Fostering and funding military laser R&D

by C. Yashar Ozberkmen

Military lasers are those devices and weapons that use amplified, monochromatic, coherent light to best advance the strategic capabilities of the armed forces.

The U.S. Army first began using military lasers in 1965. At that time, lasers were developed and used as range finders because of their extreme accuracy at measuring distances. Soldiers who were forward observers used these devices to determine long-range coordinates of enemy artillery gunners during the Vietnam War. The Nd:YAG lasers generally used in this application could be mounted on tanks and aircraft. Air Force pilots in that conflict used lasers to guide "smart" bombs into marked targets, a technique that later was used successfully by Israeli pilots in the 1973 Mid-East conflict and continues to be used today.

Current military laser technology has emerged as two distinct categories: the first involves lasers of varying wavelengths used for instrumentation-type applications; the other area of R&D relates to the use of lasers as directed energy weapons, such as those that may one day be used in SDI applications. Appropriations for both areas may be allocated through a number of governmental agencies including the Department of Defense (DoD), the Department of Energy (DOE), the Strategic Defense Initiative Organization (SDIO), the R&D divisions of the armed services, and the Defense Advanced Research Project Agency (DARPA).

In addition, of course, private sector research on laser technology also advances the military laser effort. In fact, individuals at various government labs indicate that it is becoming increasingly critical to work cooperatively with private industry or, at a minimum, to keep lines of communication open at all times. Arthur Guenther, chief scientist for Advanced Defense Technology at Los Alamos National Laboratory, notes that "my main concern is to keep everyone talking to each other, if for no other reason than to make sure that we're not doing the same research here that someone else, say at Livermore or another private laboratory, has already done."

Guenther points out that the Air Force is the largest source of military research in the area of high energy lasers. According to an Air Force spokesman, this branch alone spends $20 million annually "just looking at photons."

During the three-year funding period from FY87 to FY89, total defense-related research and development allocations were $164.5 billion. Defense Department funding dominated in terms of procurement for laser weapons research. Over this period, DoD spent $795 million on laser R&D, with more than half of this going toward laser weapons technology, according to a budget report prepared by the American Association for the Advancement of Science. Of this sum, $296 million—the largest single appropriation for laser R&D—was awarded to SDIO.

SDIO funds SDI

SDIO is particularly interested in target acquisition and tracking, guidance and weapon delivery (laser gyros), di-

Editor's note: Much of the information in this article is based on two sessions held last November during OPTCON '88: The State of the Military–Laser Symposium and the LEOS Panel on Unmet Federal Funding Needs. Follow-up interviews were conducted by Optics News.

rected energy weapons, and active optical countermeasures, a more placid euphemism for "optical warfare". No matter how insignificant their $296 million in funding may seem when stacked up against the towering military R&D appropriations in general, the Strategic Defense Initiative—SDI—remains the most critical issue in military spending. This side of the military laser R&D effort is focused on the more powerful, high-energy lasers. Funding for these expensive devices compared with their current and potential uses is at issue.

Since 1983, when the "Star Wars" program was initiated by President Reagan, a national technological effort has been forged to develop an effective defense against intercontinental ballistic missiles. "The Soviets were doing it and so should the U.S.," was part of the rationale used to support this work. As alluded to earlier, the cost vs. benefit issues in all facets of SDI have been vigorously debated by the White House and Congress, with industry playing a large role in this dialogue. Initial work centered on developing directed energy weapons, based either in Earth's orbit or on land, that would deliver destructive energy blasts onto targets thousands of kilometers away. Proposals also included massive ground-based efforts using space-based reflective relays positioned in geocentric orbits.

SDIO's recommendations on these self-contained laser battle stations, submitted to Congress in April 1987, included projections for energy weapons technology that called for space-based lasers to destroy ICBMs, identify or destroy decoys, and protect orbiting U.S. satellites.

Shen-Yuen Shey, director of DARPA's Directed Energy Office (DEO), noted that the early ground-based systems were projected to use mid-infrared range laser technology developed by the Naval Research Laboratory and TRW. Similar DoD research on space-based systems was carried out on a large scale by Lawrence Livermore National Laboratory (LLNL), under the encouragement of Edward Teller, a retired Director Emeritus of LLNL. Initial work there focused on chemical lasers fueled with hydrogen fluoride, operating at 2.7 μm in the infrared. Later work led to shorter wavelength sources like the x-ray laser, a program currently headed by Dr. Henry Shey, and the most recent free-electron laser research.

