Reactor Project Hitches onto Moon-Mars Effort

Though it is no longer needed for SDI, the space reactor program is proceeding apace, thanks to another presidential vision

IN AN ERA OF TIGHT SCIENCE BUDGETS, why is the Bush Administration continuing to support a billion-dollar effort to design and develop a nuclear reactor that was to power up President Ronald Reagan's Strategic Defense Initiative? Though even the managers of SDI say they no longer need nuclear reactors to drive orbiting battle stations and space-based sensors, the space reactor program is still forging ahead. Some $60 million is being spent on it this fiscal year and $91 million has been requested for next year.

The reason: another presidential vision—some say, pipe dream—has given the program a new lease on life. Nuclear power, it turns out, will be needed to attain President George Bush's goal of building a manned base on the moon and placing U.S. astronauts on Mars by 2019.

"It's technology in search of a mission, which by fortuitous circumstances may have found one," says John Logsdon, director of the Space Policy Institute at George Washington University. Logsdon compares the effort with the space station program: Both aim at satisfying such a wide range of potential users that they are likely to end up being so generic that they will be optimal for no particular use.

But the program's backers brush such criticism aside. They argue that it's fortunate that SDI provided a rationale for developing the reactor, otherwise it would not be available to power any human exploration of space—or, for that matter, any other potential application, such as space manufacturing. "The time required to develop this type of technology is longer than the planning cycle for a particular mission, which means you have to have a development effort under way if you ever hope to apply it," said Stephen J. Lanes, the Energy Department's acting deputy assistant secretary for space and defense power systems.

Perhaps so. But even if Bush's moon-Mars initiative gets off the drawing board, the program still faces an uphill battle. For starters, it will soak up increasing investments at a time when the federal budget is under severe pressure. By the time a key ground test is completed in the mid-1990s, the project will have cost nearly $700 million. Flight tests after that could cost up to $1 billion more, the General Accounting Office has estimated.

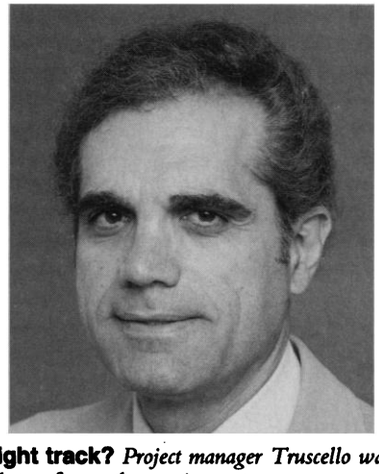
Then it must overcome public nervousness about lofting nuclear reactors into space. Right now, public opposition is muted largely because no space flights are envisioned for several years. But when the first test flight approaches, the program will come under heavy fire, predicts Steven Aftergood of the Federation of American Scientists and a critic of space nuclear power.

The battle seems likely to be most intense over the use of reactors in low Earth orbits. However, launching the reactors will be controversial regardless of the reactors' ultimate destination, as indicated by last year's court battle over the use of nuclear materials aboard NASA's Galileo Jupiter probe. Indeed, on 1 May the Hawaiian legislature passed a bill banning the launching of reactors from a commercial space facility planned for the island of Hawaii.

There is also concern that gamma-ray emissions from orbiting reactors would interfere with gamma-ray astronomy. Congress instructed the Defense Department to submit a report on the issue by 30 April, but that requirement apparently was overlooked, and the document is not expected soon, according to one Pentagon official.

Space nuclear power has always been controversial, in part because of its association with the military—especially SDI—and in part because of its checkered history of safety problems mainly in the U.S.S.R.

JPL



Right track? *Project manager Truscello wants a better fix on the requirements.*

The Soviet Union is responsible for most of the reactors placed into orbit—and for the most spectacular mishaps. The Soviets are believed to have used nuclear reactors in 33 spacecraft, primarily in radar ocean reconnaissance satellites, which track ships of the U.S. Navy.

These spy satellites operate from low orbit. This provides a good view of the fleet but it generally limits their orbital lifetimes to less than 6 months because the upper reaches of Earth's atmosphere eventually drag the spacecraft down. Before that happens, the reactors are supposed to separate and climb to a higher, long-lived orbit, where they will stay until virtually all the radioactivity has decayed.

