Work Continues on U.S. Laser Site in Desert

WHITE SANDS MISSILE RANGE, N.M. — The nation's first ground-based, free-electron laser, perhaps the precursor to weapons that could strike enemy missiles as they rise from their launch pads, is under construction.

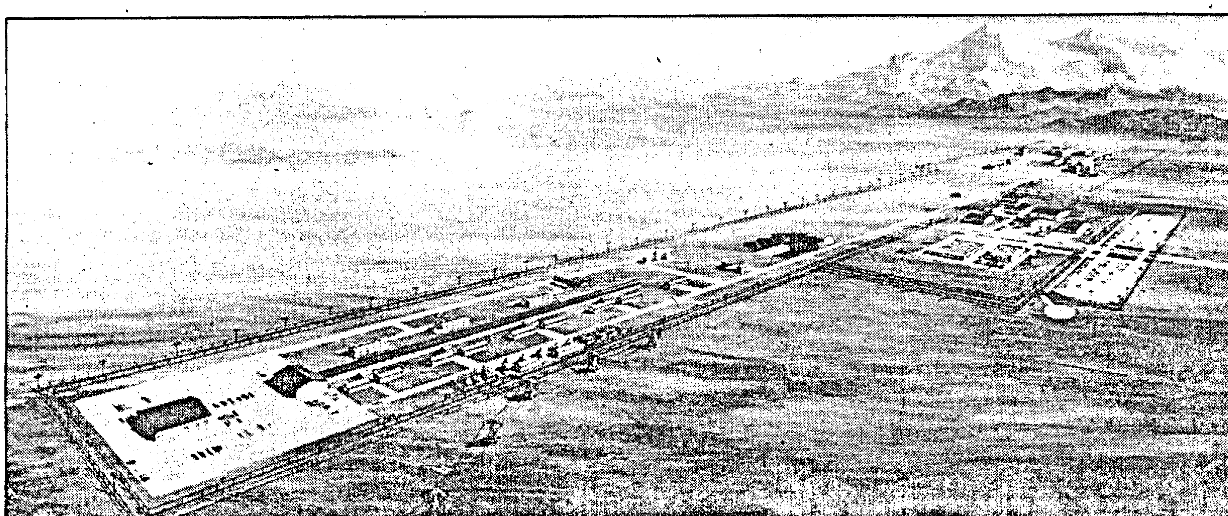
The $1.7 billion Strategic Defense Initiative project, managed by the Army's Strategic Defense Command, could develop the technology for a key element in a complex of strategic defense systems which could defend either the United States or its allies.

About 20 miles east of White Sands' main post, a wide drive angles away from the main road deep into the desert scrub brush. Culverts for drainage, a drilling derrick for water wells, power lines and building excavations line the way to an expanding rectangle of cleared land that marks the site for an ambitious experiment in laser technology.

According to treaties with the Soviets, White Sands and the Pacific atoll of Kwajalien are the two U.S. testing ranges designated for strategic defense experiments. After a series of environmental studies, the 20 square-mile Oro Grande location was selected.

"We have to bring in water, power [about five times what all of White Sands presently uses] and roads — build a whole research complex," said Col. James F. McNulty, head of the GBFEL technology integration experiment.

McNulty is a tall, silver-haired field artilleryman who served two tours of duty in Vietnam, but who also found time between field assignments to study at a half-dozen prestigious institutions, including Massachusetts Institute of Technology and Lawrence Livermore National Laboratory, where he gathered advanced degrees in nuclear physics and management before receiving his present assignment in January 1986.



White Sands Missile Range Illustration

An artist's conception of the Ground Based Free Electron Laser experiment now under construction at White Sands Missile Range shows the facilities for forming the beam in the foreground. An underground tunnel takes the laser beam to the opposite end of the facility (3 to 5 kilometers away) for transmission into space.

