coauthors).</p> | <p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites. Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p> |

David A. Williams

**Co-Authors:** Jani Radebaugh, Rosaly M.C. Lopes, Imke de Pater, Nicholas M. Schneider, Frank Marchis, Julianne Moses, Ashley G. Davies, Jason Perry, Jeffrey S. Kargel, Laszlo P. Keszthelyi, Chris Paranicas, Alfred S. McEwen, Kandis Lea Jessup, David Goldstein, Melissa Bunte, Julie Rathbun, Melissa McGrath, Krishan Khurana, Sébastien Rodriguez, Terry A. Hurford, Amanda R. Hendrix, Michelle Kirchoff

Future Io  
Exploration for  
2013-2022 and  
Beyond, Part 2:  
Recommendations  
for Missions

This revised white paper lists our recommendations for mission concepts and instruments to accomplish the science objectives for future exploration of Jupiter's moon Io for the decade of 2013-2022 and beyond. (Final version with additional coauthors).

Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.  
Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.



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| <p>John Grant</p> <p><b>Co-Authors:</b> Matt Golombek, Alfred McEwen, Scott Murchie, Frank Seelos, John Mustard, David Des Marais, Ken Tanaka, Gian Ori, Nicolas Mangold, Kate Fishbaugh, Steve Ruff, Dawn Sumner, Brad Jolliff, Ralph Harvey</p> | <p>Future Mars Landing Site Selection Activities</p> | <p>A process for identifying candidate landing sites for future missions should be started and accompanied by creation of funding to support landing site characterization activities. NASA should provide resources to existing missions to enable these activities and consider including instruments for sit</p> | <p>Mars: Not Phobos and Deimos.</p> |
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| <p>Barry Geldzahler</p> <p><b>Co-Author:</b> Les Deutsch</p> | <p>Future Plans for the Deep Space Network (DSN)</p> | <p>NASA’s Deep Space Network (DSN) is a critical part of every NASA solar system mission, serving as the entity that ties the spacecraft back to Earth and providing data from science instruments, information for navigating across the solar system, and valuable radio link science and radar observations.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/> Mars: Not Phobos and Deimos.<br/> Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/> Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/> Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
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Ganymede science  
questions and future  
exploration

This paper summarizes  
outstanding science questions  
about Ganymede and its  
place in the Jupiter system,  
and how further exploration  
would answer these  
questions.

Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.

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| <p>Pamela G. Conrad</p> <p><b>Co-Authors:</b> F. Scott Anderson, Robert C. Anderson, William J. Brinckerhoff, Peter Doran, Victoria E. Hamilton, Joel A. Hurowitz, Alfred S. McEwan, Douglas W. Ming , Dimitri A. Papanastassiou, Timothy D. Swindle</p> | <p>Geochronology and Mars Exploration: Critical Measurements for 21st Century Planetary Science</p>                                                     | <p>We present arguments for geochronology as a high scientific priority for Mars exploration in specific and planetary science in general. We also recommend funding four specific activities toward achieving technical readiness for addressing this priority.</p>                                                | <p>Mars: Not Phobos and Deimos.</p>                 |
| <p>Harrison H. Schmitt</p> <p><b>Co-Authors:</b> Andy Daga, Jeff Plescia</p>                                                                                                                                                                             | <p>Geopolitical Context of Lunar Exploration and Settlement</p>                                                                                         | <p>The Moon has attracted international attention as the current focus of peaceful competition in space. This competition has long term implications for the future of liberty on Earth. If non-democratic regimes dominate exploration and settlement of the Moon, liberty will be at risk. Only the United St</p> | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |
| <p>Mian. M. Abbas</p> <p><b>Co-Authors:</b> A.C. LeClair, D. Tankosic, D.L. Gallagher, R.B. Sheldon, E.A. West, J.C. Brasunas, D.E. Jennings</p>                                                                                                         | <p>Global Distributions of Gas &amp; Dust in the Lunar Atmosphere from Solar Infrared Absorption Measurements with a Fourier Transform Spectrometer</p> | <p>Global Distributions of Dust &amp; Gas in the Lunar Atmosphere may be determined most accurately with the highly sensitive technique of measurements of Solar IR Absorptions with a Infrared Spectrometer on a Lunar Orbiter, in full compliance with the NRC goal of measurements of Global Distributions.</p>  | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |

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Global Imaging of  
Solar Wind-  
Planetary Body  
Interactions using  
Soft X-ray Cameras

We show in this white paper that, with suitable instrumentation on planetary and terrestrial spacecraft, soft X-ray emission associated with the solar wind interaction with planetary neutral atoms can map out the solar wind distribution around planets, including the locations of plasma boundaries.

Inner Planets:  
Mercury, Venus,  
and the Moon.

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| <p>Anthony Wesley</p> <p><b>Co-Authors:</b><br/> Glenn Orton,<br/> Padma<br/> Yanamandra-<br/> Fisher, Leigh<br/> Fletcher, Kevin<br/> Baines,<br/> Christopher Go,<br/> Makenzie Lystrup,<br/> Olivier Mousis,<br/> Imke de Pater,<br/> Jean-Pierre<br/> Lebreton, Kunio<br/> Sayanagi, Timothy<br/> Livengood, Tom<br/> Stallard, Henrik<br/> Mellin, Nigel<br/> Bannister</p>                               | <p>Ground-Based<br/> Support for Solar-<br/> System Exploration:<br/> Continuous<br/> Coverage Visible<br/> Light Imaging of<br/> Solar System<br/> Objects from a<br/> Network of Ground-<br/> Based<br/> Observatories</p> | <p>We propose that the needs of planetary science for event-detection and time-critical observations could be well-served by a global network of low-cost remote-controlled (or autonomous) telescopes optimized for high-resolution visible light imaging of solar system targets.</p> | <p>Inner Planets:<br/> Mercury, Venus,<br/> and the Moon.<br/> Giant Planets:<br/> Jupiter, Saturn,<br/> Uranus, Neptune,<br/> and exoplanets,<br/> including rings<br/> and magnetic<br/> fields, but not<br/> their satellites.</p> |
| <p>Allan Treiman</p> <p><b>Co-Authors:</b><br/> Meenakshi<br/> Wadhwa, Charles<br/> K. Shearer Jr.,<br/> Glenn J.<br/> MacPherson,<br/> James J. Papike,<br/> Gerald J.<br/> Wasserburg,<br/> Christine Floss,<br/> Malcolm J.<br/> Rutherford, George<br/> J. Flynn, Dimitri<br/> Papanastassiou,<br/> Andrew Westphal,<br/> Clive Neal, John<br/> H. Jones, Ralph P.<br/> Harvey, Susanne<br/> Schwenzer</p> | <p>Groundbreaking<br/> Sample Return from<br/> Mars: The Next<br/> Giant Leap in<br/> Understanding the<br/> Red Planet</p>                                                                                                  | <p>The purpose of this white paper is to urge consideration of a groundbreaking sample return from Mars from a previously well characterized site that requires a simple mission architecture to minimize cost and engineering risk, while gaining substantial scientific return.</p>   | <p>Mars: Not Phobos<br/> and Deimos.</p>                                                                                                                                                                                              |

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| <p>Steve Vance</p> <p><b>Co-Authors:</b> Ariel Anbar, Donald D. Blankenship, Bonnie Buratti, Julie Castillo, Geoffrey C. Collins, James B. Dalton III, Jack Farmer, Eberhard Grun, Candice Hansen, Terry Hurford, Hauke Hussmann, Jeff Moore, Robert Pappalardo, Cynthia B. Phillips, Frank Postberg, Elizabeth Turtle, Robert Tyler</p> | <p>Icy Satellite Processes in the Solar System: A plurality of worlds</p> | <p>A comprehensive strategy for Solar System exploration must identify processes common to icy worlds. Such an approach requires continued investment in discovery focused on icy satellites in the size regime 100 km and larger. We elaborate on this concept, giving specific examples and recommendations</p>   | <p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets. Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Michael C. Nolan</p> <p><b>Co-Authors:</b> Lance A. M. Benner, Marina Brozovic, Ellen S. Howell, Jean-Luc Margot</p>                                                                                                                                                                                                                  | <p>Imaging of Near-Earth Asteroids</p>                                    | <p>Imaging of asteroids is necessary to understand their physical structure for studies of solar system formation, impact hazard, and resources for exploration. Ground based imaging is required to study the population of asteroids. Radar imaging at Arecibo and Goldstone currently best achieve this task</p> | <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>                                                                                        |

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| <p>Mian M. Abbas</p> <p><b>Co-Authors:</b> A.C. LeClair, D. Tankosic, P.D. Craven, J.F. Spann, E.A. West</p>                                                                | <p>Importance of Measurements of Charging Properties of Individual Submicron Size Lunar Dust Grains</p> | <p>It is absolutely necessary and of utmost importance to conduct the proposed measurements of charging properties of individual Apollo 11-17 submicron size dust grains by UV radiation and electron impact, at the lunar thermal cycle, for developing any believable lunar dust transportation models.</p>  | <p>Inner Planets: Mercury, Venus, and the Moon.</p>                                                                                                                                                                                                                                                                                                                                                                          |
| <p>Eberhard Gruen</p> <p><b>Co-Authors:</b> Frank Postberg, Harald Krüger, Mihaly Horanyi, Elmar Jessberger Sascha Kempf, Ralf Srama, Thomas Stephan, Zoltan Sternovsky</p> | <p>In-Situ Mass Spectrometry of Atmosphereless Planetary Objects</p>                                    | <p>Dust particles emitted from atmosphereless planetary objects are samples of their surfaces. By mass analyzing these particles and tracing back their trajectories to their sources the surface composition of Mercury, planetary satellites, dusty rings sources, asteroids and comets can be obtained.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |



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| <p>Brian J. O'Brien</p> <p><b>Co-Author:</b> James R. Gaier</p>                                       | <p>Indicative Basic Issues about Lunar Dust in the Lunar Environment</p>             | <p>Basic issues of lunar dust - including recent discoveries - so fundamental they affect a wide range of lunar research and exploration must be recognised as priorities. Four Recommendations and Outcomes are given.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |
| <p>Michael D. Max</p> <p><b>Co-Authors:</b> Stephen M. Clifford, Arthur H. Johnson, Jeremie Lasue</p> | <p>Is a Resource-Mars a Stepping-Stone to Human Exploration of the Solar System?</p> | <p>Methane and water on Mars are the key to a resource base to support sustainable exploration of Mars and beyond</p>                                                                                                       | <p>Mars: Not Phobos and Deimos.</p>                 |

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Jupiter Atmospheric Science in the Next Decade

We outline atmospheric science goals and requirements for Jupiter in the next decade exploration (Juno, EJSM, Observatories, probes) in 5 themes: formation and evolution, weather-layer dynamics, coupling with the interior, interactions with the external environment and time-variable phenomena.

Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.

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| <p>Vincent F. Chevrier</p> <p><b>Co-Authors:</b> Derek Sears, Megan Elwood Madden, Essam Heggy</p>                                                                                                                                                                                                                                                                                        | <p>Laboratory Measurements in Support of Present and Future Missions to Mars</p> | <p>The case is made that supporting laboratory measurements and facilities should be considered an integral element of the Nation's Mars exploration program, since they provide a meaningful interpretation of the returned data, validation of theoretical models, and calibration of instruments.</p> | <p>Mars: Not Phobos and Deimos.</p>                                                                                                          |

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| <p>Linda R. Brown</p> <p><b>Co-Authors:</b> Pin Chen, Brian J. Drouin, Charles E. Miller, John Pearson, Stanley P. Sander, Keeyoon Sung, Robert A. Toth, ShanShan Yu</p>                                                                     | <p>Laboratory Spectroscopy to Support Remote Sensing of Atmospheric Composition</p> | <p>This paper discusses the declining state of laboratory studies that are essential to support and enable remote sensing of planetary bodies. Five recommendations are given to improve this situation.</p>                                                                                                 | <p>None of the above.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <p>Murthy Gudipati</p> <p><b>Co-Authors:</b> Michael A'Hearn, Nancy Brickhouse, John Cowan, Paul Drake, Steven Federman, Gary Ferland, Adam Frank, Wick Haxton, Eric Herbst, Michael Mumma, Farid Salama, Daniel Wolf Savin, Lucy Ziurys</p> | <p>Laboratory Studies for Planetary Sciences</p>                                    | <p>The WGLA of the AAS promotes collaboration and exchange of knowledge between astronomy and planetary sciences and the laboratory sciences (physics, chemistry, and biology). Laboratory data needs of ongoing and next generation planetary science missions are carefully evaluated and recommended.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/> Mars: Not Phobos and Deimos.<br/> Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/> Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/> Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |

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Laboratory Studies  
in Support of  
Planetary  
Geophysics

We summarize the rationale for advocating a healthy and sustained program of laboratory research in support of the geophysical exploration of planetary bodies. We address the challenges inherent to this discipline, and we suggest recommendations for the review panel's consideration.

Inner Planets:  
Mercury, Venus,  
and the Moon.  
Mars: Not Phobos  
and Deimos.  
Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.  
Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.  
Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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| <p>Rhawn Joseph</p>                                                                                                                                                                                                                                                                                             | <p>Life on Earth Came From Other Planets</p>                                         | <p>Life on Earth Came From Other Planets, reviews the evidence presented in over 100 peer reviewed scientific papers published in prestigious scientific journals, and explains how life on Earth originated on other planets. The entire 45 page paper will be published in the journal, Cosmology, on 12/2009</p> | <p>None of the above.</p>                                                                                                                                                                                                                                                                                     |

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| <p>Rhawn Joseph</p>                                                                                                                        | <p>Life on Earth Came From Other Planets - 7 Page Summary/Press release</p>            | <p>If life were to appear on a desert island we wouldn't claim it was assembled in an organic soup or created by God; we'd conclude it washed to shore or fell from the sky. The Earth too, is an island, orbiting in a sea of space and this is how life on our planet began.</p>                                  | <p>None of the above.</p>                                                            |
| <p>Andrew Pohorille</p> <p><b>Co-Authors:</b><br/>Leslie Bebout,<br/>Devaki Bhaya,<br/>Rocco Mancinelli</p>                                | <p>Limits of Terrestrial Life in Space</p>                                             | <p>To pursue a better understanding of life in space and link it to future missions we propose a strategy aimed at determining the potential for terrestrial microbial life to adapt and evolve in space environments. This strategy involves ground-based research, small satellite missions and will culminat</p> | <p>None of the above.</p>                                                            |
| <p>Andrew Daga</p> <p><b>Co-Authors:</b><br/>Carlton Allen,<br/>James Burke, Ian Crawford, Richard Leveille, Steven Simon, Lin Tze Tan</p> | <p>Lunar and Martian Lava Tube Exploration as Part of an Overall Scientific Survey</p> | <p>This paper discusses the opportunity to search for and exploit lava tubes on the surfaces of the Moon and Mars as a means of enabling ambitious planetary science missions. [FINAL VERSION]</p>                                                                                                                  | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Mars: Not Phobos and Deimos.</p> |

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| <p>Harrison H. Schmitt</p> <p><b>Co-Authors:</b> Bernard H. Foing, Mark Helper, Friedrich P. Horz, Jeff Plescia, Authur Snoke, Kris Zacny</p> | <p>Lunar Field Geological Exploration</p>                    | <p>Geological exploration by experience and highly trained field geologists provides the foundation for interpretation of lunar samples in the context of the origin and evolution of the terrestrial planets. Future lunar exploration should fully utilize the best available field geologists.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |
| <p>Harrison H. Schmitt</p> <p><b>Co-Authors:</b> Mark W. Henley, Kim Kuhlman, Gerald L. Kulcinski, John F. Santarius, Lawrence A. Taylor</p>  | <p>Lunar Helium-3 Fusion Resource Distribution</p>           | <p>The Moon's regolith contains vast resources of helium-3, an ideal fuel for terrestrial fusion power systems. Development of plans for private sector investment in obtaining helium-3 and its by-products requires detailed definition of that isotope's selenographic distribution.</p>           | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |
| <p>Amalie Sinclair</p>                                                                                                                        | <p>Lunar Light - Planetary Renewal- A Holistic Viewpoint</p> | <p>This paper sets out some rationales for an integrated US space development platform within the UN forums . Such a platform might include for an international lunar settlement and for a related space sciences initiative into global development</p>                                             | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |



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| <p>Richard S. Miller</p> <p><b>Co-Authors:</b> M. Bonamente, S. O'Brien, W. S. Paciesas, M. Bonamente, S. O'Brien, W. S. Paciesas, C. A. Young, D. Ebbets</p>                                                                                                                                                                                                                                                                                                                            | <p>Lunar Occultation Observer - A Nuclear Astrophysics Mission Concept using the Moon as a Platform for Science</p> | <p>The Lunar Occultation Observer (LOCO) is a gamma-ray astrophysics mission concept being developed to probe the nuclear regime. Using the Moon to occult astrophysical sources as they rise and set along the lunar limb, the encoded temporal modulation will be used to image the sky and enable science.</p> | <p>Inner Planets: Mercury, Venus, and the Moon. None of the above.</p> |
| <p>Dana M. Hurley</p> <p><b>Co-Authors:</b> David J. Lawrence, Raul Baragiola, D. Benjamin Bussey, Anthony Colaprete, M. Darby Dyar, Anthony F. Egan, Richard C. Elphic, William Farrell, William Feldman, James R. Gaier, Jacob Grimes, Jasper S. Halekas, Erika Harnett, James N. Head, Jennifer Heldmann, Amanda Hendrix, Charles A. Hibbitts, Kurt D. Retherford, Catherine Neish, Sarah Noble, Carle Pieters, Paul D. Spudis, Timothy J. Stubbs, Bradley J. Thomson, Kris Zacny</p> | <p>Lunar Polar Volatiles and Associated Processes</p>                                                               | <p>A landed/mobile mission to a lunar permanently shadowed region (PSR) should identify the composition, abundance, and distribution of volatiles in lunar PSRs. The next step is obtaining a detailed understanding of the transport/deposition/retention system to unravel the history of polar volatiles.</p>  | <p>Inner Planets: Mercury, Venus, and the Moon.</p>                    |

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| <p>Harrison H. Schmitt</p>                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>Lunar Pyroclastic Deposits and the Origin of the Moon</p> | <p>he primary difficulty in accepting the computer modeled "giant impact" hypothesis for the origin of the Moon, versus independent derivation, comes from the analysis of the non-glass components of lunar pyroclastic deposits. These prove that volatile reservoirs exist in the mantle of the Moon.</p>     | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |
| <p>James G. Williams</p> <p><b>Co-Authors:</b><br/> James G. Williams,<br/> Slava G. Turyshev,<br/> Richard T. Baran,<br/> Kevin M. Birnbaum,<br/> Douglas Currie,<br/> William M. Folkner,<br/> Gary M. Gutt,<br/> Hideo Hanada,<br/> Hamid Hemmati,<br/> Stephen M. Merkowitz,,<br/> Kenneth L. Nordtvedt,<br/> Thomas W. Murphy, Jr.,<br/> Jürgen Müller,<br/> Nicolas Rambaux,<br/> Peter J. Shelus,<br/> Ruwan Somawardhana,<br/> Robert Spero</p> | <p>Lunar Science and Lunar Laser Ranging</p>                 | <p>Lunar Laser Ranging studies the Moon's internal structure and properties by tracking the variations in the orientation and tidal distortion of the Moon as a function of time. Future missions to the Moon's surface should include new laser ranging instrumentation capable of improved range accuracy.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |

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Lunar Science with ARTEMIS: A Journey from the Moon's Exosphere to its Core [version 2]

This white paper describes the planetary science objectives to be achieved by ARTEMIS, a two-spacecraft constellation en route to the Moon, and presents recommendations pertaining to future lunar science. [version 2]

Inner Planets: Mercury, Venus, and the Moon.

