IS THE FORCE WITH LASERS?

Will lasers be selected for the Strategic Defense Initiative?

By DIETRICK E. THOMSEN

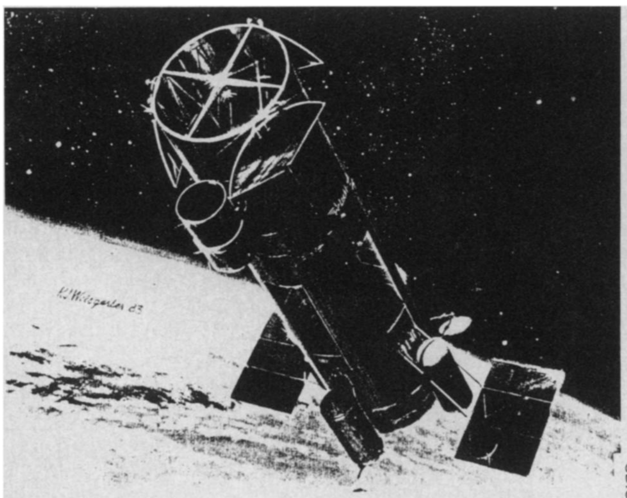
Surrounding the Strategic Defense Initiative (SDI), the dominant theme at the recent Lasers '85 meeting in Las Vegas, was one burning question, the source of emotion, anxiety and expectation: Will it be lasers? Or will it be something else, such as a particle-beam weapon?

It could, of course, be a mixture. Yet an observer got a feeling of competitiveness, as speakers outlined the advantages of lasers for basic SDI purposes.

Gerold Yonas, chief scientist in the Strategic Defense Initiative Organization (SDIO) of the Department of Defense, spelled out the requirements. The program is intended to provide a defense against an enemy's missiles — a defense that would be so accurate as to deter the enemy from launching an attack in the first place. The basic idea is to be able to shoot down the missiles on the way. That does not necessarily mean getting them as soon as they lift off the ground. Yonas divides the trajectory of such missiles into four stages: boost phase, post-boost phase (when the single missile is releasing its multiple warheads), midcourse phase and terminal phase (as the warheads drop to their targets).

Getting them in the boost phase kills multiple birds with one stone. In midcourse there is a good deal of time (as these things count it) for finding and shooting at the warheads; however, there is now the necessity of distinguishing the live ones from the decoys that the enemy will include to confuse the defenders. In the terminal phase the atmosphere "will have sifted out most or all decoys," says Yonas, but the disadvantage here is that there will be only 30 or 40 seconds to intercept and destroy. Hesitation or a slip could be terminal for a lot of targets.

In all of these stages the defense must find the moving targets, be able to distinguish the real from the decoy and shoot the real ones down. The defense apparatus must also be able to survive — the enemy will of course try to defend against the defense — and be responsive to directions of the battle managers while the battle is on.



SDIO

Artist's impression of a laser weapon deployed on station in space.

