Apr 29th, 1:00 PM - 4:00 PM

Paper Session III-C - Commercializing Strategic Defense Initiative Technology

Nick Montanarelli

Deputy Director, Technology Applications Office, OSD/SDIO/TNI, Office of the Secretary of Defense

Commercializing Strategic Defense Initiative Technology

Nick Montanarelli
Deputy Director, Technology Applications Office
OSD/SDIO/TNI
Office of the Secretary of Defense
Washington, D. C.

Presented at:
The Thirtieth Space Congress
April 27-30, 1993
Cocoa Beach, Florida

Commercializing Strategic Defense Initiative Technology
Presented by Mr. Nick Montanarelli

Part I: The Technology Transfer Process at SDI

By creating new products, improving existing products, and making manufacturing processes more efficient, new technologies can improve our standard-of-living and create or save millions of jobs. But building a better mousetrap is not enough; just as we need a infrastructure of highways, railroads, and bridges to move goods in this country, we also need an infrastructure of technical information and business assistance centers to move technology from the laboratory to the marketplace. Congress, recognizing the need for this support mechanism, passed technology transfer legislation — starting with the Stevenson-Wydler Technology Innovation Act of 1980 and ending with the National Competitiveness Technology Transfer Act of 1989[1] — that has spurred today's growing emphasis on the transfer of Federally-sponsored research and development.

The Strategic Defense Initiative Organization (SDIO) has long been a leader in implementing technology transfer legislation. SDIO established the Office of Technology Applications in 1986 to work with industry to commercialize SDI-sponsored technology and has developed innovative mechanisms for transferring Federal research to the marketplace.

Before private companies can establish any relationship with the Office of Technology Applications they need to know what technologies SDI has to offer, and SDIO is making sure they can find out. The Office of Technology Applications runs an on-line database, the Technology Applications Information System (TAIS), that is open to American corporations and citizens free-of-charge. The database contains nearly 2,000 abstracts of SDI-funded technologies, and is continually updated and expanded to include new developments in SDI research. By requesting more information on a technology, the TAIS refers users to the SDI researchers involved with the technology. This first-hand access to a technical expert helps users commercialize the research.

The Office of Technology Applications also publicizes available technologies to encourage business arrangements that produce spinoffs. These include the SDI High Technology Update, a quarterly newsletter provided free-of-charge, and the SDI Technology Applications Report, an annual report (also free-of-charge) that describes SDI's technology transfer program and highlights representative SDI spinoff successes.

Furthermore, the Office of Technology Applications co-sponsors approximately eight technology applications reviews a year to identify commercial and new governmental applications of SDI technology. Each review focuses on a different technology area (such as biomedical, optics, materials, electronics, or power) and

---

[1] A list of Acts of Congress and Executive Orders relevant to technology transfer can be found in the appendix at the end of this paper.

brings together public and private sector experts to discuss commercialization strategies for SDI technologies. After each review, the Office follows through on promising strategies to foster spinoffs that will benefit the nation's economy.

Finally, the Office of Technology Applications has a proactive outreach program designed to work with professional and government organizations such as the National Technology Transfer Center, the Federal Laboratory Consortium for Technology Transfer, NASA, and many other organizations that share the goal of improving America's economic well-being by introducing new technology into the marketplace.

While these activities comprise the core of the Office of Technology Applications' function, SDI also tests general models of technology transfer to determine how best to transfer technologies in given situations. Ongoing demonstration projects include:

- **State Economic Development Program Interface (New Mexico).** The Office of Technology Applications is working with state government and federal laboratory officials in New Mexico to identify and commercialize SDI technologies developed at Los Alamos National Laboratory, Sandia National Laboratories, and the Air Force's Phillips Laboratory. The University of New Mexico's School of Business is supporting this technology transfer project by performing market analyses of selected technologies. This is one of the first concerted efforts in the nation to get federal labs, state officials, and university business schools to work together to commercialize promising technologies.

- **Superconducting Magnetic Energy Storage (SMES) Technology Assessment.** SDI is analyzing SMES technologies for their technology transfer potential. This should produce a technical taxonomy of SMES components, track future SMES development, and enhance its transfer to other programs.

- **Civilian Applications of SDI Accelerator Technology.** SDI is documenting its contributions to state-of-the-art accelerator technology. By documenting these advances, the project should help spur commercialization of this technology.

- **Medical Research Technology Transfer.** In this two-phase project, the Office of Technology Applications is reviewing the results of medical research funded by the SDI Medical Free-Electron Laser (MFEL) program to document and promote the program's most significant successes.