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| <p>Lisa Pratt</p> <p><b>Co-Authors:</b> Carl Allen, Abby Allwood, Ariel Anbar, Sushil Atreya, Mike Carr, Dave Des Marais, Daniel Glavin, John Grant, Vicky Hamilton, Ken Herkenhoff, Vicky Hipkin, Tom McCollom, Scott McLennan, Ralph Milliken, Doug Ming, Gian Gabrielle Ori, John Parnell, Francois Poulet (Univ. Paris), Barbara Sherwood Lollar, Frances Westall, David Beaty, Joy Crisp, Chris Salvo, Charles Whetsel, Mike Wilson</p> | <p>Mars Astrobiology Explorer-Cacher (MAX-C): A Potential Rover Mission for 2018</p> | <p>This white paper describes a potential rover mission to Mars, with the name Mars Astrobiology Explorer-Cacher (MAX-C) that could be launched in 2018. The mission would conduct high-priority in situ science and make concrete steps towards the potential future return of martian samples to Earth.</p> | <p>Mars: Not Phobos and Deimos.</p> |
| <p>Douglas Stetson</p> <p><b>Co-Authors:</b> Jim Bell, Lou Friedman</p>                                                                                                                                                                                                                                                                                                                                                                      | <p>Mars Exploration 2016-2032: Rationale and Principles for a Strategic Program</p>  | <p>The Mars Exploration Program, one of the most visible and dynamic elements of NASA space science, is at a crossroads. To ensure a robust future it must embrace the related goals of life and sample return, and must begin to bridge the historical gap between robotic and human exploration.</p>        | <p>Mars: Not Phobos and Deimos.</p> |

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| <p>Michael J. Kavaya</p>                                                                                                                                                                                     | <p>Mars Orbiting Pulsed Doppler Wind Lidar for Characterization of Wind and Dust</p> | <p>Technology is described which is well developed and on a path for space. This technology could be used in Mars orbit to provide a global climatology of wind and relative dust as a function of location and altitude.</p>                                                                                    | <p>Mars: Not Phobos and Deimos.</p> |
| <p>Timothy N. Titus</p> <p><b>Co-Authors:</b><br/> Thomas H. Prettyman,<br/> Timothy I. Michaels, Jeffrey Barnes, Hugh H. Kieffer, Adrian Brown, Shane Byrne, Kathryn E. Fishbaugh, Michael H. Hecht</p>     | <p>Mars Polar Science for the Next Decade</p>                                        | <p>This white paper is intended to be a consensus of many of the active members of the Mars polar science community, and is the culmination of discussions held at the 3rd International Mars Polar Energy Balance and CO2 Cycle workshop (MPEB2009) held in Seattle, WA, 21-24 July 2009.</p>                   | <p>Mars: Not Phobos and Deimos.</p> |
| <p>Michael D. Smith</p> <p><b>Co-Authors:</b> Mark Allen, Donald Banfield, Jeffrey Barnes, R. Todd Clancy, Philip James, James Kasting, Paul Wennberg, Daniel Winterhalter, Michael Wolff, Richard Zurek</p> | <p>Mars Trace Gas Mission: Scientific Goals and Measurement Objectives</p>           | <p>Trace gases are a sensitive indicator of current martian activity, whether photochemical or biogeochemical. A Trace Gas Mission measuring atmospheric composition, circulation and state, and locating active sources would characterize this activity and its implications for climate and astrobiology.</p> | <p>Mars: Not Phobos and Deimos.</p> |

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| <p>Robert J. Lillis</p> <p><b>Co-Authors:</b> J. Arkani-Hamed, D. A. Brain, J. C. Cain, J. E. P. Connerney, G. T. Delory, J. Espley, M. Fuller, J. Gattececa, J. S. Halekas, L. L. Hood, C. L. Johnson, D. Jurdy, G. Kletetschka, B. Langlais, R. P. Lin, K. L. Louzada, M. Manga, C. Milbury, D. Mozzoni, M. Purucker, D. Ravat, J. H. Roberts, P. Rochette, C.T. Russell, S. Smrekar, S. T. Stewart, S. Vennerstrom, B. P. Weiss, K. Whaler</p> | <p>Mars" Ancient Dynamo and Crustal Remanent Magnetism</p> | <p>Mars" crustal magnetization is unique and enigmatic. It is pertinent to Mars science questions as diverse as the structure of the interior and the evolution of climate. To study it, we recommend 1) extending the MAVEN mission, 2) rover-mounted surface magnetometers and 3) oriented sample return.</p> | <p>Mars: Not Phobos and Deimos.</p>                 |
| <p>Larry W. Esposito</p>                                                                                                                                                                                                                                                                                                                                                                                                                          | <p>Mission Concept: Venus in situ Explorer (VISE)</p>      | <p>A proposed New Frontiers mission concept for Venus lander.</p>                                                                                                                                                                                                                                               | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |

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| <p>Eldar Z. Noe<br/>Dobrea</p> <p><b>Co-Authors:</b> S. Murchie, J.F. Mustard, J.L. Bishop, N.K. McKeown</p> | <p>Near-Infrared imaging spectroscopy of the surface of Mars at meter-scales to constrain the geological origin of hydrous alteration products, identify candidate sites and samples for future in-situ and sample return missions, and guide rover operations</p> | <p>Near-infrared imaging spectrometers capable of mapping hydrous minerals on the surface of Mars at meter-scales from orbit, as well as hyperspectral NIR imagers on landed rovers not only enhance the scientific return of orbital and rover missions, but will be critical in guiding future rover operation</p> | <p>Mars: Not Phobos and Deimos.</p>                                                                                                          |
| <p>Robert F. Arentz</p> <p><b>Co-Author:</b> Harold Reitsema</p>                                             | <p>NEO Survey: An Efficient Search for Near-Earth Objects by an IR Observatory in a Venus like Orbit</p>                                                                                                                                                           | <p>We present a conceptual design based on high-heritage flight systems from the Spitzer Space Telescope and the Kepler mission which will find 90% of all 140-meter NEOS in 7 years after launch, and by 2020, if started soon.</p>                                                                                 | <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |

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Neptune Ring Science with Argo - A Voyage through the Outer Solar System

Argo, an innovative concept for a New Frontiers 4 mission, will yield significant advances in our understanding of evolutionary processes of rings and small bodies in the outer Solar System by executing a flyby through the Neptune system, then going on to a scientifically-selected KBO.

Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.



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| <p>Yasunori Miura</p>                                                                                                                                                                                                                                                                                                                                                                                                | <p>New lunar science and engineering with carbon cycle.</p>                | <p>New idea and technique with carbon cycle can be applied at lunar crust origin, lunar interior and lunar double construction (surface and underground) building at the lunar base in future from new carbon-fixing cycle.</p>                                               | <p>Inner Planets: Mercury, Venus, and the Moon.</p>                                                                                    |

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| <p>Robert J. Noble</p> <p><b>Co-Authors:</b><br/> Rashied Amini,<br/> Patricia M. Beauchamp, Gary L. Bennett, John R. Brophy, Bonnie J. Buratti, Joan Ervin, Yan R. Fernandez, Will Grundy, Mohammed Omair Khan, David Q. King, Jared Lang, Karen J. Meech, Alan Newhouse, Steven R. Oleson, George R. Schmidt, Thomas Spilker, John L. West</p> | <p>New Opportunities for Outer Solar System Science using Radioisotope Electric Propulsion</p>              | <p>This whitepaper discusses how mobility provided by radioisotope electric propulsion (REP) opens up entirely new science opportunities for robotic missions to distant primitive bodies. We also give an overview of REP technology developments and the required next steps to realize REP.</p> | <p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/> Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Michael Hecht</p> <p><b>Co-Authors:</b><br/> Kathryn Fishbaugh, Shane Byrne, Ken Herkenhoff, Stephen Clifford, Timothy N. Titus, Oded Aharonson</p>                                                                                                                                                                                           | <p>Next Steps in Mars Polar Science: In Situ Subsurface Exploration of the North Polar Layered Deposits</p> | <p>The polar regions of Mars represent a unique environment for determining the mechanisms of martian climate change over geological time. Using terrestrial paleoclimatology methods, subsurface access to the polar layer deposits should be a high priority for future Mars exploration.</p>    | <p>Mars: Not Phobos and Deimos.</p>                                                                                                                                                                                                      |

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| James T. Struck     | Nobel Prize in Physics and Chemistry Could Be Awarded to Almost Anyone Who Has Done Any work In fields Including me | Almost anyone with work in chemistry and physics could be awarded the Nobel Prize; me too. Many contributions in chemistry and physics go on for several pages. The work of many are not recognized when the award is given to 1 or 2 people. Award could be given to any finding, article or discovery. | Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust. None of the above. |
| Harrison H. Schmitt | Observations Necessary for Useful Global Climate Models                                                             | Critical differences exist between scientists who observe weather and climate and those who attempt to model nature's complexities. The modelers believe complex mathematics and broad assumptions can forecast the future of climate, Earth's most complex system. Long-term observation is essential.  | Inner Planets: Mercury, Venus, and the Moon.                                                                                                             |
| Arlin Crotts        | On Lunar Volatiles and Their Importance to Resource Utilization and Lunar Science                                   | We discuss recent, compelling evidence for major lunar volatiles not necessarily found in polar permanently-shadowed crater cold traps, but originating from the deep interior. We also discuss programs underway to study lunar volatiles, which unfortunately fall far short of the NRC's SCEM goals.  | Inner Planets: Mercury, Venus, and the Moon.                                                                                                             |

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Onboard Science  
Data Analysis:  
Implications for  
Future Missions

Onboard science data analysis enables new spacecraft operational modes that improve science yield. It can relieve constraints on time, bandwidth and power, and respond automatically to events on short time scales. We examine applications to rover, aerobot, and orbital platforms.

Inner Planets:  
Mercury, Venus,  
and the Moon.  
Mars: Not Phobos  
and Deimos.  
Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.  
Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.  
Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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Planetary Formation  
and Evolution  
Revealed with a  
Saturn Entry Probe:  
The Importance of  
Noble Gases

The determination of Saturn's atmospheric noble gas abundances are critical to understanding the formation and evolution of Saturn, and giant planets in general. These measurements can only be performed with an entry probe.

Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.

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| <p>John D. Rummel</p> | <p>Planetary Protection for Planetary Science and Exploration</p> | <p>A precis of planetary protection policy concerns, their history, and the role of the SSB and NASA internal advisory activities in ensuring progress and appropriate implementation of the policy.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/> Mars: Not Phobos and Deimos.<br/> Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/> Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/> Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
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Planetary Radio  
Science:  
Investigations of  
Interiors, Surfaces,  
Atmospheres,  
Rings, and  
Environments

Scientists utilize radio links between spacecraft and Earth or between spacecraft to examine changes in the phase/frequency, and amplitude of radio signals to investigate atmospheres and ionospheres, rings, surfaces, shapes, gravitational fields, and dynamics of solar system bodies.

Inner Planets:  
Mercury, Venus,  
and the Moon.  
Mars: Not Phobos  
and Deimos.  
Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.  
Satellites:  
Galilean satellites,  
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other satellites of  
the giant planets.  
Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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| <p>Mark Skidmore</p> <p><b>Co-Authors:</b> John Priscu, Brent Christner</p> | <p>Planetary Science &amp; Astrobiology: Cold habitats for life in the Solar system</p> | <p>The paper highlights that improved knowledge of the carbon and energy transformations necessary to support life at sub-zero temperatures is key to future planetary science and astrobiological research given ice is the most abundant phase of water in the Solar system.</p> | <p>Mars: Not Phobos and Deimos.<br/>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p> |
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Prebiotic  
Atmospheric  
Chemistry on Titan

Cassini measurements reveal that organic molecules with molecular weights of hundreds of amu are formed by photochemistry in Titan's upper atmosphere. Investigating this chemistry is important for understanding the production of biological building blocks by naturally occurring processes.

Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.

