provides an independent yardstick as to whether something is interesting enough and whether it meets its yard posts."

At ARPA-E's second annual Energy Innovation Summit in Washington DC last week, the mood was upbeat and the speeches were inspirational, underscoring science's role in keeping the United States competitive in the global race for clean energy. But the fiscal backdrop is ominous. In Congress, Democrats and Republicans remain at loggerheads over federal spending, having temporarily averted a government shutdown last week when the House of Representatives passed a resolution that funds the government until 18 March (see page 144). Although the White House proposed a budget of $300 million for ARPA-E in the current fiscal year, the continuing resolution contains just $50 million for the agency, enough to launch at most one new research programme.

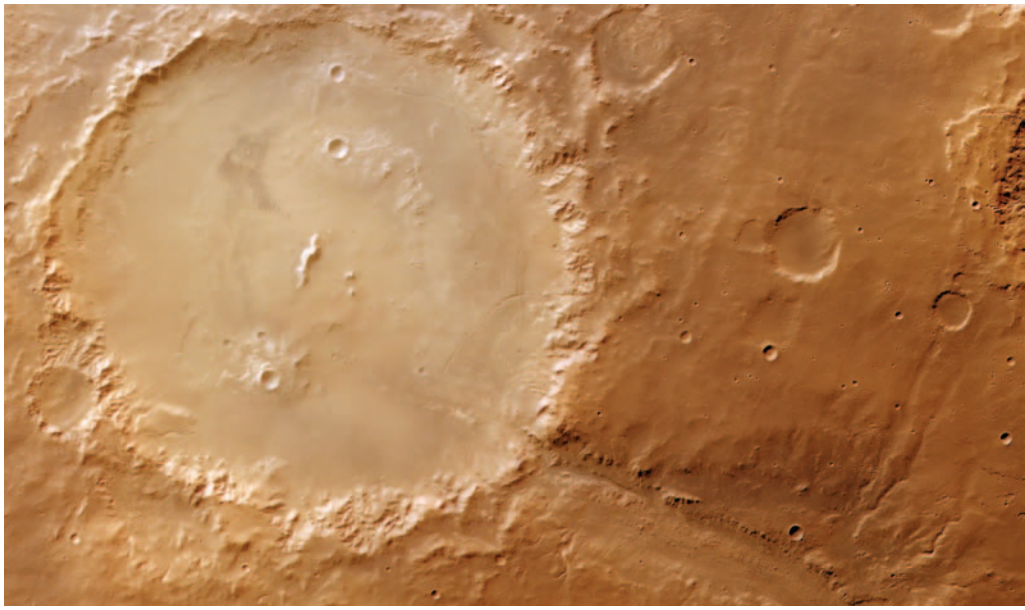
To date, the agency has committed $365.5 million to 121 projects in various fields (see 'Energy investment'). But all of that money came from the original $400-million appropriation in the economic stimulus package enacted in April 2009. Depending on how much more money comes through this year, the agency is already considering several new programmes in areas such as solar photovoltaics, the conversion of natural gas into liquid fuels, and energy technologies that reduce the consumption of water, rare-earth metals and other crucial materials. For fiscal year 2012, the administration has requested $550 million, which should allow further expansion.

ARPA-E director Arun Majumdar says that the agency is ready to move ahead once Congress resolves its funding for this year and next. But he received mixed messages from two Republican senators who attended the conference, Lisa Murkowski of Alaska and Lamar Alexander of Tennessee. Both lawmakers, while offering their support for ARPA-E, warned that Congress is in full budget-cutting mode.

The agency will soon begin making difficult choices about its first round of projects. Each project has measurable milestones, and Majumdar says that the agency will put each one on green, yellow and red alerts depending on how much progress it has made. Project managers will continue to work with the scientists to help them meet their targets, but yellow and red signal trouble if researchers don't start to make progress.

"We will help you as much as we can, but if it doesn't work, it doesn't work," Majumdar says. "Taxpayer money should not be given to things we know are not going to work." ■

NATURE.COM
For more on clean energy see:
go.nature.com/e6umpw



Mars's 150-kilometre Holden Crater, which shows signs of a watery past, could be perfect for rock hunting.

G. NEUKUM, FU BERLIN/ESA/DLR

PLANETARY SCIENCE

US Mars mission takes pole position

Sample-return trip to go ahead, but only if costs can be cut.

