tance. By restricting power levels to the megawatt range and limiting the size of any orbital relay mirrors, the authors claim, such weapons can be rendered impotent against high-altitude targets yet remain capable of attacking intercontinental ballistic missiles as part of a "Star Wars" system. Both of these measures could be strengthened by unilateral efforts to "harden" high-altitude satellites against weak or distant threats.

This approach has already attracted broad support among aerospace and intelligence community experts (*Science*, 18 May 1984, p. 693). Former Air Force Secretary Hans Mark, for example, recently wrote that he supports "some 'rules of the road' for the operation of space systems and space vehicles in peacetime." Partly in response to congressional pressure, support is also growing within the executive branch, even though pockets of opposition remain. One surprising source of support is the Strategic Defense Initiative Organization, charged with developing a panoply of ground- and space-based systems to defend against a missile attack.

In testimony last year before a closed session of the House Appropriations Committee, the organization's director, Lieutenant General James Abrahamson, noted that a "rules of the road" agreement might indeed constrain the threat of attack by space mines. "A potential kind of a treaty . . . that one might well consider to be a stabilizing treaty, for example, would be one that says you might not allow a device to be within a certain distance of a satellite of another nation," he said. Among other benefits, he added, such a treaty would enable the United States to use potent electronic countermeasures against space mines before they could draw within range.

Air Force Colonel George Hess, director of SDI's survivability and lethality office, also believes that such an agreement "might work to the advantage of the United States." It would, for example, make it more difficult for the Soviets to destroy SDI systems as they are deployed, he told *Science*. An agreement constraining the most potent directed-energy ASAT threats might also aid SDI, he said.

Despite these glimmers of interest in some form of ASAT arms control from within the Pentagon, Aldridge wants no part of it. Even an agreement that restrains high-altitude attacks is of little interest, he says. "Right now, we have no incentives to go after the Soviet Union's high-altitude systems. But that does not mean that we wouldn't have any incentive in the future," he says. "For example, suppose the Soviet low-altitude [ocean reconnaissance] system went to a higher altitude or worst of all used a relay satellite to pass its data back to the Soviet Union. We may want to shoot at that if the relay controls four or five [satellites]. If you take that one out, you've got them all." Under "some scenarios," he adds, such as "after a war had started," the United States might even want to attack the high-altitude satellites used by the Soviets to command and control their strategic nuclear forces, in an effort to constrain a Soviet attack.

Aldridge also says that he knows of "no agreement that is verifiable for high-altitude ASAT's, none." Several times each month, he says, both the Soviets and the United States test all of the capabilities of such an ASAT when they park new satellites in geosynchronous orbit. "Every one of these launches is potentially an ASAT except for the kill mechanism. It's got propulsion; it's very accurate. There could be a sensor on board the system that could just maneuver over against my satellite and go bang or just hit it. And I cannot verify that it does not have that capability."

But Nye and others who support a limited agreement note that this kind of attack would eliminate only one satellite, not an entire network, and that there would be plenty of warning. (It takes hours for a payload to reach geosynchronous orbit, 22,000 miles above the earth.) Under any arrangement, Nye says, "the vulnerability of any single satellite must be taken for granted. But to attack a whole system without timely warning under the agreement we envision seems highly implausible."

Those within the Administration who favor a limited ASAT agreement, including several who are close to the negotiations in Geneva, say that it is unlikely that a proposal will be put forward soon. "Only when it is clear that the position of both sides on offensive weapons are converging will the pressures be large enough for the United States to negotiate such an agreement. At that point, even those who dislike it will come to view it as the least damaging of bad alternatives," says one official, who adds that this moment may be at least a year away.

In the meantime, the Administration will work hard to change Congress's mind because the ASAT program cannot be completed without further tests against targets in space, such as those launched by the Air Force on the eve of the vote at a cost of $20 million. The Air Force is expected to bide its time with an additional test against a point in space, as opposed to an actual target, which Congress did not prohibit. Such a test was expected later in the program, to assess the ASAT's capability to operate at extremely low altitudes. But now the test may be moved up, so as maintain the program's momentum. ■ **R. JEFFREY SMITH**

Briefing:

Fossil Research Faces Sharp Cutbacks in '87

The basic and applied fossil energy research programs at the Department of Energy will be chopped by more than half next year, if the Reagan Administration has its way. The Office of Management and Budget has blindsided fossil energy division officials with a proposal to reduce spending from $312 million this year to a maximum of $150 million in fiscal year 1987. Accompanying this proposed budget reduction is a plan to hinge department support for applied research on industry's willingness to assume most of the costs.

Past attempts by the Administration in 1983, 1984, and 1985 to slash research expenditures on coal, gas, and oil to the $100-million range have failed. In 1986, OMB appeared to give up. It submitted a request for $241 million and its initial budget target for 1987 was $233 million. The Congress also has managed to enact a separate 3-year, $400-million Clean Coal Technology demonstration program without much of a fight from the Administration. But with the Gramm-Rudman-Hollings deficit reduction legislation having been adopted by Congress, the White House is again getting tough on fossil energy R&D.

The proposed $150-million budget in fact may be smaller than it appears. Basic fossil research is funded at $90 million, with another $60 million earmarked for so-called "private-sector cooperative R&D partnerships." Just how attractive this latter money will be is uncertain. Kirk Yeager, vice president of coal combustion for the Electric Power Research Institute, says its usefulness may be limited by Administration caveats, details of which were reported 6 January by *Inside Energy*, a McGraw-Hill, Inc., newsletter on energy policy.