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| <p>Vinatier, V.<br/> Vuitton, J.-E.<br/> Wahlund, J. H.<br/> Waite, M.<br/> Yamauchi, J.<br/> Zarnecki</p>                                 |                                                                                         |                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                           |
| <p>Andreas Rathke</p> <p><b>Co-Authors:</b><br/> Torsten Bondo,<br/> Roger Walker,<br/> Andrew Willig,<br/> Dario Izzo, Mark<br/> Ayre</p> | <p>Preliminary Design<br/> of an Advanced<br/> Mission to Pluto</p>                     | <p>A technology assessment and feasibility study is being performed within the ESA Advanced Concepts Team on sending a small-to-medium (700-900 kg) Nuclear Electric Propulsion spacecraft into orbit around Pluto with a mission launch in 2016 using existing or emerging space technology.</p> | <p>Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p> |
| <p>Friedemann T.<br/> Freund</p>                                                                                                           | <p>Previously<br/> Overlooked/Ignored<br/> Electronic Charge<br/> Carriers in Rocks</p> | <p>I would like to draw the attention of members of the Decadal Survey Committee to a rather fundamental discovery, which (I believe) will have a major impact on the Earth and Planetary Sciences in the coming years.</p>                                                                       | <p>Inner Planets:<br/> Mercury, Venus,<br/> and the Moon.<br/> Mars: Not Phobos<br/> and Deimos.</p>                                                                                      |

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| <p>Jon D. Giorgini</p> <p><b>Co-Authors:</b><br/> Lance A. M. Benner, Marina Brozovic, Michael W. Busch, Donald B. Campbell, Steven R. Chesley, Paul W. Chodas, Ellen Howell, Jean-Luc Margot, Andrea Milani Petr Pravec, Robert A. Preston, Maria-Eugenia Sansaturio, Daniel J. Scheeres, Michael K. Shepard, Arnold Silva, Martin A. Slade, Patrick A. Taylor, Giovanni Valsecchi, David Vokrouhlický, Donald K. Yeomans</p> | <p>Radar Astrometry of Small Bodies: Detection, Characterization, Trajectory Prediction, and Hazard Assessment</p> | <p>Radar astrometry reduces trajectory uncertainties by orders of magnitude, thereby improving prediction, targeting, and impact probability estimates for small-bodies, while characterizing some at levels comparable to a spacecraft flyby. This improves resource use for ground and flight investigations.</p> | <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>                                                                                  |
| <p>Tsun-Yee Yan Yan</p> <p><b>Co-Authors:</b> K. Clark, R. Rasmussen</p>                                                                                                                                                                                                                                                                                                                                                       | <p>Radiation Facts and Mitigation Strategies for the JEO Mission</p>                                               | <p>The challenge associated with operating a spacecraft for long periods within the radiation belts of Jupiter cannot be underestimated. To realize the promise of incredible science the risk must be identified and controlled. Given the identified steps, the design is well in hand and would allow this s</p> | <p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites. Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p> |

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| <p>J.B. Dalton</p> <p><b>Co-Authors:</b> J.C. Castillo, L.R. Brown, R.P. Hodyss, P.V. Johnson, M. Gudipati, R.M. Mastrapa, K. McKeegan, R.N. Clark, P.H. Schultz, A.R. Hendrix, S.T. Stewart, S. Ruff, K.P. Hand, T. Spilker</p> | <p>Recommended Laboratory Studies in Support of Planetary Science</p> | <p>Planetary science in the next decade will include major spacecraft missions to inner and outer solar system targets. Interpretation of these mission observations requires knowledge of fundamental physical and chemical properties of planetary materials. Much theoretical work at present depends upon r</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Mars: Not Phobos and Deimos.<br/>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
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| <p>Robert Hodyss</p> <p><b>Co-Authors:</b> Paul D. Cooper, Reggie Hudson, Robert Carlson, Paul V. Johnson, Arthur L. Lane, Marla Moore, Louis J. Allamandola</p>                                                                                                                | <p>Recommended Laboratory Studies in Support of Planetary Science: Surface Chemistry of Icy Bodies</p> | <p>We identify several areas where an increased emphasis on laboratory activities would lead to a significant return in scientific results, based on an enhanced understanding of the fundamental surface chemistry of icy bodies.</p> | <p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets. Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Charles D., Jr. Edwards</p> <p><b>Co-Authors:</b> William B. Banerdt, David W. Beaty, Leslie K. Tamppari, Richard W. Zurek</p>                                                                                                                                               | <p>Relay Orbiters for Enhancing and Enabling Mars In Situ Exploration</p>                              | <p>This white paper describes the role that orbital relay telecommunications have played as an integral part of science investigation of Mars, and the importance and continuing evolution for support to future missions.</p>         | <p>Mars: Not Phobos and Deimos.</p>                                                                                                                                                                                                 |
| <p>Matthew Tiscareno</p> <p><b>Co-Authors:</b> Nicole Albers, Todd Bradley, Shawn M. Brooks, Joseph A. Burns, Carlos Chavez, Joshua E. Colwell, Jeffrey N. Cuzzi, Imke de Pater, Luke Dones, Gianrico Filacchione, Silvia M. Giuliatti Winter, Mitchell K. Gordon, Eberhard</p> |                                                                                                        |                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                     |

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### Rings Research in the Next Decade

The study of planetary ring systems forms a key component of planetary science. We discuss priority activities for the next decade including full support for the Cassini Solstice Mission, a spacecraft mission to Neptune and/or Uranus, and support for Earth-based research activities.

Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.

|                                                                                                                                                                                                                                                                                                                                                                                               |                                                                  |                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                  |
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| <p>Robert Schingler</p> <p><b>Co-Authors:</b><br/>William Marshall,<br/>Alex MacDonald,<br/>Mark Lupisella,<br/>Brian Lewis</p>                                                                                                                                                                                                                                                               | <p>ROSI - Return on<br/>Science Investment</p>                   | <p>A system for mission<br/>evaluation based on<br/>maximizing science</p>                                                                                                                                                                                                                                                                                | <p>None of the<br/>above.</p>                                                                                                                                                    |
| <p>Scott Messenger</p> <p><b>Co-Authors:</b><br/>Andrew Davis,<br/>George Flynn,<br/>Lindsay Keller,<br/>Allan Treiman,<br/>Meenakshi<br/>Wadhwa, Andrew<br/>Westphal</p>                                                                                                                                                                                                                     | <p>Sample Return from<br/>Primitive Asteroids<br/>and Comets</p> | <p>This white paper makes the<br/>case for sample return from<br/>primitive asteroids and<br/>comets in the next decade to<br/>address some of the most<br/>important questions in<br/>planetary science relating to<br/>the origin and history (and<br/>particularly the origin and<br/>distribution of organics and<br/>water) of the Solar System.</p> | <p>Primitive Bodies:<br/>Asteroids,<br/>comets, Phobos,<br/>Deimos,<br/>Pluto/Charon and<br/>other Kuiper belt<br/>objects,<br/>meteorites, and<br/>interplanetary<br/>dust.</p> |
| <p>Allan Treiman</p> <p><b>Co-Authors:</b><br/>Meenakshi<br/>Wadhwa, Clive R.<br/>Neal, Charles K.<br/>Shearer, Bradley L.<br/>Jolliff, Lars E.<br/>Borg, Dimitri<br/>Papanastassiou,<br/>Malcolm J.<br/>Rutherford,<br/>Christine Floss,<br/>Andrew M. Davis,<br/>Steven Symes,<br/>Susanne<br/>Schwenzer, Mark<br/>D. Fries, Andrew<br/>Westphal, Barbara<br/>Cohen, David A.<br/>Kring</p> | <p>Sample Return from<br/>the Earth's Moon</p>                   | <p>This white paper makes the<br/>case that sample return from<br/>selected locations on the<br/>Moon in the coming decade<br/>will provide extraordinary<br/>advances in lunar and Solar<br/>System science.</p>                                                                                                                                         | <p>Inner Planets:<br/>Mercury, Venus,<br/>and the Moon.</p>                                                                                                                      |

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Sampling the Age  
Extremes of Lunar  
Volcanism: the  
Youngest and  
Oldest Lunar  
Basalts

Automated sample return  
missions to the youngest  
(Procellarum) and oldest  
(cryptomaria) basalts on the  
lunar surface will help  
improve our absolute  
chronology for the inner  
Solar System by providing  
the timing for the beginning  
and end of lunar basaltic  
volcanism.

Inner Planets:  
Mercury, Venus,  
and the Moon.



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Saturn Atmospheric Science in the Next Decade

We describe the key goals for Saturn atmospheric science (from Cassini, observatories, and new missions) organized into 5 themes: composition and chemistry, weather-layer dynamics and internal structure, clouds and hazes, time-variable phenomena and coupling to the external environment.

Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.

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|---------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Jonathan I. Lunine</p> | <p>Saturn's Titan: A strict test for life's cosmic ubiquity</p> | <p>In this white paper I argue that Titan provides a strict test for the Copernican hypothesis that life is a ubiquitous cosmic phenomenon. Planets with environments like Titan may be common in the cosmos, as they correspond to a roughly 1 AU orbit around M-dwarfs.</p> | <p>Giant Planets:<br/>Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/>Satellites:<br/>Galilean satellites, Titan, and the other satellites of the giant planets.</p> |
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Science from the  
Moon: The  
NASA/NLSI Lunar  
University Network  
for Astrophysics  
Research (LUNAR)

The Moon is a unique platform for fundamental astrophysical measurements of gravitation, the Sun, and the Universe. With the aim of providing additional perspective on the Moon as a scientific platform, this white paper describes key research projects involving astrophysics from the Moon.

Inner Planets:  
Mercury, Venus,  
and the Moon.

