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Directed-Energy Weapons Promise 'Low Cost Per Kill'

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By Sandra I. Erwin

Laser weapons for ground combat—ranging from air-defense chemical lasers that destroy incoming rockets to smaller devices that could zap enemy antennas—are the focus of several Defense Department projects currently under way. If the technology pans out, the U.S. Army, for example, would be able to equip its future combat vehicles with all-electric laser guns.

Government and industry experts agreed that, even though there are still technological and doctrinal hurdles to overcome, the use of lasers in tactical weapon systems could bring about new types of armaments that would be more accurate than explosive-based munitions and much less costly.

The word laser is an acronym for "laser amplification by stimulated emission of radiation." Lasers are possible, because of the way light interacts with electrons, which exist at different energy levels. The first laser was invented more than 40 years ago.

Interest in directed-energy weapons has been growing within the U.S. military services. The Air Force is developing a megawatt airborne laser that would destroy intercontinental ballistic missiles. The service, additionally, is in the early stages of developing a space-based laser, also as an anti-ICBM weapon.

For ground combat, the U.S. Army is working on smaller lasers that could defend against rockets, artillery, mortars, cruise missiles, helicopters and unmanned aerial vehicles. The Army and the Israeli government have spent about $200 million on a tactical high-energy laser, a program that began about five years ago. The THEL is a ground-based air-defense chemical laser designed to destroy Katyusha and other short- range rockets. The beam's heat destroys the rocket by causing it to detonate.

THEL is a promising start, but it's not what the U.S. Army needs, because it's not mobile, said Richard J. Bradshaw Jr., the service's program manager for directed energy technology.

"Israel would be happy with a tractor-trailer size THEL," he said. But the United States wants a system that can fit on a C-130 medium-lift aircraft. The current THEL weighs about 400,000 pounds, about 10 times the

payload capacity of the C-130.

The Army is expected to complete a study next month on the development of a mobile THEL. Funding could be a problem, given that all $200 million spent on THEL so far have been congressional add-ons.

For fiscal 2002, Congress is expected to allocate $30 million for THEL.

“We always come up to the wire,” said Bradshaw, during an interview in Huntsville, Ala. Rather than rely on last-minute add-ons, Bradshaw would like for the Army to provide a long-term budget for the program. “We need to get it to the troops and start testing the laser,” he said.

A lot of testing will be required before the Army could even consider deploying laser weapons, Bradshaw explained. Commanders need to be convinced that lasers are safe and that the operators are proficient, he said. “The air commanders worry about the safety of a laser pointing up into the sky,” Bradshaw said. Just like with any other weapon, one problem in a combined arms environment is identifying friend and foe. “With THEL, if there is a [friendly] aircraft in its flight path, it creates a zone around it in the computer. The beam cuts off and cuts on, on the other side.”

Bradshaw said the next step for THEL, in addition to making it mobile, is to make it work with other systems, such as Patriot. “We want to plug and play with operational Patriot systems,” he said.

One advantage of killing enemy missiles with a laser is the relatively low cost compared to kinetic-energy missiles. The Patriot’s newest missile, the PAC-3, currently costs $3.8 million a piece. A THEL shot is estimated to cost about $8,000.

The Holy Grail for the Army’s laser program, however, is a 100-kilowatt solid-state laser. Solid-state are all-electric lasers. Unlike chemical lasers, which require a chemical reaction, the solid-state devices use electric power to convert the energy of the crystal into laser power.

In the future, if the Army can develop a large solid-state laser, the cost per kill would be measured in cents, not dollars, Bradshaw said. A solid-state laser gun mounted on a hybrid-electric Humvee truck would make the cost of operating that weapon essentially whatever it costs to put diesel fuel in the truck engine. The advantages of solid-state lasers for the Army would be significant, because these systems would cost less and would be easier to maintain than chemical lasers, he said. But the solid-state technology is not mature, and there are technical problems to be solved, such as the cooling of the laser materials, which tend to overheat. “These things have a lot of complex piping,” said Bradshaw.

A solid-state laser that can be used as a tactical weapon may not be available until 2015. The Army has developed a 10-kilowatt solid-state laser, which is the largest of that kind ever built, said Bradshaw. The Army’s solid-state laser program will receive about $90 million during the next five years, he said.

For the future combat system, the Army’s next-generation tank, the goal is to have a 100-kilowatt, un-cooled, solid-state laser, Bradshaw said. Until the FCS is developed, the preferred vehicle to test a laser is a hybrid-electric Humvee, because it provides on-board power generation.

In the commercial sector, TRW Inc. has built 4-5 kilowatt solid-state lasers, for industrial machining applications. The company is a prime contractor for military chemical-laser programs, including THEL, the airborne laser and the space-based laser projects.

The Army contracted much of the development work on the 100-kilowatt solid-state laser to the Lawrence Livermore National Laboratory and to the Raytheon Company's directed energy weapons division. The company has produced more than 30,000 solid-state lasers for weapon rangefinders and target designators, said Brad Sowers, head of directed-energy weapons programs at Raytheon.

"We are looking at whether you can demonstrate a mobile directed-energy weapon on a Humvee," he said in an interview. Achieving that goal, he said, could take several years.

"We have to demonstrate that we can scale the power to weapon-class level and provide the thermal management—the cooling," he explained. It's not as simple as cooling your car's engine, he said. "A lot of engineering needs to be done to perfect the heat-exchange process and package it, so that it can fit on a mobile vehicle."

When it comes to introducing laser weapons into the battlefield, the technology is only part of the equation, Bowers said. The safety factor is no different than with other weapons, he said. "It's like a gun. If you point and shoot, it'll damage. It has to be handled like any other weapon that has destructive properties.

"As we produce these things, there is a lot to be learned about how to handle the radiation coming out of the laser, how to control the beam, how to protect the operators" from potentially being blinded by a laser beam, he said.

Until the solid-state laser technology matures, the Army plans to field small chemical lasers that would be mounted on C-130 aircraft or helicopters. This technology would be used both by the Army and by U.S. special operations forces to destroy ground targets tens of kilometers away, said Bradshaw. There are ongoing tests to prove the technology but, so far, "we have no implementation directive," he said.

The development of small chemical lasers falls under a program called advanced tactical laser, which is expected to cost $180 million through 2005, said Bradshaw. ATL uses a chemical oxygen iodine laser (COIL) that generates up to 70 kilowatts of power.

The Marine Corps also is interested in ATL, because the technology has applications in the Corps' so-called non-lethal weapons program. A small chemical laser beam would injure a human being, but it also could, for example, destroy enemy antennas or disrupt communications.

The prime contractor for the advanced tactical laser is the Boeing Company's Rocketdyne division. The ATL includes a laser, optics and control systems enabling fire control systems on fixed and rotary-wing aircraft to precisely direct laser fire on targets from 15 kilometers away.

The COIL in this program is a "sealed system," explained Don Slater, project manager at Boeing. A sealed system operates with no exhaust, thus making it possible to have a laser weapon in a small package, he said in an interview. With ATL, he said, "We can melt through sheet metal at 1 mm per second." That means the beam could destroy structures that have a 1/8-inch of sheet metal around. It could not penetrate ballistic armor, Slater said. The targets, more likely, would be civilian vehicles and communications antennas. The ATL is 15 feet long by 6 feet wide. If the Pentagon decides to produce this laser, it potentially could be used against low-flying cruise missiles, Slater said. The ATL concept provides a "good geometry for attacking terrain-following missiles," he said. One advantage of laser weapons, he added, is that they are remarkably precise. "You can do a visual identification and there is no time lag from ID to shoot. So you have a tight control over the situation."