Some researchers say that NASA should have learned at least one lesson from the Silver panel: Don't rush such a complex task. "These people had two meetings and were under tremendous pressure," says one scientist engaged in a lengthy National Research Council study of station science. Adds Acrivos: "That's just not enough time to do a good job." Despite its limitations, the report gives O'Keefe a rationale to ask for more station funding—if he chooses.

–ANDREW LAWLER

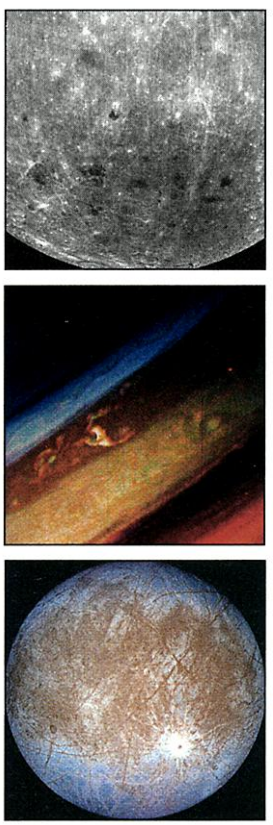
SOLAR SYSTEM EXPLORATION

Panel Plots Clear Path For Planetary Program

For the first time in its 40-year history, U.S. planetary science has a long-term, comprehensive road map for exploring the solar system. First stops would include the distant Kuiper belt and Pluto, Jupiter's icy moon Europa, and, to the surprise of many researchers, an ancient lunar crater. Now researchers must convince NASA, the White House, and Congress that those trips are worth the money.

The plan, drafted by the National Research Council (NRC) and laid out last week in a 417-page study, marks a radical shift in the way NASA plans solar system missions. In the past, the space agency has taken a piecemeal approach to planetary exploration, inviting scientists to pursue specific targets but never asking their advice on the big picture. That approach has resulted in tensions in recent years, as rival groups have pushed their own proposals and the field has suffered growing pains (*Science*, 4 January, p. 32). The NRC panel has tried to bring order to those competing claims by setting clear priorities—ranking 12 missions out of 27 candidates—and justifying them scientifically. The 15-member committee grouped potential missions into three classes: small ones costing less than $325 million, medium-sized ones costing between $325 million and $650 million and launched every 18 months, and larger flagship missions, flown once a decade (see table).

Convened by NASA and modeled on NRC's decadal astronomy panels, the committee—which formed a half-dozen subcommittees to tackle specific areas—solicited input from hundreds of planetary scientists scattered across the country. So far, reviews have been enthusiastic. "People are very supportive," says Mark Sykes, a University of Arizona, Tucson, astronomer who helped coordinate community input to the panel. "This was not just a backroom potboiler ... everyone had an opportunity to contribute." Adds panel member Joseph Burns, an astronomer at Cornell University in Ithaca, New York: "We felt it was very, very important to get the community to buy into this."



Take a number. The NRC report divides missions by cost and ranks those in the crowded middle-priced group.

One extremely satisfied customer is astrophysicist Alan Stern of the Southwest Research Institute in Boulder, Colorado. Stern is leading a $488 million project with Maryland's Applied Physics Laboratory to visit Pluto and the Kuiper belt by 2020. Rejected by NASA 2 years in a row, the mission has the unstinting support of Senator Barbara Mikulski (D–MD), who chairs NASA's spending panel, and other lawmakers. Last year Congress funded the mission against the wishes of the Administration, and Stern says that being named NRC's top priority for medium-class missions provides further momentum.

But hurdles remain. The NRC panel placed greater emphasis on Kuiper belt objects than on the Pluto system. Panel head Michael Belton believes that Stern's plan could still fill the bill, and Stern says the mission will examine one to three Kuiper belt objects as well as Pluto and

NEXT STOPS IN THE SOLAR SYSTEM*

Small
Cassini extension

Medium
Kuiper Belt–Pluto Explorer
Lunar South Pole with sample return
Jupiter Polar Orbiter with probes
Venus In Situ Explorer
Comet with sample return

Large
Europa Geophysical Explorer

*This list excludes planned missions to Mars.

