SDI SPINOFFS: UP IN THE AIR

Will the civilian sector benefit from Star Wars technology?

If present research on the Strategic Defense Initiative finds the concept to be technically and economically practical, the U.S. government could spend hundreds of billions of dollars in the 1990s and beyond to develop and deploy the system. The Reagan administration already plans to spend more than $30 billion by 1990. This would of course provide an enormous amount of business for defense contractors and other high technology industries. But how soon, if ever, will SDI produce commercial spinoffs? The answer depends on who you talk to. Many managers and supporters of SDI foresee significant commercial benefits in the near future. Critics, meanwhile, maintain that most of the program's technology will be either wrapped up in red tape for years to come or inherently unsuited to civilian applications.

SDI officials are quick to assert that the value of the program does not depend on its civilian spinoffs. But they are also eager to use the lure of these benefits to win support for the ambitious undertaking. Thus the SDI Organization's director, Lieutenant General James Abrahamson, created an Office of Educational and Civil Applications last fall to promote commercial and other uses of SDI research.

An SDI missile defense system will require major advances in many different areas of military technology—sensors, high-speed missiles, lasers, particle beam accelerators, control devices, power sources, materials, and computer hardware and software. Converting research in such areas into salable products won't be easy. Companies will have to run a gauntlet of classification procedures, export controls, and slow development cycles before they can hope to cash in.

by Kevin Finneran

Defense Department insiders are generally optimistic, however. SDI chief scientist Gerold Yonas points to space surveillance research, which accounts for 35–40% of SDI spending, as an area in which "spinoffs are expected into every part of the economy." Brigadier General Robert Rankine, Air Force special assistant for SDI, believes that tracking and pointing technology developed for surveillance "may prove valuable in commercial aircraft guidance and in ground traffic monitoring." He also sees potential applications for very precise sensing and measurement technology in automated process control.

SDI program managers expect numerous commercial spinoffs from laser weapons as well. Rankine envisions SDI research contributing to the use of monochromatic radiation in CT scanners, which would reduce the dosage of radiation necessary for diagnosis while providing higher resolution that "would allow discrimination between molecular species, not just between density variations." He also sees a potential for laser etching of microelectronic components. Other likely spinoffs suggested by SDI staff, researchers in the national laboratories, and defense contractors would benefit such areas as energy generation and storage in space, supercomputer hardware, software for artificial intelligence systems, and hybrid optical-electronic computers.

At the same time, SDI officials warn against expecting too many specific products to emerge from the research. "People miss the point when they emphasize widgets," says chief scientist Yonas. "The real commodity is the knowledge base, whose benefits are indirect but still real." Colonel Joseph Rougeau, director of SDI's Office of Educational and Civil Applications, stresses that the program is taking a "technology-push" approach to commercial applications. "We will develop the technology we need and publicize what seems commercially useful," he says. "The applications are limited only by the imagination and creativity of American companies."

But companies must first wrest the technology from the government's clutches: Despite their professed eagerness to transfer technology to the private sector, program managers have declared all SDI research "advanced development," a category that is almost always classified. "So much of the SDI research is classified," says Jerry Glen, technical director of the Laser Institute of America (Toledo, Ohio), "that it's impossible to know what its

commercial usefulness will be." In addition, the Pentagon has the right to withhold unclassified technical data with military or space applications.

Even SDI work that is unclassified, released, and appropriate for commercial applications will not readily yield business benefits to firms that are not SDI contractors, says D. Bruce Merrifield, the Commerce Department's Assistant Secretary for Productivity, Technology, and Innovation, because such research is often "bottled up by bureaucratic procedures in Washington." And even the SDI contractors—major players include Boeing, TRW, Hughes Aircraft, Lockheed, Rockwell, Teledyne Brown Engineering, and LTV Aerospace—could find themselves impeded by red tape. Bobby Inman, chairman of the Microelectronics and Computer Technology Corp., contends that the Defense Department's long procurement cycle has become a major hindrance to commercialization. Defense research produced numerous spinoffs in the 1950s when the procurement cycle was four to five years, explains Inman, but with the current 12- to 13-year cycle "the U.S. loses most of the economic commercial advantage that we once obtained from the early availability of technology." Increased technical complexity has slowed the process, and so has public and congressional pressure for closer scrutiny of military projects. Although Inman would like to see the bureaucracy streamlined, the current fuss over Defense Department procurement abuses makes that politically impractical.

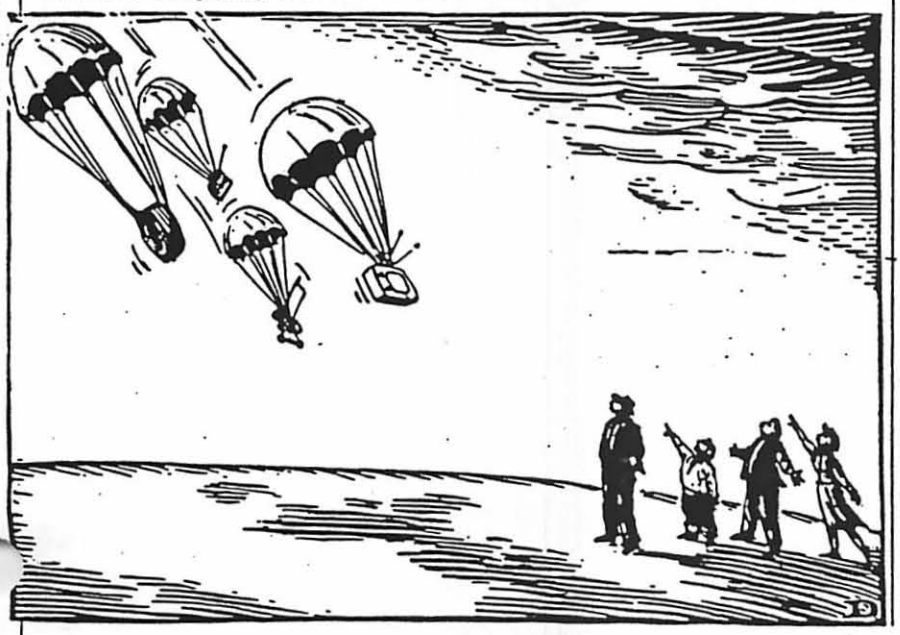
SDI spinoffs may face more basic problems, in that much of the technology could prove inherently unadaptable to commercialization—particularly as the program moves rapidly into its demonstration phase. "Probably 90% of SDI laser funding goes to the development of specific hardware," says laser physicist Robert Byer of Stanford University, "and most of it is extremely large and high-powered, not at all suited to commercial uses." SDI's x-ray laser research, for example, involves powering the laser with a nuclear explosion. Byer points out that Japan, meanwhile, is funding research in carbon dioxide and solid-state lasers for welding, annealing, and other industrial applications, and in semiconductor diode lasers for use in compact disc players and fiber optic communications—all areas of direct commercial potential. "We could," warns Byer, "see the demise of the U.S. commercial laser industry in the next decade."

The Laser Institute's Glen has a more immediate concern. Since the start-up of SDI, he claims, the government has introduced tighter restrictions on the export of lasers and laser technology because they now have potentially greater military value. "The export controls are hurting U.S. competitiveness," says Glen. "Our trading partners don't want to put up with the hassles of export license approval when they can buy the same kinds of equipment elsewhere without the delay."

The most fundamental misgivings about SDI's commercial potential stem from doubts about the underlying technology-push theory of innovation. This theory gives a distorted picture of the marketplace, says John Pike, a space and military policy analyst for the Federation of American Scientists. In practice, he says, SDI could actually cause a shortage of scientists and engineers in key commercial technologies that are already established. For example, it could compete for researchers pursuing civilian applications in supercomputers, gallium arsenide chips, and optical computers. Program officials dismiss this fear, claiming that SDI will encourage more students to enter these fields.