The current level of funding and support for SDI, both from Congress and the Administration, is somewhat uncertain. At this writing, a month into the Bush presidency, the only official reference to SDI has come in the President's address to a joint session of Congress. Discussing the need for maintaining our leadership in technology, Bush advocated that the U.S. "develop future systems in the active pursuit of the Strategic Defense Initiative."

SDI opponents allege that the technology to deploy such systems is not yet available to ensure adequate defense.

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Though this point is debatable, Congress has acknowledged that high-energy weapons required for such systems will cost a great deal. In a time of budget constraint and cost-cutting initiatives, it is doubtful whether the funding for these weapon systems will gel.

Other defense-related efforts in laser systems include research on reconnaissance and defense science and measurement being conducted by the Army. Also, the Office of Naval Research (ONR) indicates their efforts are focusing on their squeezed-state program, De Broglie Wave optics, diffraction of atoms using optical gratings, and attempts to create interferometric atomic structures that may be used as gyros.

Matthew White of ONR explained that the Navy's work in ocean optics is primarily concerned with optical computing and underwater detection schemes. Further, they are studying solid-state laser devices, diode pumped lasers, and optical filters. Howard R. Schlossberg of the Optical Science Division in the Air Force Office of Science Research, adds that the Air Force is looking at extreme UV and x-ray sources, nonlinear optics, laser photo-chemistry, and optical and electronic interaction for high speed computing.

DARPA tackles high-risk programs

Focusing on the funding efforts of the Defense Advanced Research Project Agency may serve to illustrate some of the issues affecting military laser funding in general. DARPA, a funding arm of the Defense Department, is a good example of an agency that provides money for both military and civilian R&D. Shey explained that "DARPA is a unique governmental agency that is adamantly pursuing those technologies considered by industry to be high risk by nature." It is also interested in innovative technologies that have multiple service applications.

Funds available to DARPA amount to approximately one billion dollars annually, with $35 milllion of this going toward DEO efforts. Seventy-five DARPA employees divide the billion dollar budget between competing government and private organizations. Asked what he thought his office should have, Shey replied without hesi-

tation: "$350 million—10 times the amount currently available—could easily be used." Researchers involved with laser R&D can appreciate that this figure is not unreasonable to meet current needs.

According to Shey, military applications of lasers are becoming so extensive that the emerging field is termed "optical warfare," synonymous with the term "electronic warfare" used in the post-World War II era. The only difference is that these optical systems use wavelengths from another part of the electromagnetic spectrum than those used in electronics.

R&D funded by DEO in the instrumentation-types of lasers relates to battlefield reconnaissance, tracking, target acquisition, range finding, and munitions delivery systems. Laser gyros and radar, also in this area, have attained levels of full-scale engineering so they may be integrated as a part of DoD's military platform.

More specifically, some of the technologies in which DEO is currently involved include:

- solid state lasers for fusion devices and isotope separation at LLNL;
- nonlinear optics—nonlinear crystals and materials for smaller sized and more reliable devices—at Hughes Research, TRW, and Naval Research Laboratories; and
- research on compact optical sources at Los Alamos and Fibertek, a small company in Virginia.

Shey believes future needs will necessarily depend on cooperative ventures such as these. Research divisions should concern themselves with creating devices that produce useful wavelengths and get into the higher frequencies ranges, he noted, since higher frequency light can carry more information in systems using optical data transfer. Shey also suggested that attention be paid to diode laser arrays principally used in laser communications.

The funding process

There are four levels through which organizations may obtain funding from DARPA. They are known as 6.1, 6.2, 6.3, and 6.4 and each plays a specific role in the R&D process.

The 6.1 level is heavily involved in research and this is where universities play a big part. At this level, there is also some initial exploratory development being done. Level 6.2 represents early exploration and development of existing technologies and is usually carried out by government and Department of Energy labs like LLNL and Los Alamos. Level 6.3 is the stage of advanced development, which is also done at these government laboratories. Finally, 6.4 is the level of engineering development. According to Shey, industry has some role at this stage and through the earlier phases as well.

