

Wesley A. Traub

Co-Authors:

Charles Beichman,
Ruslan Belikov,
Geoff Bryden,
Mark Clampin and
William Danchi,
Imke de Pater,
Thomas Greene,
Olivier Guyon,
Sara Heap, John
Johnson, Lisa
Kaltenegger,
Jeremy Kasdin,
James Kasting,
Douglas Lin, Jack
Lissauer, Carey
Lisse, Jonathan
Lunine, Bruce
Macintosh, Geoff
Marcy, Mark
Marley, Michael
Meyer, Matt
Mountain, Ben
Oppenheimer,
Glenn Orton, Marc
Postman, Aki
Roberge, Sara
Seager, Eugene
Serabyn and
Christophe Sotin,
Remi Soummer,
Karl Stapelfeldt,
John Trauger,
Stephen Unwin,
Michael Werner

Exoplanets and
Solar System
Exploration

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.

Giant Planets:
Jupiter, Saturn,
Uranus, Neptune,
and exoplanets,
including rings
and magnetic
fields, but not
their satellites.
Primitive Bodies:
Asteroids,
comets, Phobos,
Deimos,
Pluto/Charon and
other Kuiper belt
objects,
meteorites, and
interplanetary
dust.

<p>George Sonneborn</p> <p>Co-Authors: 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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Craig Agnor

Co-Authors: A.

Barr, B. Bierhaus,
D. Brain, B. Bills,
W. Bottke, B.
Buratti, S.
Charnoz, J. Cho, A.
Christou, G.
Collins, J. Colwell,
N. Cooper, L.
Dones, M. Evans,
R. French, A.
Gulbis,, N.
Haghighipour, D.
Hamilton, C.
Hansen,, A.
Hendrix, D.
Hurley, K. Jessup,
M. Kirchoff, W.
Kurth, H. Levison,
M. Lewis, R. Lillis,
Y. Ma, R.
Malhotra, T.
Michaels, M.
Mickelson, W.
Patterson, L.
Prockter, D.
Ragozzine, K.
Rutherford, K.
Sayanagi, P.
Schenk, M.
Summers, M.
Tiscareno, K.
Tsiganis, P. Zarka

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.

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Asteroids,
comets, Phobos,
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Pluto/Charon and
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meteorites, and
interplanetary
dust.

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, Elizabeth Turtle

Future Io
Exploration for
2013-2022 and
Beyond, Part 1:
Justification and
Science Objectives

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).

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the giant planets.

<p>David A. Williams</p> <p>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</p>	<p>Future Io Exploration for 2013-2022 and Beyond, Part 2: Recommendations for Missions</p>	<p>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).</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>Patricia M. Beauchamp</p> <p>Co-Authors: William McKinnon, Thomas Magner, Sami Asmar, Hunter Waite, Stephen Lichten, Ethiraj Venkatapathy, Tibor Balint, Athena Coustenis,</p>			

Jeffrey L. Hall,
Michelle Munk,
Alberto Elfes, Kim
Reh, John Elliott,
Jonathan Rall,
Richard Barney,
Tom Spilker,
Thomas J. Sutliff,
Craig Williams,
Andy Spry, David
Atkinson,
Subbarao
Surampudi, Nathan
Strange, Robert
Preston, Wayne
Zimmerman, Mark
Hofstadter, James
Cutts, John Clarke,
Kevin Baines,
Mohammad
Mojarradi, Eric
Pencil, Jason
Barnes, Conor
Nixon, Maria
Teresa Capria,
Vladimir B.
Zivkovic, Anezina
Solomonidou,
Carrie Anderson,
Julie Castillo, Karl
Mitchell, Leonid
Gurvits, David A.
Williams, Javier
Martin-Torres,
Andrew Coates,
Robert West,
Rosaly Lopez,
Michael Wright,
Linda Spilker,
Jonathan Lunine,
Jason Soderblom,
Bill Kurth,
Christophe Sotin,

Technologies for
Outer Planet
Missions: A
Companion to the
Outer Planet

This is the final version of a
white paper which provides
the OPAG recommendations
for technology required to
undertake outer planetary
missions. The paper

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

Olivier Mousis,
Ralf Jaumann,
Nicholas Teanby,
Edward Sittler,
Frank Sohl, George
Bampasidis,
Valeria Cottini,
Eric Wilson, Roger
Yelle, Ralph
Lorenz, Sushil
Atreya, Francois
Raulin, Patrick
Irwin, Mathieu
Hirtzig, Julian
Nott, Lucy
Norman, Murthy
Gudipati,
Véronique Vuitton,
Rolant Thissen,
Henry Throop,
Kurt Klaus,
Sebastien
Rodriguez, Ingo
Mueller-Wodarg,
James N. Head,
Don Banfield, Paul
Mahaffy, Robert
Brown, Marina
Galand, Bonnie J.
Buratti , Glen
Orton, Jesse
Beauchamp,
Samuel Gulkis,
John Brophy,
Timothy A.
Livengood, Louise
Prockter, Mark A.
Gurwell, Lorenzo
Bruzzone, Ronald
Greeley, Paolo
Tortora, Robert
Pappalado, Mimi

Assessment Group
(OPAG) Strategic
Exploration White
Paper

describes the need for an OP
technology program and
provides specific
recommendations for NASA
investments during the next
decade.

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

<p>Aung, Jesus Martinez-Frias, Jani Radebaugh, Jean-Pierre Lebreton David Senske, Alfred McEwen, Dirk Schulze-Makuch, Mark Smith, Dennis Matson, Matthew S. Tiscareno, Mathieu Choukroun, Elizabeth Turtle</p>			
<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>
<p>Robert Pappalardo</p> <p>Co-Authors: Michel Blanc, Emma Bunce, Michele Dougherty, Olivier Grasset, Ron Greeley, Torrence Johnson, Jean- Pierre Lebreton, David Senske, Louise Prockter</p>	<p>Science of the Europa Jupiter 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: 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>Tsun-Yee Yan Yan</p> <p>Co-Authors: 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>
<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: 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>

William B.
McKinnon

Co-Authors: 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

Exploration
Strategy for the
Outer Planets 2013-
2022: Goals and
Priorities

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.

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the giant planets.

<p>Olga Prieto Ballesteros</p> <p>Co-Authors: Kevin P. Hand, Ariel Anbar, Felipe Gómez-Gómez, Oleg Korablev, Ralph Lorenz, Ralph Milliken, Daniel Prieur, Francois Raulin, Steve Vance, Michel Viso</p>	<p>Astrobiology in Europa and Jupiter System Mission (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: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.</p>
<p>Matthew Tiscareno</p> <p>Co-Authors: 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 Gruen, Douglas P. Hamilton, Matthew M. Hedman, Mihaly Horanyi, Harald Krueger, Jack J. Lissauer, Philip D. Nicholson, Robert T. Pappalardo, Frank Postberg, Mark R. Showalter,</p>		<p>The study of planetary ring systems forms a key component of planetary science. We discuss priority activities for the next decade</p>	<p>Giant Planets: Jupiter, Saturn, Uranus, Neptune,</p>

<p>Frank Spahn, Linda J. Spilker, Joseph N. Spitale, Miodrag Sremcevic, Padma Yanamandra- Fisher, Gregory J. Black, André Brahic, Sébastien Charnoz, Richard H. Durisen, Michael W. Evans, Cecile Ferrari, Amara Graps, Sascha Kempf, Steven M. Larson, Mark C. Lewis, Essam A. Marouf, Colin J. Mitchell, Carl D. Murray, Cathy B. Olkin, Keiji Ohtsuki, Derek C. Richardson, Heikki Salo, Juergen Schmidt, David A. Seal, Ralf Srama, Glen R. Stewart, John W. Weiss</p>	<p>Rings Research in the Next Decade</p>	<p>including full support for the Cassini Solstice Mission, a spacecraft mission to Neptune and/or Uranus, and support for Earth-based research activities.</p>	<p>and exoplanets, including rings and magnetic fields, but not their satellites.</p>
<p>Alan P. Boss</p> <p>Co-Authors: Edward Young, Victoria Meadows, Nader Haghighipour</p>	<p>Astrobiology Research Priorities for Exoplanets</p>	<p>We recommend that the Decadal Survey place a high priority on continued, even expanded, support of the Research & 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: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.</p>

Leigh N. Fletcher

Co-Authors: G. Orton, T. Stallard, K. Baines, K. M. Sayanagi, F. J. Martin-Torres, M. Hofstadter, I. de Pater, S. Edgington, R. Morales-Juberias, T. Livengood, D. Huestis, P. Hartogh, D.H. Atkinson, J. Moses, M. Wong, U. Dyudina, A.J. Friedson, T.R. Spilker, R.T. Pappalardo, P.G.J. Irwin, N. Teanby, T. Cavalié, O. Mousis, A.P. Showman, X. Liu, M.B. Lystrup, S. Gulkis, T. Greathouse, R. K. Achterberg, G.L. Bjoraker, S.S. Limaye, P. Read, D. Gautier, D.S. Choi, T. Kostiuk, A.F. Nagy, D. Huestis, M. Choukroun, I. Muller-Wodarg, P. Yanamandra-Fisher

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.

Candice Hansen

Co-Authors:

A.S.Aljabri,
D.Banfield,
E.B.Bierhaus,
M.Brown,
J.E.Colwell,
M.Dougherty,
A.R.Hendrix,
A.Ingersoll,
K.Khurana,
D.Landau,
A.McEwen,
D.A.Paige,
C.Paranicas,
C.M.Satter,
B.Schmidt,
M.Showalter,
L.J.Spilker,
T.Spilker,
J.Stansberry,
N.Strange,
M.Tiscareno

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

Argo is an innovative pragmatic concept for a New Frontiers 4 mission which 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-selected Kuiper Belt Object.

Giant Planets:
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Mark Hofstadter

Co-Authors: 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

The Atmospheres of the Ice Giants, Uranus and Neptune

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.

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

Mark Hofstadter

Co-Authors:

David Atkinson,
Kevin Baines,
Shawn Brooks,
Imke de Pater,
Leigh Fletcher, A.
James Friedson,
Mark Gurwell,
Matthew Hedman,
Brigette Hesman,
Patrick Irwin,
Sanjay Limaye,
Steven Miller,
Robert Moeller,
Julianne Moses,
Neil Murphy,
Glenn Orton,
Robert Pappalardo,
Kathy Rages,
Nicole Rappaport,
Christophe Sotin,
Linda Spilker,
Thomas Spilker,
Tom Stallard,
Matthew
Tiscareno,
Elizabeth Turtle,
Daniel Wenkert

The Case for a
Uranus Orbiter

This paper discusses some of the fundamental science that must be done at Uranus if we are to understand our Solar System and systems discovered around other stars. We suggest a Uranus Orbiter should be launched in the next decade.

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Glenn Orton

Co-Authors:

Glenn Orton,
Padma
Yanamandra-
Fisher, Leigh
Fletcher, Kevin
Baines, Imke de
Pater, Olivier
Mousis, Jean-
Pierre Lebreton,
Steve Miller⁵,
Sang-Joon Kim,
Makenzie Lystrup,
Kunio Sayanagi,
Tom Stallard, Paul
Steffes

Earth-Based
Observational
Support for
Spacecraft
Exploration of
Outer-Planet
Atmospheres

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.