His first months on the job were spent attending the Defense Systems Management College at Fort Belvoir, Va., during the week and traveling around the country trying to organize the project on weekends. His staff has grown from zero to 42 in the first year and a half, although, he said, laser and optical experts are a rarity.

"It is exciting," he said. "I started with absolutely nothing but a piece of paper. [Lt.] Gen. [John] Wall [commander of the Washington-based SDC] said to me, 'Don't come back until it works.' "

While the project is seen as an experiment and not a weapon system, it is aimed at a well-defined military end. The Army has defense applications for the technology if it is approved for further development and deployment by the government.

It is part of a futuristic trend that will place the American soldier farther from his enemies, but will at the same time extend the strategic battlefield, McNulty said.

A ground-based laser, if used in a weapon system, would work in conjunction with a relay mirror in stationary (geosychronous) orbit over the laser site, and fighting mirrors orbiting over areas such as the Soviet Union that might be expected to launch missiles. The laser beam, generated on the ground and reflected over tens of thousands of kilometers by mirrors, would focus on and destroy targets such as the ballistic missile and the "buses" that can carry 10 to 15 warheads plus dozens of decoys.

Even under the most restrictive intepretation of the ABM treaty, work on the free-electron laser can go ahead, because it is a fixed, ground-based element and therefore "treaty compliant." Application of the treaty to the mirrors being developed by other Army and Air Force teams is under study.

Interestingly enough, even McNulty doesn't know what the final design of the laser will look like. It could be either a long, straight structure (the induction laser proposed by TRW and Lawrence Livermore National Laboratory) or a more compact, racetrack design (the radio frequency [RF] laser proposed by Boeing Aerospace Co. and Los Alamos National Laboratory). The final choice is to be made by the end of fiscal 1988.

Each system begins with the generation of a stream of electrons, the charged particles that vibrate around the nucleus of an atom. The electrons are injected into a charged medium, stripped from their atoms (thus the name free-electron) and then accelerated to near the speed of light.

The induction laser uses the magnetic fields produced by large magnets to speed up the electrons; the RF laser employs radio waves pumped into resonant cavities to do the same thing.

The speeding electrons are then passed through a device with varying magnetic fields which are used to make the electrons oscillate or move back and forth, hence the box is known as a "wiggler."

Each time the electron wiggles,

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Ambrose in No Mood for Delay on Sgt. York Replacement

Sandia National Laboratories Photo

An 8-inch howitzer used by scientists at Sandia National Laboratories shoots a new shell design through monitored targets. Researchers there are using technology developed in the nuclear weapons program to create improved conventional weapons.

[illegible] said Max Newsom, manager of the advanced projects department. It [illegible] /fuse combination would provide a wide range of options that, for example, could reduce the military's logistics tail and at the same time improve the weapon's effectiveness.

low $30.

"Advanced conventional munitions are of increasing national importance and we have only scratched the surface of their potential capability," Newsom said.

Sandia is not operating on an unlimited budget, however, and the

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photons, tiny particles of light, are produced. Through subsequent stimulation of the electrons by the photons, up to 40 percent of the electron beam's energy is extracted to produce the high power laser beam.

In the induction device, a small "seed" laser, operating at a pre-determined frequency, is fired into a 100-foot-long wiggler. The seed laser is amplified as energy is extracted from the electron beam and converted to light energy at the same frequency as the seed laser. The electron beam, as it exits the wiggler, is quickly separated and discarded so that only the laser beam goes on to the optical system.

The laser beam is focused to about the diameter of a pencil, is then allowed to expand (to about one meter) naturally in a vacuum as it moves through a 3- to 5-kilometer-long beam tunnel. It must expand, otherwise, the focused beam is powerful enough to blow apart the mirror designed to direct it into space.

The RF concept does not use a seed laser. The light produced by the electron beam is reflected back and forth in the wiggler between sets of mirrors (called a ring resonator and the size of a football field), each time generating more photons and finally being allowed to escape through a hole in the mirror to the optical system.