Rougeau says that by the end of this year the Office of Educational and Civil Applications will establish advisory panels to review SDI research for commercial potential. Promising research will be promoted through NASA publications at first and eventually through SDI's own publications. The SDI Organization is borrowing NASA staff to help in its technology transfer efforts, and intends to look into other ways of alerting companies to new technology. Rougeau points out, however, that the organization will spend only 5–10% as much as NASA in promoting spinoffs.

The embryonic nature of the research, together with the currently modest mechanisms for exploring commercial applications, leads even ardent SDI supporters to concede that it is still too early to predict the scale of commercial spinoff. "I expect to see products emerge," says Rougeau, "but it will take years. We have to be realistic about the timing." □



Kevin Finneran is Washington correspondent for HIGH TECHNOLOGY.

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Prospects of 'Star Wars' Spinoffs Stir Hope, Doubt

By RUDY ABRAMSON, *Times Staff Writer*

WASHINGTON—President Reagan's space-based missile defense program, which will soon be 4 years old, has yet to intercept its first missile with a laser, destroy a target with a particle beam or knock anything out of the sky with a rail gun.

But its boosters already insist that even if the so-called "Star Wars" project never keeps those promises, it will produce technological spinoffs of untold value for conventional arms.

Sen. Sam Nunn (D-Ga.), who will chair the Senate Armed Services Committee this year, suggests that the Soviet Union is afraid of "Star Wars" not because of its potential as an anti-missile shield but because of the likely military spinoffs.

Some scientists also hold out hope that lasers developed for "Star Wars" can be used for everything from taking the salt out of seawater to providing improved automobile tail lights, and that the mirrors used to reflect the lasers' concentrated beams toward oncoming missiles could also be used to light highways and airports.

But critics remain unimpressed. Some doubt many of the Strategic Defense Initiative's breakthroughs will prove to be very practical otherwise. And rather than stimulating conventional weapons improvement and commercial technology, they contend, "Star Wars" is likely to drain scientific talent from more productive pursuits, thus impeding university research and slowing the development of commercial high technology.

With Democrats back in control of the Senate, the program's benefits and costs are expected to be subjected this congressional session to the closest scrutiny since "Star Wars" was launched in March of 1983.

Nunn, who has championed the cause of conventional arms, has already declared his intention to push hard for more defense for less money, and critics of the Strategic Defense Initiative maintain that this compels a hard new look at the program that stands to be the most expensive military undertaking in history.

From the outset of the program, President Reagan has asserted that there is more to it than its quixotic objective of making intercontinental ballistic missiles obsolete.

Cites Space Program

Campaigning in Colorado four days before the November elections, Reagan compared the potential commercial impact of the strategic defense program to the spinoff from the civilian space program in its early years.

"Just as America's space program created new jobs and industries, SDI could open whole new fields of technology and industry," he said, "providing jobs for thousands right here in Colorado and improving the quality of life in America and around the world."

Already, enthusiasts and some scientists say, the SDI research is providing myriad potential applications that could benefit manufacturing industries, communications, medicine, conventional defense systems and other fields.

It is suggested, for example, that the precise pointing and tracking instruments required in a ballistic missile defense system could be readily adaptable to commercial air traffic control.

Multiple Possibilities

The new lasers, in addition to possible uses in desalinization and auto lights, could perform delicate surgery, and the new beam-reflecting mirrors could have any number of common uses where powerful illumination is needed.

"We are beginning to explore the use of molecular engineering to create new classes of materials that do not exist in nature," said James Ionson, director of the Strategic Defense Initiative Organization's Office of Innovative Science and Technology, which is part of the Defense Department.

"Some of the things we are striving to develop are extremely lightweight and highly thermal resistant, and what you could eventually find is that these materials will be used to make automobile engines."

Of the potential spinoffs into conventional weaponry, nothing has received more attention than the electromagnetic rail gun, an energy weapon that accelerates metallic pellets to enormous velocities by varying magnetic fields between two "rails".

In its "Star Wars" incarnation, it is has been viewed as a "booster buster," an interceptor capable of accelerating projectiles toward enemy missiles at speeds of at least several miles per second, in effect hitting a bullet with a bullet.

If it is built small enough, it could be a devastating weapon against heavily armored vehicles—Soviet tanks.

One problem is that the rail guns being looked at for SDI, which would be mounted on the ground or on a space platform, are still the length of a football field. But, said William Weldon, director of the University of Texas Center for Electromechanics, "Developing a rail gun for anti-armor purposes is probably less challenging than developing it for 'Star Wars.'"

Weldon and other researchers also are looking at another potential role for the electromagnetic gun—as a device to spray metallic coatings onto surfaces where perfect bonding is necessary for corrosion resistance, hardening or the coating of alloys.

"There is also interest in using the technique to coat ship hulls with bronze or something so they do not have to be periodically pulled out of the water and scraped off and re-coated with anti-fouling paint," he said. "Hulls could be permanently protected."

But critics argue that for all the fascination over "Star Wars" gadgets such as the rail gun, the successful spinoff application of much of the SDI technology is doubtful, and if it proves out, would come at a greater cost than if pursued directly.

"Civilian spinoffs from military spending have become harder and harder to find," MIT economist Lester Thurow wrote in Technology Review earlier this year. "The requirements for operating in space are very different from those on earth. Extreme lightness, miniaturization and reliability are of much less value on earth than in space.

"We can find many examples of civilian spinoffs from the military in the distant past—the Boeing commercial jet airliner; for in-

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Tenerife and Albacete would form the centers for Spain's air defenses.

One of the secret reports suggests that the Spanish air force may create a new wing (the 45th) at Torrejon. According to this contingency scenario, once all U.S. personnel have left the base, the Spanish air force would establish a research center to work on missiles and other weapons. Reports by NATO strategists support the stationing of 36 Spanish F-18A fighter bombers at the Torrejon base by 1988. These bombers are capable of hitting North Africa and returning to Spain without having to refuel. The F-18A also has sufficient range to reach military targets in Southern Europe should NATO need assistance in the event of war with the Warsaw Pact.

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DEFENSE FACES A SLOWDOWN—SORT OF

BUSINESS WEEK
12 JANUARY 1987
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After the longest and largest peacetime arms buildup in U.S. history, business will slacken for the $300 billion defense industry this year—but with the inertia of an M-1 tank. Congress has earmarked $85 billion for new military hardware in fiscal 1987, an 18% decline from the $104 billion peak in 1985. But because the Pentagon can supplement this by drawing against some $290 billion in funds left over from prior years, its purchases should fall less than 2% in real terms. Indeed, except for shipbuilding, most defense contractors could be spared any real belt-tightening until at least 1989.

That's not to say they won't face challenges. There may be a shakeout among subcontractors as cost-conscious prime contractors bring more work in-house, predicts Albert J. Kelley, a senior vice-president of Arthur D. Little Inc. And the Pentagon will increase pressure on the primes to get more competitive bidding from their subcontractors, to pay more tooling and research costs once borne by Washington, and to share production contracts with one another. All this will squeeze profits. "No question—the Defense Dept. is draining the industry of cash," complains John C. Bierwirth, chairman of Grumman Corp. Prodded by the Pentagon, his company has doubled its outlays for aircraft parts over the past two years, instead of relying on Defense funds to pay for them.

SHORT SHRIFT. Some executives see a long-term danger in such trends. For instance, government research money, which companies once spent largely as they saw fit, now is tied more tightly to specific projects. As a result, "technology for the future isn't getting done," frets Walter B. LaBerge, vice-president for corporate development at Lockheed Corp. Specifically, he feels that work on artificial intelligence software, a key element in the Star Wars missile defense system, is getting short shrift.