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Glenn S. Orton

Co-Authors: L. N. Fletcher, T. Stallard, K. Baines, K. M. Sayanagi, Y. Yung, S. Edgington, S. Gulkis, J. Moses, F. J. Martin-Torres, U. Dyudina, B. Marty, N. Teanby, P.G.J. Irwin, T. Cavalié, D.H. Atkinson, O. Mousis, A.J. Friedson, T.R. Spilker, M. Hofstadter, R. Morales-Juberias, A.P. Showman, X. Liu, P. Hartogh, M. Wong, T.R. Spilker, M.B. Lystrup, A. Coustenis, T. Greathouse, R. K. Achterberg, G.L. Bjoraker, S.S. Limaye, P. Read, D. Gautier, D.S. Choi, T. Kostiuk, D. Huestis, A.F. Nagy, M. Choukroun, I. Muller-Wodarg, P. Yanamandra-Fisher

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.

<p>Linda J. Spilker</p> <p>Co-Authors: C. J. Hansen, N. Albers, A. S. Aljabri, D. Banfield, E. B. Bierhaus, M. Brown, J. E. Colwell, C. Chavez, F. Crary, I. de Pater, M. Dougherty, C. Ferrari, G. Filacchione, R. French, M. Gordon, E. Gruen, M. Hedman, A. R. Hendrix, M. Horanyi, G. Hospodarsky, A. Ingersoll, Sasha Kempf, K. Khurana, B. Kurth, D. Landau, J. Lissauer, E. Marouf, A. McEwen, D. A. Paige, C. Paranicas, F. Postberg, N. Rappaport, H. Salo, C. M. Satter, B. Schmidt, M. Showalter, T. R. Spilker, J. Stansberry, N. Strange, M. S. Tiscareno, P. Yanamandra-Fisher</p>	<p>Neptune Ring Science with Argo - A Voyage through the Outer Solar System</p>	<p>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.</p>	<p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.</p>
<p>Ethiraj Venkatapathy</p>			

Co-Authors:

James
Arnold, Bernard
Laub, Helen H.
Hwang, Christine
E. Szalai, Joseph L.
Conley, Jim
Tibaudo, Robert
Knudsen, Andrew
Chambers, David
Atkinson, Sushil K.
Atreva, Joseph M.
Vellinga, William
H. Willcockson,
Janine M.
Thornton, Nicholas
G. Smith, Richard
A. Hund, John
Dec, Max L.
Blosser, Michelle
M. Munk, Robert
Maddock, Prasun
N. Desai, Walter
Engelund, Stephen
Sandford, David A.
Gilman, Steven W.
Gayle, John
Kowal, Christopher
B. Madden, Stan
Bouslog, Brian J.
Remark, Donald
Curry, Scott
Coughlin, Adam J.
Amar, Kevin H.
Baines, Tibor
Balint, Bernard
Bienstock, George
T. Chen, James A.
Cutts, Jeffery L.
Hall, Samad A.
Hayati, Pamela J.
Hoffman, Linda

Spilker, Romasso
P. Rivellini, Robert
Manning, Eric M.
Slimko, Adam D.
Steltzner, Thomas
Spilker, Jeffrey
Umland, Charles
Kiskiras, Duane
Baker, Thomas
Foster, Dominic
Calamito, James B.
Garvin, Timothy
A. Sauerwein,
Sharon Seipel, Lori
S. Glaze, Spencer
Stolis, Mark
Lippold, Francis
Schwind, James
Thompson, Raj
Narayan, Thomas
Andrews, Conley
Thatcher, Edwin B.
Curry, John
McKinney, Robert
Frampton, Todd
Stever, Charley
Bown, William
Congdon, Jennifer
Congdon, Daniel
M. Empey, Joe
Hartman, Dinesh
Prabhu, Nancy L.
Mangini, Kristina
A. Skokova,
Margaret M.
Stackpoole, Tood
White, Howard
Goldstein,
Melmoth
Covington, Robin
A. Beck, Carol W.
Carroll, Charles A.
Smith, Deepak

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.

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<p>Bose, Anthony Colaprete, David M. Driver, Edward Martinez, Donald T. Ellerby, Matthew J. Gasch, Aga M. Goodsell, James Reuther, Sylvia M. Johnson, Dean Kontinos, Mary Livingston, Michael J. Wright, Harry Partridge, George A. Raiche, Huy K. Tran, Kerry A. Trumble</p>			
<p>Jonathan J. Fortney</p> <p>Co-Authors: Kevin Zahnle, Isabelle Baraffe, Adam Burrows, Sarah E. Dodson- Robinson, Gilles Chabrier, Tristan Guillot, Ravit Helled, Franck Hersant, William B. Hubbard, Jack J. Lissauer, Mark S. Marley</p>	<p>Planetary Formation and Evolution Revealed with a Saturn Entry Probe: The Importance of Noble Gases</p>	<p>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.</p>	<p>Giant Planets: Jupiter, Saturn, Uranus, Neptune, and exoplanets, including rings and magnetic fields, but not their satellites.</p>
<p>David H. Atkinson</p> <p>Co-Authors: Thomas R. Spilker, Linda Spilker, Tony Colaprete, Tibor Balint, Robert Frampton, Sushil Atreya, Athena Coustenis, Jeff Cuzzi, Kim</p>			

<p>Reh, Ethiraj Venkatapathy, Y. Alibert, N. K. Alonge, S. Asmar, G. Bampasidis, K.H. Baines, D. Banfield, J. Barnes, R. Beebe , B. Bezard, 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, H. Hwang, A. Ingersoll, B. Kazeminejad, J.-P. Lebreton, M. Leese, R. Lorenz, P. Mahaffy, E. Martinez, B. Marty, J. Moses, O. Mousis, G. Orton, M. Patel, S. Pogrebenko, P. Read, S. Rodriguez, H. Salo, J. Schmidt, A. Sole, P. Steffes, P. Withers</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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Allan H. Treiman	Venus Geochemistry: Progress, Prospects, and Future Missions	Report and recommendation of the February 2009 workshop of the same name.	Inner Planets - Mercury, Venus, and the Moon.
<p>Eberhard Gruen</p> <p>Co-Authors: Frank Postberg, Harald Krüger, Mihaly Horanyi, Elmar Jessberger Sascha Kempf, Ralf Srama, Thomas Stephan, Zoltan Sternovsky</p>	In-Situ Mass Spectrometry of Atmosphereless Planetary Objects	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>Inner Planets: Mercury, Venus, and the Moon. 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.</p>

John F. Cooper

Co-Authors:

Steven J. Sturmer,
Chris Paranicas,
Matthew E. Hill,
Abigail M. Rymer,
Paul D. Cooper,
Dan Pascu, Robert
E. Johnson,
Timothy A.
Cassidy, Thomas
M. Orlando, Kurt
D. Retherford,
Nathan A.
Schwadron, Ralf I.
Kaiser, François
Leblanc, Louis J.
Lanzerotti, Claudia
J. Alexander,
Henry B. Garrett,
Amanda R.
Hendrix, Wing H.
Ip

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

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objects,
meteorites, and
interplanetary
dust.

<p>Dana Backman</p>	<p>SOFIA (Stratospheric Observatory for Infrared Astronomy) and Planetary Science</p>	<p>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.</p>	<p>Inner Planets: Mercury, Venus, and the Moon. 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.</p>
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Anthony Wesley

Co-Authors:

Glenn Orton,
Padma
Yanamandra-
Fisher, Leigh
Fletcher, Kevin
Baines,
Christopher Go,
Makenzie Lystrup,
Olivier Mousis,
Imke de Pater,
Jean-Pierre
Lebreton, Kunio
Sayanagi, Timothy
Livengood, Tom
Stallard, Henrik
Mellin, Nigel
Bannister

Ground-Based
Support for Solar-
System Exploration:
Continuous
Coverage Visible
Light Imaging of
Solar System
Objects from a
Network of Ground-
Based
Observatories

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.

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their satellites.

<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. 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.</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. 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.</p>
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<p>Sami W. Asmar</p> <p>Co-Authors: Kaare Aksnes, Roberto Ambrosini, Aseel Anabtawi, John D. Anderson, John W. Armstrong, David Atkinson, Jean-Pierre Barriot, Bruno Bertotti, Bruce G. Bills, Michael Bird,</p>			
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Veronique Dehant,
Peter Edenhofer, F.
Michael Flasar,
William Folkner,
Richard G. French,
Hideo Hanada,
Bernd Häusler,
David P. Hinson,
Luciano Iess,
Özgür Karatekin,
Arvydas J. Kliore,
Alex S. Konopliv,
Frank Lemoine,
Ivan Linscott,
Essam Marouf,
Jean-Charles
Marty, Koji
Matsumoto,
Hiroto Noda,
Kamal Oudrhiri,
Meegyeong Paik,
Ryan S. Park,
Martin Pätzold,
Robert Preston,
Nicole Rappaport,
Pascal Rosenblatt,
Richard A.
Simpson, David E.
Smith, Suzanne
Smrekar, Paul G.
Steffes, Silvia
Tellmann, Paolo
Tortora, G.
Leonard Tyler, Tim
Van Hoolst,
Michael Watkins,
James G. Williams,
Paul Withers,
Xiaoping Wu,
Donald Yeomans,
Dah-Ning Yuan,
Maria T. Zuber

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.

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meteorites, and
interplanetary
dust.

Julie Castillo-
Rogez

Co-Authors:

William B.
Durham, Essam
Heggy, Mathieu
Choukroun, Jerome
Noir, Sarah T.
Stewart, Steve D.
Vance, Christine
M. McCarthy,
Martin B. Barmatz,
Pamela G. Conrad

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.

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<p>J.B. Dalton</p> <p>Co-Authors: 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. 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.</p>
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<p>Murthy Gudipati</p> <p>Co-Authors: 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. 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.</p>
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J. Edmund Riedel

Co-Authors:

MiMi Aung, Paul G. Backes, David S. Bayard, David S. Berry, John R. Brophy, L. Alberto Cinghuala, Steve A. Chien, Christopher A. Grasso, Jeffery W. Levison, Tomas Martin-Mur, William M. Owen, Jr., Stephen P. Synnott

A Survey of the Technologies Necessary for the Next Decade of Small Body and Planetary Exploration

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.

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Nathan J. Strange

Co-Authors:

Daniel Scheeres,
Ryan Russell,
Kathleen Howell,
James Longuski,
Victoria
Coverstone, David
B. Spencer, Cesar
Ocampo, Belinda
Marchand, Terry
Alfriend, John
Junkins, Daniele
Mortari, John
Crassidis, Landis
Markley, David
Folta, John
Dankanich, Shyam
Bhaskaran, Dennis
Byrnes, Kim Reh,
Martin Lo, Jon
Sims, John C.
Smith, Brent
Buffington,
Anastassios
Petropoulos,
Damon Landau,
Fernando Abilleira,
Ryan Park, Jeffrey
Parker, Julie
Bellerose, Stefano
Campagnola,
Andrew Klesh,
Nitin Arora, Diane
Craig Davis, Kevin
Kloster, Alfred
Lynam, Geoff
Wawrzyniak

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.

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dust.

