# Doubt Cast on Laser Weapons

*An American Physical Society report says major technical advances and at least another decade of research will be required to determine whether directed energy weapons will work*

PRESIDENT Reagan's Strategic Defense Initiative (SDI) has come in for a lot of criticism since it was launched 4 years ago. But none of it is likely to be as damaging as a report published last week by the American Physical Society, which was not even intended as criticism.*

In 424 pages of measured prose, much of it highly technical, the report lays out the state of the art of lasers, particle beams, and other technologies that may one day provide the core of "directed energy" weapons (or DEWs, as they are known in the defense community). It underscores the enormity of what must be accomplished before any of these technologies are ready to become workable parts of a missile defense system.

Lasers and particle beams have always occupied a central place in both the popular image of "Star Wars" and SDI's long-range plans. A report to Congress from the SDI Office, made public 2 days before the American Physical Society's study was released, says, for example, that they "are critical to providing a wide selection of defense options for [SDI]." Because they can in theory flash energy over great distances at or near the speed of light, directed energy weapons have long been seen as crucial for attacking Soviet missiles in the so-called "boost phase"—the few tens of seconds between launch and the point at which the warheads are released in space.

The physical society report points, however, to "significant gaps in the scientific and engineering understanding of many issues associated with the development of these technologies." It says "most crucial elements required for a DEW system need improvements of several orders of magnitude," and "there is insufficient information to decide whether the required extrapolations can or cannot be achieved."

If the report has one central message it is that major advances are needed not only in laser and particle beam technologies themselves but also in a wide range of associated areas, such as space power supplies, tracking and targeting, and the ability to survive an attack. Breakthroughs in raising the power and brightness of directed energy devices will not be sufficient to produce workable defense systems without corresponding advances in these other areas.

"Even in the best of circumstances, a decade or more of intensive research would be required to provide the technical knowledge needed for an informed decision about the potential effectiveness and survivability of directed energy weapons systems," the report concludes. In other words, sufficient information may not be available until the late 1990s to know with any confidence whether directed energy weapons can be made to work, and actual deployment is consequently unlikely to occur until well into the 21st century, if at all.

Others have said this in the past, but the American Physical Society report is likely to be taken seriously because of the unquestioned expertise of the people who put it together. The report was written by a committee of researchers from academic, government, and industrial labs, most of whom have worked on the key technologies. The committee was cochaired by Nicholaas Bloembergen of Harvard University and Kumar Patel of AT&T Bell Labs, and the report was reviewed by a second committee that included Arthur Schawlow and Charles Townes, who won the Nobel Prize for their early work on lasers.

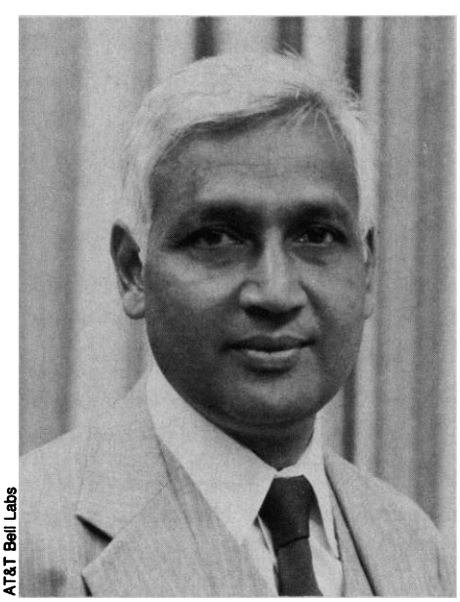
The report is generally acknowledged to be the most comprehensive study yet undertaken of directed energy weapons technologies. Its credibility is also enhanced by the fact that committee members were given access to classified information and received classified briefings from officials in the SDI organization.

The SDI program is exploring essentially two types of weapons to attack Soviet missiles and warheads: kinetic energy weapons, which consist of projectiles fired from satellites and ground-based rockets that home in on their targets and destroy them by the force of the collision, and directed energy weapons that fire laser beams or streams of particles. It has long been acknowledged that an effective defense system will require both types of weapons.

The kinetic energy weapons are likely to be ready for deployment first. The technology on which they are based is relatively mature, although considerable scientific and engineering work will be required to develop workable systems. Satellite-based rockets would be used to attack Soviet missiles in their boost phase, while ground-based rockets would be aimed at incoming warheads in the later stages of their flight.

A defense system based just on kinetic energy weapons would have many potential drawbacks, however. For example, the Soviets could overcome the space-based rockets by using missiles that burn out more quickly, which would give the defense less time to home in on the missile plumes, while ground-based defenses would face the problem of discriminating between real warheads and potentially hundreds of light decoys flying alongside them. Directed energy weapons have been viewed as possible answers to both these problems.

Because laser and particle beams can traverse great distances almost instantaneously, they would be more difficult to defeat with fast-burn boosters. They could also in theory be used to detect real warheads in a cloud of decoys by a technique known as interactive discrimination. This would in-



AT&T Bell Labs

**Kumar Patel:** *Scientific considerations do not favor early deployment.*

**Science and Technology of Directed Energy Weapons,* American Physical Society, New York. The study will be published in *Reviews of Modern Physics.*

volve firing energy beams at all the objects in an incoming "threat cloud" and monitoring the emissions. Heavy warheads would give off a characteristic energy spectrum, and the other objects could safely be ignored by the ground-based defenses.