- **Professional and Trade Association Interface.** The Office of Technology Applications' outreach staff is developing methods to transfer technology through professional and trade associations by identifying conduits for reaching association members and constituents.

All of SDI's technology transfer activities are building a spirit of cooperation between SDI research programs and industry that helps foster commercialization. In implementing the will of Congress, the Office of Technology Applications has built an impressive record of success. Through its Technology Applications Reviews, over 200 SDI researchers have received hands-on business assistance, and 19 SDI researchers have gone on to form new businesses. During its five years of operation, the TAIS has processed thousands of inquiries for SDI technologies. Over 5,000 people throughout the public and private sector receive the SDI High Technology Update, and with each issue hundreds of readers are matched up with SDI researchers that can solve their technical problems. Further, SDI's demonstration projects continue to jump-start the commercialization process and build a stronger technology transfer network in the United States. Through the help provided by these activities, commercial firms in the United States are now selling new or improved products, building new industries, and creating jobs. They are, by developing spinoff applications for SDI-sponsored research, fueling the Nation's economic engine.

Part II: SDI Spinoff Success Stories

1. Photodynamic Therapy Kills Viruses or Cancers — Baylor Research Institute

Baylor Research Institute (Dallas, TX) researchers have developed photodynamic therapy techniques in which light sensitive dyes kill viruses or cancers when irradiated with laser light. The technique uses photoactive dyes that selectively attach to a number of enveloped viruses such as HIV, hepatitis, Epstein Barre, cytomegalovirus, herpes, or cancerous cells. When light of a specific wavelength and sufficient intensity shines on a dye, a chemical reaction begins that gives off a toxic oxygen radical for a short distance and for a fraction of a second. The oxygen radical breaks down the viral sheath and kills the virus. Because dyes only produce singlet-state oxygen when they absorb laser light of a specific wavelength, the Baylor team used a free-electron laser (FEL) and other lasers to deliver the correct wavelength. Funding for the laser research came from SDI's Medical Free Electron Laser (MFEL) program, which Congress established transfer SDI-sponsored free-electron laser technology to medical and other spinoff applications.

Because photodynamic therapy is generally effective only when dyes can be illuminated without interference from other tissue, the first application to result from this research was a method to purify donor blood bank supplies. In a more exciting recent discovery, Baylor found that another dye could be irradiated before injection into blood to effectively "preactivate" it. That is, after laser irradiation the dye retains its antiviral properties until it comes into contact with enveloped viruses in the blood stream. This development makes a drug-like treatment for AIDS and similar viral infections possible. Baylor has licensed both techniques to separate companies. The photoactive dye being employed for blood purification has passed toxicology testing, but has yet to receive approval from the Food and Drug Administration (FDA). The FDA recently approved the preactivation method for clinical trials that will begin shortly.

2. Microchip Lasers Spawn New Company — MIT Lincoln Laboratory

Since spinning off from SDI laser research at the Massachusetts Institute of Technology's Lincoln Laboratory in 1988, Micracor, Inc. (Acton, MA) now has its first two products on the market: MicraLase® — a tunable, external-cavity semiconductor diode laser — and MicraChip® — a miniature diode-pumped solid-state laser. MicraLase® provides a high quality, reliable, and low-cost replacement to dye and titanium-sapphire lasers for medical and scientific applications, while MicraChip® will be sold for communications, cable television, optical disk, display, and printer applications. Further, the company will soon complete its product line by introducing its third product, MicrArray™ — a two-dimensional high-power solid-state laser display. Individual elements of the MicrArray™, as well as the power supplies that drive them, can be operated independently or in subgroups, providing a high degree of robustness for industrial and military applications. To handle demand for these products the company has moved from a 7,000 sq. ft. facility to a new 12,000 sq. ft. facility.

Microchip lasers offer the size, cost, and reliability advantages of diode lasers with the beam quality of more expensive solid-state systems. Also, microchip lasers can be made using a simple, low volume cost semiconductor processing technique. MICRACOR estimates that microchip lasers could eventually capture a significant share of the current $1 billion-a-year laser market. This, however, may understate the opportunity when one considers the new markets microchip lasers may create. For example, the microchip laser's tunability allows it to simultaneously send many optical signals over a single fiber. This could greatly increase the number of signals sent through telephone optical switches, or data sent between computers. Microchip lasers also could create cost effective medical applications in cancer therapy, dermatology, and eye and heart surgery.

3. Double Layer Capacitors for Electric Cars — Auburn University

Maxwell Laboratories, Inc. (San Diego, CA) has signed a licensing agreement with Auburn University to develop, manufacture, and market double-layer capacitors that can store 10 times more energy than the best electrostatic capacitors now available. A 15 cm^3 double-layer capacitor, which is about the size of a cigarette pack, is rated at about 6.0 Farad capacitance and 5.5 volts. This means it could power a portable welder that would melt several ounces of lead in a second. Auburn University's Space Power Institute (SPI) developed these capacitors for SDI to power lasers, railguns, and other weapons systems.