Still, most defense contractors will have little to complain about in 1987. Defense electronics—now a $54 billion business—will be a particularly bright spot. After rising 15% to 20% annually for the past four years, government spending increases will drop to 12% to 15% for the next several years, says Bernard L. Schwartz, president of Loral Corp., which makes radar warning and jamming systems. But, he adds, "there's plenty of business out there." The reason: The Pentagon is launching fewer new "platforms"—industry jargon for airplanes, ships, and other vehicles. So the services are filling old ones with new weapons, most of them electronic.

This explains why Lockheed and General Motors Corp. made defense electronics acquisitions in 1986, and why companies such as Dallas-based E-Systems Inc., which makes electronic "snooping" and combat communications equipment, are often mentioned as takeover candidates. Schwartz says he's been approached by prospective partners several times, but he's seeking an acquisition of his own. Boeing Co. and General Dynamics Corp. also are thought to be looking, and some observers think both could strike this year.

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ace," he said. "But there are few in the recent past. In fact, the major inventions of the past few decades have spun off from the civilian economy to the military. The transistor was invented by AT&T. Semiconductor chips were developed by an oil-well instrument company—Texas Instruments—and personal computers were developed by hackers."

Gains Made Elsewhere

Moreover, some critics said, there may be few real technological advances that "Star Wars," despite its grand scope, can claim as its own.

The Army and the Defense Department's Advanced Research Projects Agency were already conducting research on rail guns, as were university researchers who used them to simulate the effect of micrometeorites on space vehicles. The Navy is trying to develop lasers to defend its ships against cruise missiles.

"The first question I have to ask about SDI contributions to conventional weapons is the extent to which all of this stuff they are working on was already being done somewhere else," said John Pike, an analyst for the Federation of American Scientists. "I can walk in a long list of it."

Perhaps the greatest question, and the subject of the sharpest debate, is whether "Star Wars," as history's most expensive research and development program, stands to broadly stimulate technical and scientific productivity.

Explosion in Optics

As an illustration of technologies already given "a shot in the arm" by SDI research, Berkeley-trained physicist Louis Marquet points to optics, a field that many predict will have the technological and commercial impact in the years just ahead that electronics had in the 1960s and 1970s.

"SDI is not spending a lot of money on [optics] in terms of direct contracting. But if you look at what is happening in industry, you will see that the whole concept has just exploded over the last couple of years," he said.

Until recently, the United States had only two schools with broad-based optical education programs extending from undergraduate training through doctoral degrees—the University of Rochester and the University of Arizona.

But about the time that Reagan launched the SDI program, the University of Alabama at Huntsville responded to the recommendation from government and aerospace industry experts and launched an ambitious optics program. It now has a dozen undergraduate students and 40 graduate students.

"My great concern is that this country will lose optics to the Japanese the way we lost electronics," said John Caulfield, director of the Alabama program. "... We need 10 or 12 more schools right now."

While supporters of the SDI program contend it is a driving force in the hottest new fields of high technology, critics maintain that commercial development stands to suffer because of the "Star Wars" program and its military secrecy.

"If it gets to a point where SDI imposes a lot of restraints, then it is going to be extremely harmful to the country," said Sidney Drell of Stanford University, who is president of the American Physical Society.

There are also assertions that SDI will have a negative effect on commercial technology by creating a brain drain from fields where there is a shortage of talent, such as optics. Suggesting that the program could "crowd out" worthwhile civilian research and development and contribute to a shortage of engineers and scientists, a study by the New York-based Council on Economic Priorities noted that "SDI compares in size to the largest procurement programs in the Pentagon budget, including the Peacekeeper MX missile and the B-1B bomber.

"If strategic defense technologies reach full-scale development, the macroeconomic impacts could be substantially greater," the study said.

The Defense Department's SDI organization has been attentive to the importance of technological spinoff. It has given the subject priority in both its Office of Innovative Science and Technology which sponsors mostly unclassified research, and its Office of Educational and Civilian Applications.

The Office of Innovative Science and Technology receives so many research proposals that it can support only a fraction of them, and it has been criticized for supporting too many at the expense of quality control.

Although many experts debate the true spinoff value of SDI, few can dispute that the Soviet Union is taking it into serious account.

"The main error that people make in thinking about SDI arises from their need to visualize what they are thinking about, and so people watch television, and they invariably think about satellites zapping missiles with laser beams," said R. James Woolsey, a former Navy undersecretary and a former U.S. arms negotiator. "So people tend to think that the laser is the only thing."

"The fact is that directed energy weapons get only a small part of the SDI budget, maybe 10%. What the Russians are worried about," he said, is how SDI-related technology will be applied to other military problems. For example, "they know that in doing computer work for SDI, we are probably doing work that needs to be done for the air defense of Europe," Woolsey said.

Los Angeles Times SEP

Civilian Research Spinoffs From SDI Are a Delusion

By DANIEL S. GREENBERG 5-11

As the nuclear-free promise of the Strategic Defense Initiative founders on awesome technological barriers and easy Soviet countermeasures, we're hearing more about one of the great delusions of our time—spinoffs, the threadbare notion that SDI's billions for research will invigorate the civilian economy with an abundance of scientific discoveries.

It would be impossible, of course, to spend the $26 billion that President Reagan is seeking for SDI research without turning up some knowledge that can be turned to civilian use. But today the real menace to national security is the high-tech international competition that is walloping the American economy. And the key question is whether the United States can afford to tie up much of its outstanding technical talent in a futile military extravaganza while hoping for a bonus for civilian needs.

The answer is that we can't. And that's why SDI's enthusiasts are pushing the spinoff theme as an assurance that SDI will boost, rather than drag down, the civilian economy. According to the widely repeated forecast of a private consulting firm, Business Communications Co., SDI will eventually spawn $5 billion to $20 billion in sales of civilian products. That range of dollars is so broad that it's meaningless. Furthermore, the real issue isn't gobs of dollars on the distant horizon. It's how we can best use scarce resources, and it's doubtful that the answer is by dumping them into "Star Wars."

The spinoff spiel collects some credence from the fact that science and the military are old collaborators. Their partnership goes back at least to ancient times, when the skills of blacksmiths and the needs of warriors laid the foundation for what evolved into metallurgical science. Later, explosives became central to warfare and mining. And so on into modern times, in which the urgencies of war accelerated the development of aircraft, electronics, antibiotics and a slew of other products that characterize our era.

Why can't it go on like that, with SDI as an engine that will help speed us toward the technologies of the next century?

The answer is that for many centuries civilian and military requirements overlapped a great deal and in many instances were identical. But in recent decades military technology has diverged toward exotic, high-performance capabilities that are remote from civilian needs—as remote, say, as a 300-m.p.h. racer is from the requirements of commuter bus service.

Many military and civilian airplanes formerly originated on the same drawing boards. The venerable Boeing 707 commercial transport and the Air Force KC-135 tanker are twins in their basic design and engineering. But the happy process of two for one no longer applies. Our latest bomber, the supersonic B-1, has spawned no civilian counterpart, nor has the wide-body generation of civilian transports led to military applications.

Meanwhile, in the economically critical field of electronics Japan has taken the lead in manufacturing today's consumer products and the basic chips for the next generation of marketplace winners. The Japanese have worked long and hard for this triumph, and we've helped them along to their competitive lead. About 30% of all American spending for research and development goes to the military. The Japanese spend only 2% of their R&D money on military programs.

The irrelevance of Star Wars to civilian needs is typified by the hurrahs for progress in the development of the rail gun—an electromagnetic device that can hurl a projectile at speeds unattainable by other means. The rail gun is indeed a technological marvel, with a potential for numerous military roles. But its value for civilian needs is remote; maybe there is none.

The Star Wars hucksters insist that the money voted for their passion would otherwise go unappropriated by Congress, and that therefore the civilian benefits, no matter how small, would be a bonus.

That argument has long been pushed to justify big research budgets for the Pentagon and crumbs for the government's civilian research programs. With American industry now taking a beating in the high-tech fields in which it has traditionally led the world, the spinoff thesis is increasingly threadbare.