David R.
Thompson

Co-Authors:

David R.
Thompson, Robert
C. Anderson,
Benjamin
Bornstein, Nathalie
A. Cabrol, Steve
Chien, Tara Estlin,
Terry Fong, Robert
Hogan, Ralph
Lorenz, Daniel
Gaines, Martha S.
Gilmore, Mario
Parente, Liam
Pedersen, Ted L.
Roush, Giuseppe
Marzo, David
Wettergreen

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.

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interplanetary
dust.

Charles A. Hibbitts

Co-Authors:

James Bauer,
Pietro Bernasconi,
John Clarke,
Deborah
Domingue Josh
Emery, Randy
Gladstone, Tommy
Greathouse, Gary
Hansen, Walt
Harris, Amanda
Hendrix, Noam
Izenberg, Carey
Lisse, Larry
Paxton, Jeff
Percival, Kurt
Retherford, Andy
Rivkin, Mark
Swain, Eliot
Young

Stratospheric
Balloon Missions
for Planetary
Science

A Petition for the Formation
of a Working Group to Study
the Feasibility of a Facility
Platform to Support Planetary
Science Missions

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interplanetary
dust.

Edward R.
Martinez

Co-Author:
Robert V.
Frampton

Thermal Protection
System Sensors

This paper advocates for the development of an aeroshell TPS sensor system to the benefit of all atmospheric reentry missions Agency wide.

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<p>Carl Pilcher</p> <p>Co-Authors: Kevin P. Hand, Patricia M. Beauchamp, David Des Marais, David Grinspoon, Karen J. Meech, Sean N. Raymond</p>	<p>Astrobiology Priorities for Planetary Science 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. 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.</p>
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<p>Carl Pilcher</p> <p>Co-Authors: Kevin P. Hand, Patricia M. Beauchamp, David Des Marais, David Grinspoon, Karen J. Meech, Sean N. Raymond</p>	<p>An Astrobiological Lens on Planetary 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 [CHARACTERS NOT ACCEPTED BEYOND THIS</p>	<p>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.</p>
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<p>Barry Geldzahler</p> <p>Co-Author: 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. 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.</p>
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Reta F. Beebe

Co-Authors:

Charles Acton,
Raymond
Arvidson, Jim Bell,
Dan Boice, Scott
Bolton, Steven
Bougher, William
Boynton, Daniel
Britt, Marc Buie,
Joseph Burns,
Maria Teresa
Capria, Angioletta
Coradini, Daniel
Crichton, Peter
Ford, Richard
French, Lisa
Gaddis, Peter
Gierasch, Randy
Gladstone, Mitch
Gordon, Ronald
Greeley, Kenneth
Hansen, Jakosky,
Bruce, Yasumara
Kasaba, Krishan
Khurana, William
Kurth, Emil Law,
Ralph Lorenz,
Conor Nixon,
Chris Paranicus,
Wayne Pryor,
Thomas Roatsch,
Chris Russell,
Gerhard Schwehm,
Richard Simpson,
Mark Sykes, Dave
Tholen, Raymond
Walker, Paul
Withers, Joseph
Zender

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.

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meteorites, and
interplanetary
dust.

<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. 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.</p>
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<p>Eliot F. Young</p> <p>Co-Authors: Charles Hibbitts, Joshua Emery, Amanda Hendrix, William Merline, William Grundy, Kurt Retherford</p>	<p>Balloon-Borne Telescopes for Planetary Science: Imaging and 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: 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.</p>
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Michael H. Wong

Co-Authors: Máté Ádámkovics, Sushil K. Atreya, Don Banfield, Jim Bell, Susan Benecchi, Gordon Bjoraker, John R. Casani, John T. Clarke, Imke de Pater, Scott G. Edgington, Leigh N. Fletcher, Richard G. French, William Grundy, Amanda R. Hendrix, Erich Karkoschka, Jian-Yang Li, Franck Marchis, Melissa A. McGrath, William J. Merline, Julianne I. Moses, Keith Noll, Glenn S. Orton, Kathy A. Rages, Kurt Retherford, Kunio Sayanagi, Nick Schneider, Eric H. Smith, Lawrence A. Sromovsky, Nathan J. Strange, Anne Verbiscer, Padmavati A. Yanamandra-Fisher

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.

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

<p>James W. Ashley</p> <p>Co-Authors: M. D. Fries, G. R. Huss, J. E. Chappelow, M. P. Golombek, M. A. Velbel, S. W. Ruff, C. Schröder, W. H. Farrand, D. D. Durda, P. A. Bland, I. Fleischer, A. C. McAdam, S. P. Wright, A. T. Knudson, L. A. Leshin, and A. Steele</p>	<p>The Scientific Rationale for Studying Meteorites found on Other Worlds</p>	<p>The ongoing identification of several meteorite candidates on Mars is ushering in a new discipline in the planetary sciences. We feel that cultivating an appreciation for the potential science return represented by meteoritic specimens on Mars and the Moon may be important for the 2013-2022 decade.</p>	<p>Inner Planets: Mercury, Venus, and the Moon. Mars: Not Phobos and Deimos. Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Amy S. Lo</p> <p>Co-Authors: Howard Eller, Dean Dailey, Eric Drucker, James Wehner</p>	<p>Secondary Payloads Using LCROSS 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: Mercury, Venus, and the Moon. Mars: Not Phobos and Deimos. Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>

<p>Andrew M. Davis</p> <p>Co-Authors: 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. Mars: Not Phobos and Deimos. Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Clive R. Neal</p> <p>Co-Authors: Charles K. Shearer, Meenakshi Wadhwa, 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. Mars: Not Phobos and Deimos. Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>

<p>S. W. Ruff</p> <p>Co-Authors: S. W. Ruff, J. B. Dalton, J. L. Bishop, M. D. Dyar, T. Glotch, W. M. Grundy, V. E. Hamilton, J. R. Johnson, F. Marchis, R. M. Mastrapa, F. M. McCubbin, R. V. Morris, H. Nekvasil, M. S. Ramsey, D. Stillman, S. T. Stewart, S. K. Sharma, A. Wang, and R. C. Wiens</p>	<p>Laboratory Studies in Support of Planetary Surface Composition Investigations</p>	<p>This paper demonstrates the need to support laboratory investigations related to the surface composition of planetary bodies</p>	<p>Inner Planets: Mercury, Venus, and the Moon. Mars: Not Phobos and Deimos. 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>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. Mars: Not Phobos and Deimos. 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>Jeffrey R. Johnson</p> <p>Co-Authors: 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. Mars: Not Phobos and Deimos. 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>Andrew Daga</p> <p>Co-Authors: Carlton Allen, 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. Mars: Not Phobos and Deimos.</p>

<p>David Grinspoon</p> <p>Co-Authors: Mark Bullock, James Kasting, Janet Luhmann, Peter Read, Scot Rafkin, Sanjay Limaye, Kevin McGouldrick, Gordon Chin, Samuel Gulkis, Feng Tian, Eric Chassefiere, Hakan Svedhem, Vikki Meadows</p>	<p>Comparative Planetary Climate Studies</p>	<p>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.</p>	<p>Inner Planets: Mercury, Venus, and the Moon. Mars: Not Phobos and Deimos.</p>
<p>Friedemann T. Freund</p>	<p>Previously Overlooked/Ignored Electronic Charge 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: Mercury, Venus, and the Moon. Mars: Not Phobos and Deimos.</p>
<p>Richard S. Miller</p> <p>Co-Authors: 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>Ariel D. Anbar</p> <p>Co-Authors: David Grinspoon, Sean C. Solomon, G. Jeffrey Taylor</p>	<p>Astrobiology Research Priorities for Mercury, Venus, 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: Mercury, Venus, and the Moon.</p>
<p>Sarah E. Braden</p> <p>Co-Authors: 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>

<p>Samuel J. Lawrence</p> <p>Co-Authors: Georgiana Y. Kramer, Bradley L. Jolliff, B. Ray Hawke, Mark S. Robinson, Justin J. Hagerty, G. Jeffrey Taylor, Jeffrey Plescia, W. Brent Garry, Julie D. Stopar, Brett W. Denevi, S. E. Braden, L. R. Ostrach, David T. Blewett, Tomas Magna, Thomas R. Watters, Lisa R. Gaddis, Rongxing Li, Clive R. Neal, Jeffrey Gillis-Davis</p>	<p>Sampling the Age Extremes of Lunar Volcanism: the Youngest and Oldest Lunar Basalts</p>	<p>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.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>
<p>Georgiana Young Kramer</p> <p>Co-Authors: David Blewett, Lon Hood, Jasper Halekas, Sarah Noble, Bernard Ray Hawke, Gunther Kletetschka, Erika Harnett, and Ian 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: Mercury, Venus, and the Moon.</p>

<p>Ian Crawford</p> <p>Co-Authors: Mahesh Anand, 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 Wiczorek, 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>Ian Garrick-Bethell</p> <p>Co-Authors: Cassandra Runyon, Carle Pieters, Michael Wyatt, Peter Isaacson, 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>

Carle M. Pieters

Co-Authors:

Carlton Allen,
Mahesh Anand, W.
Bruce Banerdt,
William Bottke,
Barbara Cohen, Ian
A. Crawford,
Andrew Daga,
Rick Elphic,
Bernard Foing,
Lisa R. Gaddis,
James B. Garvin,
Timothy L. Grove,
B. Ray Hawke,
Jennifer Heldmann,
Dana M. Hurley,
Brad Jolliff,
Christian Koeberl,
Clive Neal, Brian J.
O'Brien, Anne
Peslier, Noah
Petro, Jeffery
Plescia, Amalie
Sinclair, Timothy
J. Stubbs, Ross
Taylor, Stefanie
Tompkins, Allan
H.
Treiman, Elizabeth
Turtle, Mark
Wieczorek, Lionel
Wilson, Aileen
Yingst

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.

<p>Arlin Crotts</p>	<p>On Lunar Volatiles and Their Importance to Resource Utilization and Lunar Science</p>	<p>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.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>
<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>
<p>Krishan Khurana</p> <p>Co-Authors: V. Angelopoulos, Charles W. Carlson, Gregory T. Delory, William M. Farrell, Robert E. Grimm, Ian Garrick-Bethell, Jasper S. Halekas, L. L. Hood, M. Horanyi, Robert J. Lillis, Robert P. Lin, Clive R. Neal, M. E. Purucker, Chris T. Russell, Gerry Schubert, D. G. Sibeck, Pavel Travnicek</p>	<p>Lunar Science with ARTEMIS: A Journey from the Moon's Exosphere to its Core [version 2]</p>	<p>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]</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>

<p>Kevin H. Baines</p> <p>Co-Authors: Sushil Atreya, Tibor Balint, David Crisp, David Grinspoon, Jeffery L. Hall, Gary W. Hunter, Sanjay Limaye, Viktor Kerzhanovich, Paul R. Mahaffy, Christopher T. Russell, David Senske, Stuart K. Stephens, Chris R. Webster</p>	<p>Venus Atmospheric Explorer New Frontiers Mission Concept</p>	<p>A multiple-platform mission to Venus that includes a long-duration, circumnavigating balloon-based element, two drop sondes, and an orbiter, is described that directly addresses fundamental science issues of planetary formation/evolution, dynamics/circulation, chemistry, meteorology, and geology.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>
<p>Tibor Balint</p> <p>Co-Authors: 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>Marc Fries</p> <p>Co-Authors: John Armstrong, James Ashley, Luther Beegle, Timothy Jull, Glenn Sellar</p>	<p>Extralunar Materials in Lunar Regolith</p>	<p>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.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>
<p>Sue Smrekar</p> <p>Co-Author: Sanjay Limaye</p>	<p>Venus Exploration Goals, Objectives, Investigations, and 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: Mercury, Venus, and the Moon.</p>

James G. Williams

Co-Authors:

James G. Williams,
Slava G. Turyshev,
Richard T. Baran,
Kevin M.
Birnbaum, Douglas
Currie, William M.
Folkner, Gary M.
Gutt, Hideo
Hanada, Hamid
Hemmati, Stephen
M. Merkowitz,,
Kenneth L.
Nordtvedt, Thomas
W. Murphy, Jr.,
Jürgen Müller,
Nicolas Rambaux,
Peter J. Shelus,
Ruwan
Somawardhana,
Robert Spero

Lunar Science and
Lunar Laser
Ranging

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.

