SolarSystem2012: Planetary Science Decadal Survey Update

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Vice Chairman, Planetary Science Decadal Survey

Planetary Science Subcommittee
NASA HQ, April 8, 2010
By Congressional mandate, once every ten years the National Research Council, under the Space Studies Board, carries out a “decadal survey” for planetary science.


These surveys provide the primary scientific input that NASA uses to lay out the planetary exploration program.

The survey underway (SolarSystem2012) will apply to the decade from 2013 to 2022 and includes review of and recommendations for both NASA and NSF programs.

An important goal is that the results of the survey reflect a community consensus; extensive community input and participation in the decadal study is therefore essential.
The decadal survey is governed by a “statement of task,” provided by NASA and NSF, with input from OMB.

Key features that differ from the first planetary decadal:

- “It is critically important that the recommendations be achievable within the boundaries of anticipated funding.”

- “Recommendations of top-line funding increases for planetary science are not appropriate for this survey.”

- “The prioritization of flight investigations of Mars and the Moon should be integrated with flight investigation priorities for other solar system objects.”
Key features that differ from the first planetary decadal:

- “The flight and facilities programs recommended in the survey report must be executable within anticipated resources.”

- “In designing and pricing the study, the NRC should include resources for independent and expert cost analysis support to ensure that all flight mission cost estimates can be meaningfully intercompared and are as accurate as possible.”

- “In order to impact preparation of FY13 budget submissions, the major findings and prioritized recommendations of the survey should be submitted to NSF and NASA by March 31, 2011.” (2+ yr study)
What the Survey will Address

- An overview of planetary science: its motivation and current state of knowledge
- Inventory top-level scientific questions that should guide the flight mission, ground-based, and R&A programs
- Assessment of NSF-funded infrastructure
- Role of human space exploration in planetary science
- Recommendations on NASA program balance:
  - Mix of mission targets
  - Mix of mission sizes
  - Research activities
- Prioritized list of New Frontiers and Flagship missions to be initiated in the decade 2013-2022
- Recommendations for NASA-funded research activities
- Recommendations for technology development
Decadal Survey Mission Analyses

- NASA currently has three main classes of planetary missions:
  - Discovery
  - New Frontier
  - Flagship

- Discovery missions will not be identified or prioritized by the decadal survey. This job is left to the AO and peer review process. Examples of high-value candidate science for the Discovery program will be identified.

- Prioritized lists of recommended New Frontiers and Flagship missions will be developed, their technical feasibility scrutinized and costs/cost-risk estimated.

- Recommendations will be made regarding the appropriate balance among these classes of missions.
What Missions are included?

- Only missions that have a **formal budgetary new start** in the time period 2013-2022 are assumed *a priori* to be part of the decadal plan.

- Missions that have been extensively discussed and studied but do not yet have a new start (*e.g.*, Jupiter Europa Orbiter, International Lunar Network, various future Mars missions) are “on the table” in the survey.

- NASA views SolarSystem2012 as the formal statement of priority for the coming decade by the US planetary science community and has stated their intent to give highest priority to the missions identified in the survey.
SolarSystem2012 Committee Organization

Steering Group
- Steve Squyres, Chair
- Larry Soderblom, Vice Chair
- Vice Chairs of Panels
  - 9 others

Inner Planets Panel
- Ellen Stofan, Chair
- Steve Mackwell, Vice Chair
  - 10 others

Giant Planets Panel
- Heidi Hammel, Chair
- Amy Simon-Miller, Vice Chair
  - 10 others

Primitive Bodies Panel
- Joe Veverka, Chair
- Hap McSween, Vice Chair
  - 10 others

Mars Panel
- Phil Christensen, Chair
- Wendy Calvin, Vice Chair
  - 11 others

Outer Planet Satellites Panel
- John Spencer, Chair
- Dave Stevenson, Vice Chair
  - 10 others
Steering Group