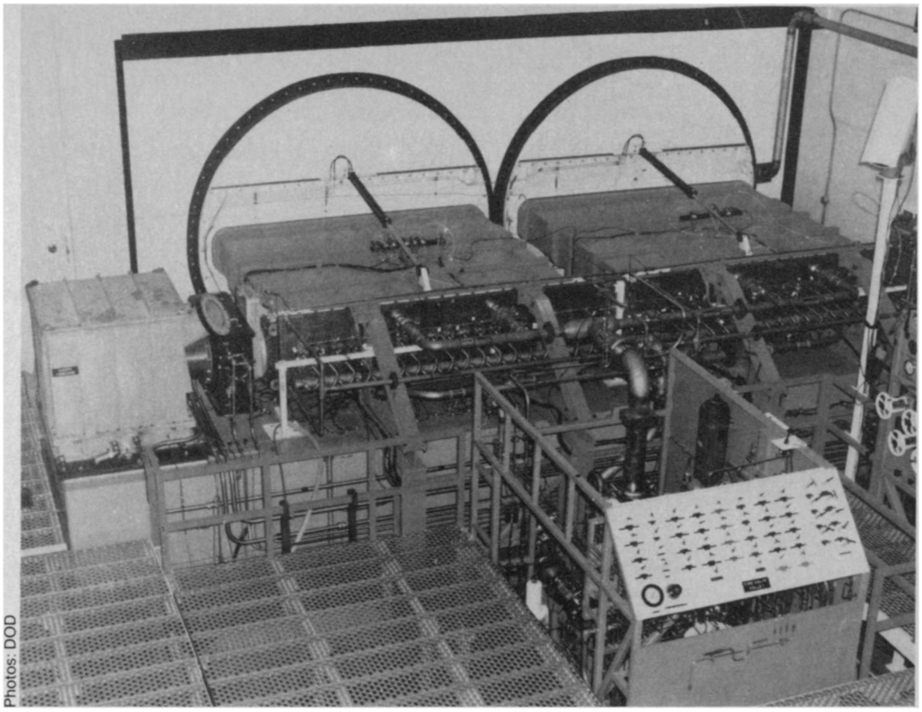
For interception and destruction, two types of weapons are being considered, according to Yonas: beam weapons (directed-energy weapons) and hypervelocity projectiles. The beam weapons could be either lasers or apparatus firing beams of subatomic particles. They could shoot from the ground or from space, and in the case of lasers, they might shoot directly or use mirrors. Laser beams can cut through the air, but clouds inhibit them. Particle beams must have a path made for them in the air, and the technology for doing this needs a lot of development (SN: 7/21/84, p. 42). Both lasers and particle beams can shoot from space, and in space a particular advantage seems to go to an apparatus that would shoot beams of electrically neutral particles: The path of these particles would be unaffected by electric and magnetic fields that might be present, particularly any electric or magnetic defenses the enemy might build into its missiles.

Proponents talk of having an SDI system in place by the early 1990s or even sooner. The audience in Las Vegas wanted to know if there were high-power laser projects far enough along to conceivably meet such a deadline.

Louis C. Marquet of SDIO reports that a space-based chemical laser is farthest along, having about 15 years of research and development behind it. This is a fairly long-wavelength device. A short-wave chemical laser "might be best," says Marquet, "but there are no viable candidates."

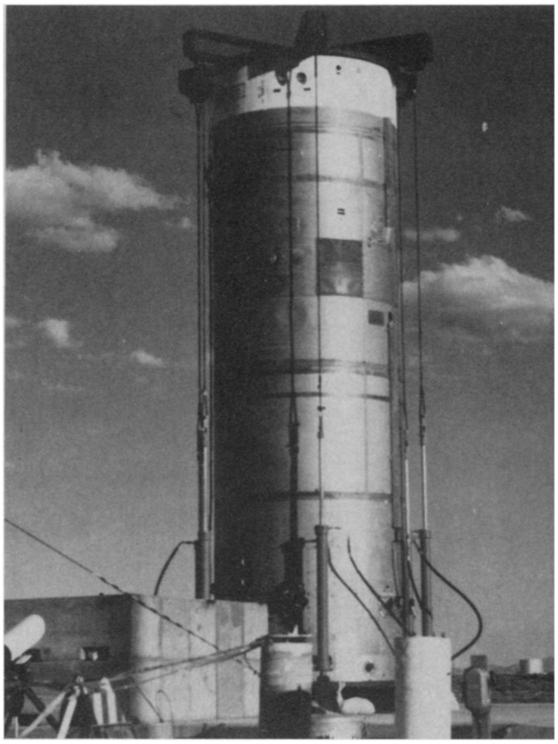
The longer-wave device goes by the optimistic name of MIRACL (Mid IR Advanced Chemical Laser) and is now located at White Sands Missile Range in New Mexico. Its wavelength lies between 2.6 and 3 microns. According to Joseph Miller of TRW in Redondo Beach, Calif., the device uses a reaction between hydrogen (or deuterium) and fluorine that yields hydrogen fluoride. On the way the reaction produces excited states that lase. Using gases as fuel, at its present stage it combines low temperature, low density and low velocity (all advantages for space operation) and yields hundreds of kilojoules of laser energy per kilogram of fuel. Approximately 10 percent of the chemical energy goes to laser energy, Miller says.