In December, a request for proposals will be sent out to industry from the ground-based laser project office. In February, industrial competitors will submit their plans and designs. And in June, McNulty and his team will pick the winner.

"Each team has technical milestones to meet before the decision is made," McNulty said.

He noted that even then the team still won't know for sure if the design works.

"But we will at least know what the unknowns are," McNulty said.

One of those unknowns is how to keep the electron and light beams stable and straight in the long wiggler of the induction laser.

"In the optical guidance scheme, the electrons ride in a trough, or tunnel, of light," McNulty said. The packets of electrons and light must be exactly in synchronization. If we can't keep them in the trough, we will never have the efficiency we need. We should have evidence by the end of December if it can work."

The RF laser also has its problems. Using mirrors to multiply the light forces researchers to the ragged edge of technology. The needed lenses (mirrors) have to be of two types: paraboloid and hyper-paraboloid. The paraboloid has an off-center focus. The hyperparaboloid is specially designed for reflections at glancing grazing angles.

"Where we can't put light directly onto a mirror, we skip it off," McNulty said.

Both types of mirrors are necessary for the RF laser to work. Both have been designed and are in the final stages of fabrication, but remain to be tested. The testing is scheduled for December and January.

After the laser beam is generated it has to be controlled in a vacuum and then shaped and corrected for atmospheric effects before it is reflected into space from a ground mirror. Reseachers have the formidable task of building a four-meter-wide mirror to direct the beam. There also is a "significant engineering challenge" to use a single aperture to receive the beacon beam coming down and transmit the weapon beam going up, McNulty said.

There are some more knotty problems with using lasers in the atmosphere over long distances.

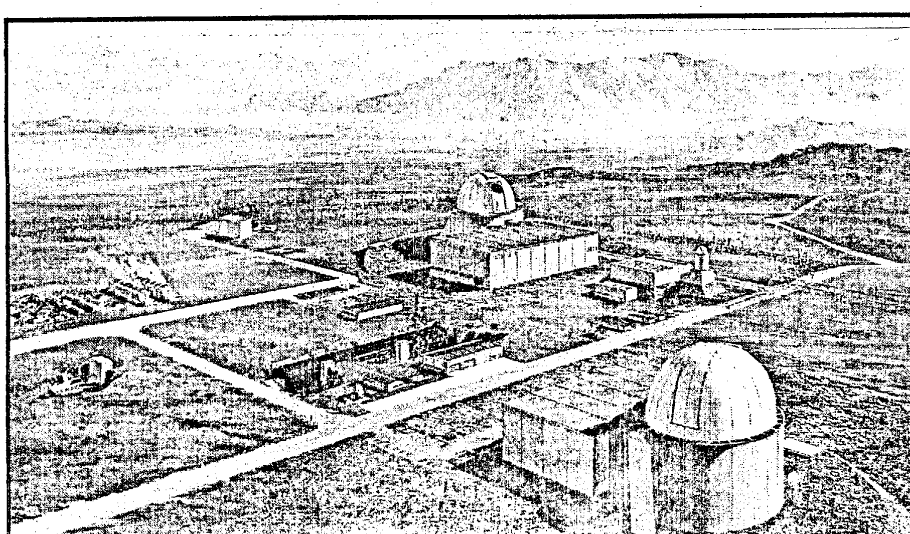
"Laser beams don't like air," McNulty said.

Turbulence, water, dust or eddy currents in the atmosphere can affect a laser beam just as fog can disperse a light beam.

Also, a laser beam heats the air through which it travels. That causes the air density to change, which bends the laser beam and produces "thermal blooming," which once again dissipates its power.

Finally, nitrogen in the air absorbs the photons, or particles of light, that make up a laser beam. Nitrogen alters the wave lengths of the light and spits it out in other directions.

"Those are the three things we have to overcome," he said.



White Sands Missile Range Illustration

Turrets will house the control system that [illegible] manufactured laser beam toward a system of mirrors based in space. Ultimately it will [illegible] destroy them.