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Flying farther on less

From visions to voyages

Juno to Jupiter: Piercing the veil

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From visions to voyages

Fiscal austerity measures anticipated under the Obama administration will have a major impact on planetary science, including some high-priority NASA projects. New plans based on a decadal survey of potential missions call for trimming and realigning some programs to maximize science output. Greater international cooperation and scaled-back hardware are just a few of the belt-tightening measures proposed.

by Craig Covault
Contributing writer

Once every decade, the National Research Council (NRC) is asked to prioritize NASA's goals, looking 10 years out. This year's planetary decadal survey, recently released, has determined that NASA must reduce the size and complexity of its large ($2-billion-$3-billion) 'flagship' planetary missions. The decadal survey was undertaken to plan U.S. exploration strategy ahead of the NASA funding cuts expected under the Obama administration's austerity measures.

Employing a more open planning process, one with broad community involvement and a focus on science, will allow a smoother process for making the needed changes in post-2013 mission designs. (The entire report may be found here: http://solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=742.)

Mission priorities

The survey team, which included top NASA and university scientists and engineers, came up with 25 candidate missions for launch between 2013 and 2022, says Cornell University's Steve Squyres, who led the review.

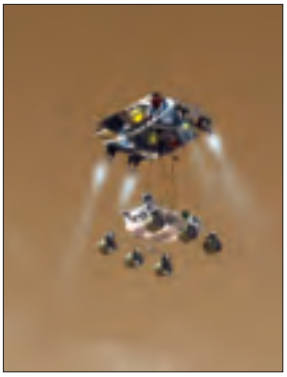
The sweeping document, formally titled *Vision and Voyages for Planetary Science in the Decade 2013-2022*, carries both the new recommendations and the reasons for them. Squyres took temporary leave as project scientist for NASA's Mars Exploration Rover program to head the survey.

A NASA/ESA twin-rover Mars sample return to search for evidence of life has the highest priority, but is slated for major changes, including the redesign of both rovers. And almost equally important, a planned 2016 flight to Jupiter to investigate a potentially habitable ocean on the Jovian moon Europa is also in for heavy cuts.

The changes to the Mars and Europa efforts will affect the European Space Agency's participation in both. The flight to Europa was to have followed NASA's Juno mission, set for launch this summer to investigate Jupiter's atmosphere for clues to early planetary formation.

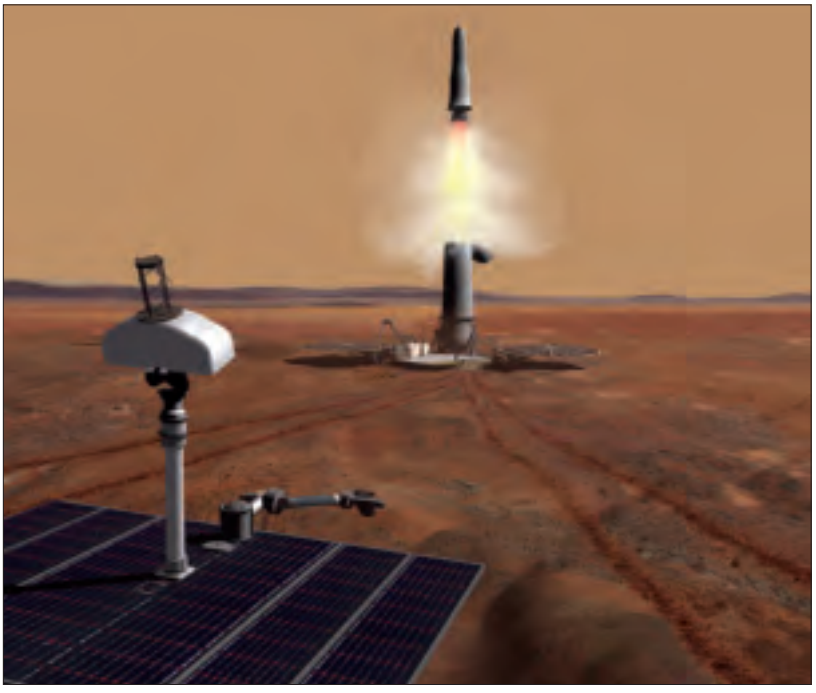
Next in priority to the Mars and Europa missions is a Uranus orbiter/probe flight, which would be the first in-depth exploration of an 'ice giant' planet in the outer solar system.