Although the American Physical Society committee did not examine kinetic energy weapons, some of its findings are relevant to their operation. The report is also likely to have a major impact on a fierce political debate currently going on over how soon kinetic energy weapons should be deployed.

Until recently, it was generally assumed that a decision would be made in the early 1990s on whether to proceed with engineering development of comprehensive defense systems, with actual deployment occurring in the late 1990s. However, supporters of SDI have recently been pushing for a decision to move toward deployment of kinetic energy weapons as swiftly as possible, with deployment of more exotic directed energy weapons following several years later. A plan for such a phased, early deployment was presented to President Reagan by Defense Secretary Caspar Weinberger late last year (*Science*, 16 January, p. 277).

At a press conference when the physical society report was released, committee member Jeremiah Sullivan of the University of Illinois at Urbana said that "the justification for early deployment of kinetic energy weapons cannot be based on the guarantee that directed energy weapons will come along in a later phase. . . . One shouldn't gamble now that the answer would be 'yes'." Even interactive discrimination is still only "in the conceptual and early experimental stage," the report says.

The committee also noted that space-based lasers and particle beams would be vulnerable to attack by Soviet rockets, space mines, and other antisatellite weapons. Patel noted that "we do not believe that the questions of survivability are any different for a kinetic energy system." He added, "If one were to rely [only] on scientific judgment, one would not make a decision for early deployment."

The SDI office has welcomed the report as "an objective independent appraisal of various technologies," but criticized the conclusions as being "unduly pessimistic." It also suggests the report is out of date, claiming that recent advances in free electron lasers and neutral particle beams have brought these technologies closer to the required performance levels. However, committee member Andrew Sessler of Lawrence Berkeley Laboratory, who is familiar with both technologies called the claimed advances "a small step, an important step, but still a small step."

The charge of being outdated is somewhat ironic, for the report was held up for 7 months by the Defense Department while it underwent classification review.

Among the report's specific findings are the following:

■ **Directed energy devices.** "All existing candidates for directed energy weapons require two or more orders of magnitude improvements in power output and beam quality before they may be seriously considered for application in ballistic missile defense systems."

■ **Ground-based lasers.** The leading candidate is currently the free electron laser but the committee noted that these devices "require validation of several physical concepts" and there are major uncertainties over whether they can be scaled up in power while their wavelength is reduced. At least five sites for ground-based lasers will be required to ensure that at least one site will be cloud-free 99.7% of the time. Moreover, all ground-based laser systems will require so-called adaptive optics to compensate for atmospheric distortions of the beam. "These techniques must be extended by at least two orders of magnitude in resolution than presently demonstrated."

■ **X-ray lasers.** Although these devices have received a lot of popular attention, "validation of many of the physical concepts [is required] before their application to strategic defenses can be evaluated."

■ **Power requirements.** Laser battle stations will require nuclear power for "housekeeping" that would "require solving many challenging engineering problems not yet explored." Power for lasers during an engagement would have to be supplied by large chemical or nuclear rocket engines, which would have to be located on separate platforms to prevent vibrations and exhaust gases from interfering with the laser operations.

■ **Survivability.** Space-based defenses would be potentially vulnerable to attack by a variety of weapons, including directed energy weapons with capabilities far below those required for ballistic missile defenses.

None of the committee members would be drawn out on the question of whether a robust SDI system is feasible. Asked for his "gut feeling," Patel replied, "I get a queasy feeling in my stomach every time someone asks me that." ■ COLIN NORMAN

# Fredrickson Takes Leave from Hughes

Donald S. Fredrickson has taken an "extended leave of absence" from his position as president of the Howard Hughes Medical Institute, the $5-billion medical research enterprise that he has headed since 1984.

The institute made no formal announcement of Fredrickson's leave and HHMI officials decline to give any explanation for it or to comment on how extended the "extended leave" is expected to be. HHMI will only say that George Thorn, a member of the board of trustees, is serving as acting president. Purnell Choppin, who came to HHMI from Rockefeller University to be vice-president for research, has assumed responsibility for the day-to-day operation of the office. Thorn, professor emeritus of medicine at Harvard Medical School, has been associated with the Hughes Institute ever since 1955, 2 years after its founding by the secretive billionaire. The veil of secrecy surrounding Fredrickson's leave is reminiscent of the way HHMI behaved for years and is in contrast to Fredrickson's efforts to make the institute's operations somewhat more open during the past couple of years.

Word of Fredrickson's apparently abrupt departure as of 20 April caught people by surprise as the news began circulating last week. Widely regarded as the ideal person for the Hughes presidency, Fredrickson has been given high marks for charting a sound course for HHMI as its research activity began expanding phenomenally in the past year after General Motors bought Hughes Aircraft from the institute for somewhat more than $5 billion. However, there have been disagreements between Fredrickson and the Hughes trustees over his personal management style that may lie behind his decision to ask for a leave. ■

BARBARA J. CULLITON

**Donald Fredrickson:** *On an extended leave of absence from Hughes presidency.*