Science Objectives and Priorities in NASA missions

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All the material displayed in this presentation is available on public websites
1981: Degree in geophysical engineering
1989: Co-I on ISM/Phobos + VIMS/Cassini
1988 – 2007: Professor at Paris/Nantes (France), creation of a laboratory in planetary geology and geophysics
1997: Launch of Cassini
2005: Launch of Venus Express (IDS)
2007 - .... Jet Propulsion Laboratory-Caltech, Pasadena
Science Objectives and Priorities in NASA missions

“Flyby, Orbit, Land, Rove, and Return Samples”
(this chart comes from a presentation by Jim Green in 2013)
Some discoveries since last december

Plumes on Europa?

Plumes on Ceres?

Enceladus Ocean?

Birth of a Moon in Saturn?
Outline

• The different classes of mission
  – Discovery: example GRAIL
  – New Frontiers: example New Horizons (Pluto)
  – Flagship: Mars Science Laboratory, Cassini/Huygens

• The Decadal Survey
  – Inputs from the community
  – Priorities
  – List of NF missions
  – List of Flagship missions
Discovery Program

• Started in 1992
• Competed missions
• Cost cap of $450M
• Test of new technologies – for example, SEP on the mission DAWN
• About one every other year

• [http://discovery.nasa.gov/program.cfml](http://discovery.nasa.gov/program.cfml)
List of Discovery missions (1/2)

1. On February 17, 1996, Near-Earth Asteroid Rendezvous (NEAR) was the first Discovery Program spacecraft to be launched and it became the first ever to orbit and land on an asteroid.

2. The Mars Pathfinder mission demonstrated a low-cost method of delivering a set of science instruments and the first free-ranging rover to the surface of Mars.

3. The science data returned from Lunar Prospector has enabled scientists to create detailed maps of the gravity, magnetic properties and chemical composition of the Moon's entire surface.

4. The Stardust spacecraft collected interstellar dust and comet dust during a close encounter with Comet Wild 2 and returned the particles to Earth for analysis by scientists worldwide.

5. The Genesis spacecraft spent two years collecting atoms of solar wind before returning them to Earth in September 2004 for detailed analysis.
6. The Comet Nucleus Tour, or CONTOUR, mission was going to encounter and study two diverse comets during their periodic visits to the solar system.

7. MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) mission is a scientific investigation of the planet Mercury.

8. The Deep Impact mission propelled a large copper projectile into the surface of a comet, creating a huge crater and yielding new information about the internal composition and structure of a comet.

9. The Dawn mission is on its way to the oldest and most massive asteroids in our solar system, to give us a glimpse of conditions and processes at the dawn of our solar system. VESTA & CERES

10. Kepler will use a unique telescope to search for Earth-size habitable planets around stars beyond our solar system.

11. The Gravity Recovery and Interior Laboratory, or GRAIL, mission will put twin satellites into orbit around the Moon to map the Moon's interior and variations in its gravitational pull & to reconstruct its thermal history

12. In preparation: InSight (Mars Seismology and Heat Flux is #12)

13. AO for #13 this year
New Frontiers Program

• Started in 2003
• Competed missions
• Cost cap around $1M
• Goal was one every 36 months

• [http://discoverynewfrontiers.nasa.gov/program/index.cfml](http://discoverynewfrontiers.nasa.gov/program/index.cfml)
List of New Frontiers missions

1. New Horizons will help us understand worlds at the edge of our solar system, by making the first reconnaissance of Pluto and Charon and then visiting one or more Kuiper Belt Objects. **Flyby on July 14, 2015**

2. Juno is a mission to Jupiter that will significantly improve our understanding of the origin and evolution of the gas giant planet, which will help us better understand our entire solar system. **OI on July 4, 2016**

3. In preparation: OSIRIS-REx is the first mission to bring pristine samples from an asteroid to study and analyze on Earth, to increase our understanding of planet formation and the origin of life. **Autumn 2016 launch**
Flagship missions

• Assigned missions
• Cost is variable > $2M
• Still in operation: Voyager, Cassini, MSL
• Recent ones: Galileo
• In preparation: Mars2020
Decadal survey (1/2)

Strategic planning activities within NASA’s Science Mission Directorate (SMD) draw heavily on reports issued by the National Research Council (NRC), particularly those from the Space Studies Board (SSB). Prime among these SSB inputs is identification of priority science and missions in the so-called decadal surveys.

