Nuclear Power for Militarization of Space

The Department of Defense eyes nuclear reactors as a powerhouse for such projects as laser battle stations and radars the size of a football field

Orbiting laser battle stations and other military satellites will require more power than can be easily generated by large arrays of solar panels. The militarization of space may therefore require the development of nuclear reactors, smaller than a compact car, that generate as much electricity in space as small cities use on Earth. All it takes is time, muscle, and money.

That was the message heard recently at the National Academy of Sciences. The symposium—attended by some 250 contractors, bureaucrats, physicists, and members of the military—aimed at stimulating discussion on how to construct reactors that might fit into the cargo bay of the space shuttle. The aim would be nuclear power for laser weapons, particle beams, large surveillance satellites, and deep-space missions. Such symposia may become more frequent, judging from the upbeat tone of the proceedings. Federal funding for the development of space reactors now stands at about $10 million a year. According to several speakers at the meeting, however, the cost of a development program leading to a working reactor might run to billions of dollars.

Not surprisingly, a bureaucratic tug of war between the departments of Defense and Energy has been provoked by the allure of big money for space reactors. Although the Department of Energy (DOE) has a long track record in reactors, energy officials fear the military is attempting a takeover. The symposium itself was funded almost entirely by the military.*

On the sidelines of the turf war is the U.S. nuclear power industry, which is closely watching the action. It apparently hopes that nuclear projects in space may compensate for a slump in nuclear sales on Earth.

The force behind the symposium was the Pentagon's drive for new missions and arms, though only a glimpse of futuristic weapons could be caught by the public. Eleven of the 28 presentations were classified. These 11 closed sessions, moreover, were the only ones that dealt with missions, as distinct from open sessions on reactors. Hints on the nature of the missions were laced throughout the public sessions, however. Examples were laser weapons and particle beams. Another example mentioned in public was a space-based radar 71 meters in diameter. Such a large antenna could distinguish very small objects. Said Robert V. Anderson of Rockwell International during his discussion of radar: "It doesn't take much imagination to see the possibilities."

Most satellites in orbit now require less than a kilowatt of electric power. In contrast, the large radar would require at least 50 kilowatts. Although speakers at the symposium discussed designs for reactors of 100 megawatts (enough to power the city of Hartford, Connecticut), the current goal is a multimission reactor of 100 kilowatts. According to some speakers at the meeting, it could be ready for launch in the space shuttle before the end of the decade.

A look at the long quest for nuclear power in space—a goal pursued by both East and West for decades—suggests that the task of developing small reactors will not be altogether easy.

Repeatedly used in space missions for several decades, the most elementary form of nuclear power has come not from a reactor but a device known as a Radioisotope Thermoelectric Generator (RTG). With this, the natural decay of plutonium releases heat that is converted into electricity. Rather than heating water or some other fluid that rotates a generator, the heat of an RTG is turned directly into electricity by strips of heat-sensitive metal known as thermoelectric generators. RTG's put out 60 to 75 watts for U.S. moon landings and Pioneer and Viking space probes. Ones generating 300 to 400 watts were used on Voyager and will be on Galileo and Solar Polar missions. Though mostly shot into space by the National Aeronautics and Space Administration (NASA), the devices have been designed and built by DOE. Perhaps the greatest notoriety for an RTG went to one that never left the Earth. It was lost during a blizzard atop Nanda Devi, one of India's highest peaks. The nuclear-powered spy device was to be used by the U.S. government for monitoring atomic tests in China (*Science*, 15 June 1979, p. 1180). The failed mission was first revealed in 1978 and raised fears in India that radioactive runoff would pollute the Ganges.

For decades, the military's pursuit of high-powered missions has created a desire for better conversion efficiencies than the 5 to 10 percent offered by RTG's. Reactors, operating at temperatures of 1000 to 2500 degrees Kelvin, pack more punch. They also are much hotter and often more complicated than RTG's or conventional reactors, requiring pumps, turbines, and plumbing made out of special alloys that can withstand high temperatures.