The Office of Management and Budget wants DOE to have an equity share in technologies receiving aid that is proportionate to the share of federal support. It says funding must be contingent on the research being "precompetitive" and not "proprietary," and specifies that the research should strengthen the technology base of an entire industry, not just that of a single company. No funding would be provided for specific product development or demonstrations. If the program is too restrictive, says Yeager, "you are not going to get the kind of commercial participation that is desirable." To the extent that companies do participate in this, he warns, it may be to reduce the overhead of private research pro-

grams, rather than to attack problems that companies are reluctant to tackle alone.

Not only is the viability of this program likely to be questioned by long-time supporters of fossil energy research, such as Robert Byrd (D–WV), the Senate minority leader, but the motivations of the Administration also will be probed. Already, National Coal Association officials are wondering if the cutback does not reflect the White House frustration with Congress's passage of the Clean Coal Technology program.

EPRI's Yeager goes further: "I think the whole trend is to slowly disassemble DOE." Indeed, fossil research is not the only program being hit hard. The nuclear fission research program also is slated to be halved. Regardless of the motivation, DOE officials and congressional aides say DOE-operated labs and contractor facilities are almost certain to face significant cutbacks in the next fiscal year. ■ MARK CRAWFORD

Acid Rain Plan Draws Mixed Review

Envoys from the United States and Canada last week recommended that the U.S. government and industry spend $5 billion to develop new technologies to control sulfur emissions. The recommendation was a major disappointment to federal lawmakers and environmentalists on both sides of the border, who had hoped that the national representatives would press for specific reductions in sulfur emissions.

The recommendation was contained in a joint report on acid rain issued by former U.S. Secretary of Transportation Drew Lewis and former Ontario premier William Davis. Lewis acknowledged in a telephone interview that "The real issue is how to come up with the money." The President said that he would consider the report.

Lawmakers, especially those from the northeastern states, had been hoping for more. In a moment of unexpected candor last September, Lewis said that "it seems to me that saying sulfur does not cause acid rain is the same as saying that smoking does not cause lung cancer." Proponents of stronger sulfur emission controls on Midwest industry took the remark as a sign that Lewis might carry a message to the White House that reductions in sulfur pollution are needed immediately. The Administration has maintained that more research is needed before controls are imposed.

The report recommended that the U.S. government and industry each contribute $2.5 billion for a 5-year program to demonstrate new, lower cost technologies that industry supports, but did not go into much more detail. It did not say how the money should be raised. The report was also vague about what technologies should be pursued, other than to say that "special consideration" should be paid to industrial plants using high-sulfur coal.

Drew Lewis

"The real issue is how to come up with the money."

In fact, last month Congress appropriated $400 million over 3 years for demonstration projects to use "clean-coal" technology in which, for example, high-sulfur coal could be washed before burning to reduce its sulfur content. The program, which will be run by the Department of Energy, requires matching funds by industry and was pushed through Congress by Senator Robert Byrd (D–WV).

Byrd and the coal and utility industries welcomed the $5-billion plan. Susan Roth, a spokeswoman for the Edison Electric Institute, a trade association for utilities, said that the industry-supported research group, the Electric Power Research Institute, has already spent $500 million over the past several years on clean coal technology research and has budgeted $580 million for the next 3 years to continue the work.

Senator Robert Stafford (R–VT), chairman of the Environment and Public Works Committee, said in a statement that he was "disappointed" that the joint report did not urge reductions immediately and contended that "polluters should pay for the total cost of control." Congressional aides doubted whether legislators would support a new, expensive program, especially if they had to divert funds away from other programs. ■ MARJORIE SUN

Nuclear Testing Up Sharply Under Reagan

The number of U.S. nuclear weapons detonations each year has increased sharply during the 1980's, according to an estimate recently prepared by the Natural Resources Defense Council (NRDC). The exact size of the increase is unclear because the government does not announce every test. But seismological data, as well as some new information on weapons yields, indicate that the increase is between 11 and 33 percent.

Officials at the nuclear weapons laboratories, such as Paul Robinson, the former associate director for national security programs at Los Alamos, have previously acknowledged that the number of tests has increased, partly to accommodate more basic physics research, and partly as a result of the "Star Wars" missile shield program. But those connected with the effort have been studiously vague, because the Reagan Administration decided several years ago to keep a significant portion of the tests secret.

The reason for this decision is unclear, and speculation has been that the Administration wants either to hinder Soviet monitoring or to ensure that the program keeps a low domestic profile. A key Energy Department memorandum obtained by NRDC, dated 2 April 1982, states only that tests must be disclosed in advance if they will shake high-rise buildings and mines or disturb construction. But it provides no clear guidance regarding announcements after a test has been conducted, except to say that DOE public affairs officers—either in Washington or Nevada—can recommend that a blast remain secret "if they perceive a possible conflict with national interest."

As a result, any conclusion about the number of weapons detonations under the Reagan Administration has been stymied until now by missing data. The NRDC report, prepared by physicists Thomas Cochran and Milton Hoenig and political scientists Robert Norris and William Arkin, supplies the missing information. Drawing on a chart released by Livermore last year, which omitted absolute test numbers but portrayed the percentage conducted at various yields, and assuming that all of the unannounced tests were conducted at low yields, the authors deduce that between 12 and 19 tests were kept secret from 1980 to 1984. Eight of these had been detected independently by seismologists at the U.S. Geological Survey.

When combined with the 82 announced tests during this period, the NRDC estimate indicates that a total of 94–101 tests have occurred, or an average of 19–20 each year. (This is close to a vague estimate provided