BY ADAM MANN

A showdown over the course of Solar System exploration has ended with a qualified victory for Mars. NASA's planetary-science decadal survey, which sets mission priorities for 2013–22, firmly favours a mission to Mars over a rival one to Jupiter's icy moon Europa (see *Nature* **466,** 168–169; 2010). But the decision marks the beginning of a much bigger battle: to secure the budget to lift the multibillion-dollar project off the survey's pages and into the heavens.

The decadal-survey committee's recommendations, released on 7 March at the Lunar and Planetary Science Conference in Houston, Texas, relied partly on President Barack Obama's 2011 budget request, which projected that NASA's annual planetary-science funding would grow from its current allocation of $1.36 billion to more than $1.6 billion by 2015. But Obama's 2012 budget foresees that funding dropping to $1.2 billion in 2016. On 3 March, planetary-sciences division director James Green told the NASA Advisory Council's science committee that this would create indefinite delays for both the Mars and Europa missions.

"This creates a big gap between what the decadal survey is planning on and what is available," agrees Fran Bagenal, a planetary scientist at the University of Colorado, Boulder, and former chairwoman of an external NASA planetary-science advisory committee, who was not involved in creating the report.

The details of the recommendation reflect the committee's attempts to navigate different budget scenarios and maintain a robust research agenda under cash-strapped conditions. "In prioritizing missions, the most important criterion was maximizing science bang per buck," says Steve Squyres, an astronomer at Cornell University in Ithaca, New York, and chairman of the decadal survey.

The top-ranked flagship mission, the Mars Astrobiology Explorer-Cacher (MAX-C), would use a rover to conduct *in situ* astrobiological experiments, and to collect and store samples for return to Earth. This mission would also deliver the ExoMars rover for the European Space Agency (ESA). "We are at the point in Solar System exploration where what we want to do is beyond the budget of a single nation," says Wendy Calvin, a geologist at the University of Nevada, Reno, and vice-chair of the decadal survey's Mars panel.

To allow room in the budget for other priorities, the report recommends that the mission should not fly in the next decade

unless a billion dollars can be shaved off the estimated $3.5-billion cost to NASA.

The second-choice flagship mission will fly only if its costs can be cut, and if NASA gets a significant budget increase for planetary exploration. Indeed, it is excluded from the panel's 'cost-constrained' mission wish-list (see 'To boldly go ...'). The Jupiter Europa Orbiter (JEO) would map the Jovian moon to assess the extent of the ocean thought to lie beneath its icy surface — a possible habitat for life. But the mission's estimated price tag — $4.7 billion, adjusted to 2015 dollar values — shocked panel members. "There were a lot of gasps when we saw the bottom line," says Stephen Mackwell, director of the Lunar and Planetary Institute in Houston, Texas, and vice-chair of the inner-planet panel. The high price was a key factor in tipping the decision towards a Mars mission and significantly lengthens the odds against the Europa mission getting off the ground this decade.

The decision to rank the JEO after MAX-C has not met with universal enthusiasm. "We've spent a little too much time on Mars," says Bagenal, adding that the red planet will be visited by the much-delayed and over-budget Mars Science Laboratory rover next year. She also finds it "hard to imagine" that MAX-C can stick to a $2.5-billion price tag, not least because it would rely on an as-yet-untested landing system.

The third flagship candidate is the Uranus Orbiter and Probe, expected to cost $2.7 billion. Like the other top recommendations, this project should be delayed or cancelled if costs increase significantly, the committee says. Indeed, these flagship missions should be the first to be put on hold if the planetary-science budget shrinks too much. This would protect the small Discovery missions and medium-sized New Frontiers projects, both of which are relatively low cost, narrowly focused and selected by competitive peer review. "One message we got from the community was not to let those missions get damaged from overruns on the flagships," says Squyres.

The survey does not prioritize competing Discovery missions — the costs of which are capped at $500 million — but advocates strongly that the programme should continue to deliver 'economy probes' such as the Mercury surface, space environment, geochemistry and ranging (MESSENGER) mission, which is scheduled to arrive in orbit around the planet next week (see 'MESSENGER's arrival').

The report also suggests adding two projects over the next decade to the New Frontiers programme. These projects cannot exceed $700 million and include the New Horizons mission, which launched in 2006 to study Pluto and the Kuiper belt. The additions would come from a list of seven candidates, including a sample-return mission to a comet, a Venus lander and an orbiter for Jupiter's moon Io. The committee also strongly endorsed the ESA–NASA Mars Trace Gas Orbiter. Expected to launch in 2016, the orbiter will study the behaviour of trace gases in Mars's atmosphere — particularly methane, which could indicate ongoing geological activity or even the presence of microorganisms.