The nub of the reactor problem is how to transfer tremendous heat. Reactors, in fact, are classed according to the substance used to carry heat from the radioactive core to an exchanger where it is converted into electricity. High-temperature reactors use liquid metals such as sodium, which are corrosive but carry much more heat than water. Domestic reactors, operating at lower temperatures, typically rely on water for heat transfer.

The Atomic Energy Commission (AEC) in 1955 began to study solid-core fission reactors for the production of electricity in space, a program known as Space Nuclear Auxiliary Power (SNAP). The initial aim was 50 kilowatts. Many reactors were built, but only one made it into space. This was SNAP-10A, a fairly low-temperature device that was fueled by uranium and cooled by a mix of liquid sodium and potassium pumped in a closed cycle. Its aim, considerably scaled back from the original, was to generate 500 watts of power. On 3 April 1965 an Atlas-Agena rocket at Vandenberg Air Force Base shot the reactor into a near-circular polar orbit of 13,000 kilometers. The reactor worked flawlessly for 43 days and then failed. (It still orbits and will reenter the atmosphere some 4000 years hence, after it has lost most of its radioactivity.) A twin reactor

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on the ground worked successfully for more than a year.

Despite modest success with the generation of power, the historic focus of the nuclear quest has been reactors for propulsion—a quest that has resulted in several fiascoes. One such program was an attempt, begun in 1955, to construct a nuclear-powered rocket. The challenge was graphically summed up by Glenn T. Seaborg, then chairman of the AEC: "What we are attempting to make is a flyable compact reactor, not much bigger than an office desk, that will produce the power of Hoover Dam from a cold start in a matter of minutes."

The purpose of the project was never quite clear. At first envisioned for use on ICBM's, the reactors were later viewed as power for interplanetary voyages. Test engines roared to life in 1962. A decade later the Rover program at Los Alamos National Laboratory in New Mexico had consumed $1.4 billion, but had not produced a nuclear-powered rocket. The story of grand goals and poor payoff was repeated in the saga of the nuclear-powered aircraft, which ate up a billion dollars without ever getting off the ground.

By 1972, governmental support for such nuclear adventures had worn thin. With the demise of the AEC and the Joint Congressional Committee on Atomic Energy around 1973, support collapsed. Plans for nuclear planes, rockets, and space reactors were scrapped.

An autopsy of the era points to a number of factors that contributed to early demise: The programs had been oversold. Enthusiasm for nuclear technology often outran the capacity to deal with complex problems posed by high temperatures. Some symposium panelists cited the impact of Admiral Hyman Rickover, "father" of the nuclear navy and a high AEC official, who opposed work on compact nuclear reactors (*Science*, 18 June 1976, p. 1210). Public fear of things nuclear also contributed, as did social unrest. Perhaps most important, the missions had not been well defined. Why was a nuclear airplane that could fly for months without refueling a necessary part of the nation's arsenal? The programs were often case studies in pure infatuation with nuclear power.

By the late 1970's, however, exotic uses of nuclear power again started to exert a fascination, this time in conjunction with military missions in space. The Pentagon drew up specifications for a reactor that would put out 100 kilowatts and operate without human intervention for 7 years. Today, the main project is a reactor known as the SP-100, which is

OMB Plans Level NIH Budget

The Office of Management and Budget (OMB) has proposed major organizational changes among health care agencies under the Department of Health and Human Services (HHS). It would also freeze, in fiscal year 1984, the current operating budget of the National Institutes of Health (NIH).

According to an internal OMB document sent to HHS Secretary Richard Schweiker, the budget office proposes to dramatically diminish the duties of the assistant secretary of health. The post is currently held by Edward N. Brandt, Jr., who, like his predecessors, is known as a strong defender of biomedical research and health programs. His office oversees the Public Health Service, including NIH, the Centers for Disease Control, the Food and Drug Administration, the Alcohol, Drug Abuse, and Mental Health Administration, and the Health Resources Administration. OMB would reduce the office to a unit that concentrates solely on health policy. Schweiker, a staunch advocate of preventive medicine, is reportedly steaming mad about the proposed changes and has already protested to the budget office.