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As part of its budget-cutting efforts, Congress reduced DARPA funding by $90 million in FY89. Although the agency is now expected to "do more with less," its 75-person staff is not enough to efficiently funnel these funds into programs with the greatest potential. Thomas Hahn, one of the few permanent administrators on the House Armed Services Committee, argues that there is "absolutely" room for reform in terms of military procurement for R&D and inter-service review.

Four major committees in Congress review the entire defense budget—the Armed Services panels and the Appropriations panels in each chamber. In theory, the Armed Services committees are the authorizers—they review the recommended funding levels and write the checks for each program and date them. The Appropriations committees sign the checks. They may also lower the amount on a particular check before signing it.

The House Armed Services Committee is generally the first to see the R&D funding recommendations and the Senate Appropriations Committee is the last. Each of the four reviews is supposed to complement one another so that what results is the best budget possible based on set priorities. What really happens, Hahn claims, is that all four committees go over every budget item, wasting time and generally finishing with a budget that is politically driven rather than task driven. Greater cooperation at this level is frequently recommended by both executive and legislative sides.

Lack of communication persists throughout the federal government, and diminishes the effective cross-agency management meant to benefit specific programs. As an example, military service programs are supposed to be critically reviewed by the Office of the Secretary of Defense (OSD). In truth, according to Hahn, they are being watched over by the individual services. The Army has its own programs that are separate from the Navy, etc.

Hahn relates a story that is descriptive of the problems encountered in defense management. Funding for laser range finders and laser target designators that are proliferated throughout the three services went through the budget proceedings described earlier. "We were talking about targets on ranges," Hahn explained, "and a Naval Officer

said to me, 'I don't know how OSD ever let us get away with it, but there are Air Force targets for Air Force ranges and there are Navy targets for Navy ranges, and we can't fly our targets in their ranges because our equipment is unique to us and they can't fly their targets in our ranges. But we shoot the same weapons at the same targets and they're all national ranges."

Small business struggles to compete

Small business does not fare well in the DARPA funding scenario. Unless they subcontract with larger firms that receive R&D from DARPA, small companies are really kept out of the picture even in the 6.4 phase of funding.

Gary Forrest, with *FYI Reports* in Redwood City, Calif., says that "When small companies know that the larger R&D firms like the 'Duponts' and the 'IBMs' hold the patents for new developments, they won't risk entering new markets for fear of being sued by the 'big guys'." Smaller firms may be given seed money to do the initial research for a particular project, he noted. But once DARPA accepts a program, it opens the funding process to competitive bidding, forcing the company that has already done the original work to compete in order to benefit from its own research. Smaller companies obviously have problems when it comes to competitive bidding, Forrest points out.

This is a fundamental issue on both sides, government and industry. When people in positions such as Shey's encourage U.S. industry to maintain technological competitiveness while maintaining cost competitiveness, yet fail to provide an avenue for small business to compete, then a dialogue leading to reform is called for.

To create a more vigorous, more competitive situation for laser R&D, one possible avenue is reform of the patent system. Patent laws allow the company that comes up with a new technology to have exclusive rights to that technology for 17 years. The fundamental question in today's legalistic environment is whether it may be in the nation's best interest for the U.S. government to encourage large companies to license the technology they have patented. According to Hahn, in some countries, if the patent holder is not using the technology after three years, competitors can ask for a mandatory license. This prevents organizations or individuals from just sitting on the technology to keep it from being use against them.

However, as with any system, a key goal in corporate environments is self-perpetuation, which tends to foster the continuation of research programs in confined environments. When discussion turns to technology transfer, the question is often: "How can you transfer the fruits of research from the national labs to industry?" Perhaps the more appropriate question is: "Are the national labs really the best facilities to do the work in the first place?"

Forrest suggests, and those involved with DARPA funding seem to agree, that a possible solution, in principal, would be to "take the money given to the national labs, like Livermore or Los Alamos, particularly in cases where R&D is subcontracted out to smaller firms, and give that money directly to the people in the smaller firms that would eventually do the work anyway." The Small Business Innovative Research program (SBIR) implemented by DARPA does just this, but is vastly underfunded, Forrest asserts.

There is not a laser company in the world that does not have Shey's ideals of high efficiency, lower costs, smaller sizes, and greater reliability in mind. The funneling of current resources should be independent of size and solely dependent on a lab's ability to get the R&D done while adhering to Shey's ideals. The major obstacle standing in the way of this greater cooperation between private industry and the military is government management and regulations, says Hahn.