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| <p>Robert Pappalardo</p> <p><b>Co-Authors:</b><br/> Michel Blanc,<br/> Emma Bunce,<br/> Michele<br/> Dougherty, Olivier<br/> Grasset, Ron<br/> Greeley, Torrence<br/> Johnson, Jean-<br/> Pierre Lebreton,<br/> David Senske,<br/> Louise Prockter</p> | <p>Science of the<br/> Europa Jupiter<br/> System Mission</p>                                                    | <p>The Europa Jupiter System Mission (EJSM) is guided by the overarching theme: the emergence of habitable worlds around gas giants, with goals to determine whether the Jupiter System harbors habitable worlds, and to characterize the processes within the Jupiter system.</p>                                  | <p>Giant Planets:<br/> Jupiter, Saturn,<br/> Uranus, Neptune,<br/> and exoplanets,<br/> including rings<br/> and magnetic<br/> fields, but not<br/> their satellites.<br/> Satellites:<br/> Galilean satellites,<br/> Titan, and the<br/> other satellites of<br/> the giant planets.</p>    |
| <p>Paul A. Abell</p> <p><b>Co-Authors:</b><br/> Daniel Adamo,<br/> Thomas Jones,<br/> David Korsmeyer,<br/> Rob Landis</p>                                                                                                                             | <p>Scientific<br/> Investigation of<br/> Near-Earth Objects<br/> via the Orion Crew<br/> Exploration Vehicle</p> | <p>NASA has examined the feasibility of sending the Orion Crew Exploration Vehicle to near-Earth objects during the next decade and beyond as part of its future Human Space Flight program. This paper describes the in-depth scientific investigations that could be accomplished by such missions.</p>           | <p>Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p>                                                                                                    |
| <p>Amy S. Lo</p> <p><b>Co-Authors:</b><br/> Howard Eller,<br/> Dean Dailey, Eric<br/> Drucker, James<br/> Wehner</p>                                                                                                                                   | <p>Secondary Payloads<br/> Using LCROSS<br/> Architecture</p>                                                    | <p>The ESPA architecture used by the LCROSS mission enables two capable missions for the cost of one launch. This paper describes our approach for leveraging the capability of the new generation of EELVs to enable secondary planetary missions at well below the cost of an independently launched mission.</p> | <p>Inner Planets:<br/> Mercury, Venus,<br/> and the Moon.<br/> Mars: Not Phobos<br/> and Deimos.<br/> Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p> |

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| <p>John F. Mustard</p>                                                                                                                                                                                                                                                     | <p>Seeking Signs of Life on a Terrestrial Planet: An Integrated Strategy for the Next Decade of Mars Exploration</p> | <p>We propose an integrated strategy to implement missions of high scientific priority, as recommended by the last decadal survey, while still responding to new discoveries. The proposed step-by-step approach to sample return would provide a credible path and conduct important in situ science.</p>          | <p>Mars: Not Phobos and Deimos.</p> |
| <p>Jeffrey L. Bada</p> <p><b>Co-Authors:</b><br/>Andrew D. Aubrey, Frank J. Grunthaner, Michael Hecht, Richard Quinn, Richard Mathies, Aaron Zent, John H. Chalmers</p>                                                                                                    | <p>Seeking Signs of Life on Mars: In Situ Investigations as Prerequisites to Sample Return Missions</p>              | <p>We argue for deployment of increasingly sophisticated in situ techniques to definitively identify biomarkers before engaging in Mars Sample Return. We focus on "following the nitrogen," using techniques such as micro capillary electrophoresis to identify and determine the chirality of primary amines</p> | <p>Mars: Not Phobos and Deimos.</p> |
| <p>Thomas Ruedas</p> <p><b>Co-Authors:</b><br/>Nicholas Schmerr, Natalia Gómez Pérez, W. Bruce Banerdt, Constance M. Bertka, Mathieu Choukroun, Yingwei Fei, Matthew J. Fouch, Walter S. Kiefer, Philippe Lognonné, Amy C. McAdam, Andrew Steele, Bernhard Steinberger</p> | <p>Seismological investigations of Mars" deep interior</p>                                                           | <p>This paper explains the importance of investigating the deep interior of Mars by seismological methods. Seismometers on Mars can bring insights to questions concerning planetary structure, tectonics, mantle and core dynamics, dynamo and mantle chemistry. The technical feasibility is assessed.</p>        | <p>Mars: Not Phobos and Deimos.</p> |

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| <p>Dan Britt</p> <p><b>Co-Authors:</b> Paul Abell, Eleonora Ammannito, Erik Asphaug, MiMi Aung, Jim Bell, Julie Bellerose, Mehdi Benna, Lance Benner, David Blewett, William Bottke, Frank Brenker, Humberto Campins, Julie Castillo-Rogez, Andrew Cheng, Clark Chapman, Harold C. Connolly Jr., Maria Cristina De Sanctis, Richard Dissley, Dan Durda, Joshua Emery, Eugene Fahnestock, Yanga Fernandez, Michael J. Gaffey, Nader Haghhighipour, Mark</p> |                                                                                                      |                                                                                                                                                                                                                                                              |                                     |

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Small Bodies  
Community White  
Paper: Asteroids

This paper identifies the top-level science issues, mission priorities, research and technology needs, and programmatic balance for the exploration of Asteroids. This paper was organized by the Small Bodies Assessment Group.

Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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Small Bodies  
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Paper: Exploration  
Strategy for the Ice  
Dwarf Planets  
2013-2022

This paper identifies the top-level science issues, mission priorities, research and technology needs, and programmatic balance for the exploration of Dwarf Planets. This paper was organized by the Small Bodies Assessment Group.

Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.



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Small Bodies  
Community White  
Paper: Goals and  
Priorities for the  
Study of Comets in  
the Next Decade  
(2011-2020)

This paper identifies the top-level science issues, mission priorities, research and technology needs, and programmatic balance for the exploration of Comets. This paper was organized by the Small Bodies Assessment Group.

Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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| <p>Michael Nolan</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                               |                                                                                                                                                                                                                                                   |                                                                                                                                                                                           |

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Small Bodies  
Community White  
Paper: Near-Earth  
Asteroids

This paper identifies the top-level science issues, mission priorities, research and technology needs, and programmatic balance for the exploration of Near-Earth Objects. This paper was organized by the Small Bodies Assessment Group.

Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
| David O'Brien,<br>William Owen,<br>Joseph Riedel,<br>Harold Reitsema,<br>Nalin Samarasinha,<br>Daniel Scheeres,<br>Derek Sears,<br>Michael Shepard,<br>Mark Sykes, Josep<br>M. Trigo-<br>Rodriguez, David<br>Trilling, Ronald<br>Vervack, James<br>Walker, Benjamin<br>Weiss, Hajime<br>Yano, Donald<br>Yeomans, Eliot<br>Young, Michael<br>Zolensky |  |  |  |
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Small Bodies  
Community White  
Paper: The Small  
Satellites of the  
Solar System

This paper identifies the top-level science issues, mission priorities, research and technology needs, and programmatic balance for the exploration of Small Satellites. This paper was organized by the Small Bodies Assessment Group.

Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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| <p>Janet A. Vertesi</p> <p><b>Co-Authors:</b><br/> Robert Pappalardo,<br/> Claudia Alexander,<br/> William J.<br/> Clancey, Barbara<br/> Cohen, Paul<br/> Dourish, Jeffrey<br/> Johnson, Barbara<br/> Larsen, Kimberly<br/> Lichtenberg,<br/> Charlotte Linde,<br/> Scott Maxwell,<br/> Zara Mirmalek,<br/> Jeff Moore</p> | <p>Sociological<br/> Considerations for<br/> the Success of<br/> Planetary<br/> Exploration<br/> Missions</p> | <p>Alongside scientific and technical considerations, the Planetary Science Decadal Survey should require that missions incorporate deeper consideration of the social science of spacecraft operations to maximize their missions' scientific, technical and fiscal success.</p> | <p>None of the above.</p> |
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| Dana Backman | SOFIA<br>(Stratospheric<br>Observatory for<br>Infrared<br>Astronomy) and<br>Planetary Science | This paper consists of the intro & observatory capabilities (ch. 1) plus the planetary science (ch. 5) portions of the SOFIA Science Vision doc pub. in 2009 as an update of the scientific case for SOFIA. D. Backman produced this extract; the original doc is authored by the SOFIA Science Team. | Inner Planets:<br>Mercury, Venus,<br>and the Moon.<br>Giant Planets:<br>Jupiter, Saturn,<br>Uranus, Neptune,<br>and exoplanets,<br>including rings<br>and magnetic<br>fields, but not<br>their satellites.<br>Satellites:<br>Galilean satellites,<br>Titan, and the<br>other satellites of<br>the giant planets.<br>Primitive Bodies:<br>Asteroids,<br>comets, Phobos,<br>Deimos,<br>Pluto/Charon and<br>other Kuiper belt<br>objects,<br>meteorites, and<br>interplanetary<br>dust. |
| Tore Straume | Solar Radiation<br>Output: Reading the<br>Record of Lunar<br>Rocks                            | Reconstructing solar<br>energetic particle output by<br>measuring signatures in lunar<br>surface samples                                                                                                                                                                                              | Inner Planets:<br>Mercury, Venus,<br>and the Moon.                                                                                                                                                                                                                                                                                                                                                                                                                                   |



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| <p>Walter Harris</p> <p><b>Co-Authors:</b><br/> Walter Harris, Eric Burgh, John Clarke, Joshua Colwell, Michael Davis, Daniel Durda, Charles Hibbitts, Stephan McCandliss, Jeffrey Morgenthaler, Kurt Retherford, Ronald Vervack</p> | <p>Solar System Suborbital Research: A Vital Investment in the Scientific Techniques, Technology, and Investigators of Space Exploration in the 21st Century.</p>                                                                                                   | <p>Recent calls for increased NASA technology and training development cite shortages with current trends. Suborbital and Explorer missions are key this but have been cut in the past 20 years. Planetary research supports no small missions at all. We describe how suborbital research can address this gap</p> | <p>None of the above.</p>                                                                                                                                       |
| <p>James T. Struck</p>                                                                                                                                                                                                               | <p>Some Anthropology of Humans in Space. Can Human Stability Provide Some Support for Non-Evolutionary or Religious Concepts? Are we able to Speak of a Homo-Astronomicus or a Human Group Involved in Space Travel? What Happens to Humans in Space? (ID-0135)</p> | <p>Some anthropology of humans and space. I propose a relationship between religious artifacts and astronomical stability. I establish why calling humans in space a new species fits current species understandings and mention 2 other groups-slavery and sending objects a distance. Space effects raised.</p>   | <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust. None of the above.</p> |

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Space Weathering  
Impact on Solar  
System Surfaces  
and Mission  
Science

Space weathering is the collection of physical processes acting to erode and chemically modify planetary surfaces directly exposed to space environments of planetary magnetospheres, the heliosphere, and the local interstellar environment of the solar system. Space weathering affects the physical and

Inner Planets:  
Mercury, Venus,  
and the Moon.  
Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
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fields, but not  
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Satellites:  
Galilean satellites,  
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the giant planets.  
Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
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dust.

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Strategic  
Technology  
Development for  
Future Mars  
Missions (2013-  
2022)

This white paper focuses on enabling technologies for several candidate concepts for future Mars missions. These missions are described in MEPAG position white papers developed for the decadal survey. The technologies, their current status, and their approximate costs and schedules are described.