OMB also would hold the line on NIH's present operating budget which is almost sure to total about $4 billion, pending the passage of appropriations legislation. The budget office would allot NIH $4.0 billion for FY 1984. Schweiker had requested $4.1 billion. OMB would increase the number of new and competing awards to 5000 from 4100 in FY 1983, but the amount of money available for each grant would be reduced. The document also suggested that funding for both direct and indirect costs be cut, which is sure to raise a hue and cry once again from institutions receiving federal grant money. Last year, the Administration proposed shaving 10 percent from overhead reimbursement, but the NIH appropriations bill for FY 1983 is expected to restore the funds. Indirect costs cover expenses for such things as building maintenance, libraries, and electricity.

OMB would also consolidate several health-related agencies under NIH. It would dissolve the Alcohol, Drug Abuse, and Mental Health Administration and transfer its research functions to NIH. Mental health research was originally conducted at NIH before the creation of the broader health agency. NIH, under the OMB proposal, would also absorb the National Center for Health Statistics and the National Center for Health Services Research. The budgets of the three agencies are not included in the $4.0 billion that OMB has proposed.

The budget office would also begin charging fees to patients treated at the NIH hospital to be consistent with the practice at institutions receiving institute funds. NIH patients previously have not been billed for treatment because they are participating in experimental therapy. Yet patients undergoing experimental treatment at other institutions supported by NIH have been required to pay basic hospital costs. An NIH official in an interview said that it is unclear how much revenue the change in policy could generate.

Another federal agency, the National Institute for Occupational Safety and Health, would also fall under the OMB ax. Its budget would be slashed by almost 25 percent to $41 million or $43 million. The institute's budget is currently $56 million; in FY 1981, it was $67 million.

There is also an unconfirmed report that OMB would eliminate the commissioned corps of the Public Health Service, but the OMB document contained no such proposal. The corps consists of 5900 physicians, nurses, and other health professionals who can be called on to serve with the military in emergencies. About 1000 professionals at NIH are corps members and, as a result, receive added bonuses and benefits.

President Reagan is likely to face strong congressional resistance to the proposed changes, especially concerning the NIH budget. The Administration proposed for FY 1983 a $3.7 billion budget for the institutes, but Congress is about to increase it by $300 million. The House and Senate are likely to go to conference on the NIH appropriations bill before the lame-duck session concludes. The House has already passed the bill, and a Senate appropriations subcommittee recently passed legislation similar in its provisions.—**Marjorie Sun** currently undergoing design studies at Los Alamos. The reactor is fueled by uranium oxide. Its unique feature is that the fluid (lithium) that transfers heat to thermoelectric generators is carried not by a complex web of plumbing and turbines but by devices known as heat pipes. These carry heat without the aid of moving parts and thus with less chance of a breakdown, a big help in space. The hot fluid flows down a pipe to the electric generators and then returns to the reactor via a wick in the center of the pipe. To date, 2-meter pipes have been tested. The SP-100 design calls for 120 pipes, each 9 meters long. The reactor core itself, minus pipes and shielding and thermoelectric generators, is about the size of a bread box.

The Soviets have lofted nuclear reactors into space for several years, a fact that became quite evident in 1978 when radioactive pieces of Cosmos 954 fell on Canada (*Science*, 16 February 1979, p. 632). Early Soviet reactors were known as Romashka, and a later generation as Topaz. The designs are unique. With Topaz, the Soviets rely on thermionic converters, known as diodes, right in the core of the reactor. This eliminates the need for complex plumbing or heat pipes. It also ensures a short lifetime for the reactors, because of intense heat and radiation. Topaz reactors are often used to power ocean-surveillance radars. According to Rockwell official Anderson, the Soviets launched four such radars during the past year.

One dream of American military planners is to have space-based radars that are bigger and better, and would last longer, than the Soviet ones now patrolling the oceans. Such nuclear-powered radars could cut through clouds and monitor sea traffic, and possibly help trace the deep movements of submarines. They also could have a role in target acquisition on land, working on a much grander scale the kind of electronic magic recently performed by Israeli Hawkeye radar planes flying in the Middle East on combat missions.