The reality of the Strategic Defense Initiative is twofold: Militarily it's a loser, and it's a costly and inefficient way to subsidize civilian research.

Daniel S. Greenberg writes a syndicated column, and is editor and publisher of the newsletter Science & Government Report.

SDI HAS ALREADY PROVED A $6-BILLION OPPORTUNITY FOR MANAGERS TO REAP PROFITS FROM

DEFENSE BUSINESS

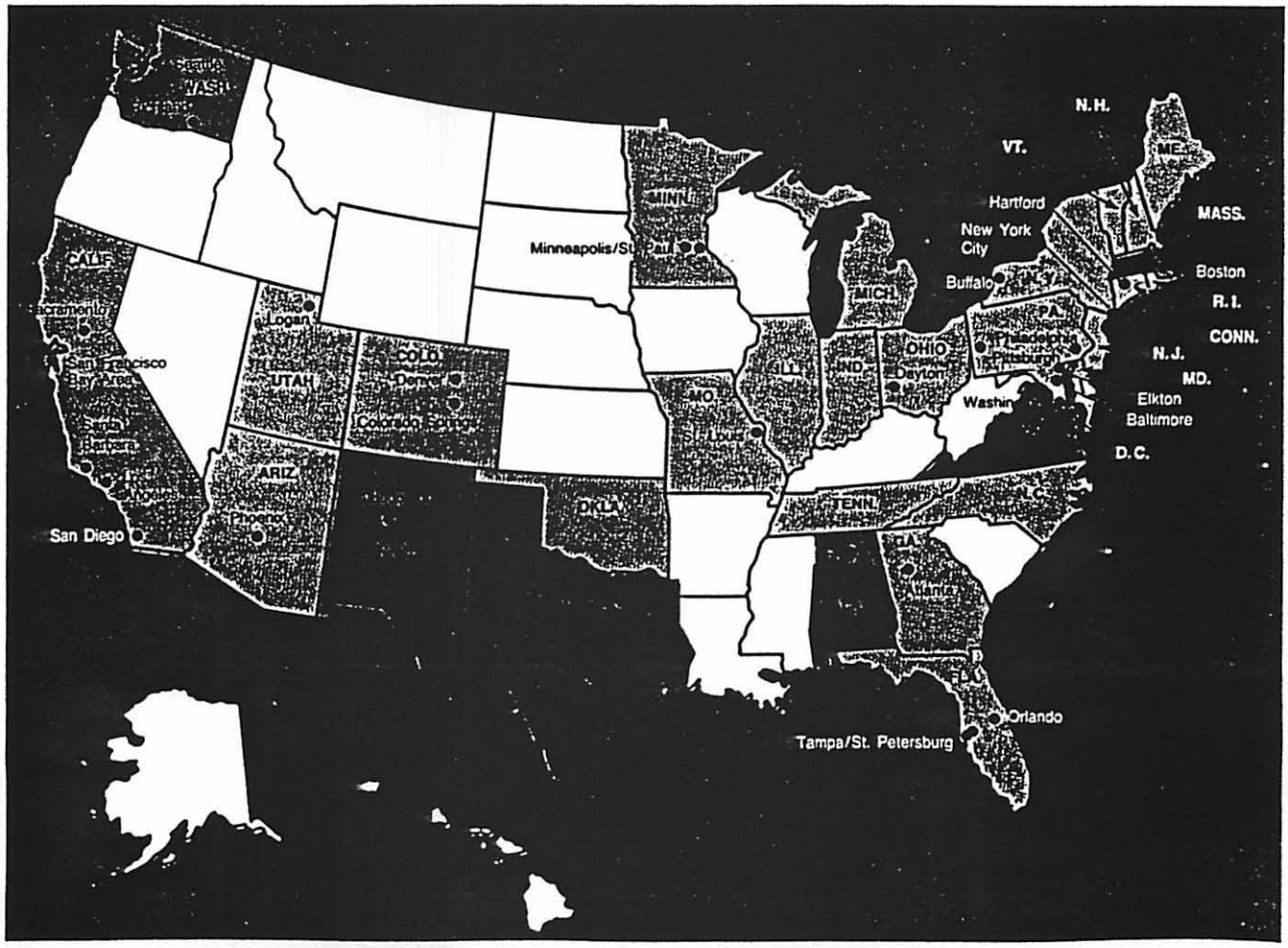
Theresa M. Foley/Washington

The Strategic Defense Initiative research program, while spending billions of dollars to develop technology for possible future space-based weapons, may bring unexpected side benefits to commercial and terrestrial industries that are positioned to capitalize on SDI technology spinoffs or to serve as subcontractors or suppliers.

Steps are being taken now within SDI management to allow U. S. industry to capitalize on SDI technology transfer in the same way that civilian space projects have stimulated terrestrial economic growth for years. Hundreds of new products were introduced in the United States by creative commercial enterprises as a result of the $24 billion the National Aeronautics and Space Administration spent on the Apollo program in the 1960s and 1970s. SDI holds the same potential. Billions more will be spent on SDI in the coming years, and while much of that money will go to the traditional defense industry, a significant amount is likely to end up with small business and non-defense firms.

"What if free people could live secure in the knowledge that their security did not rest upon the threat of instant U. S. retaliation to deter a Soviet attack; that we could intercept and destroy strategic ballistic missiles before they reached our own soil or that of our allies?"

Placing that question before the American public on Mar. 23, 1983, President Reagan embarked on the controversial, multibillion research program officially known as the Strategic Defense Initiative and often referred to as Star Wars. Although SDI may eventually lead to the deployment in space of dozens or hundreds of weapons that could defend against nuclear missile attack, the currently structured program does not represent a decision to deploy such a system.



Green shading over California indicates its rank as No. 1 among the 50 states in Strategic Defense Initiative contracts, with over $2.6 billion. Six states, shown in orange, have over $100 million in SDI contracts. States shown in tan have contracts valued at between $1 billion and $100 billion. Urban areas drawing more than $10 million in SDI business are designated with red dots. Los Angeles area businesses boast $1.5 billion in SDI contracts.

Instead, the Defense Department has undertaken an intensive research and development program that is resulting in the expenditure of billions of dollars on promising technologies that might allow an effective shield to be deployed in the coming decades. Much research in SDI-related areas had begun before Reagan announced the new program, which has created a central organization for the technology efforts and drawn enormous public attention.

A ballistic missile defense system would need multiple layers of defense to have any hope of destroying all attacking missiles.

The Strategic Defense Initiative is organized into five main technical areas:

- **Surveillance, Acquisition, Tracking and Kill Assessment,** known also as SATKA. Sensors would detect the launch of attacking missiles, identify and track them. A key problem in this area is developing a method for sensors to tell the difference between decoys and real warheads. Kill assessment will determine whether a target missile has been knocked out so that resources are not wasted by expending effort on targets that already have been killed.
- **Directed energy.** Weapons based on this technology would use directed energy, such as lasers or particle beams, to destroy an attacking missile. A laser, which stands for light amplification by stimulated emission of radiation, creates an intense, single-wavelength beam of light.
- **Kinetic energy.** Weapons based on this technology would use a projectile or other object moving at a very high speed to knock out an attacking missile.
- **Battle management and command, control and communications.** Technologies in this area allow information to be processed and decisions to be made. Because a nuclear attack would allow only a few minutes to make a response decision, highly reliable automated equipment would be needed to control the system with minimal human involvement.
- **Survivability and lethality.** SDI weapons will require protection from attack, so a strong effort is being undertaken to develop the means to safeguard the system from enemy attack. Lethality is aimed at determining the damaging effects of various weapons that might be deployed in an SDI system and target hardening attempts to determine what countermeasures might be taken to protect the attack missiles from being knocked down by SDI.

