Solar System showdown

Competition is fierce as committee weighs NASA's planetary priorities.

Steve Squyres, the indefatigable principal investigator for NASA's Mars rover missions, sells the seductive charms of the red planet better than just about anyone. But as chairman of the planetary science decadal survey, a US National Academies study that will decide on NASA's Solar System mission priorities for 2013–22, he has to play a different part: that of the dispassionate and disinterested pan-planetarian.

"I've worked on topics across the Solar System," says Squyres, a planetary scientist at Cornell University in Ithaca, New York. "The public perception of me is completely separate from how I view my own work and how I view my responsibility to the decadal survey." His impartiality will be put to the test the next time the committee meets, on 13 July in Washington DC, as a potential conflict emerges between the two biggest projects under consideration, both angling for a launch at the end of the decade. One is a mission to Europa, the fourth-largest of Jupiter's moons, which is thought to have a salt-water ocean lurking beneath its icy crust (see 'Jupiter Europa Orbiter'). The other is a risky, three-pronged effort to drill core samples from Mars and return them to Earth (see Mars Sample Return'). Both would be joint efforts with the European Space Agency (ESA).

NASA

"We've got a lot more good science than we can reasonably afford."
— Steve Squyres

Confidential and independent cost estimates have just started to arrive for these and the 24 other missions (see 'A war of worlds') that the committee will rank on the basis of their expected science return per dollar. As usual, says committee member Stephen Mackwell, director of the Lunar and Planetary Institute in Houston, Texas, there is too little money for too many ideas. "We have to deal with a whole Solar System of possibilities," he says.

Because of uncertainties in the budgeting process, Squyres is cagey about disclosing his cost cap for planetary exploration in 2013–22, but NASA's share of the two biggest contenders for the funding — estimated at US$3.2 billion for the Europa mission and US$6 billion–US$7 billion for the Mars sample return project — make it likely that there is room for only one of them within the constraints with which Squyres has to work.

"I find it very hard to see doing them both in the decade," says Fran Bagenal, former chairwoman of an external NASA planetary-science advisory committee. If the cost of the first stage of a Mars sample-return mission grows enormously, as it did for the US$2.3-billion Mars Science Laboratory rover scheduled for launch next year, then the Europa mission could be delayed, she says.

What's more, attempting a Europa mission and the Mars sample return at the same time could crowd out smaller missions to other parts of the Solar System, says Alfred McEwen, principal investigator for the HiRISE camera on the Mars Reconnaissance Orbiter, which is currently imaging Mars. "If both go forward, can NASA — and ESA for that matter — do much of anything else?" he asks.

The pressure to get started on the missions has only grown. In the last decadal survey, which considered Mars missions separately from all others, both projects rose to the top of their respective, segregated lists. But the delays and cost overruns of the Mars Science Laboratory, along with a NASA-wide emphasis on the Moon during the Bush administration, meant that progress on both missions stalled.

Supporters of a Europa mission are confident that they are now in pole position. Significant amounts of money have been poured into the technologies that would protect instruments from their major risk: radiation from Jupiter. In an assessment completed early last year, the mission also beat a rival concept that would have explored Saturn's moon Titan (see *Nature* **457**, 366–367; 2009). William McKinnon, chairman of NASA's Outer Planets Assessment Group, says that Europa won not because its science potential is so much better than Titan's — although many of its champions point to the potential of Europa's ocean to support life — but because its technological readiness, and price tag, are more certain.

Mars Sample Return does not inspire the same confidence. The latest concept has three stages: a rover, launched in 2018 together with ESA's ExoMars rover, would collect and cache

A war of worlds

The planetary science decadal survey will rank 28 missions from 4 NASA centres: the Jet Propulsion Laboratory (JPL) in Pasadena, California; the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland; the Applied Physics Laboratory (APL) in Laurel, Maryland; and the Marshall Space Flight Center (MSFC) in Huntsville, Alabama. Three of the proposals are finalists in a funding competition for medium-cost missions to be decided in 2011, when the survey's report is released. The survey will not interfere, but will adjust its rankings on the basis of the outcome so that runners up can be considered for funding.