However, that safety system has not always worked. In 1978, the booster engine aboard Cosmos 954 malfunctioned and the reactor reentered the atmosphere, spewing radioactive debris across northwestern Canada. Despite improvements, Cosmos 1402 also reentered the atmosphere in 1983.

By contrast, the United States largely has eschewed the use of nuclear reactors. All but one of the United States' 24 nuclear spacecraft have used radioisotope thermoelectric generators (RTGs), which generate electricity using the heat produced by the natural decay of plutonium-238. NASA's Galileo Jupiter probe, launched on 18 October, carries two such RTGs.

The only time the United States did launch a reactor, the mission was not exactly a roaring success. In 1965, NASA lofted an experimental spacecraft called Snapshot to test an electrical propulsion system and a 500-watt reactor to power it. A malfunction in a voltage regulator forced the reactor to shut down after 45 days. The satellite remains in an 800-mile orbit and will not reenter the atmosphere for several thousand years, according to the Energy Department. Eight years later, the United States abandoned space reactor research because there were no missions in sight that needed nuclear power.

Then, in 1983, the Defense Advanced Research Projects Agency (DARPA), which sponsors cutting-edge research projects of military interest, convinced NASA and the Energy Department to try again. The SP-100 ("Space Power—100 kilowatts") program was born as a joint venture of the three agencies.

Coincidentally, within months, Reagan's SDI provided a new rationale for the effort and gave the program a sense of urgency. Lightweight and compact sources of energy for orbiting weapons and sensors would be needed, and SP-100 was an obvious candidate. The Defense Department's fledgling

SDI Organization (SDIO) soon replaced DARPA in the program's sponsoring troika.

The focus has been on developing technology for a space reactor that could produce tens to hundreds of kilowatts. The SP-100 reactor now under development will be a far cry from the systems currently used on Earth. It will be cooled by liquid lithium circulating at very high temperatures and be designed to operate for several years without any maintenance (see box).

Program officials have prepared a base line "generic flight system" which could produce 100 kilowatts-electric, and workers are building components for a ground test reactor to validate the design. That test, in a containment facility at the Energy Department's Hanford Engineering Development Laboratory in Washington State, is scheduled for 1995, 3 years later than originally expected. The Energy Department last year said the stretch-out was required to cope with the fact that Congress had appropriated only $88 million for SP-100 in 1986–1988, rather than the $143 million requested.

But the Pentagon's support for the effort went rapidly from boom to bust as SDI went through numerous gyrations. Groping for an affordable way to keep the politically floundering defense initiative afloat, the Pentagon has recently embraced Brilliant Pebbles, a notion for a constellation of thousands of small orbiting interceptors.

That move may have been the death knell for use of nuclear power in strategic defense. Not only are the pebbles themselves to be solar powered, but their surveillance capabilities may make unnecessary large surveillance satellites, which were a potential user of nuclear power. "There is nothing that we want to do that we can't do without a reactor," says Richard Verga, head of space nuclear power research at SDIO. Some systems might be more feasible with nuclear power, he says, but advances in solar power technology, combined with the steadily dropping power estimates for SDI systems, mean that reactors are not a make-or-break factor for strategic defenses.

Already, SDIO has canceled one space reactor program, the Multi-Megawatt Reactor, a long-term effort aimed at developing a system with even higher power levels than SP-100. And it is reducing its funding for the SP-100 program.

But George Bush and Vice President Dan Quayle came to the rescue—albeit indirectly—last year when Bush, on 20 July 1989, committed the United States to return astronauts to the moon and to make a journey to Mars. And, in line with its new civilian mission, NASA is set to pick up a larger share of the tab.

"To meet the heavy demands for power on the moon or Mars, nuclear electric power eventually will be essential," a National Academy of Sciences panel concluded earlier this year in a review of NASA's plans for human exploration of space.

Solar power is widely regarded as impractical for permanent lunar bases, because massive batteries would be needed to store energy for use during the 2-week lunar night. Nuclear reactors also would be essential for the energy-intensive task of mining lunar materials to help sustain the base, Gregory M. Reck, director of NASA's propulsion, power, and energy division, told a House subcommittee on 28 February.

