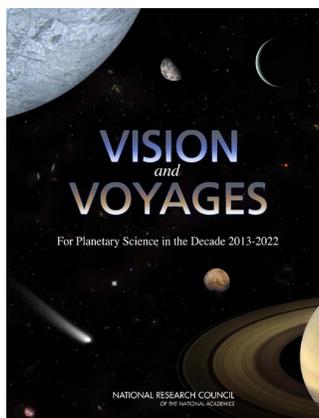


# Vision and Voyages for Planetary Science in the Decade 2013-2022

Space Studies Board  
 March 2011



Every ten years, the National Research Council undertakes a large-scale survey of planetary scientists, to identify key scientific questions and recommend a portfolio of missions to address those questions to the National Aerospace and Space Administration (NASA). The latest of these surveys recommends a balanced mix of small-, medium-, and large-scale spaceflight missions whose achievements will together tell us about how the solar system came into existence, if neighboring planets have ever had the conditions to support life, and what the future of our own planet might be. It also highlights the importance of research, analysis, and technology development to maximize the scientific gain from spaceflight missions. The table correlates the major scientific questions to the recommended missions.

The report presents independent cost and technical evaluations of the major mission proposals. To accommodate these estimates to possible changes in the budget outlook, the committee responsible for the study also provided NASA with decision rules that would enable it to develop a planetary science program in the event of budget reductions. For example, were if NASA's budget were to shrink, the committee recommended first that some or all of the recommended large-scale missions be delayed in favor of the medium or small scale missions, which provide continual advances and create a foundation for larger endeavors.

**Priority Questions in Planetary Science and the Missions in the Recommended Plan That Address Them**

		Mars Sample Return/Mars Explorer Catcher (MAX-C)	Jupiter Europa Orbiter (JEO)	Uranus Orbiter and Astrobiology	Venus Climate and Probe*	Enceladus Orbiter*	Comet Surface Sample Mission*	Lunar South Pole Return	Lunar Geophysical Network	Io Observer	Lunar South Pole Aitken Basin Sample	Trojan Tour and Rendezvous	Saturn Probe	Venus In Situ Explorer	Discovery Missions	
<i>Priority Questions</i>																
Building New Worlds	What were the initial conditions, processes, and stages of solar system formation?							●						●		●
	How did the giant planets and their satellite systems come to have their present orbits?	●			●	●	●		●				●	●		
	How did the environments of the planets evolve, and what role did large projectiles play?			●		●			●			●	●		●	●
Planetary Habitats	What were the primordial sources of organic matter? Does organic synthesis continue today?	●		●	●	●	●		●					●		●
	Did Mars or Venus once have environments conducive to life, and did life emerge?			●				●							●	●
	Today, are there habitats beyond Earth that could sustain life, and do organisms live there now?	●		●												●
Workings of Solar Systems	How do the giant planets serve as laboratories to study Earth, the solar system, and other planetary systems?	●			●								●			
	What bodies in our solar system endanger Earth's biosphere, and what mechanisms shield it?								●							●
	How can understanding climates on other planets help us understand changes in Earth's climate?	●		●	●	●	●	●					●		●	●
	What chemical and physical processes shaped the solar system and how have they evolved?	●	●	●	●	●	●	●	●	●	●	●	●	●		●

\*Indicates a lower-priority recommended large-scale mission

## Recommended Program of Planetary Science Missions

### *Large-scale flagship missions, in order of priority*

**Mars Astrobiology Explorer Cacher (MAX-C):** This mission will answer questions about the evolution of Mars' geology and climate, and facilitate the return of Martian samples to Earth, which will help determine whether or not the planet ever supported life. In order to be viable, however, NASA and its collaborator in this project, the European Space Agency, should reduce the mission's scope while retaining its long-term objectives so that the cost is reduced by about \$1 billion from the independent cost estimate obtained by the committee. If this is not possible, the mission should be deferred or canceled.

**Jupiter Europa Orbiter (JEO):** JEO will evaluate the habitability of Jupiter's moon Europa; survey its oceans, interior, ice shell, chemistry, and composition; and identify prospective spacecraft landing sites. Because JEO offers great potential scientific benefit, the committee recommended that its currently prohibitive cost be reduced significantly and that NASA's planetary science budget be increased slightly in order to accommodate the mission.

### *Medium-scale missions*

The New Frontiers program selects smaller missions that use medium-class spacecraft for focused solar system exploration. In addition to two New Frontiers missions currently in progress and a third undergoing selection, the survey recommends that two new missions be selected for the years 2013-2022. The fourth mission would be selected by NASA on the basis of competitive peer review from among the following list of candidates:

**Comet Surface Sample Return:** returns samples of organic material from the surface of a comet nucleus to Earth for study

**Lunar South Pole-Aitken Basin Sample Return:** returns samples from an ancient impact basin to Earth for study

**Saturn Probe:** uses a probe in Saturn's atmosphere to determine its structure and composition

**Trojan Tour and Rendezvous:** examines small bodies sharing the orbit of Jupiter

**Venus In Situ Explorer:** examines the chemistry and physics of Venus' atmosphere and crust

The competition for a fifth mission should add the following candidates:

**Io Observer:** determines the internal structure of Io and investigates its volcanic activity

**Lunar Geophysical Network:** places several landers on the Moon's surface to measure its geological characteristics

### *Small-scale missions*

The survey recommends that NASA's prolific Discovery program be continued at its current level of funding, adjusted for inflation, over the next ten years. It also expresses strong support for the Mars Trace Gas Orbiter mission, scheduled to take place in 2016 in collaboration with the European Space Agency, due to its high expected scientific return and low cost to the United States. Finally, continuation of both the Discovery and New Frontiers programs is recommended, regardless of NASA's success in reducing the scope of the recommended large-scale flagship missions to meet projected budget resources.

**To learn more about the survey's other recommendations, download a [summary](#) of *Vision and Voyages in Planetary Science for the Decade 2013-2022* at [www.nap.edu](http://www.nap.edu).**

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Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the agencies that provided support for the project. Copies of the full report can be downloaded or purchased from the National Academies Press at [www.nap.edu](http://www.nap.edu). Permission granted to reproduce this brief in its entirety with no additions or alterations. Permissions for images/figures must be obtained from their original source. © 2011 The National Academy of Sciences