Inner Planets:
Mercury, Venus,
and the Moon.

<p>Dana M. Hurley</p> <p>Co-Authors: 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>
<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>

<p>Allan Treiman</p> <p>Co-Authors: Meenakshi Wadhwa, Clive R. Neal, Charles K. Shearer, Bradley L. Jolliff, Lars E. Borg, Dimitri Papanastassiou, Malcolm J. Rutherford, Christine Floss, Andrew M. Davis, Steven Symes, Susanne Schwenger, Mark D. Fries, Andrew Westphall, Barbara Cohen, David A. Kring</p>	<p>Sample Return from the Earth’s Moon</p>	<p>This white paper makes the case that sample return from selected locations on the Moon in the coming decade will provide extraordinary advances in lunar and Solar System science.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>
<p>David J. Loftus</p> <p>Co-Authors: 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: Mercury, Venus, and the Moon.</p>
<p>Tore Straume</p>	<p>Solar Radiation Output: Reading the Record of Lunar Rocks</p>	<p>Reconstructing solar energetic particle output by measuring signatures in lunar surface samples</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>
<p>Ethiraj Venkatapathy</p>			

Co-Authors:

Helen H. Hwang,
Bernard Laub,
Joseph L. Conley,
James Arnold,
Christine E. Szalai,
Jim Tibaudo,
Robert Knudsen,
Andrew Chambers,
David Atkinson,
Sushil K. Atreva,
Joseph M.
Vellinga, William
H. Willcockson,
Janine M.
Thornton, Nicholas
G. Smith, Richard
A. Hund, John
Dec, Max L.
Blosser, Michelle
M. Munk, Robert
Maddock, Prasun
N. Desai, Walter
Engelund, Stephen
Sandford, David A.
Gilman, Steven W.
Gayle, John
Kowal, Christopher
B. Madden, Stan
Bouslog, Brian J.
Remark, Donald
Curry, Scott
Coughlin, Adam J.
Amar, Kevin H.
Baines, Tibor
Balint, Bernard
Bienstock, George
T. Chen, James A.
Cutts, Jeffery L.
Hall, Samad A.
Hayati, Pamela J.
Hoffman, Linda

Spilker, Romasso
P. Rivellini, Robert
Manning, Eric M.
Slimko, Adam D.
Steltzner, Thomas
Spilker, Jeffrey
Umland, Charles
Kiskiras, Duane
Baker, Thomas
Foster, Dominic
Calamito, James B.
Garvin, Timothy
A. Sauerwein,
Sharon Seipel, Lori
S. Glaze, Spencer
Stolis, Mark
Lippold, Francis
Schwind, James
Thompson, Raj
Narayan, Thomas
Andrews, Conley
Thatcher, Edwin B.
Curry, John
McKinney, Robert
Frampton, Todd
Stever, Charley
Bown, William
Congdon, Jennifer
Congdon, Daniel
M. Empey, Joe
Hartman, Dinesh
Prabhu, Nancy L.
Mangini, Kristina
A. Skokova,
Margaret M.
Stackpoole, Tood
White, Howard
Goldstein,
Melmoth
Covington, Robin
A. Beck, Carol W.
Carroll, Charles A.
Smith, Deepak

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.

Bose, Anthony Colaprete, David M. Driver, Edward Martinez, Donald T. Ellerby, Matthew J. Gasch, Aga M. Goodsell, James Reuther, Sylvia M. Johnson, Dean Kontinos, Mary Livingston, Michael J. Wright, Harry Partridge, George A. Raiche, Huy K. Tran, Kerry A. Trumble			
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Michael R. Collier

Co-Authors:

Thomas E.
Cravens, Mats
Holmstrom, James
Burch, Konrad
Dennerl, Herbert
Gunell, David G.
Sibeck, Steven
Snowden, F. Scott
Porter, Ina P.
Robertson, Nick
Omidi, Kip Kuntz,
Steven Sembay,
Jennifer Carter,
Andrew Read,
Dimitra
Koutroumpa,
Massimiliano
Galeazzi, Susan
Lepri, K.C.
Hansen, Dan
McCammon, Ruth
Skoug, H. Kent
Hills, Timothy J.
Stubbs, Pavel M.
Travnicek, George
Fraser, Mark
Lester

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.

<p>James B. Garvin</p> <p>Co-Authors: Lori S. Glaze, Sushil Atreya, Bruce Campbell, Don Campbell, Peter Ford, Walter Kiefer, Frank Lemoine, Greg Neumann, Roger Phillips, Keith Raney</p>	<p>Venus: 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>Stephen M. Merkowitz</p> <p>Co-Authors: Edward Aaron, Neil Ashby, David Carrier, Douglas Currie, John J. Degnan, Simone Dell’Agnello, Giovanni Delle Monache, Jan McGarry, Thomas W. Murphy, Jr., Kenneth Nordtvedt, Robert D. Reasenberg, Slava G. Turyshev, James G. Williams, Thomas Zagwodzki</p>	<p>The Moon as a Test Body for General Relativity</p>	<p>This whitepaper describes how the next generation of lunar laser ranging addresses four key gravitational science questions. In addition, we discuss the current state of retroreflector technology and describe ways in which further advances can be made in laser ranging technologies.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>

<p>W. M. Farrell</p> <p>Co-Author: 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>Robert M. Kelso</p>	<p>A commercially-leveraged, science-focused, lunar exploration program</p>	<p>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.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>
<p>Mian. M. Abbas</p> <p>Co-Authors: 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 & Dust in the Lunar Atmosphere from Solar Infrared Absorption Measurements with a Fourier Transform Spectrometer</p>	<p>Global Distributions of Dust & 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>

<p>Mian M. Abbas</p> <p>Co-Authors: 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>William F. Bottke</p> <p>Co-Authors: Carlton Allen, Mahesh Anand, Nadine Barlow, Donald Bogard, Gwen Barnes, Clark Chapman, Barbara A. Cohen, Ian A. Crawford, Andrew Daga, Luke Dones, Dean Eppler, Vera Assis Fernandes, Bernard H. Foing, Lisa R. Gaddis, Jim N. Head, Fredrick P. Horz, Brad Jolliff, Christian Koeberl, Michelle Kirchoff, David Kring, Harold F., Levison, Simone Marchi, Charles Meyer, David A. Minton, Stephen J. Mojzsis, Clive Neal, Laurence E. Nyquist, David</p>	<p>Exploring the Bombardment History of the Moon</p>	<p>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.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>

Nesvorny, Anne Peslier, Noah Petro, Carle Pieters, Jeff Plescia, Mark Robinson, Greg Schmidt, Sen. Harrison H. Schmitt, John Spray, Sarah Stewart- Mukhopadhyay, Timothy Swindle, Lawrence Taylor, Ross Taylor, Mark Wieczorek, Nicolle Zellner, Maria Zuber			
---	--	--	--

Mark A. Bullock

Co-Authors:

David A. Senske,
Tibor. S. Balint,
Alexis Benz, Bruce
A. Campbell, Eric
Chassefiere,
Anthony Colaprete,
James A. Cutts,
Lori Glaze,
Stephen Gorevan,
David H.
Grinspoon, Jeff
Hall, George L.
Hashimoto, James
W. Head, Gary
Hunter, Natasha
Johnson, Viktor V.
Kerzhanovich,
Walter S. Kiefer,
Elizabeth A.
Kolawa, Tibor
Kremic, Johnny
Kwok, Sanjay S.
Limaye, Stephen J.
Mackwell, Mikhail
Y. Marov, Adriana
Ocampo, Gerald
Schubert, Ellen R.
Stofan, Hakan
Svedhem, Dimitri
V. Titov, Allen H.
Treiman

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.

<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>
<p>Jasper Halekas</p> <p>Co-Authors: 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>

Jack Burns

Co-Authors: E.

Hallman, D.

Duncan, J. Darling,
& J. Stocke, J.

Lazio, K. Weiler, J.

Hewitt, C. Carilli,

R. Bradley, T.

Bastian, J.

Ulvestad, J. Kasper

& L. Greenhill, R.

MacDowall, S.

Merkowitz, J.

McGarry,

Zagwodzki, P.

Yeh, H. Thronson,

S. Ne, D. Currie, T.

Murphy, S.

Furlanetto & A.

Mesinger, A. Loeb,

J. Pritchard & E.

Visbal, D. Jones,

G. Taylor, K.

Nordtvedt, J.

Bowman, J.

Grunsfeld, S. Bale,

B. Wandelt, H.

Falcke

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.

<p>Clive R. Neal</p> <p>Co-Authors: 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>
<p>Clive R. Neal</p> <p>Co-Authors: Bruce Banerdt, Don Bogard, Bill Bottke, Jack Burns, Ben Bussey, Barbara Cohen, Greg Delory, Richard Elphic, Bill Farrell, Lisa Gaddis, Ian Garrick-Bethel, Timothy Grove,</p>			

James Head III,
Jennifer Heldmann,
Dana Hurley,
Debra Hurwitz,
Bradley Jolliff,
Catherine Johnson,
Christian Koeberl,
Georgiana Kramer,
David Lawrence,
Samuel J.
Lawrence, Gary
Lofgren, John
Longhi, Tomas
Magna, David
McKay, David
Morrison, Sarah
Noble, Marc
Norman, Laurence
Nyquist, Dimitri
Papanastassiou,
Noah Petro, Carle
Pieters, Jeff
Plescia, Kevin
Richter, Mark
Robinson, Greg
Schmidt, Harrison
Schmitt, Peter
Schultz, James
Spann, Paul
Spudis, Tim
Stubbs, Tim
Swindle, Lawrence
Taylor, G. Jeffrey
Taylor, S. Ross
Taylor, Mark
Wieczorek, Peter
Worden, Maria
Zuber

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.