- Steven W. Squyres, Cornell University
- Laurence A. Soderblom, U.S. Geological Survey
- Wendy M. Calvin, University of Nevada, Reno
- Dale Cruikshank, NASA Ames Research Center
- Pascale Ehrenfreund, George Washington University and Leiden Institute of Chemistry
- G. Scott Hubbard, Stanford University
- Margaret G. Kivelson, University of California, Los Angeles
- B. Gentry Lee, Jet Propulsion Laboratory
- Jane Luu, Massachusetts Institute of Technology, Lincoln Laboratory
- Stephen Mackwell, Lunar and Planetary Institute
- Ralph L. McNutt, Jr., Johns Hopkins University, Applied Physics Laboratory
- Harry Y. McSween, Jr., University of Tennessee, Knoxville
- George A. Paulikas, The Aerospace Corporation (Retired)
- Amy Simon-Miller, NASA Goddard Space Flight Center
- David J. Stevenson, California Institute of Technology
- A. Thomas Young, Lockheed Martin Corporation (Retired)
## Overall Schedule 2008-2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Quarter</th>
<th>Event</th>
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<tbody>
<tr>
<td>2008</td>
<td>4th</td>
<td>Informal request received by NRC, NRC approves initiation, Formal request received, Proposal to NASA.</td>
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<tr>
<td>2009</td>
<td>1st</td>
<td>Funding received, Chair identified, Chair and Vice Chair appointed</td>
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<tr>
<td></td>
<td>2nd</td>
<td>Steering Group appointed, Panels Appointed</td>
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<tr>
<td></td>
<td>3rd</td>
<td>Meetings of the Steering Group and Panels begin</td>
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<tr>
<td></td>
<td>4th</td>
<td>Panels’ period of peak activity</td>
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<tr>
<td>2010</td>
<td>1st-2nd</td>
<td>Final Panel meetings, Panel reports finalized</td>
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<tr>
<td></td>
<td></td>
<td>Satellites 4/12-14, Mars 4/14-16, Inner Planets 4/21-23,</td>
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<td></td>
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<td>Primitive Bodies 4/26-28, Giant Planets 5/5-7</td>
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<tr>
<td></td>
<td>2nd-3rd</td>
<td>Prioritization and drafting of survey report</td>
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<tr>
<td></td>
<td>4th</td>
<td>Draft survey report to reviewers, Report revised</td>
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<tr>
<td></td>
<td>3rd</td>
<td>Printed report released</td>
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Steering Group/Panel Interactions

Mission Studies and Cost Estimation

- **Inner Planets 1, D.C.; Aug 26-28, 2009**
- **Mars 1, Tempe, AZ; Sep 9-11**
- **Satellites 1, D.C.; Aug 24-26**

- **Giant Planets 1, D.C.; Aug 24-26**

- **Steering Group 1, D.C.; July 6-8, 2009**
- **Primitive Bodies 1, D.C.; Sep 9-11**

- **Steering Group Conference Call(s)**
- **Steering Group 2, Irvine; Oct 26-28**
- **Primitive Bodies 2, Irvine; Oct 28-30**
- **Satellites 2, Irvine; Sep 21-23**

- **Giant Planets 2, Irvine; Oct 26-28**
- **Giant Planets 3, MA; May 5-7**
- **Outer Planet Satellites 3 CO; Apr 12-14**

- **Steering Group 2, Irvine; Nov. 16-18, 2009**
- **Steering Group 3, Irvine; Feb 22-24 2010**
- **Steering Group 3, TN; Apr 26-28**
- **Steering Group 4, DC; Jul 13-15**
- **Steering Group 5, DC; Sep 2010**

- **Inner Planets 2, Irvine; Oct 26-28**
- **Mars 2, Pasadena Nov. 4-6**
- **Mars 3, CO; Apr 14-16**

- **Steering Group 3, CO; Apr 21-23**

- **Steering Group 4, DC; Jul 13-15**
- **Steering Group 5, DC; Sep 2010**
Community Interactions

Broad community input defines a decadal survey

- Town halls and sessions at meetings have been held starting early and often (e.g., AGU, VEXAG, MEPAG, OPAG, RAS, LPSC, NLSI, CAPTEM, EPSC, DPS).

- White papers from the community were submitted via the SolarSystem2012 web site.