The Strategic Defense Initiative program has awarded more than $6 billion in contracts since it started in 1983, and it is expected to offer excellent future business opportunities for industry, universities and national laboratories. Contractors—including for-profit companies and non-profit organizations—stand to reap billions of dollars in SDI awards every year.

While entrepreneurs and nondefense contractors may not have much chance of winning large SDI contracts, they may be assisted by a new technology transfer program that SDI is establishing. The program would help commercial users obtain unclassified SDI-related technology to develop new products. The technology

Technician at Lawrence Livermore National Laboratory works on one of 190 accelerator modules of the advanced test accelerator, which is used in research on free-electron lasers for the Strategic Defense Initiative.

transfer program, in the early planning stages now, could be available by the end of 1986, Col. James A. Ball, SDI deputy director for civil applications, said.

If the program is approved, SDI-developed technologies will be reviewed to identify those with potential industry applications. Abstracts describing technology that may be useful will be stored in a data base that can be accessed by persons or companies on the qualified U. S. contractor list. Access to the data base will be restricted to persons or organizations that have signed a military critical technology data agreement certifying that the information will be used for legitimate business purposes and will not be transferred to a foreign entity.

Within a year, there may be as many as 1,000 entries in the data base, according to Ball. Although Ball could not cite examples of technology that will be in the SDI data base, he described civil applications that have grown out of other Defense Department technology transfer programs. Technology for a spinal bypass technique that can help paraplegics walk was spun off from a Navy antisubmarine warfare program. Laser technology frequently has been applied to medical procedures and advanced composite technology has been used to develop new materials for sporting goods such as skis.

The technology in the data base will be developed by government laboratories or companies receiving SDI funding.

An analysis of SDI contracts shows that most of the money is going to a handful of organizations that are located in a few concentrated geographical pockets of the United States. The SDI budget, at $4.8 billion in Fiscal 1987, is still well below either the National Aeronautics and Space Administration or the Air Force space budgets. But the faster growth of the SDI budget, which climbed from $1.4 billion in Fiscal 1985 to $2.8 billion in Fiscal 1986 and $4.8 billion in Fiscal 1987, could boost SDI far ahead of other government space organizations in terms of contracting power in the coming years. SDI is a favorite of President Reagan and has been exempted from the Gramm-Rudman-Hollings deficit reduction bill.

In a time when many space projects and some areas of U. S. leadership in aerospace technology are being threatened by severe budget cutbacks, the SDI organization is overseeing technology development budgets that have almost doubled every year in the last few years.

Chart below was compiled by the Federation of American Scientists. Amounts include funds that have been obligated over the last three fiscal years, that are obligated in future years and some priced contract options still to be exercised. In listing Lawrence Livermore at the top, FAS estimates Livermore will receive $500 million for a free electron laser to be built over the next three years.

SDI OFFERS SPACE-BASED BILLION-DOLLAR BONANZA

UNIVERSITIES, RESEARCH FIRMS AND PRIVATE ENTERPRISE CASH IN ON SDI

RECIPIENT	1983-86 CONTRACTS
DOE Lawrence Livermore	$725,257,000
General Motors	$578,807,751
Lockheed	$520,524,798
TRW	$354,166,146
McDonnell Douglas	$349,773,029
Boeing	$346,215,059
DOE Los Alamos Lab	$195,961,000
Rockwell International	$187,750,235
Teledyne Inc.	$179,922,886
EG&G	$139,600,000
Gencorp Inc.	$134,794,456
Textron	$92,796,098
DOE Sandia Labs	$91,830,000
LTV Corp.	$90,417,238
Flow General	$89,428,179
Raytheon Co.	$72,049,148
Science Applications	$69,136,451
Honeywell	$68,541,289
Nichols Research	$66,477,069
MIT Lincoln Lab	$61,069,000
Westinghouse Electric	$59,589,274
Martin Marietta	$58,837,850
Litton Systems	$56,947,276
DOE Hanford National Lab	$40,000,000
BDM International	$38,834,105
Utah State Univ.	$38,556,373
Grumman	$37,439,877
Univ. of Texas	$33,232,892
Burroughs	$32,504,111
General Dynamics	$32,290,350
General Electric	$31,305,629
Ford Motor	$30,059,852
W. J. Schafer	$29,265,451
Karman Sciences	$29,110,692
Sparta Inc.	$28,007,873
United Technologies	$27,848,878
Georgia Inst. of Tech.	$27,218,594
Western Research	$25,413,960
AF Weapons Lab	$22,977,000
Stanford University	$22,247,164
Logicon	$21,894,812
Dynetics Inc.	$20,871,835
Atlantic Research Corp.	$19,577,465
Ashland Oil	$19,100,000
Charles S. Draper Labs	$18,322,576
Morton Thiokol	$16,437,046
Mission Research	$15,959,721
SRS Technologies	$15,421,574
Control Data Corp.	$13,956,517
Army Corps of Engineers	$13,693,000
AF Geophysics Lab	$13,190,000
Computer Sciences Corp.	$12,581,928
Adaptive Optics	$12,173,130
Physical Research	$12,063,598
Mass. Gen. Hospital	$11,950,000
New Technology Inc.	$11,371,842
NASA	$11,130,000
Vetco Inc.	$10,723,271
Perkin-Elmer	$10,699,490
SRI International	$10,544,802
Riverside Research	$10,434,518
Maxwell Laboratories	$10,135,138
UK Atomic Energy Auth.	$10,000,000
Naval Research Laboratory	$9,874,833
AF Space Command (BMO)	$9,800,000
Allied Signal	$9,779,618
Hercules	$9,421,114
IBM	$9,284,725
Systems	$9,283,854
Army BMD Adv. Tech. Center	$9,201,000
U.S. Philips Trust	$8,748,104
GTE Devices	$8,661,846
GA Technologies	$8,248,298
Bellcore Research Inc.	$8,037,217
Calspan Inc.	$8,005,444
Goodyear	$7,903,756
Aerojet	$7,825,946
Applied Technology Assoc.	$7,459,282
PDA Engineering	$7,349,000
Automated Sciences Group	$7,110,929
Univ. of California	$6,876,960
System Planning Corp.	$6,686,416
Texas Instruments	$6,254,183
AF Electronic Systems Div.	$6,119,000
Inst. for Defense Analysis	$5,883,000
Univ. of Dayton	$5,869,108
Sperry Corp.	$5,844,808
Centro Soy Development	$5,829,056
Acuray Corp.	$5,679,416
Army Missile Command	$5,596,000
Battelle	$5,525,683
Arthur D. Little	$5,483,924
Carnegie Mellon Univ.	$5,384,127
Johns Hopkins University	$5,292,000
GTE Corp.	$5,284,354
Northrop	$5,207,825
Motorola	$4,990,266
State University of N.Y.	$4,975,682
Physics International	$4,900,101
Titan Systems Inc.	$4,856,389
DOE Brookhaven Nat'l. Lab	$4,842,734
Naval Sea Systems Command	$4,687,000
Time and Space Processing	$4,648,841
Auburn University	$4,566,080
Army White Sands M.R.	$4,540,000
Arvin Industries Inc.	$4,426,423
Defense Nuclear Agency	$4,002,000
Texas Tech University	$3,965,055
Planning Research Corp.	$3,906,849
Penn State University	$3,805,638
New York Polytechnic	$3,800,000
S-Cubed	$3,798,000
Physical Dynamics	$3,776,002
Thermacore	$3,767,110
Analytic Decision	$3,701,000
Optical Sciences	$3,690,896
Eastman Kodak	$3,560,920
Naval Surface Weapons Ctr.	$3,532,700
IIT Research Institute	$3,348,564
Physical Sciences	$3,339,573
Coleman Research	$3,269,885
AF Space Division	$3,261,000
MIT	$3,117,000
Fenix & Scisson	$3,050,000
Alphatech Inc.	$2,951,269
Eng. & Econ. Research	$2,770,955
Univ. of Arizona	$2,643,633
Cubic	$2,608,028
Washington Patrol Service	$2,546,202
Army Letterman Inst.	$2,500,000
Uniformed Services Univ.	$2,500,000
Polaris	$2,498,175

Lawrence Livermore National Laboratories is the top SDI contract winner, with about $725 million in awards since 1983, according to statistics filed by the Federation of American Scientists (FAS). In listing Livermore at the top, FAS estimated the lab will receive $500 million for its contribution to a free electron laser that will be built at White Sands, New Mexico, over the next three years. A free electron laser is a shortwave laser that tunes its wavelength by passing its beam through "wiggler magnets."