Planets in the solar system imaged by previous NASA spacecraft show the breadth of targets covered in the decadal survey. The new strategy for 2013-2022 envisions the first missions to the 'ice giants' Neptune and Uranus.



The MAX-C, a new rover for collecting Mars samples, will be lowered by a rocket-powered Sky Crane just like the new Curiosity Mars Science Laboratory being launched in November for landing in late 2012. After MAX-C has completed its mission, another rover, possibly a European one, will also use a Sky Crane landing to collect and load samples into a return rocket.

A Martian ascent vehicle lifts off from Mars with samples selected and picked up by the NASA MAX-C rover and then retrieved for launch by an ESA rover. That rover would place them in a U.S. launcher that will send them to a Mars orbiter, which would then place them in another vehicle for return to Earth.



If the Mars, Europa, or Uranus missions falter in their development, then either an Enceladus orbiter at Saturn, to sense that moon's subsurface ocean, or a Venus climate mission could be flown.

Sharp cuts, sharp responses

There is some sharp criticism in the planetary exploration community—not about the decadal survey findings trying to salvage exploration, but rather about the sharply reduced Obama administration budgets that are forcing the actions recommended by the survey. "The flow of scientific creativity and technical innovation cannot be turned on and off like a spigot. To make progress, there must be steady support," says Bill Nye, executive director of the Planetary Society. "NASA is charged with exploring and innovating, but the Congress and administration routinely turn the spigot on and off, and then seem outraged when NASA fails to meet their schedules and expectations."

In the proposed FY12 budget numbers, all science disciplines will take a hit, especially planetary science. No money has been allocated for a Mars mission in 2018. In fact, there is no money for any future Mars mission in this budget after 2016, including a Mars sample return. The high-priority Europa orbiter is not even in the budget, Nye points out.

"Just as the planetary science decadal survey presented its thoughtful recommendations, NASA is faced with reworking the whole thing to save as much science as possible within this new federal budget," he explains.

Jim Green, the director of NASA's planetary science division, is working hand in hand with Squyres in the effort to preserve mission content and equality across different disciplines. Nonetheless, the Planetary Society is "deeply disappointed that there may well be no flagship mission to the outer planets," says a statement issued by the group.

Trimming costs

"Europa's probable ocean may be the best candidate in the solar system beyond Earth for a currently habitable environment," says Squyres. But an independent estimate from the Aerospace Corporation puts the cost for a full-up Jupiter Europa orbiter (JEO) mission at $4.7 billion—a level far too high under the new federal budget realities. The decadal committee thinks that even if the spacecraft's capabilities are reduced and ESA shares the expenses, it will not fit within a cost-constrained program.

Work on reducing JEO costs must begin now, says Squyres, adding, "JEO science would be enhanced by conducting the mission jointly with ESA's proposed Ganymede orbiter"—perhaps by launching them together to Jupiter.

Technology work on a Uranus or Neptune mission needs to begin now, and the mission, perhaps not to be flown until after 2022, would still open a whole new region of the solar system for exploration.

But Mars exploration is where major cuts must be made. This would kill ESA's 2018 ExoMars rover and replace it with a single NASA rover that could carry most of the ESA science instruments while fulfilling the primary U.S. objective of collecting samples for later pickup.

The proposed strategy would conduct sample return as a campaign with three separate elements:

- *A 'caching rover,' the Mars astrobiology explorer-cacher (MAX-C)*, which would select samples and position them for pickup.
- *A Mars sample return lander (MSR-L)*, likely an ESA rover to fetch the sample cache, and a U.S. ascent vehicle to loft it into Martian orbit.
- *Rendezvous and return by a Mars sample return orbiter (MSR-O).* The Mars ascent vehicle, with the samples, would rendezvous with the MSR-O, which would fire the samples back to Earth.

The process could take many years, given that at each point the samples would be relatively safe from loss, unless the ascent vehicle failed. NASA must also keep the cost of MAX-C below $2.5 billion.

"This campaign would be scientifically robust, with the flexibility to return to a previously visited site (for example, if motivated by an MSL discovery), go to a new site, or fly a second MAX-C rover if the first mission was unsuccessful for any reason," says the decadal survey. "It would also be technically and programmatically robust, with a modular approach and multiple caches left on the surface by MAX-C to recover from a failure of either the MSR-L or MSR-O elements without requiring a reflight of MAX-C," adds the survey.

Missions already approved and funded for near-term launch would continue. Discovery, held to $500-million projects, is a good example of a program where the creativity of the mission's principal investigator will not be countered by decadal survey findings.

