

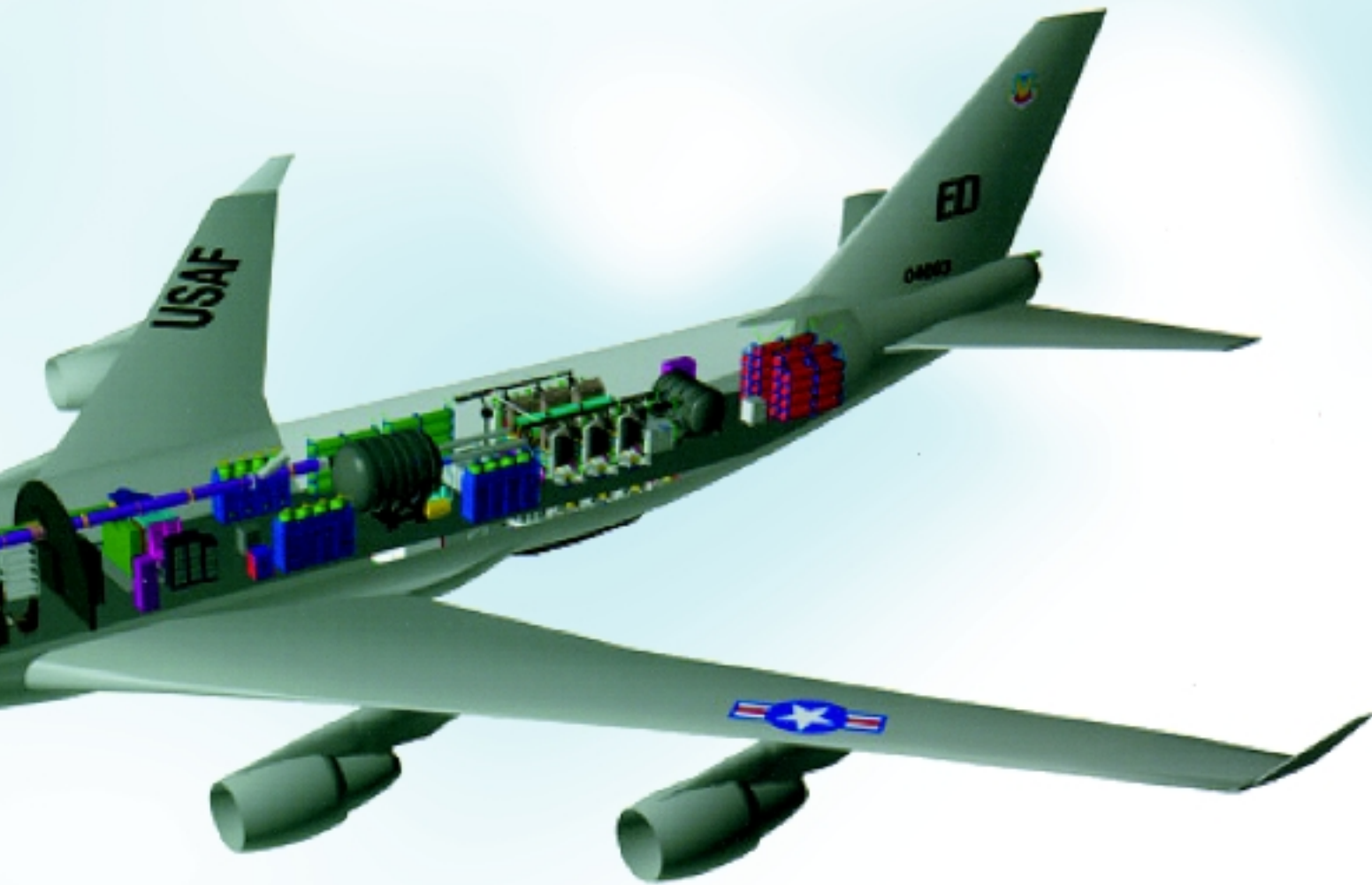
Over the next 20 years, the services will probably field a whole family of operational lasers.

# The Promise and Problem of Laser Weapons

By Catherine MacRae

**A**RTISTS' conceptions of laser weapons typically portray sharp beams of neon green or purplish light that always hit their targets. The images are plastered onto posters, mouse pads, and military briefing charts and are handed out at defense conferences like cotton candy at a fair.