Livermore also holds a $210-million contract for the Excaliber program, an X-ray laser driven by a nuclear explosion.

General Motors/Hughes Aircraft is the number two contractor with $580 million in contracts. Hughes holds large subcontracts on several SDI programs, including airborne optical sensor, exoatmospheric reentry vehicle interception system and high endoatmospheric defense interceptor.

Lockheed, with $520 million in contracts, is in third place. Lockheed's big SDI contract is the exoatmospheric reentry vehicle interception system (ERIS), a ground-based optically guided rocket for midcourse nonnuclear hit-to-kill reentry vehicle interception.

TRW, the main contractor on the Alpha laser program, holds $354 million in SDI contracts awarded since 1983. Alpha is a chemical laser technology development project that would have space-based laser applications. Next on the list is McDonnell Douglas, which holds $350 million in SDI awards. McDonnell Douglas' big project is the high endoatmospheric defense interceptor, a ground-based nonnuclear kill interceptor for terminal defense.

Boeing Aerospace, the sixth largest SDI contract winner, is developing the airborne optical sensor, a missile tracking system mounted on a modified Boeing 767, which uses laser and infrared sensors.

All of the above organizations, with the exception of Boeing, have major installations in California. Companies and universities in California have received more than 54 percent of SDI contracts over the last three years, according to data compiled by the FAS. In fact, more than 93 percent of SDI contract funds have been spent in 10 states: California, 54.4 percent; New Mexico, 8.5 percent; Massachusetts, 7.9 percent; Alabama, 7.5 percent; Washington, 6.4 percent; Texas, 2.7 percent; Virginia, 1.9 percent; New York, 1.6 per-

Naval Ocean Systems Ctr.	$2,390,000	Ralph M. Parsons Co.	$1,298,025	AF Rotomam AFB	$970,000	Naval Weapons Support Ctr.	$600,000
Mayo Foundation	$2,370,000	Varian Associates	$1,295,218	Beta	$945,616	Infotec	$598,639
Applied Research Inc.	$2,314,609	Acsi Inc.	$1,244,240	Optical Coating Lab Inc.	$941,209	Univ. of New Mexico	$594,875
Analytic Services	$2,290,000	Optimization Technology	$1,242,896	Research	$926,636	Mandex	$588,800
Fiber Materials Inc.	$2,232,525	Univ. of Massachusetts	$1,239,864	Austin Research	$925,395	CVD Inc.	$572,415
Computer Science Appl.	$2,214,600	AF Materials Lab	$1,222,000	National Bureau of Stds.	$924,000	Creative Arts Studio	$567,093
Ceradyne	$2,156,725	Advanced Info. & Decs.	$1,205,942	Space Power Inc.	$906,569	Integrated Systems Inc.	$556,589
California Inst. of Tech.	$1,963,911	Univ. of Utah	$1,200,000	Univ. of Maryland	$880,862	Spectron Development Labs	$552,653
Univ. of Alabama	$1,941,811	Baylor University	$1,200,000	California State Univ.	$868,000	Texas A&M University	$550,000
S-Systems	$1,937,000	Creare Inc.	$1,128,745	Space Vector	$842,088	Univ. of Michigan	$547,308
Bedford Research	$1,924,996	AF Arnold Eng. Dev. Ctr.	$1,127,000	La Jolla Institute	$830,603	Continuous Goerz Corp.	$538,000
Orlando Technology	$1,922,922	Rand	$1,120,548	Science Research	$818,021	Photometrics	$527,867
Advanced Research & Appls.	$1,894,000	Univ. of S. Calif.	$1,116,641	Sci Tec Inc.	$815,859	AF Avionics Laboratory	$500,000
Army Kwajalein Missile Rg.	$1,894,000	Aeronautical Research	$1,100,000	Desa Research and Eng.	$813,758	AF Technical Appls. Ctr.	$500,000
Army Materials Tech. Lab.	$1,850,000	Brown University	$1,100,000	AF Armament Tech. Labs	$800,000	Army Armament R&D Command	$500,000
Spectra Tech.	$1,829,448	Colorado School of Mines	$1,100,000	DOE Lawrence Berkeley Nat.	$800,000	Army Finance Center	$500,000
Int'l Software Sys.	$1,785,383	Drexel University	$1,100,000	AF Western Space/Mssl. Ctr.	$778,000	Defense Tech. Supply Ctr.	$500,000
Central Intelligence Agcy.	$1,725,000	Rensselaer Polytechnic	$1,100,000	Practical Technology	$764,000	Naval Air Test Center	$500,000
IAP Research	$1,670,000	Ultrasystems Inc.	$1,100,000	Univ. of Washington	$747,824	Loyola Research	$494,857
Photon Research	$1,664,001	Univ. of Florida	$1,091,413	Univ. of Illinois	$747,411	AF Rocket Prop. Lab.	$490,000
Sanders Inc.	$1,640,921	Directed Technologies	$1,068,626	Computer Corp. of America	$745,246	Tektronix Inc.	$487,000
Jaycor	$1,633,481	Purdue University	$1,062,995	Visionic	$727,000	Scientific Systems	$476,233
Ball Corp.	$1,624,033	Geo-Centers Inc.	$1,061,781	Dept. of Energy	$690,000	Microwave Associates	$474,921
Aptek	$1,575,463	Environmental Res. Inst.	$1,052,871	Engineering Analysis Inc.	$673,594	Lockie Williams	$469,474
Syracuse Research Corp.	$1,513,920	Auburn Research	$1,041,562	AF Gen. AFB	$670,000	Automated Data Mgt.	$457,220
MITRE Corp.	$1,492,000	Technology International	$1,038,753	Hartz Corp.	$658,000	Par Technology	$454,860
Electro-Magnetic Appls.	$1,490,793	Princeton University	$1,037,000	Univ. of Florida	$650,498	New York Inst. of Tech.	$447,508
EML Research	$1,479,625	Syracuse University	$1,032,861	Systems Integration	$640,217	Army BMD Systems Command	$439,000
DOE Oak Ridge Nat'l Lab.	$1,400,000	Dynamic Enterprises	$1,018,597	Aves Inc.	$635,666	Mactal	$432,273
U. of Berkeley	$1,386,000	Asst. Director Walton	$1,000,000	MEI Associates	$613,172	John Cockerham Assoc.	$412,475
Northwestern Univ.	$1,349,000	Dataraps Inc.	$995,076	Dynamics Research	$612,000	Optimetrics	$412,089
Rockcor Inc.	$1,314,966	Univ. of Wisconsin	$982,755	AF Flight Dynamics Lab	$610,000	Univ. of Tennessee	$403,352
Army Harry Diamond Labs.	$1,300,000	Anamet Labs	$980,000	(Unknown)	$609,000		

Continued on next page

cent; Colorado, 1.3 percent, and Maryland, 1.1 percent.

The best cities for a company to be located in to increase its odds of holding SDI awards are Los Angeles, the San Francisco Bay Area, Albuquerque, Boston and Huntsville, Alabama, according to FAS statistics. FAS has been compiling statistics on SDI contracting since last summer and plans to publish a comprehensive report soon.