Discovery missions now in flight include Messenger, orbiting Mercury; Dawn, heading to orbit planetoid bodies in the asteroid belt; and Kepler, using its unique optics to spot planets around other stars.

Other candidates

NASA will pick one 2016 mission from among three science investigations it has selected: looking at Mars' interior for the first time; studying an extraterrestrial sea on one of Saturn's moons; or studying the surface of a comet's nucleus in unprecedented detail.

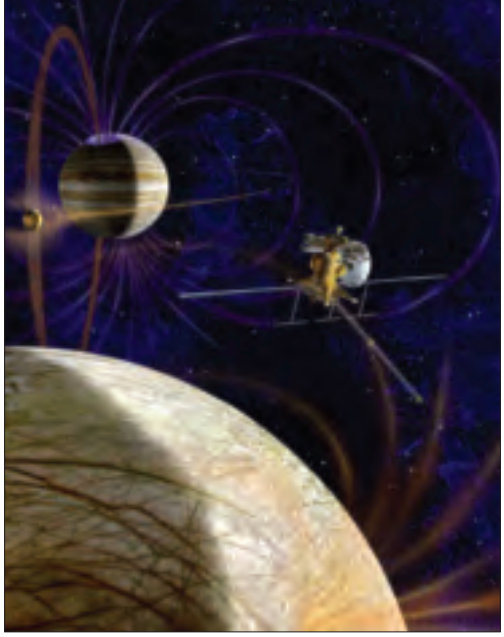
NASA scientists and engineers have just completed a major assessment of 28 new Discovery mission candidates. They picked three to receive $3 million each for the mission's concept phase or preliminary design studies. In 2012, after another detailed review of the concept studies, NASA will select one for continuing development efforts leading up to launch.

The selected mission will be cost-capped at $425 million, not including launcher funding. The missions selected for pursuit of preliminary design studies are:

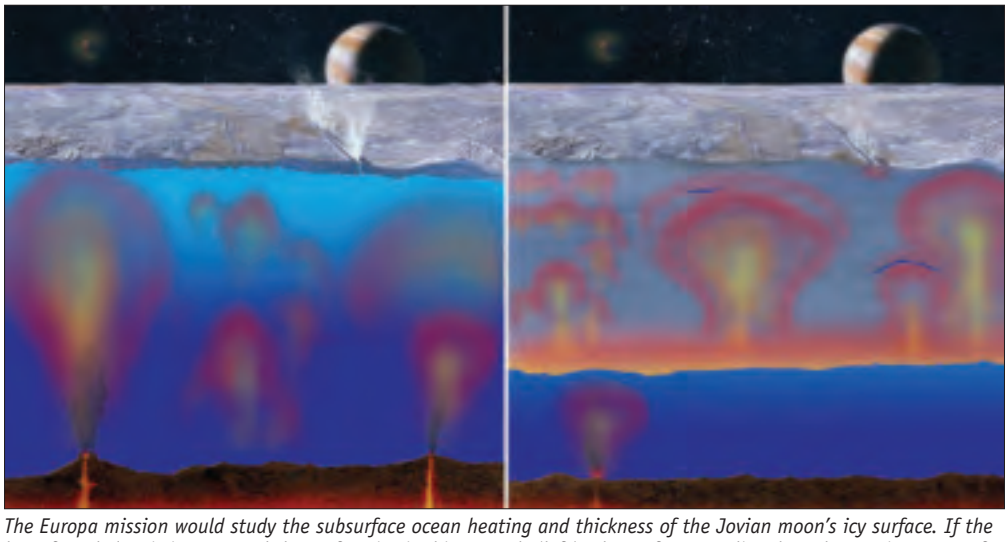
• *Geophysical monitoring station*, or GEMS, would study the structure and composition of the interior of Mars and advance understanding of the formation and evolution of terrestrial planets. Bruce Banerdt of JPL in Pasadena, California, is principal investigator. JPL would manage the project.

• *Titan Mare explorer*, or TiME, would provide the first direct exploration of an ocean environment beyond Earth, by landing in and floating on a large methane-ethane sea on Saturn's moon Titan. Ellen Stofan of Proxemy Research in Gaithersburg, Maryland, is principal investigator. Johns Hopkins University's Applied Physics Laboratory would manage the project.