Some day, a laser beam may well streak across the sky to blast megawatts of energy into flying missiles, but it won't look like neon light. Most lasers being developed by the military are invisible to the naked eye. These weapons of the future will pump megawatts of energy into



targets, forcing their charred bits to fall back onto the launching enemy, scientists say, but you are unlikely ever to see the beam.

More importantly, there is uncertainty about whether unfinished research will get sufficient funding and attention to make these weapons useful to warfighters in the next 10 or 20 years.

The technology certainly is promising, far exceeding its current use for target designation to improve the accuracy and performance of costly precision bombs. Defense scientists say that new laser weapon systems could be mounted on warships, large aircraft, fighters, tanks, land vehicles, and even on space vehicles.

A recent report from DOD's top scientific advisors has concluded that weapons based on the power of the laser will prove to be faster, more precise, and cheaper than any now in the US inventory. "High-power la-

sers have the potential to change future military operations in dramatic ways," the report said.

The report went on, "The United States is in a position to exploit current high-energy laser technology to take advantage of speed-of-light engagement, precisely controlled effects, deep magazines, low cost per shot, and reduced logistics footprint."

#### **"21st Century Arsenal"**

It concluded lasers, "appropriately developed and applied, ... can become key contributors to the 21st century arsenal."

A Defense Science Board task force on high-energy lasers completed the study in the summer, releasing it this fall. It said that lasers can melt the skin of a target missile in as few as 10 seconds, and even more quickly if internal pressure increases significantly. Pressurized fuel tanks and aerodynamic control

surfaces offer vulnerable spots for a laser's blast.

The success of existing service laser programs over the last two or three years has prompted renewed focus on such systems and a renewed Pentagon commitment in the way of cash and senior-level management. USAF's Airborne Laser is on track to shoot down a Scud-type missile sometime in 2003, according to program officials. Meanwhile, the Army's Tactical High-Energy Laser, a joint program with Israel, has performed so well against Katyusha rockets that both partners agreed to pursue a mobile variant. In 2000, progress on ABL and THEL sparked the Navy's first expressed interest in lasers since the mid-1990s.

DOD recently created the Joint Technology Office to revitalize high-energy laser science and technology throughout the Defense Department and to function as a clearinghouse for new science and technology ini-

## The Challenges Ahead

DSB's laser task force said basic research should be focused on a handful of challenges. The board wanted action on:

**Lethality.** DOD must examine whether short-pulse lasers would be more damaging to a target than systems firing a long steady beam. Fire control and battlespace management are key lethality areas.

**Atmospheric Propagation and Compensation.** A fired laser encounters turbulence, scintillation, and other hurdles in the atmosphere that must be compensated for in order to deliver a solid beam to the target. Compensation now comes primarily through optics such as deformable mirrors. The DSB recommends expanding research efforts.

**Modeling and Simulation.** Better fidelity is required in this area for lasers, beam control, propagation, lethality, and overall performance.

**Deployable Optics.** The Pentagon should start a new technology development program in large, lightweight, deployable optics for high-power space-based applications.

**Solid-State Lasers.** Jack up the level of research in four key areas, combining laser beams, designing and manufacturing reliable diode pump lasers, thermal control of laser media, and scaling the output power weapon systems.

**Chemical Oxygen-Iodine Laser.** COIL and other iodine-based lasers need to be made lighter and given enhancements for better space and tactical operations.

**Hydrogen Fluoride and Deuterium Fluoride.** DOD needs to demonstrate a nearly diffraction-free beam at high power (either uncorrected or with adaptive optics).

**Beam Control.** Research should include long-range looks for novel beam control methods such as phased-array, electronic beam steering, and "nonlinear phase conjugation."

**Optical Components.** Overall system performance needs improvement via a major increase in technology development. This would also help bolster the "fragile manufacturing base."

**Free-Electron Lasers.** This technology area needs a boost with a focus on scaling down a system's size while increasing its power.

tiatives. In January, DOD moved the JTO from the Pentagon to Kirtland AFB, N.M. The Air Force Directed Energy Directorate and Airborne Laser program office are located at Kirtland, and the Army's High-Energy Laser Systems Test Facility is situated not far away at White Sands Missile Range, N.M.