- 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
- A broad survey of the current state of knowledge of the solar system
- An inventory of the top-level science questions that should guide flight programs and supporting research programs
- Recommendations on the optimum balance among small (Discovery), medium (New Frontier), and large missions (Flagship) and supporting activities;
Decadal survey (2/2)

- An assessment of NSF-supported infrastructure;
- A discussion of strategic technology development needs and opportunities;
- A prioritized list of major flight investigations in the New Frontiers and larger classes recommended for initiation over the decade 2013-2022;
- Recommendations for supporting research required to maximize the science return from the flight investigations; and
- A discussion of the opportunities for conducting science investigations involving humans in situ and the value of human-tended investigations relative to those performed solely robotically
Decadal survey

• Community is asked to write white papers
• Some white papers come from Assessment Groups: MEPAG, OPAG, VEXAG, SBAG, LEAG, ...
• For the last DS, there was one steering group (Steve Squyres and Larry Soderblom) and 5 panels:
  – Inner Planets
  – Mars
  – Giant planets
  – Satellites
  – Primitive bodies
• Report of more than 400 pages with recommendations and list of priorities
Recent advances

1. An explosion in the number of known exoplanets;
2. The Moon is less dry than once thought;
3. Minerals that must have formed in a diverse set of aqueous environments throughout Martian history;
4. Extensive deposits of near-surface ice on Mars;
5. An active meteorological cycle involving liquid methane on Titan;
6. Variability of the giant planets;
7. Recent volcanic activity on Venus;
8. Geothermal and plume activity at the south pole of Enceladus;
9. The anomalous isotopic composition of the planets;
10. The unexpected nature of comet dust;
11. Mercury’s liquid core
12. The richness and diversity of the Kuiper belt.
Decadal Survey - priorities

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<thead>
<tr>
<th>Crosscutting Themes</th>
<th>Priority questions</th>
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<tbody>
<tr>
<td><strong>Building New Worlds</strong></td>
<td>What were the initial stages, conditions and processes of solar system formation and the nature of the interstellar matter that was incorporated?</td>
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<td>How did the giant planets and their satellite systems accrete, and is there evidence that they migrated to new orbital positions?</td>
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<td>What governed the accretion, supply of water, chemistry, and internal differentiation of the inner planets and the evolution of their atmospheres, and what roles did bombardment by large projectiles play?</td>
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<td><strong>Planetary Habitats</strong></td>
<td>What were the primordial sources of organic matter, and where does organic synthesis continue today?</td>
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<td>Did Mars or Venus host ancient aqueous environments conducive to early life, and is there evidence that life emerged?</td>
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<td>Beyond Earth, are there modern habitats elsewhere in the solar system with necessary conditions, organic matter, water, energy, and nutrients to sustain life, and do organisms live there now?</td>
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<td><strong>Workings of Solar Systems</strong></td>
<td>How do the giant planets serve as laboratories to understand the Earth, the solar system, and extrasolar planetary systems?</td>
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<td>What solar system bodies endanger and what mechanisms shield the Earth’s biosphere?</td>
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<td>Can understanding the roles of physics, chemistry, geology, and dynamics in driving planetary atmospheres and climates lead to a better understanding of climate change on Earth?</td>
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<td>How have the myriad chemical and physical processes that shaped the solar system operated, interacted, and evolved over time?</td>
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List of recommended missions for NF#4

- Comet Surface Sample Return
- Lunar South Pole-Aitken Basin Sample Return
- Saturn Probe
- Trojan Tour and Rendezvous
- Venus In Situ Explorer
List of recommended missions for NF#5

- Comet Surface Sample Return
- Lunar South Pole-Aitken Basin Sample Return
- Saturn Probe
- Trojan Tour and Rendezvous
- Venus In Situ Explorer
- Io Observer
- Lunar Geophysical Network
List of Flagship missions

• Mars Astrobiology Explorer-Cacher / Descope / Mars 2020 – Moving forward

• Jupiter Europa Orbiter / Descope / Europa Clipper – still being debated - possibility of probes/small sats is discussed

• Uranus Orbiter and Probe (no Solar Electric Propulsion stage)
Uranus: Archetype for Exo-planets?

Numbers of Planet Candidates

- 68 Earth-size
- 288 super-Earth size
- 662 Neptune size
- 165 Jupiter size
- 19 super-Jupiter size
Some Conclusions

• It happens that science objectives and priorities can be covered by missions from international partners
• Missions are usually international - new NASA rule on Discovery that only 1/3 of the payload can be contributed
• Probes: In situ analysis are very important – probes may be used more in the future – probes have made important discoveries
• Recent advances in the development of nano/micro satellites – breakthrough technologies may provide new means of addressing science objectives