Since teaming, Maxwell and Auburn have won a Department of Energy contract to develop the capacitors for electric vehicles. Double-layer capacitors could help eliminate the two biggest flaws of electric vehicles: the lack of range and acceleration. In an electric vehicle using capacitors, a battery would still be used for cruising, but capacitors — because they release energy much more quickly than batteries — would kick in whenever the car needs to accelerate for merging, passing, emergency maneuvers, and hill climbing. Traditional capacitors can augment battery power for about two seconds, while the double-layer capacitor can provide acceleration power for 10-15 seconds. Since acceleration rapidly depletes battery charge, capacitors would also increase range by reducing power demands on the battery.

As part of their agreement, Maxwell has opened a R&D facility in the City of Auburn's Center for Developing Industries incubator. Maxwell has hired two scientists to work at the facility, both of whom will work with Auburn's SPI to make and evaluate prototypes. If research proceeds as expected, Maxwell will later establish a capacitor manufacturing facility in Auburn. Double-layer capacitors may also power industrial lasers, pulsed-light generators, and magnetic-forming machines, and may someday replace some of the traditional capacitors now used in computers, telephones, air conditioners, and many other electrical devices.

4. Adaptive Optics — MIT Lincoln Laboratory

SDI's ground-based laser program had a technical problem that has plagued astronomers for centuries: atmospheric distortion. Through a telescope, stars (or, in SDI's case, targets in space) should look like bright individual points. Instead, they appear as blurry blobs because light passes through wind and temperature variations in the atmosphere. These variations distort light waves the same way ripples in water make pebbles on the bottom of a pond appear to wiggle. These atmospheric effects are what make stars appear to twinkle.

To solve this problem, SDI investigated adaptive optics, a system for correcting atmospheric distortion effects by using a reference star, deformable mirrors, and feedback control. SDI recently declassified its adaptive optics program, donating hardware, software, and technology to the National Science Foundation's (NSF's) civilian astronomy program. The technology, including hardware sent to the Massachusetts Institute of Technology's Lincoln Laboratory (Lexington, MA), may save civilian astronomers years of research and development needed to give earth-based telescopes the clarity of those deployed in space.

Traditionally, atmospheric distortion limits resolution no matter how large the telescope, making four-meter telescopes no better at resolving images than a backyard amateur's telescope. Adaptive optics, however, will provide new earth-based uses for extremely large, segmented main mirrors that previously served only to gather light (which has limited value to astronomers for measuring star brightness). An earth-based telescope using adaptive optics costs about $12 to $20 million, compared to $1.5 billion for the Hubble Space Telescope. (It should be noted, however, that space-based telescopes such as the Hubble Space Telescope are still needed to image high-energy, short-wavelength radiation — such as ultraviolet, x-ray, and gamma ray radiation — which is absorbed by the atmosphere.)

While working in the visible and infrared spectrum, a four-meter diameter segmented mirror with adaptive optics should provide a resolution 10 times better than other earth-based telescopes, and equal to the Hubble Space Telescope. Newer, larger telescopes may provide a resolution two to three times better than the Hubble Space Telescope.

Since declassification of adaptive optics technology, Lincoln Laboratory researchers have installed a 69-channel adaptive optics system on the 60-inch telescope at the Mt. Wilson Observatory in southern California. SDI funded installation of this system to broaden the performance database for operational adaptive optics systems. The NSF will fund further work at the Mt. Wilson adaptive optics system.

5. Magnetic Suspension Used for Removing Cataracts — Aura Systems, Inc.

Aura Systems, Inc. (El Segundo, CA) developed electromagnetic suspension to test the high power thrusters of SDI's Lightweight Exoatmospheric Projectile (LEAP) in laboratory conditions and is turning this technology into a new cataract surgery procedure.

Traditional cataract procedures remove or destroy the lens capsule, requiring the patient to wear reading glasses. In this new procedure — named the Kelman Electromagnetically-Assisted Surgical Technique (KELMAST) after its inventor, Dr. Charles Kelman — the surgeon places an electromagnetic control system from Aura Systems around the patient's head and makes a one millimeter incision into the lens capsule. The surgeon then introduces a magnetic bead through the incision. The control system rotates the bead within the lens capsule, emulsifying the cataract tissue. When the procedure is completed, the surgeon carefully removes the bead and cataract material with a syringe and replaces the tissue with collagen. The lens capsule emerges unscarred from this procedure and the patient retains the ability to focus.

