U.S. Airmen perform a combat offload in the dead of night using only night vision goggles during an operational readiness exercise at West Freugh Airfield, Scotland.

Tom Price

OPTICS and the U.S. DEPARTMENT of DEFENSE

The U.S. Department of Defense is a major source of support for optics research done in American labs, academic institutions and private businesses.

The U.S. military has been tapping the fruits of optical science since sailors squinted through spyglasses during the Revolutionary War.

Civil War officers used binoculars to track the progress of battles being waged under their command. World War I pilots and their crews took reconnaissance photos. The Norden bombsight gave U.S. air forces a significant advantage over the enemy during World War II.

Today, optics research is of great—and growing—importance to America's ability to maintain a strong military, according to David Honey, research director in the Pentagon's Defense Research and Engineering Directorate.

Honey—who counts an M.S. in optical science among his four degrees—termed the Norden the "first major optical breakthrough" developed specifically for warfare. It enabled U.S. aircraft to drop bombs with tremendous accuracy. It also now helps to demonstrate the quantum leaps that the U.S. Department of Defense has taken in exploiting discoveries in optical science.

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Despite the Norden's vaunted accuracy, one study found that only about 10 percent of the bombs it aimed hit within 500 feet of their targets. Today, laser-guided munitions strike with pinpoint precision, helping to prevent damage to any area outside of the intended strike zone.

Night-vision technology enables U.S. troops to "own the night," in Honey's words. Optical sensors allow personnel on the ground to control unmanned aircraft that are playing key combat roles in Afghanistan and Pakistan.

Significant advantage goes to the military force that can most quickly act on informed decisions, said Honey, who is a retired Air Force pilot. Optics advances have enabled U.S. commanders and combatants to be quick and nimble, he added. With today's optical sensors and digital communications, for instance, commanders, pilots or other military personnel can instantly see what the sensors capture and rapidly make decisions to act.

U.S. combat capability is also enhanced by optical technologies applied away from the battlefield. Optical metrology and the use of lasers in precision manufacturing are crucial to the production of some high-tech weapons. Advances in lithography improved microchip technology, for example.

Without that technology, Honey said, "many of our weapons systems would not be not anywhere near as capable as they are."

Among the advances that the Department hopes to acquire from current and future research are:

- Detectors that are better able to discover nuclear, biological and chemical threats.
- Autonomous weapons systems that can carry out missions without human control.
- Countermeasures to foil antiaircraft missiles.
- Heads-up displays in aircraft.
- Flexible displays that could be rolled up and carried like a map and could download information from a wireless network.
- Laser weapons, including an airborne laser that could shoot down ballistic missiles.

The Department takes a balanced approach to conducting research in-house and through grants to external researchers, Honey said.

Some classified research must be done in government labs, according to Honey. The department needs in-house experts to oversee the extramural research, and the best way to nurture that capacity is by having in-house researchers, he added.

"It's great to have these DoD scientists, who are very knowledgeable about DoD problems, being able to help guide extramural efforts," he said. "It's very important to have the diversity of approaches to engage a broader community of scientists who have other ideas, other experiences, and other expertise."

Each service maintains its own research program, in military laboratories and through extramural grants. Much cutting-edge research is managed by the Defense Advanced Research Projects Agency, which was created in 1958 in response to the Soviet Union's launch of the first satellite *Sputnik*. DARPA's mission was to prevent the U.S. from ever having to be in the same position it was with *Sputnik*—of being surprised by how far ahead an adversary country was in a technological area. The agency is perhaps best known outside the military for its role in creating the Internet—which was known as ARPANet during its early development in the late 1960s and early 1970s.

Peter Delfyett in the lab.

U.S. Air Force/Kenny Holston

Credit

Peter Delfyett recently completed DARPA-supported research into the development of a compact laser system for nonthermal ablation. The research had a commercial spin-off, leading to the founding of Raydiance Inc.

Peter Delfyett—a University of Central Florida optical scientist who has conducted research under several DARPA grants—found work for the agency to be "very goal-oriented, very milestone-driven, and very focused."

When responding to a DARPA request for proposals, Delfyett said, the researcher's job is to show how exactly how he or she will get from the current state of the art to DARPA's vision, with a detailed plan for where the research will be every three or six months along the way. DARPA-supported research starts at the cutting edge, he said, and seeks improvement "by a factor of 10 or 20 or 100." A recent DARPA solicitation specifically excluded "research that primarily results in evolutionary improvements to the existing state of practice." Instead, the agency sought "innovative approaches that enable revolutionary advances" in integrated photonic engineering.

Delfyett recently completed DARPA-supported research into the development of a compact laser system for nonthermal ablation. The research had a commercial spin-off, leading to the founding of Raydiance Inc., which builds machines for precision manufacturing.

But Delfyett has no idea what, if anything, the Defense Department has done with his findings. They might be part of a classified attempt to build laser weapons; he has no way of finding out. The Department constantly reevaluates its needs and what kind of research would address those needs, Honey said.

Since Barack Obama became president last year, the administration and Congress have placed greater emphasis on the Pentagon's basic research programs, according to Patrick Clemins, who tracks federal research and development policies for the American Association for the Advancement of Science.

The administration's 2011 budget proposal would cut the Defense Department's total research budget by 5.8 percent, to $6.5 billion, Clemins said. But the department's basic-research spending would increase by 6.7 percent, bringing it up to $2 billion. DARPA's total research budget would jump 14 percent, to $1.6 billion, while its basic-research spending would soar by 59 percent, to $328 million.

Basic research is critical to the Department's overall research agenda, Honey said, even though it accounts for less than a third of DoD's total research and a fifth of DARPA's.

"Basic science is the seed corn for the next generation of ideas," Honey said. ◭

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