Mercury
Mercury Lander, APL

Venus
Surface and Atmosphere Geochemical Explorer (SAGE), JPL (competition finalist)
Venus Mobile Explorer, GSFC
Venus Tessera Lander, GSFC
Venus Climate Mission, GSFC

Moon
Moonrise (South Pole-Aitken Basin Sample Return), JPL (competition finalist)
Lunar Polar Volatiles Lander, APL
Lunar Network Mission, MSFC

Mars
Mars Trace Gas Orbiter, JPL
Mars Polar Mission, JPL
Mars Network Mission, JPL
Mars Sample Return, JPL, included as three missions: Mars Astrobiology Explorer–Cacher; Mars Sample Return Lander; and Mars Sample Return Orbiter

Outer planets
Jupiter Europa Orbiter, JPL
Io Mission, JPL
Ganymede Mission, JPL
Saturn Probe, JPL
Titan Flagship Mission, JPL
Titan Lake Lander, JPL
Enceladus Mission, JPL
Uranus System Mission, APL
Neptune System Mission, JPL

Small bodies
Origins Spectral Interpretation Resource Identification Security Regolith Explorer (OSIRIS REX), GSFC (competition finalist)
Main Belt Asteroid Lander, APL
Chiron Orbiter, GSFC
Trojan Asteroid Tour, APL
Comet Surface Sample Return, APL **E.H.**

NASA/JPL/APL

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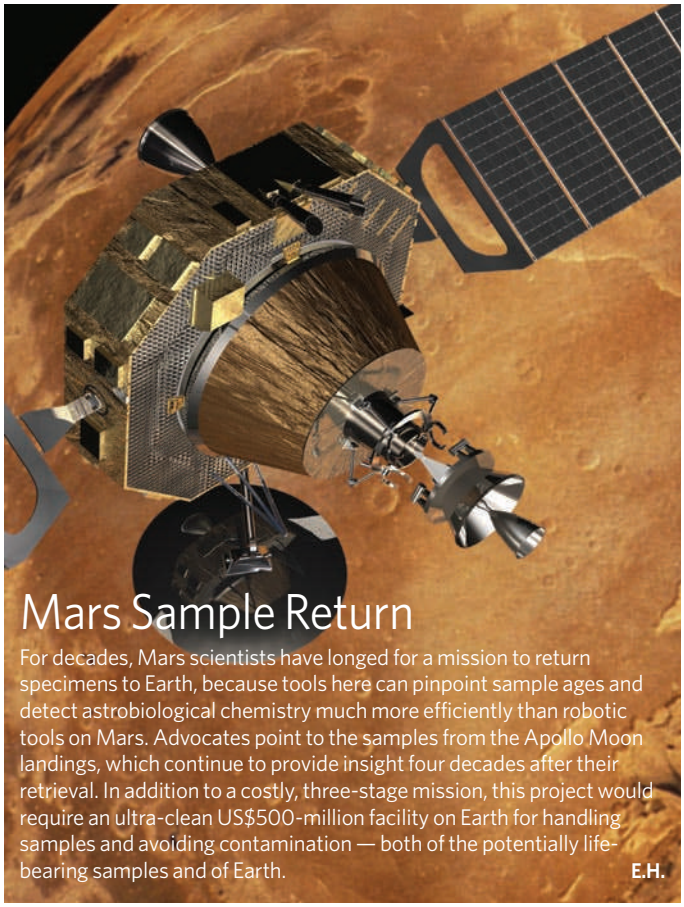
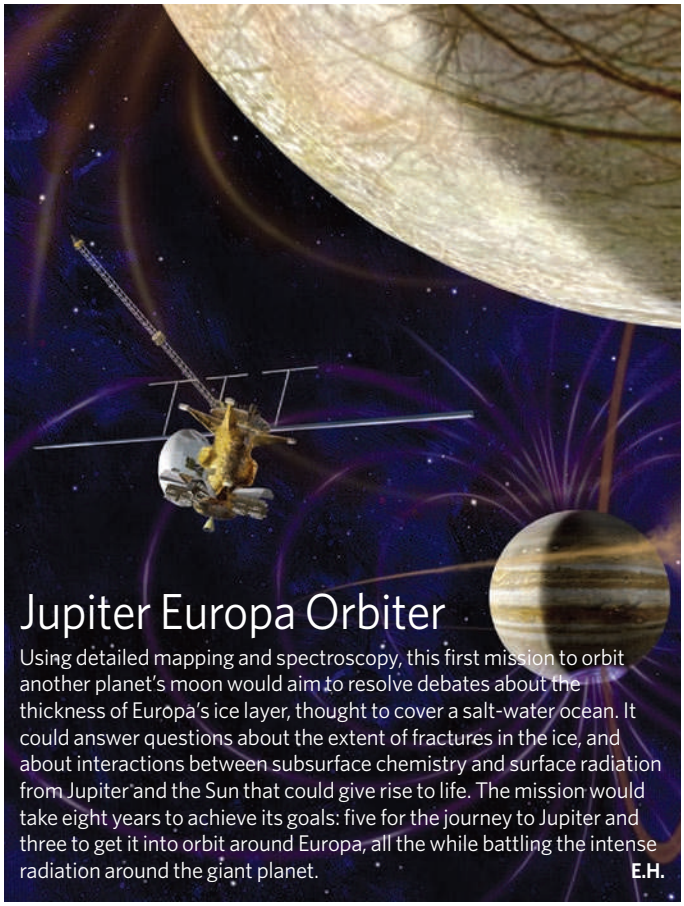
MARS: ESA; JUPITER: EPL/NASA