Clive R. Neal

Co-Authors:
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'Agello,
Andrew Dombard,
Fred Duennebier,
Linda Elkins-
Tanton, Matthew
Fouch, Cliff
Frohlich, Jeannine
Gagnepain-
Beyneix, Raphael
F. Garcia, Ed
Garnero, Ian
Garrick-Bethel,
Domenico Giardini
Robert Grimm,
Matthias Grott,
Jasper Halekas,
Lon Hood,
Berengere Houdou,
Shaopeng Huang,
Catherine Johnson,
Bradley Jolliff,
Katie Joy, Amir
Khan, Oleg
Khavroshkin,
Krishan Khurana,
Walter Kiefer,
Naoki Kobayashi,
Junji Koyama,
Oleg Kuskov, Jesse
Lawrence, Mathieu
Lefeuvre, Lynn

The Rationale for
Deployment of a
Long-Lived
Geophysical

This paper outlines the
rationale establishing a global
lunar geophysical network
and the authorship
demonstrates the broad

Inner Planets:
Mercury, Venus,

Lewis, John
Longhi, Philippe
Lognonné, Mioara
Mandea, Michael
Manga, Pat
McGovern, David
Mimoun, Antoine
Mocquet, Jean-
Paul Montagner,
Paul Morgan,
Seiichi Nagihara,
Yosio Nakamura,
Jürgen Oberst,
Roger Phillips, Jeff
Plescia, J. Todd
Ratcliff, Lutz
Richter, Chris
Russell, Yoshifumi
Saito, Gerald
Schubert, Nikolai
Shapiro, Charles
Shearer, Hiroaki
Shiraishi, Sue
Smrekar, Tilman
Spohn, Bob
Strangeway,
Eléonore
Stutzmann, Satoshi
Tanaka, Toshiro
Tanimoto, Patrick
Taylor, Ross
Taylor, Junya
Terazono, Mike
Thorne, Nafi
Toksöz, Vincent
Tong, Elizabeth
Turtle, Slava
Turyshev, Roman
Wawrzazek, Renee
Weber, Jonathan
Weinberg, Ben
Weiss, Mark

Network on the
Moon

community support for such
an endeavor, both within the
USA and internationally.

and the Moon.

<p>Wieczorek, James Williams, Maria Zuber</p>			
<p>Brian J. O'Brien Co-Author: 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>Sanjay S. Limaye Co-Authors: 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>

<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>Harrison H. Schmitt</p> <p>Co-Authors: 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>Observations Necessary for Useful Global Climate Models</p>	<p>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.</p>	<p>Inner Planets: Mercury, Venus, and the Moon.</p>

<p>Harrison H. Schmitt</p> <p>Co-Authors: 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>Harrison H. Schmitt</p> <p>Co-Authors: 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>

Brad Jolliff

Co-Authors: Noah Petro, Leon Alkalai, Carlton Allen, Irene Antonenko, Lars Borg, William Bottke, Barbara Cohen, Michael Duke, Amy Fagan, Bernard Foing, Lisa Gaddis, John Gruener, Justin Hagerty, James Head III, Harold Hiesinger, Peter Isaacson, Randy Korotev, Georgiana Kramer, Samuel Lawrence, Gary Lofgren, Tomas Magna, Clive Neal, Marc Norman, Larry Nyquist, Gordon Osinski, Dimitri Papanastassiou, Carle Pieters, Bhairavi Shankar, Tim Swindle, G. Jeffrey Taylor, Allan Treiman, Paul Warren, Mark Wieczorek, Ryan Zeigler, Nicolle Zellner

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.

<p>Steven Howe</p> <p>Co-Authors: Brian Gross, Jeff Katalenich, Robert O'Brien, Logan Sailer</p>	<p>The Mars Hopper: Long Range Mobile Platform Powered by Martian In-Situ 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 and Deimos. Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p>
<p>Mark Skidmore</p> <p>Co-Authors: John Priscu, Brent Christner</p>	<p>Planetary Science & 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. Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p>
<p>Jack D. Farmer</p> <p>Co-Authors: Mark Allen, Tori Hoehler, Michael Mischna</p>	<p>Astrobiology Research and Technology 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>
<p>Vincent F. Chevrier</p> <p>Co-Authors: 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>

Paul Withers

Co-Authors: Jared Espley, Rob Lillis, Dave Morgan, Laila Andersson, Mathieu Barthélemy, Stephen Bougher, David Brain, Stephen Brecht, Tom Cravens, Geoff Crowley, Justin Deighan, Scott England, Jeffrey Forbes, Matt Fillingim, Jane Fox, Markus Fraenz, Brian Gilchrist, Erika Harnett, Faridah Honary, Dana Hurley, Muffarah Jahangeer, Robert Johnson, Donald Kirchner, Francois Leblanc, Mark Lester, Michael Liemohn, Jean Lilensten, Janet Luhmann, Rickard Lundin, Anthony Mannucci, Susan McKenna-Lawlor, Michael Mendillo, Erling Nielsen, Martin Pätzold, Carol Paty, Kurt Retherford, Cyril Simon, James Slavin, Bob Strangeway, Roland Thissen,

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.

Feng Tian, Olivier Witasse			
Dr. John F. Mustard	Why Mars Remains a Compelling Target for Planetary Exploration	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.	Mars: Not Phobos and Deimos.
John F. Mustard	Seeking Signs of Life on a Terrestrial Planet: An Integrated Strategy for the Next Decade of Mars Exploration	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.	Mars: Not Phobos and Deimos.
<p>Andrew Steele</p> <p>Co-Authors: Amundsen H.E.F., Benning L., Blake D., Borg L., Bower D.M., Brantley S., Brinkerhoff W., Cleaves J., Coates A., Cody G., Conrad P.G., Dieing T., Fogel M., Foing B., Fries M., Fritz J., Fsicher H., Glamoclija M., Garrett M., Glotch</p>			

T., Hauber E.,
Hoffman H.,
Huntsberger T.,
Jaumann R.,
Johnson C.,
Karunatillake S.,
Kish A., Kress M.,
Hoehler T.,
McCullom T.,
McCubbin F.M.,
Ming D., Monaco
L., Morrill P.,
Ohmoto H., Paar
G., Pacros A.,
Pullan D., Robb F.,
Rull F., Sarrazin
P., Schmitz N.,
Schoonen M.A.A.,
Schrenk M.,
Shahar A.,
Sherwood-Lollar
B., Shirey S.,
Siljstrom S., Sims
M., Smirnov A.,
Starke V., Toporski
J.K.W., Vago, J.,
Wainwright N.,
Weishaupt K.,
Westall, F., Yonse,
P., Zare R.N.

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.

Thomas Ruedas

Co-Authors:

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

Seismological
investigations of
Mars" deep interior

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.

Mars: Not Phobos
and Deimos.

Lisa Pratt

Co-Authors: 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

Mars Astrobiology Explorer-Cacher (MAX-C): A Potential Rover Mission for 2018

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.

Mars: Not Phobos and Deimos.

<p>William Bruce Banerdt</p> <p>Co-Authors: Bruce Banerdt, Tilman Spohn, Ulli Christensen, Veronique Dehant, Linda Elkins-Tanton, Robert Grimm, Matthias Grott, Bob Haberle, Martin Knapmeyer, Philippe Lognonné, Franck Montmessin, Yosio Nakamura, Roger Phillips, Scot Rafkin, Peter Read, Gerald Schubert, Sue Smrekar, Mike Wilson</p>	<p>The Rationale for a Long-Lived Geophysical Network Mission to Mars</p>	<p>We advocate the placement of a geophysical network on Mars to investigate the deep interior using seismic, heat flow, precision tracking and electromagnetic sounding measurements. These stations should also support meteorological atmospheric boundary layer experiments.</p>	<p>Mars: Not Phobos and Deimos.</p>
<p>Pamela G. Conrad</p> <p>Co-Authors: 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>Charles D., Jr. Edwards</p> <p>Co-Authors: 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>Samad A. Hayati</p> <p>Co-Authors: Michelle Munk, Dick Powell, Bob Gershman, Ying Lin, Karen Buxbaum, Paul Backes, Steve Gorevan, Dave Stephenson, Dave Anderson, John Dankanich, Carl Allen, Don Pearson, Tom Rivellini, Issa Nesnas, Gary Bolotin, Charles Budney, Aron Wolf, Joseph Riedel</p>	<p>Strategic Technology Development for Future Mars Missions (2013-2022)</p>	<p>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.</p>	<p>Mars: Not Phobos and Deimos.</p>
<p>Michael Hecht</p> <p>Co-Authors: W. Thomas Pike, Walter Goetz, Morten Bo Madsen, Janice L. Bishop, Urs Stauer, Kjartan M. Kinch, Kristoffer Leer</p>	<p>The microstructure of the martian 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 and Deimos.</p>

<p>Michael Hecht</p> <p>Co-Authors: 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>
<p>Michael Mischna</p> <p>Co-Authors: Michael Smith, Rob Kursinski, 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>
<p>David Oh</p> <p>Co-Authors: Richard R. Hofer, Ira Katz, Jon A. Sims, Noah Z. Warner, Thomas M. Randolph, Ronald T. Reeve, and Robert C. Moeller</p>	<p>Single Launch Architecture for Potential Mars Sample Return Mission Using Electric Propulsion</p>	<p>Paper describes how a single launch Mars Sample Return (MSR) mission could potentially be enabled by using of Electric Propulsion with Hall Thrusters: a well established, off-the-shelf technology commonly used on communications satellites today.</p>	<p>Mars: Not Phobos and Deimos.</p>

<p>Lars Borg</p> <p>Co-Authors: 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>Susanne P. Schwenzer</p> <p>Co-Authors: 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>Allan Treiman</p> <p>Co-Authors: Meenakshi Wadhwa, Charles K. Shearer Jr., Glenn J. MacPherson, James J. Papike, Gerald J. Wasserburg, Christine Floss, Malcolm J. Rutherford, George J. Flynn, Dimitri Papanastassiou, Andrew Westphal, Clive Neal, John H. Jones, Ralph P. Harvey, Susanne Schwenzer</p>	<p>Groundbreaking Sample Return from Mars: The Next Giant Leap in Understanding the 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 and Deimos.</p>
<p>Michael D. Max</p> <p>Co-Authors: 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>
<p>Michael D. Smith</p> <p>Co-Authors: 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>

<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>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>Eldar Z. Noe Dobrea</p> <p>Co-Authors: 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>Kimberly R. Kuhlman</p> <p>Co-Authors: Alberto Behar, Jack Jones, Penelope Boston, Jeffrey Antol, Gregory Hajos, Warren Kelliher, Max Coleman, Ronald Crawford, Lynn Rothschild, Martin Buehler, Greg Bearman, Daniel W. Wilson, 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>Jeffrey L. Bada</p> <p>Co-Authors: 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>Bruce A. Campbell</p> <p>Co-Authors: John A. Grant, Ted Maxwell, Jeffrey J. Plaut, Anthony Freeman</p>	<p>Exploring the Shallow Subsurface of Mars with Imaging Radar: Scientific Promise and Technical Rationale</p>	<p>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.</p>	<p>Mars: Not Phobos and Deimos.</p>
<p>John Grant</p> <p>Co-Authors: 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>
<p>Scot Rafkin</p> <p>Co-Authors: Robert. M. Haberle, Don Banfield, Jeff. Barnes</p>	<p>The Value of Landed Meteorological Investigations on Mars: The Next Advance for Climate Science</p>	<p>Major advances in the understanding of the present and past Mars climate system are most likely to be accomplished by in situ meteorological surface measurements operating from both a network configuration and individual stations.</p>	<p>Mars: Not Phobos and Deimos.</p>