- Open sessions of steering committee and panel meetings have been webcast live and archived in full.

- Activities are being coordinated with other groups that have overlapping interests (e.g., Astro2010)

- Special session at the upcoming AbSciCon meeting.
White Papers

- One of the most important ways for members of the science community to participate in the decadal survey was via submission of white papers.

- A total of 199 white papers were received in September of last year, with 4935 total authors/endorsers.

- White papers were assessed in detail by the panels, and folded into all panel activities.
Early on the five panels deliberated to update the top-level scientific objectives and questions that should motivate priorities during the 2013-2022 decade.

Scientific input included white papers and community discussions, presentations and reports from the PSS AGs, reports from earlier NRC studies including the 2003 Planetary Decadal Study and 2008 New Frontiers update.
Inner Planets Science Goals

1. Understand the origin and diversity of terrestrial planets
   - Bulk composition
   - Interior evolution and differentiation
   - Geological history of surfaces

2. Understand how the evolution of terrestrial planets enables and limits the origin and evolution of life
   - Distribution of volatile chemical species
   - Effects of internal planetary processes
   - Effects of processes external to a planet

3. Understand the processes that control climate on the Earth-like planets
   - Current climate processes
   - Climate evolution
   - Primordial climates
Mars Science Goals and Objectives

A durable set of themes linked first by “Follow the Water” and now by “Seeking Signs of Life”. A series of focused scientific questions emerge from a decade of discovery.

- **Geology**
  - Understand the geological processes affecting Mars’ interior, crust, and surface

- **Climate**
  - Characterize the present and past climate and climate processes

- **Life**
  - Understand the potential for life elsewhere in the Universe

- **Seeking Signs of Life**
Giant Planets: Science Goals

- Ground truth for planets around other stars
  - Diversity of bulk characteristics, atmospheres, evolution
  - Planetary extrema
- Tracers of interplanetary environment
  - Energy balance, solar-mag interactions,
  - Planetary migration, role in creating earths
- Laboratories for Earth
  - Properties, internal processes
  - Influence of external processes
Satellites: Science Goals and Objectives

• How did the satellites of the outer solar system form and evolve?
  – What were conditions during satellite formation?
  – What determines the abundance and composition of satellite volatiles?
  – How are satellite thermal and orbital evolution and internal structure related?
  – What is the diversity of geological activity and how has it changed over time?

• What processes control the present-day behavior of these bodies?
  – How do active endogenic processes contribute to surface-interior exchange
  – What processes control the composition and dynamics of satellite atmospheres?
  – What exogenic processes, including atmospheric processes, modify these bodies?
  – How do satellites influence their own magnetospheres and those of their parent planets?

• What are the processes that result in habitable environments?
  – Where are subsurface bodies of liquid water located, and what are their characteristics?
  – What are the sources, sinks and evolution of organic material?
  – What energy sources are available to sustain life?
Goal 1: Decipher the record in primitive bodies of epochs and processes not obtainable elsewhere

- Understand presolar processes recorded in the materials of primitive bodies
- Study condensation, accretion, and other formative processes in the solar nebula
- Determine the effects and timing of secondary processes on primitive bodies
- Assess the nature and chronology of planetesimal differentiation

Goal 2: Understand the role of primitive bodies as building blocks for planets and life

- Determine the composition, origin and primordial distribution of volatiles and organic matter in the solar system
- Understand how and when planetesimals were assembled to form planets
- Constrain the dynamic evolution of planets by their effects on the distribution of primitive bodies
Compared to previous decadal surveys, this one must place much greater emphasis on evaluation of the technical maturity and probable costs of candidate missions.

The panels and the steering group include members who are expert in engineering, project management, and cost estimation.

NASA has provided resources to do moderate-fidelity mission design studies and (conservative) cost estimates for the high priority candidate missions.

The goal is to recommend a prioritized set of candidate missions for NASA to carry out in the coming decade that can be realistically achieved within the projected available funds (as provided by NASA).
A lack of technical evaluation and cost analysis of candidate missions has been a major weakness of past decadal surveys (in planetary science and other disciplines). This decadal survey has adopted a twin-track approach to crafting a fiscally and technically more robust set of prioritized missions.