Besides cataract surgery, KELMAST could replace invasive surgery when inaccessible parts of the body must be reached. This includes delicate knee surgery, heart surgery, removing plaque from arteries, and removing obstructions from the digestive tract, bladder, or other organs. Dr. Kelman and Aura Systems, Inc., which developed electromagnetic suspension, have formed a new company called Aura Medical Systems, Inc. to market this technology. "Three million cataract procedures are performed worldwide each year, costing $3,000 to $5,000 apiece," said Harry Kurtzman, president of Aura Systems. "The number of procedures is expected to grow by 100,000 a year to reach four million in ten years. We expect the KELMAST procedure to gain a large following among eye surgeons." KELMAST is undergoing extensive testing on animals and will be used on patients once the Federal Drug Administration approves it.

6. Carbon Foam Material Licensed to Hip Implant Maker — Ultramet, Inc.

Under SDI SBIR contracts, Ultramet, Inc. (Pacoima, CA) developed structural foams to insulate hot gas nozzles in rockets. On January 24, 1992, Implex Corporation signed a license agreement to use Ultramet's structural foams for musculoskeletal applications. Because Ultramet can tailor the foam's properties by depositing different materials on the carbon foam matrix, the foam can provide an excellent biocompatible matrix structure to promote bone growth. Preliminary tests at Clemson University on goats have shown that the foams enhance and accelerate bone growth better than any material now in use. The National Institutes of Health also has awarded Ultramet a grant to investigate these foams for use in musculoskeletal and dental applications.

Because Ultramet can tailor the properties of their coated carbon foams, the foams have a variety of applications. For example, Ultramet's foams insulate against temperatures 500° C greater than what NASA's Space Shuttle tiles can withstand, thus generating interest from the Air Force in using the foams to insulate its rocket hot gas nozzles. Ultramet sells foams in smaller specialty markets, such as high-temperature filters for pollution control, while the foams also have structural applications in the building construction and aerospace industries.

APPENDIX: FEDERAL TECHNOLOGY TRANSFER LEGISLATION AND EXECUTIVE ORDERS

Stevenson-Wydler Technology Innovation Act of 1980
Established and funded Offices of Research and Technology Applications (ORTAs) at major laboratories to identify information on technologies and provide that information to private industry, universities and state and local governments.

Bayh-Dole University and Small Business Patent Procedures Act of 1980
Allowed small firms and universities to obtain title to inventions funded by the Federal Government.

Small Business Innovation and Development Act of 1982
Mandated that federal agencies develop small business innovation research programs and establish specific goals to help small businesses and minority, disadvantaged organizations participate in contracts, grants and cooperative research and development agreements (CRADAs).

National Cooperative Research Act of 1986
Permitted registered consortia to engage in joint R&D ventures without violating anti-trust laws. This permission did not allow co-production.

Federal Technology Transfer Act of 1986
Granted government laboratory directors permission to enter CRADAs with for-profit corporations, to assign patent rights to firms participating in CRADAs and to license technologies. The act also allowed government laboratories to retain licensing royalties and mandated that a minimum of 15 percent of royalties on federal patents be awarded to federal inventors. Finally, the act chartered the Federal Laboratory Consortium (FLC), whose job is to transfer technologies from federal laboratories to industry, universities and state and local governments.

National Defense Authorization Act of 1987
Encouraged the Secretary of Defense to promote domestic technology transfer of DOD-developed technology to the extent consistent with national security objectives. The act also called for the Secretary of Defense to examine and implement methods for DOD personnel to promote technology transfer.

Executive Order 12591, Facilitating Access to Science and Technology
Called on the Secretary of Defense to identify new technologies that could be useful to U.S. industries and universities and to accelerate efforts to make new technologies more readily accessible to those users. The President enacted this Executive Order in April 1987 to promote the commercialization of federally-funded science and technology.

Omnibus Trade and Competitiveness Act of 1988
Changed the name of the National Bureau of Standards to the National Institute of Standards and Technology (NIST) to reflect NIST's broadened role of promoting the commercialization of federally-developed technology and to transfer that technology to universities, private industry and state and local governments. The act also created regional centers for the transfer of manufacturing technologies, made provisions to assist state technology extension programs, and established a clearinghouse for state and local initiatives on productivity, technology and innovation.

National Competitiveness Technology Transfer Act of 1989
Granted contractor-operated federal laboratories the authority to enter CRADAs and to license technologies. The act also established time frames to accelerate government negotiations for starting CRADAs and exempted CRADAs from freedom of information stipulations for up to five years.