• *Comet hopper*, which would study cometary evolution by landing on a comet multiple times to observe its changes as it interacts with the Sun. Jessica Sunshine of



A mission focusing on Europa could help determine whether it has a habitable ocean under just a 100-ft frozen surface. An artist's concept shows a notional spacecraft collecting radar data on the ocean and its frozen surface, which some future mission could penetrate to reach the water below.



The Europa mission would study the subsurface ocean heating and thickness of the Jovian moon's icy surface. If the heat from below is intense and the surface ice is thin enough (left), the surface can directly melt, causing areas of broken, rotated, and tilted ice block, as seen in many Galileo spacecraft images. But if the surface ice is sufficiently thick (right), the less intense interior heat will be transferred to the warmer ice at the bottom of the shell, coupled with heat generated by tidal squeezing of the warmer ice. This warmer ice will slowly rise, flowing as glaciers do on Earth, and the slow but steady motion may also disrupt the extremely cold, brittle ice at the surface.

Water vents firing from Enceladus, discovered by the Saturn orbiter Cassini, indicate there is a warm water ocean under the surface. A mission to Enceladus, nearly 1 billion mi. from Earth, is cited in the survey as highly desirable and would investigate the tiny body, a moon where early microbial life could have formed.

A new $500-million Discovery mission candidate would be this proposed 2016 spacecraft that would fly to Saturn and drop into a large methane lake on the moon Titan. The spacecraft in this graphic uses a floodlight while moving along the surface. The lake lander, developed by Johns Hopkins Applied Physics Laboratory, would compare Titan's characteristics to the hydrological cycle on Earth.

the University of Maryland in College Park is principal investigator; NASA Goddard would manage the project.

"This is high science return at a price that's right," says Green. "The selected studies clearly demonstrate a new era, with missions that all touch their targets to perform unique and exciting science. NASA continues to do extraordinary science that is rewriting textbooks."

Explains NASA Administrator Charles Bolden, "Missions like these hold great promise to vastly increase our knowledge, extend our reach into the solar system."

New Frontiers

NASA's New Frontiers program carries the creative aspects of the Discovery program to missions costing $1.05 billion, a figure that includes launcher costs. But to give New Frontiers missions more funding margin, the decadal survey recommends that NASA lower the funding cap to an even $1 billion (in FY15 dollars), excluding launch vehicle costs, says Squyres.

"This change represents a modest increase in the effective cost cap and will allow a scientifically rich and diverse set of New Frontiers missions to be carried out," according to the survey. It will also help protect the science content of the program against increases and volatility in launch vehicle costs.

Two New Frontiers missions have been selected by NASA to date, and a third selection is under way now: "The committee recommends that NASA select two New Frontiers missions in the decade 2013-2022. These are referred to here as New Frontiers Mission 4 and New Frontiers Mission 5.

New Frontiers Mission 4 should be selected from among the following five candidates: a comet surface sample return, a high mission priority; lunar south pole-Aitken Basin sample return; a Saturn probe; a Trojan tour and rendezvous, to explore several of the 4,000 'Trojan asteroids' that orbit Jupiter ahead of and behind the giant planet; and a Venus in-situ explorer."

No relative priorities are assigned to these five candidates. Instead, the selection from among them should be made on the basis of competitive peer review, says the decadal survey.

For the New Frontiers Mission 5 selection, in addition to the list of candidates that lost out in the NF 4 selection, Squyres says, other options, such as an Io observer and a lunar geophysical network, should be considered.

The bigger picture

In a briefing at this year's Lunar and Planetary Science Conference in Houston, Texas, Squyres says the mission strategy selected by the NRC survey participants cross-cuts three main themes:

- **Building new worlds**: Missions to different planets can all add data to key questions asked in the survey, such as: What were the initial stages, conditions, and processes of solar system formation, and how did the giant planets and their satellite systems accrete? What governed the accretion, supply of water, chemistry, and internal differentiation of the inner planets and their atmospheres?
- **Searching for habitats**: Locations that could harbor life range from Saturn's moon Enceladus, where subsurface water is warmed, to the closer Jovian moon Europa, whose subsurface ocean is warmed by Jupiter's tidal forces. Mars is central to the search for habitats. And some survey questions that cut across all mission areas are: What were the primordial sources of organic matter? Where does organic synthesis continue today? Did Mars or Venus host ancient aqueous environments conducive to early life, and is there evidence that life emerged?
- **The workings of solar systems**: The study of planetary processes through time includes questions such as, how do the giant planets serve as laboratories for understanding Earth, the solar system, and extrasolar planetary systems being discovered by the Kepler spacecraft and Earth-based observatories? ⩓