Studies of candidate missions are being conducted by:

- Jet Propulsion Laboratory
- Applied Physics Laboratory
- Goddard Space Flight Center

Independent cost and technical evaluations are provided by:

- Aerospace Corporation
Mission Candidates

- Based on community inputs including white papers, a total of 25 mission candidates were selected for detailed study in this survey.

- The three selected candidates for New Frontiers 3 missions are also on the list for consideration in the next decade, but are not included in the mission studies:
  - SAGE (Venus lander)
  - Moonrise (South Pole-Aitken Basin lunar sample return)
  - OSIRIS REX (Near-Earth asteroid sample return)
Mission Candidates

- Mercury Lander (APL)
- SAGE (*NASA NF-3 Candidate*)
- Venus Mobile Explorer (GSFC)
- Venus Tessera Lander (GSFC)
- Venus Climate Mission (GSFC)
- Moonrise (*NASA NF-3 Candidate*)
- Lunar Polar Volatiles Lander (APL)
- Lunar Network Mission Mission (MSFC)
Mission Candidates

- Mars Trace Gas Orbiter (JPL) – study suspended owing to ongoing NASA payload selection for the ESA ExoMars trace gas orbiter; will use NASA costs
- Mars Polar Mission (JPL)
- Mars Network Mission (JPL)
- Mars Sample Return (JPL):
  - Mars Astrobiology Explorer with Cacheing (MAX-C)
  - Mars Sample Return Lander/with MAV
  - Mars Sample Return Orbiter
Mission Candidates

- EJSM Europa Jupiter Flagship Mission (JPL)
- Io Mission (JPL)
- Ganymede Mission (JPL)
- Saturn Probe (JPL)
- TSSM Titan Saturn Flagship Mission (JPL)
- Titan Lake Lander (JPL)
- Enceladus Mission (JPL)
- Uranus System Mission (APL)
- Neptune System Mission (JPL)
Mission Candidates

- **OSIRIS REX (NASA NF-3 Candidate)**
- Main Belt Asteroid Lander (APL)
- Chiron Orbiter (GSFC)
- Trojan Asteroid Tour (APL)
- Comet Surface Sample Return (APL)
Additional Studies

- **NEO target study.** (Assess NEO targets that can be reached with an electric propulsion spacecraft).

- **Reactor-based thermoelectric generator technology study.**

- **Saturn Ring Observer technology study.**

- **Comet cryogenic sample return technology study.**
Beyond describing a prioritized set of NASA planetary missions, the survey report will address several other issues:

- **Technology development** for future NASA planetary missions, particularly for the decade after 2022
- NSF-funded ground-based telescopes
- The NASA and NSF planetary R&A programs
- Education
- Public Outreach
The End Game

- Draft report will be written in the summer of this year

- Report will undergo rigorous external peer review, per NRC policies and standards

- Once revised and approved, report will be released, and briefed widely:
  - NASA
  - NSF
  - Office of Management and Budget
  - Congress
  - Science community
The decadal survey process is aimed at articulating a program for the coming decade that represents as fully as possible the **true consensus view** of the US planetary science community.

The distinguishing features of the decadal survey process are **inclusiveness** and **transparency**.

In contrast to past decadal surveys, this one will place a strong emphasis on **cost realism**.

Community participation in all aspects of the decadal survey is strongly encouraged!
Our Web Site

http://sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412

Planetary Science Decadal Survey

Project Information
- Statement of Task (PDF)
- Project Summary
- White papers
- Upcoming Decadal Survey Meetings
- Past Meetings
- Future Outreach Events
- Past Outreach Events
- Organization of the Planetary Sciences Decadal Survey Committee
- Panel Information
- Steering Committee Members
- Staff
- Letters from Steve Squyres, Chair of the Planetary Science Decadal Survey
- Graduate Student Opportunity to Participate in the Planetary Science Decadal Survey
- Useful Links
- Webcasts