<p>Douglas Stetson</p> <p>Co-Authors: 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>
<p>E. Robert Kursinski</p> <p>Co-Authors: James Lyons, Claire Newman, 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>Robert J. Lillis</p> <p>Co-Authors: 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>Bruce Jakosky</p> <p>Co-Authors: Richard W. Zurek, Jan Amend, Michael H. Carr, 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>Jeffrey R. Johnson</p> <p>Co-Authors: 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>Timothy N. Titus</p> <p>Co-Authors: Thomas H. Prettyman, 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>Ethiraj Venkatapathy</p> <p>Co-Authors: Bernard Laub, Joseph L. Conley, Helen H. Hwang, James Arnold, Christine E. Szalai, Jim Tibaldo, Robert Knudsen, Andrew Chambers, David Atkinson, Sushil K. Atreva, Joseph M.</p>			

Vellinga, William
H. Willcockson,
Janine M.
Thornton, Nicholas
G. Smith, Richard
A. Hund, John
Dec, Max L.
Blosser, Michelle
M. Munk, Robert
Maddock, Prasun
N. Desai, Walter
Engelund, Stephen
Sandford, David A.
Gilman, Steven W.
Gayle, John
Kowal, Christopher
B. Madden, Stan
Bouslog, Brian J.
Remark, Donald
Curry, Scott
Coughlin, Adam J.
Amar, Kevin H.
Baines, Tibor
Balint, Bernard
Bienstock, George
T. Chen, James A.
Cutts, Jeffery L.
Hall, Samad A.
Hayati, Pamela J.
Hoffman, Linda
Spilker, Romasso
P. Rivellini, Robert
Manning, Eric M.
Slimko, Adam D.
Steltzner, Thomas
Spilker, Jeffrey
Umland, Charles
Kiskiras, Duane
Baker, Thomas
Foster, Dominic
Calamito, James B.
Garvin, Timothy
A. Sauerwein,

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 System Exploration road

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

map.

Sharon Seipel, Lori
S. Glaze, Spencer
Stolis, Mark
Lippold, Francis
Schwind, James
Thompson, Raj
Narayan, Thomas
Andrews, Conley
Thatcher, Edwin B.
Curry, John
McKinney, Robert
Frampton, Todd
Stever, Charley
Bown, William
Congdon, Jennifer
Congdon, Daniel
M. Empey, Joe
Hartman, Dinesh
Prabhu, Nancy L.
Mangini, Kristina
A. Skokova,
Margaret M.
Stackpoole, Tood
White, Howard
Goldstein,
Melmoth
Covington, Robin
A. Beck, Carol W.
Carroll, Charles A.
Smith, Deepak
Bose, Anthony
Colaprete, David
M. Driver, Edward
Martinez, Donald
T. Ellerby,
Matthew J. Gasch,
Aga M. Goodsell,
James Reuther,
Sylvia M. Johnson,
Dean Kontinos,
Mary Livingston,
Michael J. Wright,

<p>Harry Partridge, George A. Raiche, Huy K. Tran, Kerry A. Trumble</p>			
<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>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>
<p>Linda R. Brown</p> <p>Co-Authors: 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>Andrew Pohorille</p> <p>Co-Authors: Leslie Bebout, Devaki Bhaya, 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>Robert Schingler</p> <p>Co-Authors: William Marshall, Alex MacDonald, Mark Lupisella, Brian Lewis</p>	<p>ROSI - Return on Science Investment</p>	<p>A system for mission evaluation based on maximizing science</p>	<p>None of the above.</p>
<p>Walter Harris</p> <p>Co-Authors: 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>Janet A. Vertesi</p> <p>Co-Authors: Robert Pappalardo, Claudia Alexander, William J. Clancey, Barbara Cohen, Paul Dourish, Jeffrey Johnson, Barbara Larsen, Kimberly Lichtenberg, Charlotte Linde, Scott Maxwell, Zara Mirmalek, Jeff Moore</p>	<p>Sociological Considerations for the Success of Planetary Exploration 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>
<p>Alan Tokunaga</p> <p>Co-Authors: 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>
<p>James T. Struck</p>	<p>Nobel Prize in Physics and Chemistry Could Be Awarded to Almost Anyone Who Has Done Any work In fields Including me</p>	<p>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.</p>	<p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust. None of the above.</p>
<p>Michael Nolan</p> <p>Co-Authors: Paul Abell, Erik Asphaug, MiMi Aung, Julie Bellerose, Mehdi</p>			

Benna, Lance
Benner, David
Blewett, William
Bottke, Daniel
Britt, Donald
Campbell,
Humberto
Campins, Clark
Chapman, Andrew
Cheng, Harold C.
Connolly Jr., Don
Davis, Richard
Dissley, Gerhard
Drolshagen, Dan
Durda, Eugene
Fahnestock, Yanga
Fernandez,
Michael J. Gaffey,
Mark
Hammergren,
James Head, Carl
Hergenrother,
Ellen Howell,
Robert Jedicke,
Steve Kortenkamp,
Ekkehard Kuehrt,
Stephen Larson,
Dante Lauretta,
Larry Lebofsky,
Carey Lisse, Amy
Lovell, Joseph
Masiero, Lucy
McFadden,
William Merline,
Patrick Michel,
Beatrice Mueller,
Joseph Nuth,
David O'Brien,
William Owen,
Joseph Riedel,
Harold Reitsema,
Nalin Samarasinha,
Daniel Scheeres,

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.

<p>Derek Sears, Michael Shepard, Mark Sykes, Josep M. Trigo- Rodriguez, David Trilling, Ronald Vervack, James Walker, Benjamin Weiss, Hajime Yano, Donald Yeomans, Eliot Young, Michael Zolensky</p>			
<p>Thomas D. Jones Co-Authors: Rob R. Landis, David J. Korsmeyer, Paul A. Abell, Daniel R. Adamo</p>	<p>Strengthening U.S. Exploration Policy via Human Expeditions to Near-Earth Objects</p>	<p>By conducting a series of piloted Near-Earth Object (NEO) missions beginning about 2020, the U.S. will reinforce the scientific, economic, programmatic, operations, planetary defense, and public outreach elements of its human exploration program.</p>	<p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Robert F. Arentz Co-Author: 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>

<p>Michael C. Nolan</p> <p>Co-Authors: 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>
<p>Andreas Rathke</p>	<p>Testing for the Pioneer Anomaly on a Pluto Exploration Mission</p>	<p>An overview of the phenomenon, commonly dubbed the Pioneer anomaly, is given and the possibility for an experimental test of the anomaly as a secondary goal of an upcoming space mission is discussed using a putative Pluto Orbiter Probe as a paradigm.</p>	<p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Andreas Rathke</p> <p>Co-Authors: Torsten Bondo, Roger Walker, Andrew Willig, Dario Izzo, Mark Ayre</p>	<p>Preliminary Design of an Advanced 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: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>

Charles Alcock
Co-Authors:
Matthew Holman,
Matthew Lehner,
Stephen Murray,
Pavlos Protopapas,
Michael Werner

Whipple: Exploring
the Solar System
beyond Neptune
Using a Survey for
Occultations of
Bright Stars

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.

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

Bonnie Buratti

Co-Authors:

Eleonora
Ammannito, Erik
Asphaug, MiMi
Aung, James
Bauer, Julie
Bellerose, David
Blewett, William
Bottke, Daniel
Britt, Julie Castillo-
Rogez, Tommy
Grav, Eberhard
Gruen, Nader
Haghighipour,
Doug Hamilton,
James Head,
Andrew Klesh,
Steve Kortenkamp,
Jian-Yang Li, Scott
Murchie, David
Nesvorny,
Catherine Olkin,
William Owen,
Joseph Riedel,
Andrew Rivkin,
Daniel Scheeres,
Scott S. Sheppard,
Mark V. Sykes,
Peter Thomas,
Anne Verbiscer,
Faith Vilas, Hajime
Yano, Eliot Young

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.

<p>Jon D. Giorgini</p> <p>Co-Authors: 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>
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Candice Hansen

Co-Authors: J.A. Stansberry, A.S. Aljabri, D. Banfield, E.B. Bierhaus, M. Brown, J. E. Colwell, M. Dougherty, A.R. Hendrix, K. Khurana, D. Landau, A. McEwen, D.A. Paige, C. Paranicas, C.M. Satter, B. Schmidt, M. Showalter, T. Spilker, L.J. Spilker, N. Strange, M. Tiscareno, W.M. Grundy, N. Haghhipour, K.S. Noll, E. Schaller, S. Sheppard

KBO Science with
Argo - A Voyage
through the Outer
Solar System

Argo is an innovative pragmatic concept for a New Frontiers 4 mission which 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-selected Kuiper Belt Object.

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

<p>Linda Spilker</p> <p>Co-Authors: Robert Pappalardo, Robert Mitchell, Michel Blanc, Robert Brown, Jeff Cuzzi, Michele Dougherty, Charles Elachi, Larry Esposito, Michael Flasar, Daniel Gautier, Tamas Gombosi, Donald Gurnett, Arvydas Kliore, Stamatios Krimigis, Jonathan Lunine, Tobias Owen, Carolyn Porco, Francois Raulin, Laurence Soderblom, Ralf Srama, Darrell Strobel, Hunter Waite, David Young</p>	<p>Cassini-Huygens 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: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Andrew F. Cheng</p> <p>Co-Authors: Andrew Rivkin, Patrick Michel, Carey Lisse, Kevin Walsh, Keith Noll, Darin Ragozzine, Clark Chapman, William Merline, Lance Benner, Daniel Scheeres</p>	<p>Binary and Multiple 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: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>

<p>Scott L. Murchie</p> <p>Co-Authors: 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>
<p>Andrew Rivkin</p> <p>Co-Authors: Joshua Emery, Antonella Barucci, James F. Bell, William F. Bottke, Elisabetta Dotto, Robert Gold, Carey Lisse, Javier Licandro, Louise Prockter, Charles Hibbits, Michael Paul, Alessondra Springmann, Bin Yang</p>	<p>The Trojan Asteroids: Keys to Many Locks</p>	<p>The Trojan asteroids of Jupiter lie at the crux of several of the most interesting outstanding issues regarding the formation and evolution of the Solar System. We present science questions centering on the Trojans are lay out recommendations for their future study and exploration.</p>	<p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>

<p>Andrew S. Rivkin</p> <p>Co-Authors: Julie C. Castillo-Rogez, Neyda M. Abreu, Erik Asphaug, Andrew F. Cheng, Beth E. Clark, Barbara A. Cohen, Pamela G. Conrad, Paul Hayne, Ellen S. Howell, Torrence V. Johnson, Georgiana Kramer, Jian-Yang Li, Larry A. Lebofsky, Lucy F. Lim, Amy J. Lovell, Dennis L. Matson, Thomas M. McCord, Lucy-Ann McFadden, William B. McKinnon, Ralph E. Milliken, William Moore, James H. Roberts, Christopher T. Russell, Britney E. Schmidt, Mark V. Sykes, Peter C. Thomas, Mikhail Zolotov</p>	<p>The Case for Ceres: Report to the Planetary Science Decadal Survey Committee</p>	<p>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.</p>	<p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Hal Weaver</p> <p>Co-Authors: K. J. Meech, P. Abell, E. Ammannito, E. Asphaug, M. Aung, J. Bellerose, M. J. S. Belton, M. Benna, J. Blum, F.</p>			

Brenker, D. Britt,
D. Brownlee, B.
Buratti, H.
Campins, A.
Cangahuala, J.
Castillo-Rogez, A.
Cochran, M.
Combi, H. C.
Connolly, Jr., N.
Dello Russo, M.
De Sanctis, M.
DiSanti, R. Dissly,
T. Farnham, L.
Feaga, P. Feldman,
Y. R. Fernández,
E. Gruen, N.
Haghighipour, W.
M. Harris, C.
Hergenrother, M.
Horanyi, E.
Howell, W. Irvine,
M. Kueppers, E.
Kuehrt, S. Larson,
J.-Y. Li, C. M.
Lisse, A. Lovell,
K. Magee-Sauer,
L. A. McFadden, J.
P. Morgenthaler,
B. E. A. Mueller,
M. Nolan, J. Nuth,
W. M. Owen, P.
Palumbo, W.
Reach, J. Riedel,
N. Samarasinha, D.
Scheeres, M. Sitko,
M. V. Sykes, J. M.
Trigo-Rodríguez, J.
Veverka, R.
Vervack, H. Yano,
E. Young, M.
Zolensky

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.