CREDITS: (TOP TO BOTTOM) USGS/NASA; JPL/NASA; NSSDC/JPL/NASA

ScienceScope

Venus Trip An aborted European plan to send a mission to Venus has been resurrected. Last week, the European Space Agency's (ESA's) Science Programme Committee agreed to aim for the original launch date of November 2005 for Venus Express, the first flight to Venus since NASA's Magellan surveyed the planet in 1994.

Venus Express was cancelled 2 months ago after David Southwood, ESA's director of science, concluded that ESA's member space agencies could not meet the necessary tight schedule (*Science*, 31 May, p. 1585). But a reevaluation has made the agency more optimistic. Planetary scientist Fred Taylor of Oxford University says the ESA Council responded to a "massive wave of support" for the mission from scientists, politicians, and the general public.

However, one dark cloud remains: Budget woes might prevent Italy from making what ESA expects will be a substantial contribution to the Venus Express payload. The Italian Space Agency plans to decide by mid-October.

Mission Impossible? The surreal hunt for radioactive Soviet leftovers in the Republic of Georgia is entering a dangerous new phase. Officials in the strife-torn country are trying to track down abandoned canisters packed with strontium-90 before terrorists—or unwitting members of the public—lay their hands on the potent radioactive material.

In February, the International Atomic Energy Agency helped the Georgians recover two canisters, bringing the total number safely secured to six (*Science*, 1 February, p. 777). But last month, a 2-week follow-up search for as many as six more thought to be missing in the mountains near the breakaway Abkhazia region came up empty.

Officials now believe that the outstanding canisters, once the heart of thermogenerators used for remote radio relay stations, might be in territory outside Georgian army control. Negotiations are under way toward deploying a joint Georgian-Abkhaz team, with atomic agency support, to search for the canisters in what one official calls "lawless territory overrun with criminal groups." One key sticking point remains: "No one can guarantee the safety of the team in the field," says Zurab Saralidze, deputy director of the Institute of Physics in Tbilisi.

Contributors: Jocelyn Kaiser, Daniel Clery, Govert Schilling, Richard Stone

its moon Charon.

The project also needs $122 million next year for a 2006 launch, which depends on a gravity assist by Jupiter. And even with the necessary funding—NASA requested nothing this year—agency officials worry that the mission might not be able to test the new launch vehicle and win approval of the radioactive thermal device needed to power the spacecraft's electrical system in time. An innovative solar electric engine could allow for a later launch, but Stern says that the change would add complexity and cost.

A Europa mission is even more uncertain, despite being ranked first in what would be a series of large new spacecraft. "I'm happy to have [a large mission] identified, but the office of space science has absolutely no money for it," says Colleen Hartman, NASA's solar system exploration chief. The Jet Propulsion Laboratory in Pasadena, California, has been working on a Europa mission, which is now on hold after its estimated cost doubled to nearly $1 billion.

The most surprising recommendation, researchers say, was the one that listed a sample return mission to the moon's Aitken Basin as runner-up in the medium class. The basin is the largest known impact basin in the solar system and could yield old rocks from deep in the mantle without extensive drilling. The subcommittee that examined inner planets research preferred a flight to Mercury—a project well under way—and an atmospheric and surface study of Venus. But the full committee overturned that ranking, Belton says, on the grounds that a lunar sample return could provide good science and lay the groundwork for Mars and Venus sample returns. A comet sample return, widely considered a priority within medium-class missions, came in last because of the greater interest in planetary exploration.

The subcommittee panel handling Mars research concluded that a sample return starting in 2011 was the top priority. But the full committee, cognizant of a price tag of $2 billion or more, overrode that recommendation. Instead, it suggested a date between 2013 and 2023, prodding NASA to seek foreign partners. The group kept NASA's existing Mars exploration plan intact through the end of this decade.