Mars: Not Phobos  
and Deimos.

|                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                          |                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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| <p>Thomas D. Jones</p> <p><b>Co-Authors:</b> Rob<br/>R. Landis, David J.<br/>Korsmeyer, Paul<br/>A. Abell, Daniel R.<br/>Adamo</p>                                                                                                                                                                                                                                                                     | <p>Strengthening U.S.<br/>Exploration Policy<br/>via Human<br/>Expeditions to<br/>Near-Earth Objects</p> | <p>By conducting a series of<br/>piloted Near-Earth Object<br/>(NEO) missions beginning<br/>about 2020, the U.S. will<br/>reinforce the scientific,<br/>economic, programmatic,<br/>operations, planetary defense,<br/>and public outreach elements<br/>of its human exploration<br/>program.</p> | <p>Primitive Bodies:<br/>Asteroids,<br/>comets, Phobos,<br/>Deimos,<br/>Pluto/Charon and<br/>other Kuiper belt<br/>objects,<br/>meteorites, and<br/>interplanetary<br/>dust.</p>                                                                                                                                                                                                                                                                                                                                                                          |

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| <p>George Sonneborn</p> <p><b>Co-Authors:</b> J. Lunine, R. Doyon, M. McCoughrean, M. Rieke</p> | <p>Study of Planetary Systems and Solar System Objects with JWST</p> | <p>Determination of the physical and chemical properties of planetary systems is a key scientific goal of the James Webb Space Telescope (JWST). This white paper summarizes the mission's capabilities in our solar system and extrasolar planetary systems.</p> | <p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.</p> <p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p> <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
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Summary and  
Highlights of the  
NRC 2007 Report:  
The Scientific  
Context for the  
Exploration of the  
Moon (SCEM)

Understanding processes that  
have occurred on the Moon  
provide a framework for  
understanding the origin and  
evolution of the other  
terrestrial planets. The SCEM  
science goals and priorities  
remain fundamentally  
relevant to our understanding  
of the solar system and  
central to its exploration.

Inner Planets:  
Mercury, Venus,  
and the Moon.

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| <p>Jeffrey R. Johnson</p> <p><b>Co-Authors:</b> Tori Hoehler, Frances Westall, Scot Rafkin, Paul Withers, Jeffrey Plescia, Victoria Hamilton, Abhi Tripathi, Darlene Lim</p>                                                | <p>Summary of the Mars Science Goals, Objectives, Investigations, and Priorities</p> | <p>This document reflects the synthesis of recent MEPAG Goals Committee activities, MEPAG Science Analysis Groups, workshops, feedback, and discussion of these topics at recent MEPAG meetings. It was prepared by the MEPAG Goals and Executive Committees with assistance of many Mars community members.</p> | <p>Mars: Not Phobos and Deimos.</p>                 |
| <p>Naoya Imae</p>                                                                                                                                                                                                           | <p>Supporting the sample return from Mars</p>                                        | <p>I heartfully indicate the support on the sample return mission from Mars, and the indispensable facilities in laboratories. Because the sample return mission is the keys of essential problems for Planetary Science.</p>                                                                                    | <p>Mars: Not Phobos and Deimos.</p>                 |
| <p>Tibor Balint</p> <p><b>Co-Authors:</b> James Cutts, Mark Bullock, James Garvin, Stephen Gorevan, Jeffery Hall, Peter Hughes, Gary Hunter, Satish Khanna, Elizabeth Kolawa, Viktor Kerzhanovich, Ethiraj Venkatapathy</p> | <p>Technologies for Future Venus Exploration</p>                                     | <p>This VEXAG community white paper covers both heritage, and key enhancing and enabling technologies, which are required for future Venus exploration missions in all three mission classes. It also argues for a targeted technology development program, including a large environmental test chamber.</p>    | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |
| <p>Patricia M. Beauchamp</p> <p><b>Co-Authors:</b></p>                                                                                                                                                                      |                                                                                      |                                                                                                                                                                                                                                                                                                                  |                                                     |

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Technologies for  
Outer Planet  
Missions: A  
Companion to the  
Outer Planet  
Assessment Group  
(OPAG) Strategic  
Exploration White  
Paper

This is the final version of a white paper which provides the OPAG recommendations for technology required to undertake outer planetary missions. The paper describes the need for an OP technology program and provides specific recommendations for NASA investments during the next decade.

Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.  
Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.

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| <p>Andreas Rathke</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <p>Testing for the<br/> Pioneer Anomaly<br/> on a Pluto<br/> Exploration Mission</p> | <p>An overview of the<br/> phenomenon, commonly<br/> dubbed the Pioneer anomaly,<br/> is given and the possibility<br/> for an experimental test of<br/> the anomaly as a secondary<br/> goal of an upcoming space<br/> mission is discussed using a<br/> putative Pluto Orbiter Probe<br/> as a paradigm.</p> | <p>Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p> |

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| <p>Mark Hofstadter</p> <p><b>Co-Authors:</b> Don Banfield, Linda Brown, Thibault Cavalie, Imke de Pater, Scott Edgington, Leigh Fletcher, A. James Friedson, Daniel Gautier, Sam Gulkis, Mark Gurwell, Patrick Irwin, Erich Karkoschka, Jean-Pierre Lebreton, Julianne Moses, Glenn Orton, Kathy Rages, Peter Read, Adam P. Showman, Nicholas Teanby, P. Yanamandra-Fisher</p> | <p>The Atmospheres of the Ice Giants, Uranus and Neptune</p> | <p>We believe many important atmospheric science questions can only be addressed by studies of the ice giants Uranus and Neptune. These questions relate to fundamental atmospheric processes that help us understand the formation, evolution, and current structure of all planets.</p> | <p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.</p> |
| <p>Ralph Lorenz</p> <p><b>Co-Authors:</b> Terry Hurford, Bruce Bills, Frank Sohl, James Roberts, Christophe Sotin, Hauke Hussmann</p>                                                                                                                                                                                                                                          | <p>The Case for a Titan Geophysical Network Mission</p>      | <p>Notes the science value of a network of small inexpensive landers focussed on Titan geophysics and that if appropriate radioisotope sources are available, this mission could be affordable under New Frontiers.</p>                                                                   | <p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p>                                          |

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| <p>Terry Hurford</p> <p><b>Co-Authors:</b> B.<br/> Buratti, A.<br/> Coustenis, A.<br/> Dombard, R.<br/> Greenberg, H.<br/> Husmann, M.<br/> Kirchoff, C. Porco,<br/> A. Rymer</p>                                                                                                                                                                                                                                                                                                                                                                                                                                | <p>The Case for an<br/> Enceladus New<br/> Frontiers Mission</p> | <p>In this white paper, we will summarize one possible mission concept to explore Enceladus within a New Frontiers-level mission: to stay below the cost cap of \$650M (FY09 dollars) and within the launch capability of the Atlas V 551. We imagine that there are other possible mission scenarios...</p> | <p>Satellites:<br/> Galilean satellites,<br/> Titan, and the<br/> other satellites of<br/> the giant planets.</p>                                                         |

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The Case for Ceres:  
Report to the  
Planetary Science  
Decadal Survey  
Committee

We present recent findings about Ceres, stressing its unique nature. Outstanding remaining science questions are discussed along with recommendations for the next steps in Ceres research in the Dawn and post-Dawn era.

Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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| <p>Terry Hurford</p> <p><b>Co-Authors:</b> B. Buratti, A. Coustenis, A. Dombard, R. Greenberg, H. Hussmann, M. Kirchoff, C. Porco, A. Rymer, S. Vance, A. Verbiscer</p> | <p>The Case for Enceladus Science</p>                                      | <p>In this white paper, we will outline important science questions regarding Enceladus and show the link between these science questions and major themes of exploration as identified by NASA.</p>                                                                                                                | <p>Satellites:<br/>Galilean satellites, Titan, and the other satellites of the giant planets.</p> |
| <p>David J. Loftus</p> <p><b>Co-Authors:</b> Erin M. Tranfield, Jon C. Rask, Clara McCrossin</p>                                                                        | <p>The Chemical Reactivity of Lunar Dust Relevant to Human Exploration</p> | <p>As NASA prepares to return to the Moon, a clear understanding of the chemistry of lunar dust is required to set the stage for extended duration lunar surface operations. All aspects of the unique environment of the Moon—micrometeorite bombardment, UV light exposure, solar wind radiation, solar parti</p> | <p>Inner Planets:<br/>Mercury, Venus, and the Moon.</p>                                           |

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The Comet Coma  
Rendezvous Sample  
Return (CCRSR)  
Mission Concept –  
The Next Step  
Beyond Stardust

This paper describes the scientific goals and implementation design of the Comet Coma Rendezvous and Sample Return (CCRSR) mission, one of the concept study missions funded by the recent NASA DSCME Program.

Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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The Exploration of  
Neptune and Triton

Neptune and its captured moon Triton are unexplored with modern spacecraft instrumentation. Observations of these objects are urgently needed to address planet formation and the evolution of ice giant planets, icy satellites, Kuiper Belt Objects, and the solar system itself.

Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
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Galilean satellites,  
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Primitive Bodies:  
Asteroids,  
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other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.



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| <p>Susanne P. Schwenger</p> <p><b>Co-Authors:</b> O. Abramov, C. Allen, S. Clifford, J. Filiberto, D.A. Kring, J. Lasue, P.J. McGovern, H.E. Newsom, A.H. Treiman, A. Wittmann</p>                    | <p>The importance of (Noachian) impact craters as windows to the sub-surface and as potential hosts of life</p> | <p>The paper demonstrated the research that can be done in small craters punctuating larger Noachian craters. Topics include: small craters as natural drills, impact-generated hydrothermal systems and lakes in Noachian craters, and the ecological niches created by them.</p>                               | <p>Mars: Not Phobos and Deimos.</p>                                                                                                                                                                                                                                                                                       |
| <p>Jeffrey R. Johnson</p> <p><b>Co-Authors:</b> B. Archinal, R. Kirk, L. Gaddis, J. Anderson, B. Bussey, R. Beyer, L. Bleamaster, W. Patterson, J. Gillis-Davis, T. Watters, P. Schenk, B. Denevi</p> | <p>The Importance of a Planetary Cartography Program: Status and Recommendations for NASA 2013-2023</p>         | <p>We describe 7 areas where greater attention should be paid to data returned from planetary missions, beyond minimum “mission success”. The alternative is duplication of efforts and greater chances for errors, thereby diminishing the cost return and scientific potential provided by planetary data.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Mars: Not Phobos and Deimos.<br/>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Paul Withers</p> <p><b>Co-Authors:</b> Jared Espley, Rob Lillis, Dave Morgan, Laila Andersson, Mathieu Barthélemy, Stephen Bougher,</p>                                                            |                                                                                                                 |                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                           |

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The ionosphere of Mars and its importance for climate evolution

The ionosphere of Mars is a key part of the boundary between Mars and the solar wind. The MAVEN mission will improve our understanding of ionospheric properties and processes, including how they affect the escape to space of atmospheric species, but other important questions will remain unanswered.