Former DOD acquisition chief Jacques S. Gansler called for DSB's study late last year. The reason, he said, was that THEL's progress suggested laser weapons may have matured enough to begin integration into operational forces.

### Barriers

Given the successes, proponents tend to portray the fielding of operational lasers almost as a forgone conclusion. So what's holding them up?

A major challenge is how to integrate laser systems into weight-sensitive aircraft, ships, and land vehicles that already are bursting with radar, network, and fire-control equipment. Lasers, in some cases, derive their energy from interactions within large vats of chemicals. Nonchemical lasers offer some ben-

efits in the way of reduced storage and safety requirements, but so far it isn't enough.

The developing Airborne Laser provides an example of the integration challenges. Scientists long ago demonstrated the chemical oxygen-iodine laser designed for ABL. Now, however, engineers are working overtime trying to find ways to install it on a modified Boeing 747 airframe. The 14,000-pound nose turret, which is being built by Lockheed Martin to aim the laser, is more complex than originally thought, program officials say. For example, many interfaces between laser and aircraft need perfecting to ensure the credibility of ABL performance.

Getting a solid laser beam delivered to its target is another major challenge. This requires compensating for atmospheric turbulence that otherwise absorbs and diffuses light energy.

"The impact of the environment—in the atmosphere, over land, over water, and in space—on system performance can be significant," the DSB reported.

Adaptive optics offer an answer to the beam control problem, ac-

ording to the DSB's experts. On ABL, for example, a deformable mirror inverts the distortion and delivers a compact light beam to the target.

Money is the biggest obstacle to laser weapons, scientists said. They urged the Defense Department to allocate an additional \$100 million to \$150 million per year indefinitely to basic research into laser-related science and technology.

"Without this investment, the potential of high-energy laser weapon systems is unlikely to be realized," wrote retired Air Force Gen. Larry D. Welch and General Dynamics executive Donald C. Latham in a cover letter to the task force report.

Welch, a former USAF Chief of Staff, and Latham chaired the DSB laser task force, which spent eight months reviewing the progress of current laser programs and interviewing experts to determine the potential military utility of lasers. The task force concluded that potential laser missions include "ballistic missile defense, air defense, attack against ground and maritime targets, space control, and urban operations."

The task force strongly recommended that DOD establish a departmentwide laser technology program and provide sustained investment.

Despite the challenges, the task force concluded that it would be feasible to develop and field a "family" of operational laser weapons over the next 20 years. The weapons would include land, sea, air, and space applications. This family could include ABL, THEL, and the Air Force's Space Based Laser, plus a few budding concepts that DSB said look promising.

The DSB study said, for example, that an airborne "Advanced Tactical Laser (ATL) is an emerging concept for a family of compact, modular, high-energy laser weapon systems." A standoff capability would lessen its vulnerability to small-arms fire or shoulder-launched anti-aircraft missiles. "In fact, it could be far enough away that its action is almost covert," the task force concluded.

The key to the ATL is a roll-on and roll-off design that makes it independent from any particular platform. The laser could be added to or removed from several tactical plat-

forms such as ground combat vehicles, fighters, or rotorcraft, according to the report.

The ATL is in a four-year, advanced concept technology demonstration phase approved by the Defense Department's Joint Requirements Oversight Council in Fiscal 2001.