Although funding helped to dictate the many trade-offs in the survey, Squyres says that the panel relied heavily on input from the planetary-science community and worked to build consensus before making decisions.

Despite some dissension, Squyres urges the planetary-science community to pull together behind the plan, speaking "with one clear and loud voice when talking to elected representatives in Congress to fight for funding".

"We have to be willing to implement some programmes at a reduced cost," says Squyres, "and we have to be willing to fight." ■

TO BOLDLY GO ...

If NASA's planetary-sciences funding remains on track with Obama's 2011 budget request, the decadal survey recommends two flagship missions and a planned joint mission with ESA. It also suggests keeping the Discovery programme intact and choosing two more New Frontiers missions from a shortlist of seven.

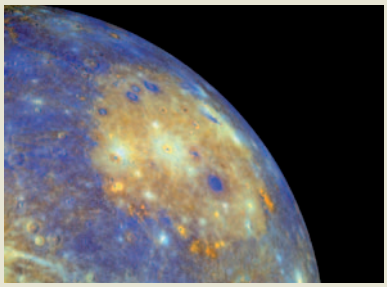
Mission	Goals
■ MAX-C (downsized to $2.5 billion)	Look for evidence of ancient life or prebiotic chemistry; collect samples for return to Earth
■ Uranus Orbiter and Probe	Investigate Uranus, its moons and its rings
■ Mars Trace Gas Orbiter	Study atmospheric trace gases, particularly methane
■ Discovery missions	Cost less than $500 million, launch roughly every two years
■ Comet Surface Sample Return	Bring substantial comet samples back to Earth
■ Saturn Probe	Investigate Saturn's atmosphere
■ Trojan Tour and Rendezvous	Study multiple Trojan asteroids
■ Venus In Situ Explorer	Land on Venus and analyse environment, including a pristine rock core
■ Lunar South Pole–Aitken Basin Sample Return	Return samples of the Moon's ancient deep crust
■ Io Observer	Understand volcanism on Jupiter's moon Io
■ Lunar Geophysical Network	Study interior of Moon

■ Flagship missions ■ Joint mission ■ Discovery missions ■ New Frontiers missions

SOURCE: VISION AND VOYAGES FOR PLANETARY SCIENCE IN THE DECADE 2013–2022

DESTINATION MERCURY

MESSENGER's arrival



SCIENCE/AAAS, CARNEGIE INST. WASHINGTON/ARIZONA STATE UNIV./JOHNS HOPKINS UNIV. APPL. PHYS. LAB./NASA

After a six-year flight, NASA's MESSENGER spacecraft is set to enter orbit around Mercury on 18 March, dipping as close as 200 kilometres to the planet's surface to make a long-awaited survey of this Sun-scorched world.

MESSENGER (Mercury surface, space environment, geochemistry and ranging) is only the second spacecraft to reach the planet. The first, Mariner 10, made three fleeting passes in 1974 and 1975 and glimpsed only 45% of the planet's surface. The new mission has already imaged 98% of Mercury during fly-bys in 2008 and 2009 (see **picture**). Once in orbit, MESSENGER will map the entire surface, recording its topography and composition on scales as small as a few tens of metres. Over the one-year mission, MESSENGER will also study Mercury's tenuous atmosphere of hydrogen, helium and metal ions, and look for water ice in permanently shadowed craters near the poles.

Mercury has an oversized iron core, three-quarters the size of the planet. This is utterly different from other rocky planets, the cores of which are small relative to their mantles. Did Mercury lose some of its mantle after a massive collision with another rocky body, or was it stripped down by an ancient flare-up of the Sun? Each scenario would have left a geochemical fingerprint on the surface, so MESSENGER may settle the matter. A year of magnetometer observations could also reveal whether some of the core is molten.

The wealth of new data expected from MESSENGER isn't likely to be topped for a while, as NASA has no plans for another Mercury mission. BepiColombo, a joint project between the European Space Agency and the Japan Aerospace Exploration Agency, aims to orbit Mercury with two probes simultaneously in 2020, but has cancelled plans for a lander. **Adam Mann**

For more on MESSENGER's mission, see **go.nature.com/devj9y**