Mars: Not Phobos and Deimos.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                               |                                                                                                                                                                                                                                                                                              |                                                     |
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| <p>W. M. Farrell</p> <p><b>Co-Author:</b><br/>Mihaly Horanyi</p>                                                                                                                                                                                                                                                                                                                                                                                          | <p>The Lunar Dusty Exosphere: The Extreme Case of an Inner Planetary Atmosphere</p>                                                           | <p>The Moon is an extreme type of atmosphere – a surface bounded exosphere – and may represent the final ‘ground state’ of any geologically dormant body. Neutral gas and dust are emitted from its surface via universal processes believed to be occurring at all near-airless bodies.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |
| <p>Clive R. Neal</p> <p><b>Co-Authors:</b> Brad Bailey, Dave Beaty, Mary Sue Bell, Mike Duke, Paul Eckert, John Gruener, Jeff Jones, Robert Kelso, David Kring, Dan Lester, Paul Neitzel, Lewis Peach, Neal Pellis, Mike Ramsey, Debra Reiss-Bubenheim, James Rice, Gerald Sanders, Kurt Sacksteder, Greg Schmidt, Charles Shearer, Kelly Snook, Jim Spann, Paul Spudis, George Tahu, G. Jeffrey Taylor, Lawrence Taylor, Jeff Volosin, Michael Wargo</p> | <p>The Lunar Exploration Roadmap. Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2009</p> | <p>This paper summarizes the long term Lunar Exploration Roadmap that has been developed by the lunar community and coordinated by the Lunar Exploration Analysis Group.</p>                                                                                                                 | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |

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| <p>Georgiana Young<br/>Kramer</p> <p><b>Co-Authors:</b><br/>David Blewett,<br/>Lon Hood, Jasper<br/>Halekas, Sarah<br/>Noble, Bernard<br/>Ray Hawke,<br/>Gunther<br/>Kletetschka, Erika<br/>Harnett, and Ian<br/>Garrick-Bethell</p> | <p>The Lunar Swirls</p>                                                                                 | <p>The lunar swirls are high albedo curvilinear surface features coincident with regions of strong remanent magnetism. Investigating the lunar swirls is important to understand the Earth-Moon system, the interaction of planetary surfaces with the solar wind, and how to best explore our solar system.</p>   | <p>Inner Planets:<br/>Mercury, Venus,<br/>and the Moon.</p>                                                                                        |
| <p>Steven Howe</p> <p><b>Co-Authors:</b> Brian<br/>Gross, Jeff<br/>Katalenich, Robert<br/>O'Brien, Logan<br/>Sailer</p>                                                                                                              | <p>The Mars Hopper:<br/>Long Range Mobile<br/>Platform Powered<br/>by Martian In-Situ<br/>Resources</p> | <p>The CSNR is designing an instrumented platform that can acquire detailed data at hundreds of locations during its 10 year lifetime - a Mars Hopper. By accumulating thermal power from a radioisotope source, the platform will be able to “hop” from one location to the next every 2-3 days with a separa</p> | <p>Mars: Not Phobos<br/>and Deimos.<br/>Satellites:<br/>Galilean satellites,<br/>Titan, and the<br/>other satellites of<br/>the giant planets.</p> |
| <p>Michael Hecht</p> <p><b>Co-Authors:</b> W.<br/>Thomas Pike,<br/>Walter Goetz,<br/>Morten Bo<br/>Madsen, Janice L.<br/>Bishop, Urs<br/>Staufer, Kjartan M.<br/>Kinch, Kristoffer<br/>Leer</p>                                      | <p>The microstructure<br/>of the martian<br/>surface</p>                                                | <p>Martian soil is a microcosm of the mineralogical history of the planet, and it exerts a primary influence on atmospheric, geological, and periglacial properties. We propose an increased emphasis on microanalysis in future Mars surface exploration.</p>                                                     | <p>Mars: Not Phobos<br/>and Deimos.</p>                                                                                                            |

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| <p>Alan Tokunaga</p> <p><b>Co-Authors:</b> S.J. Bus, J.T. Rayner, E.V. Tollestrup</p>                                                                                                                                                                                                                               | <p>The NASA Infrared Telescope Facility</p>           | <p>This white paper describes the NASA Infrared Telescope Facility, its capabilities, and its role in current and future research in planetary astronomy.</p>                                                                                                                                     | <p>None of the above.</p>                           |

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| <p>Clive R. Neal</p> <p><b>Co-Authors:</b><br/> Marek Banaszkiewicz, Bruce Banerdt, Bruce Bills, James Carpenter, Peter Chi, Ulli Christensen, Eric Clévéde, Barbara Cohen, Ian Crawford, Doug Currie, Paul Davis, Veronique Dehant, Simone Dell’Agnello, Andrew Dombard, Fred Duennebier,</p>                                                          |                                                                           |                                                                                                                                                                                                                                                                                      |                                     |

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The Rationale for  
Deployment of a  
Long-Lived  
Geophysical  
Network on the  
Moon

This paper outlines the  
rationale establishing a global  
lunar geophysical network  
and the authorship  
demonstrates the broad  
community support for such  
an endeavor, both within the  
USA and internationally.

Inner Planets:  
Mercury, Venus,  
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The Science of  
Titan and its Future  
Exploration

This paper describes the  
science rationale for the next  
steps beyond Cassini-  
Huygens of exploration of  
Saturn's moon Titan.

Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.

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| <p>Ian Crawford</p> <p><b>Co-Authors:</b><br/> Mahesh Anand,<br/> Professor Mark Burchell, James Carpenter, Barbara Cohen, Leon Croukamp, Andrew Daga, Hilary Downes, Sarah Fagents, Terence Hackwill, James N Head, Essam Heggy, Adrian Jones, Katherine Joy, Christian Koeberl, Philippe Lognonné, Clive Neal, Noah Petro, Professor Sara Russell, Joshua Snape, Larry Taylor, Allan Treiman, Shoshana Weider, Mark Wieczorek, Lionel Wilson</p> | <p>The Scientific Rationale for Renewed Human Exploration of the Moon</p>    | <p>This paper outlines the scientific benefits that will follow from renewed human exploration of the Moon. [Final version with updated author list]</p>                                                                                                                          | <p>Inner Planets: Mercury, Venus, and the Moon.</p>                                                                                          |
| <p>Scott L. Murchie</p> <p><b>Co-Authors:</b><br/> Andrew S. Rivkin, Joseph Veverka, Peter C. Thomas, Nancy L. Chabot</p>                                                                                                                                                                                                                                                                                                                          | <p>The Scientific Rationale for Robotic Exploration of Phobos and Deimos</p> | <p>Mars' two moons, Phobos and Deimos, are D-type small bodies that may be remnants of the population that delivered volatiles to the inner solar system. A Discovery class mission can address key science questions at the moons, and prepare for future human exploration.</p> | <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |

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| <p>Erin Lee Ryan</p> <p><b>Co-Authors:</b> Sarah M. Hörst, Michael P.J. Benfield, Fred Calef III, Dario Cersosimo, Valeria Cottini, Robert Citron, Katherine E. Gibson, Joel A. Hesch, Dana Ionita, Craig C. Jolley, Driss Takir, Matthew Turner, Elizabeth A. Jensen</p>       | <p>The TRACER mission: a proposed Trojan and Centaur flyby mission</p>        | <p>This paper presents a proposed flyby mission for one Trojan and one Centaur as designed by the participants of the JPL Planetary Science Summer School. This mission meets the current New Horizons guidelines and will address fundamental questions about the history of the solar system.</p>                | <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>                                                                                   |

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| <p>Andrew Rivkin</p> <p><b>Co-Authors:</b><br/> Joshua Emery,<br/> Antonella Barucci,<br/> James F. Bell,<br/> William F. Bottke,<br/> Elisabetta Dotto,<br/> Robert Gold, Carey<br/> Lisse, Javier<br/> Licandro, Louise<br/> Prockter, Charles<br/> Hibbits, Michael<br/> Paul, Alessondra<br/> Springmann, Bin<br/> Yang</p> | <p>The Trojan<br/> Asteroids: Keys to<br/> Many Locks</p>                                                                            | <p>The Trojan asteroids of<br/> Jupiter lie at the crux of<br/> several of the most<br/> interesting outstanding issues<br/> regarding the formation and<br/> evolution of the Solar<br/> System. We present science<br/> questions centering on the<br/> Trojans are lay out<br/> recommendations for their<br/> future study and exploration.</p> | <p>Primitive Bodies:<br/> Asteroids,<br/> comets, Phobos,<br/> Deimos,<br/> Pluto/Charon and<br/> other Kuiper belt<br/> objects,<br/> meteorites, and<br/> interplanetary<br/> dust.</p> |
| <p>Scot Rafkin</p> <p><b>Co-Authors:</b><br/> Robert. M.<br/> Haberle, Don<br/> Banfield, Jeff.<br/> Barnes</p>                                                                                                                                                                                                                 | <p>The Value of<br/> Landed<br/> Meteorological<br/> Investigations on<br/> Mars: The Next<br/> Advance for<br/> Climate Science</p> | <p>Major advances in the<br/> understanding of the present<br/> and past Mars climate system<br/> are most likely to be<br/> accomplished by in situ<br/> meteorological surface<br/> measurements operating from<br/> both a network configuration<br/> and individual stations.</p>                                                               | <p>Mars: Not Phobos<br/> and Deimos.</p>                                                                                                                                                  |

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The Venus Science  
and Technology  
Definition Team  
Flagship

This white paper describes  
the scientific goals,  
objectives, instruments and  
mission architecture and  
design for a Flagship class  
mission to Venus.

Inner Planets:  
Mercury, Venus,  
and the Moon.

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| <p>Edward R. Martinez</p> <p><b>Co-Author:</b><br/>Robert V. Frampton</p> | <p>Thermal Protection System Sensors</p> | <p>This paper advocates for the development of an aeroshell TPS sensor system to the benefit of all atmospheric reentry missions Agency wide.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.<br/>Mars: Not Phobos and Deimos.<br/>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.<br/>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.<br/>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
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Thermal Protection System Technologies for Enabling Future Mars/Titan Science Missions

This paper describes currently available TPS technologies and identifies new technologies needed to support Mars missions in the 2013 - 2022 timeframe, drawing on past mission studies, recent Mars Technology workshop for Mars Sample Return Mission, and the Solar

Mars: Not Phobos and Deimos. Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.

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Thermal Protection  
System  
Technologies for  
Enabling Future  
Outer Planet  
Missions

This paper discusses the capability of heritage TPS technology used on the Galileo probe and new materials required for future outer planet probe missions. A prime conclusion is that there are important issues regarding the availability of the TPS required for Outer Planet entry probes.