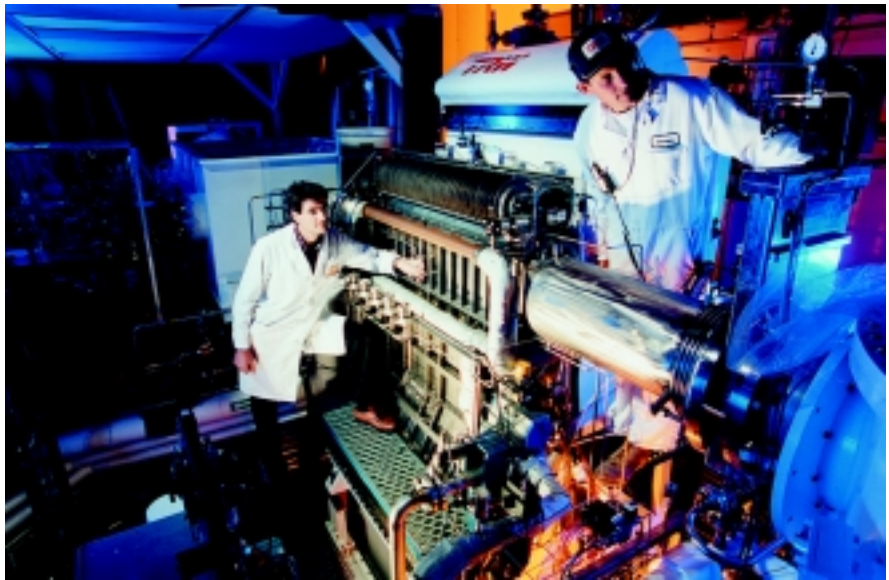
### Space Control

The report said ground-based lasers could be useful in achieving space control, while offering theater support via laser communications and illumination and designation. Ground-based lasers would also be easier and less costly to maintain than space-based lasers, the task force said. However, they would have a more limited capability to propagate through atmospheric turbulence.

One postulated spaced-based laser system, dubbed Evolutionary Aerospace Global Laser Engagement System, could provide global, 24-hour coverage of missile launch sites. Such a system would cost "tens of billions of dollars" and take decades to develop and deploy but is worth considering, the report said. Air Force Research Laboratory has allied itself with industrial concerns and academia to pursue capabilities necessary to the EAGLE concept. These include a space-based mirror system that could relay and redirect high-energy laser beams.

The DSB members concluded that an airborne tactical laser capability is a logical step to come after the Airborne Laser. They said that a Tactical High-Energy Laser Fighter would offer great flexibility to US military forces. In addition to speed-of-light engagement in air-to-air combat, cruise missile defense, and neutralization of enemy air defenses, a fighter aircraft armed with a high-energy laser weapon could provide surveillance, identification of targets, and damage assessments after a conflict.

In the view of the DSB task force, the Army's high-profile Future Combat System shapes up as another good prospect for laser weaponry. The FCS is a top-priority weapon system for the Army's so-called Objective Force, which should be fielded a decade or more hence. Some FCS requirements, including countersurveillance, active protection, air defense, and mine clear-



Staff photo by Guy Aceto

**TRW technicians work on a high-energy laser. The DSB maintains that laser weapons may be ready to field. The issue is how to integrate them into aircraft, ships, and land vehicles already weighed down with high tech equipment.**

ance, fit well within potential laser applications, the report said.

The DSB study noted the reality that, if US access to foreign theaters continues to decline, long-range aircraft such as bombers will probably be tapped for strike operations. Without tactical air support, these aircraft will likely need a self-defense capability, and their larger size and payload make them an easier fit for a laser-based defensive system.

Chemical lasers are the most advanced. The level of power that they produce is measured in megawatts, but chemicals must be stored and mixed on board the aircraft, a factor that would create safety hazards for all concerned. It was the level of risk associated with the storage of chemicals on ships that prompted the Navy to drop out of the laser business some years ago. The advance of electric-drive ships kick-started the Navy's new laser roadmap, which held that the ship's power could be used not only to drive the vessel but also to power the laser.

### The Dark Horse

The proposed solution is called a solid-state laser. It's electrically powered and more compact than chemical lasers, making it a better choice for ground combat vehicles and tactical aircraft. Another option is the all-electric free-electron laser, which the DSB task force called "a dark horse competitor to the solid-state laser."

The free-electron laser has a high-optical quality but uses only water and electricity, which reduces its logistics tail. The laser is based on technology called "superconducting radio-frequency accelerators" and departs "significantly from other solid-state, chemical, and diode technologies," the report said.

The laser could be "very compact and rugged" and small enough to provide portable kilowatt power levels. But the laser is also suitable for a larger platform such as an electric-drive ship and at megawatt levels.

In sum, the DSB advised that the Defense Department develop a "coherent," defensewide, high-energy laser investment program. "The strategy should be based on determining top-level systems needs, assessing critical technology barriers to meeting those needs, and funding the research needed to overcome the barriers," the report stated. "In the face of funding pressures, the practice of providing inadequate funding to a wide variety of programs should be replaced with focused, sequential developments funded at the level of effort needed to make real progress." ■

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*Catherine MacRae is the managing editor of Inside the Pentagon, a Washington-based defense newsletter. This is her first article for Air Force Magazine.*