SDI money is spent on both research and technology demonstrations in several advanced areas that have space and ground applications. Ground-based lasers and kinetic energy weapons, which could be used in systems that would shoot down incoming ballistic missiles, are heavily funded. Laser and particle beam funding, included in the directed energy weapons program element, grew from $378 million in Fiscal 1985 to $1.615 billion two years later. Kinetic energy weapons, which include electromagnetic railguns and other systems that would knock down missiles by firing small, high-speed projectiles at the attacking rockets, also has an expanding budget. In Fiscal 1985, kinetic energy weapons received $256 million. The request for Fiscal 1987 had grown to $1.002 billion.

Sensors and surveillance systems would provide notice of the launch of enemy missiles and allow the attacking rockets to be tracked in the boost phase, in space and during reentry into the atmosphere. The surveillance program includes technologies to allow a weapon to discriminate between an armed reentry vehicle and decoys. The surveillance program, with a budget that grew from $546 million in Fiscal 1985 to $1.262 billion in Fiscal 1987, includes research in radar technology, signal processing, lasers and infrared sensors.

Battle management and command, control and communications (C^3) was funded at $100 million in Fiscal 1985, and has grown to $462 million in Fiscal 1987. Much of the work in this area is focused on the highly sophisticated computer software necessary to run a strategic defense system, if one is deployed.

In the survivability and lethality area, the SDI organization spent $108 million in Fiscal 1985 and has requested $454 million for Fiscal 1987. These funds will be spent on technologies that would allow a strategic defense system in space to be protected from attack. Methods of protection include shielding and hardening against lasers or radiation. ●

RECIPIENT	1983-86 CONTRACTS
SSG Inc.	$402,938
Sohar Inc.	$402,478
Carl Zeiss	$400,216
Small Bus. High Tech. Inst.	$400,000
Control Dynamics	$398,268
Pulse Sciences	$397,379
H.H. Aerospace	$396,449
Harold Rosenbaum	$396,000
Microwave Monolithics	$394,580
Plasma Research	$393,000
Helix Technology Corp.	$385,000
Yale University	$375,000
Ferrionics Corp.	$373,789
Univ. of Denver	$371,716
Research Support Instrum.	$350,545
Army Research Office	$350,000
Naval Intell. Support Ctr.	$350,000
Aerodyne Research	$336,421
3-C System	$335,524
Dynalectron	$331,000
Polytechnic Inst. of N.Y.	$325,240
Pacific Sierra Research	$323,451
AF Rome Air Dev. Ctr.	$320,000
Radowski Associates	$308,859
EOS Technologies	$307,928
Talandic Research	$306,856
Science and Tech. Assoc.	$301,000
Technical Assistance Inf.	$300,177
Pennwalt Corp.	$300,000
Software Productivity	$295,000
Surface Optics Corp.	$287,745
Kent State University	$275,869
ETA Corp.	$273,601
AF Foreign Technology Div.	$270,000
Univ. of Pittsburgh	$264,830
B-K Dynamics	$258,000
Technology Service Corp.	$257,000
Measurement Concept Corp.	$253,544
Geonautics	$252,800
New Mexico Inst. of Mining	$249,995
Impact Inc.	$249,993
Naval Weapons Center	$239,000
Effects Technology	$233,000
SCEEE Inc. Ed. Mgt. Office	$232,448
Boston College	$228,000
DOE Pacific Area Spot. Off.	$215,000
Brigham Young Univ.	$214,620
Xerod	$205,000
Army Missile Intell. Agcy.	$200,000
General Electric (UK)	$200,000
DOE Albuquerque Ops.	$200,000
Patel Enterprises	$199,925
Optel	$199,511
Ectron Corp.	$199,117
Xontech	$199,000
Science and Eng. Assoc.	$197,215
Analytic Sciences	$192,700
White Scientific	$192,440
CSA Eng. Inc.	$187,124
Triad	$184,009
New York University	$179,500
Electro-Optek	$175,515
General Services Admin.	$172,000
Univ. of Iowa	$161,139
Lehigh University	$160,000
Rohm and Haas	$158,000
DCS Corp.	$154,818
MMR Tech.	$152,000
Spire Corp.	$150,000
Southwest Research Inst.	$149,000
Triel	$148,954
Electronic Decisions	$145,781
Ferranti	$142,500
Heriot-Watt University	$142,500
Analytical Systems	$141,000
Fairchild Space Co.	$138,836
Advanced Kinetics	$136,410
Army Laboratory Command	$131,000
Southern Research Inst.	$129,543
Old Dominion Univ.	$129,440
Ann Arbor Nuclear	$122,857
Energy Resources Group	$122,857
Rasor Assoc.	$122,857
MJR Inc.	$122,213
Univ. of Oklahoma	$119,922
Berner, Lampohler, & Assoc.	$117,151
Vanguard Research Inc.	$117,000
Schlumberger	$115,000
Mountain Valley Energy	$114,267
Xerox	$112,727
Alabama A&M	$110,000
Univ. of Kansas	$110,000
Dept. of the Interior	$108,000
Tinsley Labs	$108,000
FMC	$105,986
Artec Associates	$100,000
Kansas State University	$100,000
Nat'l Ocean & Atmo. Ad.	$100,000
Technical Research Assoc.	$100,000
Pacific Missile Test Ctr.	$100,000
Comptek Corp.	$99,468
Pacific Applied Research	$99,407
Tracor	$98,000
Army Armament Command	$94,000
Radiation Research	$92,984
Strategy Corp.	$88,222
Lambda Physik	$87,200
Applied Research Assoc.	$85,000
Hyatt Regency	$84,900
Computer Code Consultants	$84,598
Information Sys. Network	$81,657
Harvard University	$80,000
Montana State	$79,982
Great Lake Science	$77,119
J.H. Wiggins	$73,245
Astron Research	$72,705
AF Alaskan Air Command	$70,000
USAF	$70,000
Pinnacle Research	$67,555
K-Tech Corp.	$67,000
Orincon	$66,968
Vanderbilt Univ.	$65,000
Soniaraft	$59,048
Aerospace Corp.	$55,000
AF Space Tech. Center	$55,000
Naval Post Grad.	$55,000
Colorado State Univ.	$50,000
Leading Technologies	$50,000
Material Concepts	$50,000
Potomac Digital	$50,000
Atmospheric Science Lab.	$50,000
Adaptive Sensors Inc.	$49,956
Schwartz Electro-Optics	$49,895
Cyberdynamic Inc.	$49,615
General Systems Grp.	$49,615
Adaptive Technology	$49,000
Ultramet	$47,645
Marquardt	$46,263
John Brown Associates	$45,325
AF Office of Sci. Res.	$45,000
Systems & Appl'd. Sciences	$44,403
Tulane University	$41,320
Univ. of Nevada	$40,700
Destiny Plus Two	$35,189
Prime Source Associates	$35,189
Univ. of Wyoming	$34,500
Systems Control	$28,120
Astrophysics Res. Corp.	$28,000
AF Logistics Command	$23,000
International Tech. Corp.	$20,000
Space & Naval Warfare Com.	$20,000
Information Sciences	$15,000
AF 5010th Combat Sppt. Grp.	$10,000
M&W Microfilm	$10,000
Mosler Gov't. Sales	$5,587
Microcoatings	$4,440
IRT Corp.	$2,000
Business Machines of Am.	$664
Ebsco Subscription Svce.	$427
Huntsville Radio	$290

Source: Federation of American Scientists

NEW YORK TIMES MAGAZINE 24 AUGUST 1986 (25) Pg. 19

THE STAR WARS SPINOFF

The controversial defense system is yielding technologies that seem sure to change the world.