Giant Planets:  
Jupiter, Saturn,  
Uranus, Neptune,  
and exoplanets,  
including rings  
and magnetic  
fields, but not  
their satellites.

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Ethiraj  
Venkatapathy

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Thermal Protection  
System  
Technologies for  
Enabling Future  
Sample Return  
Missions

Currently available TPS materials can meet the needs of Sample Return missions with entry velocity 13 km/s, heritage carbon phenolic is fully capable, but potentially unavailable and currently available TPS will need to be qualified.

Primitive Bodies:  
Asteroids,  
comets, Phobos,  
Deimos,  
Pluto/Charon and  
other Kuiper belt  
objects,  
meteorites, and  
interplanetary  
dust.

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Thermal Protection  
System  
Technologies for  
Enabling Future  
Venus Exploration

This paper discusses the capability of currently available TPS and the availability of heritage carbon phenolic used on the Pioneer-Venus probes. A prime conclusion is that there are important issues regarding the availability of the TPS required for future Venus entry probes.

Inner Planets:  
Mercury, Venus,  
and the Moon.

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| <p>J. Hunter, Jr. Waite</p> <p><b>Co-Authors:</b> T. Brockwell, D.T. Young, W.S. Lewis, C.P. McKay, Francois Raulin, G. Schubert</p>                                                                                                                                                                                                                                                | <p>Titan Lake Probe</p> | <p>This White Paper describes the concept for a Titan Lake Probe, which could be implemented either as an element of a TSSM-type mission or as a stand-alone New Frontiers mission. The Lake Probe could be configured either as a boat or, for increased science return, as a submersible.</p> | <p>Satellites:<br/>Galilean satellites, Titan, and the other satellites of the giant planets.</p> |
| <p>Conor A. Nixon</p> <p><b>Co-Authors:</b><br/>Carrie M. Anderson, F. Michael Flasar, Christophe Sotin, J. Hunter Waite Jr., V. Malathy Devi, Olivier Mousis, Kim R. Reh, Konstantinos Kalogerakis, A.</p>                                                                                                                                                                         |                         |                                                                                                                                                                                                                                                                                                 |                                                                                                   |



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Titan's Greenhouse  
Effect and Climate

Herein we examine the atmospheric parallels between the Earth and Titan including the possibility of dramatic climate change. In the next decade, we urge extending the duration of the Cassini mission, planning for a future mission focused on Titan's climate and other measures.

Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.

|                                                                                                                                                                                                                                                                                                                           |                                                                         |                                                                                                                                                                                                                                                                                                                      |                                                                                                    |
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| <p>Imke de Pater,<br/> Véronique Vuitton,<br/> Paul N. Romani,<br/> Robert A. West,<br/> Lucy H. Norman,<br/> Mary Ann H.<br/> Smith, Kathleen<br/> Mandt, Sebastien<br/> Rodriguez, Máté<br/> Ádámkovics, Jean-<br/> Marie Flaud, Kurt<br/> K. Klaus, Michael<br/> Wong, Jean-Pierre<br/> Lebreton, Neil<br/> Bowles</p> |                                                                         |                                                                                                                                                                                                                                                                                                                      |                                                                                                    |
| <p>Julian Nott</p>                                                                                                                                                                                                                                                                                                        | <p>Titan's unique attraction: it is an ideal destination for humans</p> | <p>With so many opportunities in the Solar System it may be hard to choose destinations. Titan has a one quality that sets it apart: it is uniquely suitable for humans. One reason for robotic Mars exploration is that humans will arrive in due course. An identical justification applies to exploring Titan</p> | <p>Satellites:<br/> Galilean satellites, Titan, and the other satellites of the giant planets.</p> |

Candice Hansen

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Triton science with  
Argo - A Voyage  
through the Outer  
Solar System

Argo is an innovative  
pragmatic concept for a New  
Frontiers 4 mission to  
significantly expand our  
knowledge of the outer Solar  
System. It exploits an  
upcoming launch window  
that permits a close Triton  
encounter during a flyby  
through the Neptune system,  
and then continues on to a  
scientifically-sel

Satellites:  
Galilean satellites,  
Titan, and the  
other satellites of  
the giant planets.

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| <p>Kimberly R. Kuhlman</p> <p><b>Co-Authors:</b><br/> Alberto Behar,<br/> Jack Jones,<br/> Penelope Boston,<br/> Jeffrey Antol,<br/> Gregory Hajos,<br/> Warren Kelliher,<br/> Max Coleman,<br/> Ronald Crawford,<br/> Lynn Rothschild,<br/> Martin Buehler,<br/> Greg Bearman,<br/> Daniel W. Wilson,<br/> Christopher P. McKay</p> | <p>Tumbleweed: A New Paradigm for Surveying the Surface of Mars</p> | <p>Tumbleweeds are lightweight, highly configurable and inexpensive wind-driven vehicles that could enable long-range surveys of the surface of Mars. Their analytical capabilities can be optimized for measurements for astrobiology or in situ resources over relatively large swaths of terrain.</p>           | <p>Mars: Not Phobos and Deimos.</p>                 |
| <p>Sarah E. Braden</p> <p><b>Co-Authors:</b><br/> Samuel J. Lawrence, Mark S. Robinson, Bradley L. Jolliff, Julie D. Stopar, Lillian R. Ostrach, Lisa R. Gaddis, Justin J. Hagerty, Steven B. Simon, B. Ray Hawke</p>                                                                                                                | <p>Unexplored Areas of the Moon: Nonmare Domes</p>                  | <p>Analysis of samples returned from unexplored areas of lunar volcanism such as the Gruithuisen Domes will (1) increase our knowledge of the history of the Earth-Moon system, (2) advance theories of lunar magmatic evolution and (3) provide valuable points of comparison with other terrestrial planets.</p> | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |

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| <p>Bruce Jakosky</p> <p><b>Co-Authors:</b><br/>Richard W. Zurek,<br/>Jan Amend,<br/>Michael H. Carr,<br/>Daniel J. McCleese, John F. Mustard, Kenneth Nealson, Roger Summons</p>                                                                                                                                                                                                                                                                    | <p>Update: Are There Signs of Life on Mars? A Scientific Rationale for a Mars Sample-Return Campaign As The Next Step in Solar System Exploration</p> | <p>Update: Discussion of the scientific rationale for Mars sample return as the next step in understanding solar-system exploration and Mars astrobiology. Sample return is discussed in the context of a Mars exploration program and the fiscal reality of the Mars program.</p>                               | <p>Mars: Not Phobos and Deimos.</p>                 |
| <p>Sanjay S. Limaye</p> <p><b>Co-Authors:</b> Mark Allen, Sushil Atreya, Kevin H. Baines, Jean-Loup Bertaux, Gordon Bjoraker, Jacques Blamont, Mark Bullock, Eric Chassefiere, Gordon Chin, Curt Covey, David Grinspoon, Samuel Gulkis, Viktor Kerzhanovich, Stephen Lewis, Kevin McGouldrick, W. J. Markiewicz, Rosalyn A. Pertzborn, Christopher Rozoff, Giuseppe Piccioni, Gerald Schubert, Lawrence A. Sromovsky, Colin F. Wilson, Yuk Yung</p> | <p>Venus Atmosphere: Major Questions and Required Observations</p>                                                                                    | <p>This paper describes the major questions about the atmosphere of Venus and the observations required to understand it. “How Does Venus atmosphere work?” A dedicated and renewed exploration effort is required to address this fundamental question. Key questions requiring new observations include: H</p> | <p>Inner Planets: Mercury, Venus, and the Moon.</p> |

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| <p>Sue Smrekar</p> <p><b>Co-Author:</b><br/> Sanjay Limaye</p>                                                                                                                                                                                                                                                                                     | <p>Venus Exploration<br/> Goals, Objectives,<br/> Investigations, and<br/> Priorities</p> | <p>This white paper describes the science priorities developed by the Venus Exploration Analysis Group, through a series of meetings with the Venus science community. The science themes for Venus are Origin and Evolution, Venus as a Terrestrial Planet, and Climate Change and the Future of Earth.</p>     | <p>Inner Planets:<br/> Mercury, Venus,<br/> and the Moon.</p>  |
| <p>Allan H. Treiman</p>                                                                                                                                                                                                                                                                                                                            | <p>Venus<br/> Geochemistry:<br/> Progress, Prospects,<br/> and Future Missions</p>        | <p>Report and recommendation of the February 2009 workshop of the same name.</p>                                                                                                                                                                                                                                 | <p>Inner Planets -<br/> Mercury, Venus,<br/> and the Moon.</p> |

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| <p>James B. Garvin</p> <p><b>Co-Authors:</b> Lori S. Glaze, Sushil Atreya, Bruce Campbell, Don Campbell, Peter Ford, Walter Kiefer, Frank Lemoine, Greg Neumann, Roger Phillips, Keith Raney</p> | <p>Venus:<br/>Constraining Crustal Evolution from Orbit Via High-Resolution Geophysical and Geological Reconnaissance</p> | <p>Major gaps in understanding Venus include how planetary-scale crustal resurfacing operated, the formation and evolution of highlands, and whether evidence of past environments is preserved. These questions can be addressed through an orbiting radar altimeter and high resolution SAR imager.</p>         | <p>Inner Planets: Mercury, Venus, and the Moon.</p>                                                                                          |
| <p>Charles Alcock</p> <p><b>Co-Authors:</b> Matthew Holman, Matthew Lehner, Stephen Murray, Pavlos Protopapas, Michael Werner</p>                                                                | <p>Whipple: Exploring the Solar System beyond Neptune Using a Survey for Occultations of Bright Stars</p>                 | <p>Whipple is a Discovery class mission to explore the outer Solar System. A small telescope will compile lightcurves of ~40,000 stars sampled at 40 Hz. Small bodies from the Kuiper Belt to the Oort Cloud will occult targeted stars, revealing their distances, sizes, and abundances.</p>                    | <p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p> |
| <p>Dr. John F. Mustard</p>                                                                                                                                                                       | <p>Why Mars Remains a Compelling Target for Planetary Exploration</p>                                                     | <p>Mars has been an extremely compelling exploration target. The Decadal Survey is re-evaluating the priority of different sectors of the planetary exploration program. Based on the data collected since 2002, our conclusion is that the exploration of Mars is even more compelling now than it was then.</p> | <p>Mars: Not Phobos and Deimos.</p>                                                                                                          |
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Why the Moon is  
important for Solar  
System Science

This paper outlines the  
importance of the Moon for  
Solar System science and in  
its own right as a critical  
target for scientific  
investigation during the next  
decade of exploration.

Inner Planets:  
Mercury, Venus,  
and the Moon.



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