Scott Messenger

Co-Authors:

Andrew Davis,
George Flynn,
Lindsay Keller,
Allan Treiman,
Meenakshi
Wadhwa, Andrew
Westphal

Sample Return from
Primitive Asteroids
and Comets

This white paper makes the case for sample return from primitive asteroids and comets in the next decade to address some of the most important questions in planetary science relating to the origin and history (and particularly the origin and distribution of organics and water) of the Solar System.

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

William Grundy

Co-Authors: W.B. McKinnon, E. Ammannito, M. Aung, J. Bellerose, F. Brenker, D. Blewett, J.C. Castillo, A.F. Cheng, M.C. De Sanctis, J.P. Emery, J.-Y. Li, C. Hansen-Koharcheck, M.J. Kuchner, A. Lovell, L.A. McFadden, W.J. Merline, K.S. Noll, C.B. Olkin, W.M. Owen, N. Pinilla-Alonso, D. Ragozzine, J.E. Riedel, A.S. Rivkin, C.T. Russell, J.A. Stansberry, M.V. Sykes, S.C. Tegler, A.J. Verbiscer, F. Vilas, H.A. Weaver, H. Yano, E.F. Young

Small Bodies
Community White
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.

<p>Scott Sandford</p> <p>Co-Authors: Michael A’Hearn, Louis J. Allamandola, Daniel Britt, Benton Clark, Jason P. Dworkin, George Flynn, Danny Glavin, Robert Hanel, Martha Hanner, Fred Hörz, Lindsay Keller, Scott Messenger, Nicholas Smith, Frank Stadermann, Darren Wade, Ernst Zinner, Michael E. Zolensky</p>	<p>The Comet Coma Rendezvous Sample Return (CCRSR) Mission Concept – The Next Step Beyond Stardust</p>	<p>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.</p>	<p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Ethiraj Venkatapathy</p> <p>Co-Authors: Christine E. Szalai, Bernard Laub, Helen H. Hwang, Joseph L. Conley, James Arnold, Jim Tibaud, Robert Knudsen, Andrew Chambers, David Atkinson, Sushil K. Atreva, Joseph M. Vellinga, William H. Willcockson, Janine M. Thornton, Nicholas G. Smith, Richard A. Hund, John</p>			

Dec, Max L.
Blosser, Michelle
M. Munk, Robert
Maddock, Prasun
N. Desai, Walter
Engelund, Stephen
Sandford, David A.
Gilman, Steven W.
Gayle, John
Kowal, Christopher
B. Madden, Stan
Bouslog, Brian J.
Remark, Donald
Curry, Scott
Coughlin, Adam J.
Amar, Kevin H.
Baines, Tibor
Balint, Bernard
Bienstock, George
T. Chen, James A.
Cutts, Jeffery L.
Hall, Samad A.
Hayati, Pamela J.
Hoffman, Linda
Spilker, Romasso
P. Rivellini, Robert
Manning, Eric M.
Slimko, Adam D.
Steltzner, Thomas
Spilker, Jeffrey
Umland, Charles
Kiskiras, Duane
Baker, Thomas
Foster, Dominic
Calamito, James B.
Garvin, Timothy
A. Sauerwein,
Sharon Seipel, Lori
S. Glaze, Spencer
Stolis, Mark
Lippold, Francis
Schwind, James
Thompson, Raj

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.

Narayan, Thomas
Andrews, Conley
Thatcher, Edwin B.
Curry, John
McKinney, Robert
Frampton, Todd
Stever, Charley
Bown, William
Congdon, Jennifer
Congdon, Daniel
M. Empey, Joe
Hartman, Dinesh
Prabhu, Nancy L.
Mangini, Kristina
A. Skokova,
Margaret M.
Stackpoole, Tood
White, Howard
Goldstein,
Melmoth
Covington, Robin
A. Beck, Carol W.
Carroll, Charles A.
Smith, Deepak
Bose, Anthony
Colaprete, David
M. Driver, Edward
Martinez, Donald
T. Ellerby,
Matthew J. Gasch,
Aga M. Goodsell,
James Reuther,
Sylvia M. Johnson,
Dean Kontinos,
Mary Livingston,
Michael J. Wright,
Harry Partridge,
George A. Raiche,
Huy K. Tran,
Kerry A. Trumble

<p>Paul A. Abell</p> <p>Co-Authors: Daniel Adamo, Thomas Jones, David Korsmeyer, Rob Landis</p>	<p>Scientific Investigation of Near-Earth Objects via the Orion Crew 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: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>James D. Walker</p> <p>Co-Authors: Walter F. Huebner, Sidney Chocron, Walt Gray, Daniel Boice</p>	<p>Active Seismology of Asteroids through Impact and/or Blast 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: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</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>
<p>Dante S. Lauretta</p> <p>Co-Authors: Paul Abell, Carlton Allen, Ariel Anbar, Olivier Barnouin- Jha, M. Antonella</p>			

Barucci, E. Beau
Bierhaus, Richard
P. Binzel, William
F. Bottke, Steven
R. Chesley, Beth E.
Clark, Edward
Cloutis, Harold C.
Connolly, Jr.,
Michael J. Drake,
Jason P. Dworkin,
M. Darby Dyar,
Jack Farmer,
Rebecca Ghent,
Daniel P. Glavin,
Nader
Haghighipour,
Vicky E. Hamilton,
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

Astrobiology
Research Priorities
for Primitive
Asteroids

Study of primitive asteroids is fundamental to understanding the origin, distribution, and evolution of volatile and organic 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.

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

<p>Yan Fernandez</p> <p>Co-Authors: P. A. Abell, E. Ammannito, M. Aung, J. M. Bauer, J. Bellerose, H. Campins, J. Castillo-Rogez, A. F. Cheng, C. M. Dalle Ore, M. C. de Sanctis, J. P. Emery, T. Grav, W. M. Grundy, N. Haghhighipour, M. J. Kuchner, J.-Y. Li, K. J. Meech, B. E. A. Mueller, K. S. Noll, C. B. Olkin, W. M. Owen, N. Pinilla-Alonso, D. Ragozzine, J. E. Riedel, E. L. Schaller, D. J. Scheeres, S. S. Sheppard, J. A. Stansberry, M. V. Sykes, J. M. Trigo-Rodríguez, D. E. Trilling, A. J. Verbiscer, H. A. Weaver, H. Yano, E. Young</p>	<p>Small Bodies Community White Paper: Goals and Priorities for the Study of Centaurs and Trans-Neptunian Objects in the Next Decade</p>	<p>This paper identifies the top-level science issues, mission priorities, research and technology needs, and programmatic balance for the exploration of Centaurs and Small Irregular TNOs. This paper was organized by the Small Bodies Assessment Group.</p>	<p>Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Dan Britt</p> <p>Co-Authors: Paul Abell, Eleonora Ammannito, Erik Asphaug, MiMi Aung, Jim Bell, Julie Bellerose,</p>			

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
Haghighipour,
Mark
Hammergren, Paul
Hardersen, Mihaly
Horanyi, Ellen
Howell, Robert
Jedicke, Andrew
Klesh, Steve
Kortenkamp, Marc
Kuchner, Stephen
Larson, Dante
Lauretta, Larry
Lebofsky, Jian-
Yang Li, Amy
Lovell, Franck
Marchis, Joseph
Masiero, Lucy
McFadden, Karen
Meech, William
Merline, Patrick
Michel, Beatrice
Mueller, David

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.

Nesvorny, Michael Nolan, Joseph Nuth, David O'Brien, William Owen, Vishnu Reddy, Joseph Riedel, Andrew Rivkin, Chris Russell, Daniel Scheeres, Michael Shepard, Mark V. Sykes, Paolo Tanga, Josep M. Trigo-Rodriguez, David Trilling, Ronald Vervack, Faith Vilas, James Walker, Benjamin Weiss, Hajime Yano, Eliot Young, Michael Zolensky		
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Ashley Espy

Co-Authors:

Amara Graps,
Nicolas Altobelli,
Jürgen Blum, Don
Brownlee,
Humberto
Campins, Sigrid
Close, William
Cooke, Stanley
Dermott, Gerhard
Drolshagen,
Eberhard Grün,
Doug Hamilton,
Matthew Hedman,
Mihaly Horányi,
Peter Jenniskens,
Thomas Kehoe,
Steve Kortenkamp,
Harald Krüger,
Marc Kuchner, J.-
C. Liou, Carey
Lisse, Greg
Madsen, Ingrid
Mann, Brian May,
Scott Messenger,
Nicole Meyer-
Vernet, David
Nesvorny,
Pasquale Palumbo,
William Reach,
Chris Russell, Ralf
Srama, Mark
Sykes, Josep
Trigo-Rodríguez,
Jeremie
Vaubailon, Harold
Weaver, Hajime
Yano, Michael
Zolensky

Small Bodies
Community White
Paper:
Interplanetary Dust

This paper identifies the top-level science issues, mission priorities, research and technology needs, and programmatic balance for the exploration of Interplanetary Dust. 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.