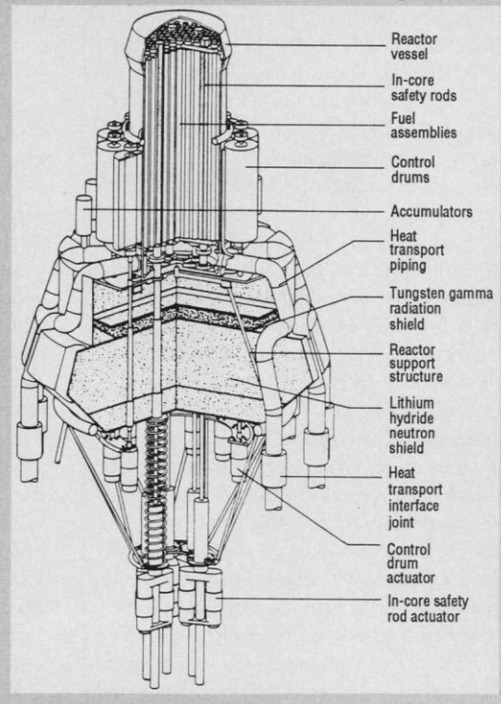
Similarly, nuclear-powered propulsion could make sojourns to Mars feasible by producing quick transit times that would minimize astronauts' exposure to radiation. Nuclear propulsion could slash the space travel time in half—from 3 years to 18

An Engineering Challenge

As with commercial nuclear reactors on Earth, the SP-100 space nuclear reactor simply would produce heat. Other systems are required to use the heat to do the useful work of generating electricity.

But in many ways the parallel stops there. SP-100 is a formidable technical challenge. The liquid metal cooled reactor is expected to operate at temperatures more than twice that of terrestrial liquid metal cooled reactors. It must be able to withstand the stress of launch and radiation from space for 7 years—all without ever requiring a service call.

The reactor is to contain nearly 60,000 pellets of uranium nitride, which were fabricated at the Los Alamos National Laboratory in New Mexico. Those pellets are to be loaded into approximately 1000 2-foot-long fuel pins, which are to be manufactured starting in November.



Preliminary results of a test of General Electric's manufacturing process for the pins showed it produces sound pins 95% of the time, said Vincent Truscello, SP-100 project manager. That test is to be completed in November.

In the SP-100 reactor, liquid lithium circulating around the fuel pins will be heated to about 2100°F. A commercial reactor uses water to transfer the heat, at much lower temperatures.

And while commercial reactors use the water to generate steam which in turn drives turbines to generate electricity, the hot lithium will heat one side of each of 8640 thermoelectric cells. The other side of each cell will be bathed in cooler lithium, and the cells will use that temperature difference to generate electricity.

The SP-100 thermoelectric cells are technological descendants of the radioisotope thermoelectric generators now used on some U.S. spacecraft to generate electricity from the heat produced by the decay of plutonium. But the SP-100 cells had to be miniaturized and built in such a way that the stresses from the simultaneous heating and cooling would not tear them apart.

The "generic flight system" design for SP-100 is guiding the design of a ground test reactor to be activated in 1995.

Design requirements for the generic system include the capability of providing continuous full 100 kilowatts-electric for 7 years and surviving in space for 10 years.

The reactor also is to be incapable of reaching criticality accidentally and is to be able to operate safely without constant supervision from the ground. ■ V.K.

months, according to NASA studies.

Supporters maintain that nuclear power also would make practical some civilian applications of space, such as satellites for air and ocean radar traffic control and commercial materials processing. "As we move toward more industrialization in low Earth orbit, we're going to need more power than we've been able to achieve with solar panels," said Representative Robert S. Walker (R–PA), an advocate of space nuclear power and the SP-100.

The program's shift from a military emphasis may foster additional support on Capitol Hill, allowing legislators who have been leery of SDI to support the program. "If anything, I think it's a plus," said one Democratic staff member for the House science, space and technology committee.

So far, at least, the shift toward civilian applications has not affected the nuts and bolts of SP-100 research, Lanes maintains. "Until we have a very specific mission, with very specific mission requirements, we're trying to design a technology that is applicable to the requirements of both NASA and SDI," Lanes said.

Vincent Truscello, SP-100 project manager at the Jet Propulsion Laboratory in Pasadena, California, said he has asked NASA for a set of detailed requirements for a reactor, to be sure that SP-100 is on the right track for use on the surface of the moon or Mars.