Mars Sample Return

For decades, Mars scientists have longed for a mission to return specimens to Earth, because tools here can pinpoint sample ages and detect astrobiological chemistry much more efficiently than robotic tools on Mars. Advocates point to the samples from the Apollo Moon landings, which continue to provide insight four decades after their retrieval. In addition to a costly, three-stage mission, this project would require an ultra-clean US$500-million facility on Earth for handling samples and avoiding contamination — both of the potentially life-bearing samples and of Earth. **E.H.**



Jupiter Europa Orbiter

Using detailed mapping and spectroscopy, this first mission to orbit another planet's moon would aim to resolve debates about the thickness of Europa's ice layer, thought to cover a salt-water ocean. It could answer questions about the extent of fractures in the ice, and about interactions between subsurface chemistry and surface radiation from Jupiter and the Sun that could give rise to life. The mission would take eight years to achieve its goals: five for the journey to Jupiter and three to get it into orbit around Europa, all the while battling the intense radiation around the giant planet. **E.H.**

about 20 cores, each 5 centimetres long and 1 centimetre wide. An orbiter would arrive years later, followed by a lander, which would retrieve the cached samples, put them in a 5-kilogram capsule, and blast off to join with the orbiter before returning to Earth.

The importance of getting rocks back to Earth — where they can be analysed much more precisely — is undeniable, says Jack Mustard, chairman of NASA's Mars Exploration Program Assessment Group. "Sample return has the potential to completely revolutionize our understanding of the planet."

But measuring the price could require a "new Richter scale", says McEwen. And many are concerned that because each individual stage must perform correctly for the mission's objective to be achieved, it would require nearly impossible levels of confidence to be worth the risk. Even some members of the Mars community are reluctant to put all of their eggs in one basket, says Mustard, when there is still work to be done in determining the best spot from which to retrieve a precious few kilograms of rock.

What Squyres has called "sticker shock" for the biggest missions could bias the survey in favour of small- and medium-cost mission lines known as Discovery and New Frontiers. "I could put together a spectacular programme without either one of those [flagship missions]. There are many ways to slice this," says Squyres. Or, as Bagenal puts it: "They could say, 'A pox on both your houses. Let's just continue with New Frontiers and Discovery until you come up with an easier, cheaper way to do these missions.'"

Help with the fiscal constraints could come from a surprising direction: NASA's human exploration programme, which tends to take from the science division more often than it gives. A new programme line in US President Barack Obama's proposed budget calls for a 5-year, US$3-billion series of robotic precursor missions to pave the way for human exploration of the Moon, asteroids and Mars.

If Congress funds the programme — and that's a big if — launches would come at a rate of a nearly one a year. And although they are intended to aid human exploration, such missions can also do science. The 2009 Lunar Reconnaissance Orbiter, for example, was intended to provide high-resolution maps of resources and terrain for the now-defunct vision of returning astronauts to the Moon. But it has nonetheless achieved notoriety for its confirmation of water ice in extremely cold lunar polar craters.

A study team within NASA's human exploration programme has already released possible mission schedules and destinations. A new reconnaissance orbiter for Mars could be launched in 2016, carrying a camera capable of imaging the surface with a resolution of 7 centimetres per pixel, three to four times the resolution of the HiRISE camera. A Mars lander would follow in 2018. Neither mission would be a substitute for the Mars Sample Return, but it is obvious that the Mars community, more than those interested in other Solar System destinations, will be the beneficiary of the robotic-precursor money.

All that will be a wild card as Squyres' committee drafts its recommendations in late September — with an aim to publish by April — because the ultimate size and shape of the robotic-precursor programme are not yet known. "There is not a lot of meat on those bones yet," says Mackwell.

Until then, Squyres is trying to negotiate a fiscal landscape as challenging as the terrain that his rovers encountered on Mars. "We've got a lot more good science than anyone can expect us to reasonably afford. We have to pick the best stuff." ■

Eric Hand