Project Summary
The Space Studies Board has established a decadal survey committee to develop a comprehensive science and mission strategy for planetary science that updates and extends the Board’s 2003 solar system exploration decadal survey, “New Frontiers in the Solar System: An Integrated Exploration Strategy.” The new decadal survey will broadly canvas the planetary science community to determine the current state of knowledge and then identify the most important scientific questions expected to face the community during the interval 2013-2022. The scope of the survey and report shall encompass the inner planets (Mercury, Venus, and Mars), the Earth’s Moon, giant planets (Jupiter, Saturn, Uranus, and Neptune), the moons of the major planets, dwarf planets and small bodies, primitive bodies including comets and Kuiper Belt objects, and astrobiology. The principal components of the report shall include:

1. An overview of planetary science—what it is, why it is a compelling undertaking, and the relationship between space- and ground-based planetary science research;
2. A broad survey of the current state of knowledge of the solar system;
3. An inventory of the top-level scientific questions that should guide flight programs and supporting research programs;
4. Recommendations on the optimum balance among small, medium, and large missions and supporting activities, informed by the Board’s study on NASA’s “Missions enablers” (mission-enabling activities) currently in progress;
5. An assessment of NSF-supported infrastructure;
6. A discussion of strategic technology development needs and opportunities;
7. A prioritized list of major flight investigations in the New Frontiers and larger classes recommended for initiation over the decade 2013-2022;
8. Recommendations for supporting research required to maximize the science return from the flight investigations; and,
9. A discussion of the opportunities for conducting science investigations involving humans in situ and the relative value of human-tended investigations to those performed solely remotely.
Backup material
Schedule, Community Input, Status

Schedule:
• 2 IPP meetings to date, numerous telecons
• Next meeting: April 21-23, Boulder, CO

White Papers:
• 78 white papers relevant to IPP
• All papers were read by all panelists
• Each paper reviewed during panel meeting 2

Presentations to Panel:
• NASA, NSF, LEAG, VEXAG, CAPTEM
• MESSENGER, LRO, Chandrayaan-1, Venus Flagship, Artemis, ILN
• In-situ dating, Venus technologies

Panel Presentations at Community Meetings:
• DPS, AGU, LPSC
• VEXAG, CAPTEM

Status:
• Mission concepts under study / cost analysis
• Inner Planets chapter in work (~60% done)
Panel meetings in Sept, Nov. 2009. Next meeting April 14-16 in Boulder.

Attended MEPAG (Fall 09, next week), AGU, AbSciCon

MEPAG in its 10th year – building on strategic missions considered through MEPAG SAGs, past decadal priorities, and new missions with large community support.

65 Mars related white papers, 15 invited presentations at panel meetings, for others, the intellectual content incorporated into Mars chapter.

Tall tent poles: technology for the MSR campaign.
Schedule, Community Input and Status

- White papers
  - ~100 relevant white papers
  - Read, discussed and providing important basis for ongoing activities

- Sessions at OPAG, DPS, AGU

- GPP meetings
  - August 2009, October 2009, May 2010
  - Presentations on probes, DSN, missions, magnetospheres, technology, etc.

- Chapter Status
  - Progressing well – writing is proceeding
  - Mission studies underway

Thank You for your input!
Schedule, Community Input and Status

• All white papers have been read by at least two people, and discussed by the full group. This is important input. Thanks!

• Two full meetings thus far; next meeting in April; weekly telecons. These have included presentations and detailed discussions (e.g. penetrators, DSN, outreach, technology challenges, etc).

• A large part of the report written, the prioritization and recommendations are yet to be done but we are on schedule
**Primitive Bodies Panel**

**Status and Schedule:**
- Panel has completed a draft of the science section of its report
- Final (of 3) meetings to review and prioritize mission studies on April 26-28 (Knoxville)

**Community Input:**
- 65 white papers reviewed by the panel
- Forum at DPS
- Invited presentations on SBAG’s mission priorities, current missions to asteroids/comets, new telescope facilities, planetary ices, cryogenic comet sample return, New Frontiers selections, science discoveries and advances on asteroids, comets, KBOs, meteorites