The dream could become a reality by around 1990, according to one military estimate. The radar could be powered by the SP-100 reactor. A bit further down the line are nuclear-powered battle stations, devices that would require megawatts instead of kilowatts. Vast amounts of electricity would especially be needed for the short-wavelength lasers that have recently taken a prominent place on the Pentagon's wish list (*Science*, 4 June, p. 1082). Unlike long-wavelength lasers, whose beams are often powered by chemical reactions, short-wavelength devices such as free electron lasers use huge amounts of electric power in radiofrequency generators and large electromagnets. The same holds true of weapons that shoot beams of subatomic particles.

Since military reactors would be operating in a hostile environment (some firing at enemy battle stations), "it will be necessary to design a system that can withstand some damage," William A. Ranken of Los Alamos told the symposium. These reactors also must be able to maneuver rapidly in space. "People ask me if I can design a power plant that can withstand 1, 2, or 3 times the acceleration of gravity, and the answer is yes; 10*g* is another story," said Ranken.

The political fallout from the Cosmos crash in Canada was a fair amount of public concern. (President Carter, for one, pledged that the United States would pursue a ban on nuclear power in space. Subsequently, the United Nations approved guidelines for such projects, and the United States abandoned its position.) So, too, public fear might arise in the future, especially with the possibility of nuclear battle stations blasting away at each other and raining radioactive debris down on Earth. The symposium addressed the questions of safety and regulation, although mostly in the context of peacetime missions.

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"None of the 23 nuclear power systems used thus far to supply electricity or heat for space missions has been subject to licensing," L. Manning Muntzing, a Washington, D.C., lawyer and president of the American Nuclear Society, told the symposium. Muntzing said the systems have been considered research devices, and therefore exempt from licensing due to a provision of the Atomic Energy Act. However, as the space nuclear enterprise grows older and standardized reactors and RTG's are more and more frequently shot into space, some form of regulation will be necessary. Rather than tossing the problem in the lap of the Nuclear Regulatory Commission, Muntzing suggested an independent agency, which might be named the Space Nuclear Power Systems Safety Board. "Establishment of such a board," he remarked, "can have benefits not only on the plane of reality, but—as can sometimes be almost as important in the field of public regulation—on the plane of appearances as well. There is a widespread public perception that when program sponsors are evaluating risks, technological enthusiasm can overwhelm prudence." He left open the question of whether the findings of the board should be binding, or merely advisory.

Despite the distant nature of a large program for the development of space reactors, the bureaucratic battles are now being waged in earnest. Politicking over turf was clearly evident at the symposium, where Gordon L. Chipman, Deputy Assistant Secretary of Energy, took pains to emphasize in his presentation that "We have been charged with the responsibility of space reactor development and we have had years of experience."

Fighting the Department of Energy for control of the program is the Defense Advanced Research Projects Agency. DARPA, which allied itself with NASA in the turf war, requested bids in December for a 100 kilowatt space reactor from contractors across the country, the goal being power for reconnaissance satellites. DARPA, according to energy officials, is also trying to exert control over DOE programs. DARPA's inroads may well be illegal, due to the separation provisions of the Atomic Energy Act. Said Muntzing in an interview after the symposium: "As I understand the philosophy that has been used from the beginning, it would be appropriate to keep the leadership in civilian hands."

Whether the militarization of space will be aided by the development of small reactors is ultimately a question of policy for which there is currently no clear guidance. Proponents say nuclear technology has evolved remarkably. Materials science has yielded insights, and new approaches, such as heat pipes, have opened completely new avenues. Most important, proponents say there are now clear reasons, mostly military, for the pursuit of nuclear power in space. On the other hand, there are technical risks, public fears, and the long history of project failures. Perhaps the most important question is whether the superpowers really need to embark on a race to build a nuclear-powered battlefield in space. The military and technological pressure is obviously there. But so is the possibility of bilateral negotiations that would limit nuclear power to peaceful projects such as engines for deep-space missions of exploration. The issues are potentially controversial, and the debate, in Congress and other forums, will undoubtedly be lively.

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