<p>Erin Lee Ryan</p> <p>Co-Authors: 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>
<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>

<p>Robert Hodyss</p> <p>Co-Authors: 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>Steve Vance</p> <p>Co-Authors: 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>Robert J. Noble</p> <p>Co-Authors: Rashied Amini, 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. Primitive Bodies: Asteroids, comets, Phobos, Deimos, Pluto/Charon and other Kuiper belt objects, meteorites, and interplanetary dust.</p>
<p>Mark Allen</p> <p>Co-Authors: Carrie Anderson, Andrew Coates, A. James Friedson, Murthy Gudipati, Kostas Kalogerakis, Ralph Lorenz, Jonathan Lunine, Catherine Neish, Conor Nixon, Lucy Norman</p>	<p>Astrobiological Research Priorities for Titan</p>	<p>Titan, the haze-enshrouded moon of Saturn, has the largest accessible inventory of organic molecules in the Solar System outside of the Earth. The prospects are high for the formation of prebiotic compounds not unlike what might have preceded the origin of life in the early history of the Earth.</p>	<p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p>

<p>Candice Hansen</p> <p>Co-Authors: A.S.Aljabri, D.Banfield, E.B.Bierhaus, M.Brown, J.E.Colwell, M.Dougherty, A.R.Hendrix, H.Hussmann, K.Khurana, D.Landau, A.McEwen, D.A.Paige, C.Paranicas, C.M.Satter, B.Schmidt, M.Showalter, L.J.Spilker, T.Spilker, J.Stansberry, N.Strange, M.Tiscareno, Steve Vance</p>	<p>Triton science with Argo - A Voyage through the Outer Solar System</p>	<p>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</p>	<p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p>
<p>Peter Tsou</p> <p>Co-Authors: 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>

<p>Ralph Lorenz</p> <p>Co-Authors: 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>
<p>Terry Hurford</p> <p>Co-Authors: B. Buratti, A. Coustenis, A. Dombard, R. Greenberg, H. Hussmann, M. Kirchoff, C. Porco, A. Rymer</p>	<p>The Case for an Enceladus New 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: Galilean satellites, Titan, and the other satellites of the giant planets.</p>
<p>Terry Hurford</p> <p>Co-Authors: 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: Galilean satellites, Titan, and the other satellites of the giant planets.</p>

<p>David E. Smith</p>	<p>A budget phasing approach to Europa Jupiter System Mission Science</p>	<p>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.</p>	<p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</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: Galilean satellites, Titan, and the other satellites of the giant planets.</p>

<p>Julian Nott</p> <p>Co-Authors: Kim Reh, Jonathan Lunine, David L. Pierce, Patricia Beauchamp, Tim Colonus, R.C. Downs, Jerrold Marsden, Carl F. Braun, Don Day, Michael Arnold, Wade Allmon, Dick Bohannon, Alberto Elfes, John Elliot, Debora Fairbrother, Jack Jones, Jeff Hall, Greg Mungas, Michael Pauken, Rob Sinclair, Luke Brooke, David Wakefield</p>	<p>Advanced Titan Balloon Design 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: Galilean satellites, Titan, and the other satellites of the giant planets.</p>
<p>Athena Coustenis</p> <p>Co-Authors: 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. Soderblom, F. Sohl, C. Sotin, T. Spilker, N.</p>			

Strange, T.
Tokano, E. Turtle,
H. Waite, L.
Gurvits, C. Nixon,
T. Livengood, J.
Blamont, R.
Achterberg, M.
Allen, C.
Anderson, D.
Atkinson, T.
Balint, G.
Bampasidis, D.
Banfield, A. Bar-
Nun, J. Barnes, R.
Beebe, E. Bierhaus,
G. Bjoraker, D.
Burr, F. Crary, J.
Cui, J. Elliott, M.
Flasar, A.
Friedson, M.
Galand, D. Gautier,
M. Gurwell, J.
Head, M. Hirtzig,
T. Hurford, T.
Johnson, K. Klaus,
W. Kurth, E.
Lellouch, J.
Martin-Torres, K.
Mitchell, X.
Moussas, M.
Munk, C. Neish, L.
Norman, B.
Noyelles, G. Orton,
A. Pankine, D.
Pascu, E. Pencil,
S. Rafkin, T. Ray,
F. Rocard, S.
Rodriguez, A.
Solomonidou, L.
Spilker, R. West,
D. Williams, E.
Wilson, M. Wright,
V. Zivkovic

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.

Cynthia Phillips

Co-Authors: D. L.

Blaney, R. T.

Pappalardo, H.

Hussman, G. C.

Collins, R. M.

Mastrapa, J. F.

Cooper, R.

Greeley, J. B.

Dalton, T. A.

Hurford, E. B.

Bierhaus, F.

Nimmo, D. A.

Williams, D. A.

Senske, D.

Grinspoon, R. E.

Johnson, S.

Kattenhorn, P.

Hayne, B. Betts,

W. B. McKinnon,

L. M. Prockter, A.

P. Showman, J. H.

Shirley, K.

Khurana, S.

Grasby, B. G.

Bills, L. Friedman,

J. Castillo, C.

Sotin, G. Hansen,

K. Klaus, B. J.

Buratti, S. W.

Asmar, M. J. S.

Belton, E. Heggy,

L. Sklar, A. R.

Hendrix, J. R.

Spear, S. Ulamec,

L. Bruzzone, F.

Tosi, R. Jaumann,

G. Strazzulla, A.

Coates, J. Emery,

L. Allamandola, A.

Coustenis, R. W.

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.

<p>Carlson, W. Grundy, S. D. Vance, G. Branduardi- Raymont, M. Barmatz, P. M. Beauchamp, A. D. Anbar, C. A. Raymond, K. P. Hand, E. Shock, K. Stephan, D. L. Goldsby, D. D. Blankenship, M. Choukroun, W. Moore, E. P. Turtle, T. Pierson, S. Neuer, M. Zolotov</p>			
<p>J. Hunter, Jr. Waite</p> <p>Co-Authors: 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: Galilean satellites, Titan, and the other satellites of the giant planets.</p>

<p>Jonathan I. Lunine</p> <p>Co-Authors: A. Coustenis, P. Beauchamp, K. Reh, G. Bampasitis, L. Bruzzone, M.T. Capria, Coates, A., A.J. Friedson, D. Gautier, R. Jaumann, K.K. Klaus, J-P. Lebreton, T. Livengood, R. Lopes-Gautier, E. Lellouch, R. Lorenz, F-J. Martin-Torres, X. Moussas, C. Nixon, J. Nott, S. Rafkin, F. RaulinLISA Univ. Paris, S. Rodriguez, F. Sohl, A. Solomonidou, E.C. Sitler, J. Soderblom, R. West, M. Wright</p>	<p>The Science of Titan and its Future Exploration</p>	<p>This paper describes the science rationale for the next steps beyond Cassini-Huygens of exploration of Saturn's moon Titan.</p>	<p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p>
<p>Roger Yelle</p> <p>Co-Authors: S. Horst, M. Allen, R. Amils, S. K. Atreya G. Bampasidis, A. Bar-Nun, P. Beauchamp, M. Cabane, M. Capria, R. Carlson, N. Carrasco, A. Coates, J. Cooper,</p>			

M. Combes, T.
Cours, H. Cottin,
A. Coustenis, T.
Cravens, J. Cui, R.
de Kok, I. dePater,
M. Dobrijevic, G.
Durry, Y. Dutil, O.
Dutuit, M.
Fulchignoni, M.
Galand, Y. Gao, D.
Gautier, M.
Gurwell, E.
Hebrard, F.
Hersant, H.
Imanaka; W. Ip, R.
Jaumann, A. Jolly,
S. Karoly, E.
Kostiuk, L.-M.
Lara, P. Lavvas, S.
Lebonnois, J.- P.
Lebreton, M.
Leese, S. Le
Mou_elic, T.
Livengood, R.
Lopes, J. Lopez-
Moreno, J. Lunine,
P. Mahaffy, V.
Mangano, T.
McCord, R.
Modolo, A. Morse,
O. Mousis, I.
Muller-Wodarg, A.
Mura, G. Murthy
C. Nixon, D. Nna-
Mvondo, L.
Norman, G.
Ortega, G. Orton,
M. Patel, A.
Pavlov, C.
Plainaki, P.
Rannou K. Reh, M.
Rengel, F. Robb, S.
Rodriguez, R.

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.

Rodrigo, E.
Schaller, B.
Schmitt, D.
Schulze-Makuch,
E. Sciamma
O'Brien, J.
Soderblom, A.
Somogyi, E.
Sittler, D. Strobel,
L. Spilker, T.
Spilker, M. Smith,
A. Steele, K.
Stephan, N.
Strange, C. Szopa,
R. Thissen, F. Tosi,
D. Toublanc, M.
Trainer S. Tripathi,
S. Ulamec, S.
Vinatier, V.
Vuitton, J.-E.
Wahlund, J. H.
Waite, M.
Yamauchi, J.
Zarnecki

Conor A. Nixon

Co-Authors:

Carrie M.
Anderson, F.
Michael Flasar,
Christophe Sotin, J.
Hunter Waite Jr.,
V. Malathy Devi,
Olivier Mousis,
Kim R. Reh,
Konstantinos
Kalogerakis, A.
James Friedson,
Henry Roe, Yuk L.
Yung, Valeria
Cottini, Giorgos
Bampasidis,

Richard K.
Achterberg,
Nicholas A.
Teanby, Gordon L.
Bjoraker, Eric H.
Wilson, Tilak
Hewagama, Mark
A. Gurwell, Roger
Yelle, Mark A.
Allen, Nathan J.
Strange, Linda J.
Spilker, Glenn
Orton, Candice J.
Hansen, Jason W.
Barnes, Jason M.
Soderblom,
Vladimir B.
Zivkovic, Anezina
Solomonidou,
David L. Huestis,
Mark A. Smith,
David H. Atkinson,
Patrick G. J. Irwin,
Mathieu Hirtzig,
Simon B. Calcutt,
Timothy A.
Livengood,
Sandrine Vinatier,
Theodor Kostiuk,
Antoine Jolly,
Nasser Moazzen-
Ahmadi, Darrell F.
Strobel, Mao-
Chang Liang,
Patricia M.
Beauchamp,
Remco de Kok,
Robert Pappalardo,
Imke de Pater,
Véronique Vuitton,
Paul N. Romani,
Robert A. West,
Lucy H. Norman,

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.

<p>Mary Ann H. Smith, Kathleen Mandt, Sebastien Rodriguez, Máté Ádámkovics, Jean-Marie Flaud, Kurt K. Klaus, Michael Wong, Jean-Pierre Lebreton, Neil Bowles</p>			
<p>Dirk Schulze-Makuch</p> <p>Co-Authors: 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>
<p>Geoffrey Collins</p> <p>Co-Authors: Claudia J. Alexander, Amy C. Barr, Edward B. Bierhaus, Michael T. Bland, Veronica J. ray, Lorenzo Bruzzone, Emma Bunce, Andrew Coates, John F. Cooper, Frank Crary, Andrew J. Dombard, Gianrico Filacchione, Olivier Grasset, Gary B. Hansen, Amanda R. Hendrix, Charles</p>			

<p>A. Hibbitts, Terry A. Hurford, Hauke Husmann, Ralf Jaumann, Ozgur Karatekin, Krishan K. Khurana, Michelle R. Kirchoff, Jean- Pierre Lebreton, Melissa A. McGrath, Jeffrey M. Moore, Robert T. Pappalardo, G. Wesley Patterson, Christina Plainaki, Louise M. Prockter, Kurt Retherford, James H. Roberts, Paul M. Schenk, David A. Senske, Adam P. Showman, Katrin Stephan, Federico Tosi, Roland J. Wagner</p>	<p>Ganymede science questions and future exploration</p>	<p>This paper summarizes outstanding science questions about Ganymede and its place in the Jupiter system, and how further exploration would answer these questions.</p>	<p>Satellites: Galilean satellites, Titan, and the other satellites of the giant planets.</p>
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