One concern is that lunar dust might accumulate on the radiator which is to eliminate excess heat from the reactor, said Jack Mondt, Truscello's deputy.

The National Academy of Sciences committee, chaired by former presidential science adviser H. Guyford Stever, recommended that the requirements for SP-100 be sharpened to better support human exploration of space. SP-100 should be "committed to development," the group said.

But the panel also warned that "the use of nuclear technology in space faces formidable barriers of public acceptance, however, especially if employed in Earth orbit."

The Energy Department's Lanes, a former nuclear safety engineer, said he believes the antinuclear sentiment can be overcome.

He stressed that the reactor fuel would not be radioactive at launch. Not until the reactor was activated, in a long-lived orbit, would radioactive fission products begin to accumulate.

"We believe that the reactor can be made to operate safely, and we are hoping to convince the public that is the case," Lanes said. ■ VINCENT KIERNAN

Vincent Kiernan is a reporter with Space News.

AIDS and the Future

Will prostitutes serve as a "bridge" to bring HIV (human immunodeficiency virus) into the heterosexual population? Probably not. Will there be a greater proportion of female AIDS patients in the second decade of the epidemic than there were in the first? Undoubtedly so. And will HIV infection start creeping into a younger and younger population, forcing intervention strategies for adolescents? Unfortunately, that also appears to be the case.

The changing character of the AIDS epidemic is chronicled in a new report* by the National Research Council committee on AIDS research and the behavioral, social, and statistical sciences, released earlier this week at the Sixth International Conference on AIDS in San Francisco. With no effective vaccine in sight, public health officials have no magic bullet to halt the course of the epidemic. Instead, they have had to rely on the far blunter instruments of education campaigns, screening programs, and interventions aimed at altering the practices of prostitutes and intravenous drug abusers. There have been some success stories—providing a blood supply essentially free from HIV contamination stands out as the prime example—but these have been few and far between.

As the epidemic enters its second decade, new subpopulations are being affected by the disease. Sharing contaminated needles has long been known as a way to transmit the disease among individuals, but as the proportion of AIDS cases in this population grows, so too does the number of women infected with the AIDS virus. "The needs of women are going to be a big thing in the next decade," says Heather G. Miller, who directed the report's publication for the Research Council. "In the first decade it was largely seen as a male epidemic. Now we're beginning to realize that there are not only considerable numbers of women who are at risk, but the population of women at risk is a very diverse one." Although intravenous drug use is a common theme, Miller says a woman's exposure to the virus may not only be from personal experience with drugs, but also through sexual contact with drug users. That many women being exposed are of childbearing age just complicates the problem.

Combating AIDS is particularly difficult because it means talking frankly about two societal taboos: sex and drugs. Starting with former president Ronald Reagan's panacea "just say no," political leaders have been loath to institute programs that would ruffle feathers, choosing instead more palatable half-measures. But Miller says people must be provided information that means something to them: "For people who inject drugs, what's meaningful to them is the unpolished truth—what some people who don't inject drugs might find unpalatable or discomforting or abhorrent." The truth in this case can mean the need for sterilizing needles with bleach or obtaining fresh needles when possible. There's no support for the idea that sharing this information will encourage nonusers to dabble with drugs. "Information and services do not appear to entice the uninitiated into risk-associated actions," the report states.

At one time it seemed possible that infected prostitutes would accelerate the spread of HIV into the heterosexual community. This does not appear to be happening, according to the report. In fact, "it appears that prostitutes are more at risk of *acquiring* HIV than they are of transmitting it." The report urges the Centers for Disease Control to track the incidence of both HIV infection and sexually transmitted diseases in this group.

Hampering public health efforts is a lack of information about the communities most clearly at risk. It can be extremely difficult to get people to admit details of their drug use or sexual practices, but this information is crucial to designing interventions to slow the spread of the virus. The report encourages the Public Health Service to "provide increased support for methodological research on the measurement of behaviors that transmit HIV."

It won't be simple—or cheap—to carry out either the basic research or the applied programs needed to implement the report's recommendations. But a commitment to do so must be made "to forestall the bleak prospect of a third decade of this epidemic that is little different from the last."

■ JOSEPH PALCA

**AIDS: The Second Decade* (National Academy Press, Washington, D.C., 1990).