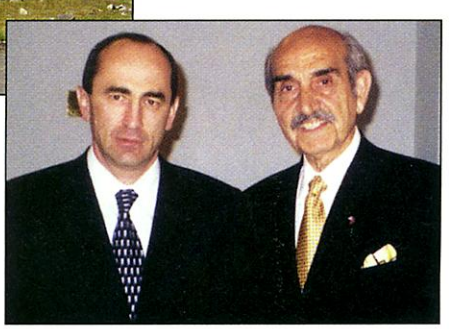
The report endorsed NASA's plans to develop technologies for faster and smaller spacecraft, including nuclear propulsion. It also urged the agency to contribute half of the cost of a ground-based Large-Aperture Synoptic Survey Telescope being developed by the National Science Foundation so that it could carry out solar system observations as well as all-sky surveys. Money should be set aside to upgrade NASA's Deep Space Network, which gathers distant spacecraft signals, the report added, and for a planetary data system to archive the vast amounts of data being generated.

The panel didn't calculate the cost of these missions and upgrades, which remains a critical question for NASA. Burns believes that much of the report's recommendations "realistically fall within the envelope of future planned expenditures," but NASA officials privately are skeptical. With a jittery economy and other pressing national concerns, NASA will need lobbying muscle as well as NRC's wish list to get the solar system train rolling. **–ANDREW LAWLER**

FORMER SOVIET UNION

Armenia Gears Up For Synchrotron

YEREVAN—This decrepit building on the outskirts of Armenia's capital doesn't look like much now, but in a few years' time it might be abuzz with activity as the headquarters for a gleaming new research facility the size of a football field: a $48 million, 3-giga-electron-volt (GeV) synchrotron. Backed by an unlikely alliance of high-energy physicists and a New Jersey homebuilder, it will be one of the biggest single scientific assistance projects ever undertaken in the former Soviet Union (FSU) if it goes ahead.



CANDLE power. Construction magnate Jirair Hovnanian (*far right*, with Armenian President Robert Kocharian) helped secure down payment from the United States for a synchrotron in a building near Yerevan (*above*).

CREDITS: (TOP TO BOTTOM) MUTSUMI STONE; J. HOVNANIAN

Earlier this month, the U.S. Department of State asked a special panel to review design plans for the project, called the Center for the Advancement of Natural Discoveries using Light Emission (CANDLE). Backers portray CANDLE, which would generate intense beams of x-rays and ultraviolet light for everything from protein crystallography to materials science, as manna for the Caucasus region's impoverished scientific community. It would be the first of today's third-generation synchrotrons to appear in the FSU and the only such facility within a radius of 2000 kilometers. And despite the machine's far-flung location, some foreign scientists are looking forward to working on it. "One can carry out experiments at CANDLE very easily that will be more difficult here," says Josef Hormes, director of the Center for Advanced Microstructures and Devices, which hosts a less powerful synchrotron at Louisiana State University, Baton Rouge.

The project is also a stunning example of overseas pork-barrel politics—a fact not lost on some observers of FSU science, who wonder how many researchers will end up using the facility. First, however, the review panel must approve the design, then $15 million of the State Department's foreign aid for Armenia would be released to the project. But CANDLE researchers must raise at least $30 million more to finish the synchrotron and the first five beamlines and labs, then come up with $4 million a year to operate the facility if it comes online as planned in September 2007.

Much of the credit for kindling CANDLE belongs to Jirair Hovnanian, a 75-year-old construction magnate from New Jersey. In a Philadelphia church in December 1999, Hovnanian met, by chance, a Stanford physicist who described Armenia's hopes to acquire the mothballed BESSY I synchrotron, which was being offered by Germany as the centerpiece for a new international research center in the Middle East, dubbed SESAME. Armenia had good credentials to host SESAME: In Soviet times the republic was a physics stronghold and in the 1960s built a 6-GeV synchrotron. Hovnanian saw SESAME as a major prize for his compatriots, but he discovered to his dismay that Jordan was the front-runner to host it.

The wealthy Iraqi-born Armenian-American swung into action. He persuaded SESAME's overseers to agree that if Jordan failed to find funds to house and upgrade BESSY, then the synchrotron would go to