MIRACL's development began in the early 1970s under the aegis of the Defense Advanced Research Projects Agency in Arlington, Va., and the U.S. Navy. By 1973 it had reached power levels above 100,000 watts and 200 kilojoules of energy



Photos: DOD

The MIRACL laser (left), the most powerful continuous-wave chemical laser outside the Soviet Union, is the furthest developed of laser candidates for application to the Strategic Defense Initiative. On Sept. 6, 1985, MIRACL took part in a lethality test in which it destroyed a Titan I booster missile body (below) set up to simulate conditions typical of Soviet missile flights.



per kilogram of fuel. In 1975 it underwent tests against "dynamic" (that is, moving) targets. These first targets, Miller says, were "pertinent to ballistic missile defense," as that was the sort of defense people contemplated in those days. In 1980 the laser was moved to White Sands.

It is a simple system, Miller says. It provides direct conversion of chemical energy to laser energy, and so does not need any electrical power supply, which would be a heavy load to send into space. It gives high beam quality and scales beautifully. In all, it would make a self-contained space system.

But it is not a space system yet. It is "big, heavy and clumsy," Miller says, and so necessarily ground based. However, a project called ALPHA, designed to reduce and engineer its components for positioning in space, is well under way, Miller says, and its developers expect MIRACL eventually to be deployable in space. "Chemical lasers are really a contender," Miller says.

In addition to the present MIRACL concept, Miller cites the possibility of a laser using oxygen and iodine to achieve about half the wavelength of the hydrogen fluoride combination, or 1.3 microns. (The shorter the wavelength, the greater the energy per photon or particle of light, and the greater the penetrating and destroying power.)

Even shorter wavelengths can be delivered by another class of chemical lasers, the excimer lasers. These use chemical reactions involving noble gases. According to Leroy Wilson of the Air Force Weapons Laboratory in Albuquerque, N.M., substances of particular interest include xenon fluoride, xenon chloride and xenon iodide. They will produce blue-green wavelengths around 350 nanometers (about a third of a micron). These are pulsed lasers, and getting the repetition rate up to SDI standards as well as getting the beam quality up to requirements is a difficult technical undertaking.

More immediately competitive with MIRACL, according to both Miller and Marquet, is the free-electron laser (FEL). As Charles Braun of Los Alamos (N.M.) National Laboratory puts it, "An FEL is an electron accelerator working backwards." An electron accelerator converts electrical energy into energy of accelerated electrons. An FEL takes accelerated electrons and converts their energy to laser radiation.

"Free electrons are not cheap," says Braun. Nevertheless, the possibility is worth investigating because FELs are "elegant," tunable over a fairly wide range of wavelengths (unlike other kinds of lasers), and have possible efficiencies up to 99 percent (although a few percent is the best attained experimentally so far). In addition, high-power electron accelerators to provide the expensive free electrons already exist — the one at Los Alamos, for example, yields a megawatt of power.

Braun describes relevant FEL projects at Los Alamos, Lawrence Livermore (Calif.) National Laboratory, the University of California at Santa Barbara and Orsay, France. Like the present configuration of MIRACL, FELs, because of their cumbersome and heavy components, would probably be ground-based weapons. Ground-based lasers would use several ground stations to avoid problems with local cloud cover, and so they would need mirrors and focusing devices in space. Marquet cites a project at Itek Optical Systems in Lexington, Mass., to produce a mirror half again as large as the Space Telescope's 2.4 meters. Livermore has a large optical turning machine called LODUM, which is making optics for the spaceflight version of MIRACL. Laser beams do get through the atmosphere in good shape. Marquet cites a recent successful test by Lincoln Laboratories of Lexington, Mass., in which a visible low-power laser beam was propagated to an aircraft and to an instrumented-sounding rocket over 600 kilometers.

A final, vaguely visible competitor is the gray eminence of this business, the nuclear-driven X-ray laser. Although press reports purportedly inspired by inside sources claim it doesn't exist, official statements claim it does. According to Marquet it could be a pop-up ground-based interceptor. Its energy could be partitioned into many beams, he says, and so one shot could strike multiple targets. However, all we know about these X-ray lasers seems to indicate that each shot of one requires a nuclear explosion. An ignorant observer might be forgiven for wondering whether, in the thick of battle, such a defense might not become self-defeating. □