By Malcolm W. Browne

THE LANDSCAPED INDUSTRIAL park that flanks San Diego's Balboa Avenue hints of well-appointed board rooms, robotic assembly lines and healthy workers bronzed by weekends on the nearby beaches. The street is only a few minutes' drive from Sea World and other tourist magnets, and to the casual visitor it seems as far removed as an American suburb could be from any hint of war or weaponry. But the peaceful mien of the neighborhood is disturbed several times a week by the blast of a stunningly powerful cannon that sends flocks of startled birds into the air and sets off burglar alarms in parked cars over a wide area.

The source of the noise is one of the world's first rail guns, a new breed of electromagnetic artillery potentially capable of piercing the most heavily armored tanks, of picking off intercontinental missiles and battle satellites, and even of hurling projectiles to distant planets.

The rail gun, built by Maxwell Laboratories Inc., and named Checmate (an acronym for Compact High Energy Capacitor Module Advanced Technology Experiment), is about the size of a large merry-go-round and stands in a hangarlike building. One recent morning, flashing red lights and insistent loudspeakers warned nonessential personnel away while technicians sealed off the test building and retreated to the safety of a control shack. As the countdown progressed, pictures and computer data flowed across monitor screens, and workers readied the lasers, X-ray flash cameras and diagnostic sensors used for assessing each shot. The whine of high-power electrical equipment rose to a scream, a supervisor nodded to a controller, and the rail gun fired, sending a shudder through the factory compound, slapping clothing against the legs of passers-by and leaving ears ringing.

Hastily donning gas masks, technicians swarmed into the smoke-filled rail-gun building to look for equipment damage and check the target. Incredibly, a metal projectile scarcely larger than a household nail had been driven into a sandwich of thick steel plates to a depth of several inches. "Nice clean shot," someone observed. "We're moving right along."

In fact, experts say, American efforts to develop an electromagnetic rail-gun launcher — a gadget conceived by weapons makers as long ago as World War I — have achieved in the last two years alone what Defense Department planners had once predicted would take a decade. And credit for the project's impressive progress goes to what may be the most costly and intensive military research program in history: the Strategic Defense Initiative. Together with hundreds of other arcane, high-technology devices, ideas and systems, the rail gun has been selected for grooming and development as part of President Reagan's controversial vision of a defense shield capable of defending the United States against a Soviet ballis-

Malcolm W. Browne is a science reporter for The Times.

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DEFENSE NEWS 25 AUGUST 1986 Pg. 24

Sweeney Pushes Education on 'Stealth' Technology

Representative Says Insight Into Program Will Heighten Congressional Support for ATB

Special to Defense News

WASHINGTON — Rep. Mac Sweeney (R-Texas) is encouraging members of Congress to get classified briefings on "Stealth" technology so they will understand the "revolutionary capabilities" of the planned Advanced Technology Bomber (ATB).

He said this learning will lead to increased support for the Stealth bomber, planned as a 1990s companion and follow-on to the fleet of 100 B-1B bombers.

In a recent letter to his colleagues, Sweeney said, "The vast majority of unfavorable comments about the (ATB) program come from people who are not completely educated" about it.

Sweeney has joined with Rep. Nick Mavroules (D-Mass.) in sponsoring a bipartisan House resolution (HJR662) to express congressional support for the ATB.

The resolution noted the ATB will be capable of evading present and future Soviet air defense systems, force the Soviet Union to concentrate on defensive rather than offensive systems and represents a technology "we cannot afford to ignore."

The secret nature of the advanced technology program makes it an easy mark for attack and misinformation. "Any congressman who takes the time to get a classified briefing will understand our confidence in the ATB system and the tremendous capabilities it has to offer," Sweeney said.

He expressed opposition to spending millions of dollars for keeping the B-1B "production line warm" at Rockwell International after the last of the 100 bombers are delivered by spring 1988.

He said the ATB program "is on schedule and on budget," and praised both the Air Force and Northrop Corp., the ATB contractor, in the management of the high-technology program.

"Only ignorance and misinformation stand in the way of wholesale congressional support for the ATB," Sweeney said.

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tic-missile attack.

The merits of the President's plan — promptly bed "Star Wars" by advocates and opponents e — have become a matter of intense world-de debate. Supporters see it as a means of ending the threat of nuclear devastation. Opponents charge that the program is an exorbitant boondoggle whose stated objective is ruled out by the limitations of technology. Worse, these critics contend, Star Wars defenses might so upset the fragile balance of forces between East and West that war might become more rather than less likely.

Yet even as the debate has raged, Star Wars research has moved ahead quickly, consuming more than $3 billion in the last year alone, and giving unprecedented momentum to a broad range of advanced scientific programs.

The exotic new materials and technologies produced or encouraged by Star Wars research promises to have particular importance for conventional warfare, fostering changes in land combat as radical as those wrought by the introduction of gunpowder in the Middle Ages. But spinoffs from the President's initiative are also finding their way into a myriad of civilian fields, including energy production, transportation, communications and medicine. Meanwhile, science itself is gaining new research tools from S.D.I. projects.

Critics of S.D.I. point out that the technological side benefits of Star Wars research could be had much more cheaply and efficiently if they were pursued directly rather than as the unintended offshoots of an extravagant military spending program. But S.D.I. proponents assert that in the absence of such a visionary scheme, it is unlikely that such research would have taken place at all. Weapons research, they say, has been a key element in technological progress throughout histo- and has nearly always produced byproducts of mense value to mankind. Costly though World War II was in human suffering and destruction, for example, wartime research bequeathed a cornucopia of consolation prizes to the survivors, including plastics, synthetic textiles, antibiotics, jet aircraft and nuclear energy.

How far the President's vision of a space-based strategic defense will ultimately be carried is an open question. Spurred by concern over Federal budget deficits, Congress has already voted significant cuts in S.D.I. funds, and even the program's strongest supporters concede that enormous technical obstacles still loom ahead.

Yet, even if a continental defense is never actually deployed, the long-term impact of S.D.I. research programs promises to be enormous. In laboratories from San Diego to Boston, Star Wars is no longer a mere phrase or debating point. For better or worse, the controversial Strategic Defense Initiative is already yielding new technologies that seem destined to change the world.

AIR FORCE LIEUT. GEN. JAMES A. ABRAhamson is no stranger to monster-size Federal projects. From 1976 to 1980, he ran the Air Force program that developed the F-16 fighter. Later, he took charge of space-shuttle development for the National Aeronautics and Space Administration, a post he held until 1984.

Now, as director of the Pentagon's Strategic Defense Initiative Organization (S.D.I.O.), the 53-year-old General Abrahamson is responsible for what may turn out to be the biggest Federal research project ever. He currently oversees the distribution of about $6 billion to some 1,300 Star ars contractors in a program whose size rivals even that of the Manhattan Project, the secret World War II program that created the atomic bomb. (The Manhattan Project, from its inception to the destruction of Hiroshima and Nagasaki, cost $2 billion in 1945 dollars, equivalent to approximately $12 billion today. The current five-year S.D.I. program, which is intended merely to assess possibilities rather than to build a working weapons system, is expected to cost up to $20 billion.)

"When I got here," General Abrahamson said recently as he shared a sandwich with a visitor to his gadget-strewn Pentagon office, "I began looking for a common denominator in all the big technology programs that had been successful — a common factor applicable to S.D.I. But I couldn't find one. For instance, both the German and British jet-propulsion programs were highly successful, but they achieved success under totally different conditions.

"Finally, I came to realize that the common denominator was to be found not in the successful programs, but in the programs that had failed or come in second best. An example was the German atomic-bomb program of World War II, a program that was so highly structured and formal that it was unable to correct itself. By contrast, the Manhattan Project was dynamic, contentious, full of scientific give-and-take, and therefore capable of speedily correcting its own errors.

"I concluded that we needed the same rough-and-tumble intellectual approach — the American approach — to S.D.I. research. I decided that it was better to achieve 90 percent of a bold solution than 100 percent of a timid solution."

The resources now dedicated to finding that "bold solution" represent an enormous national commitment. During the last year, American taxpayers have paid some $3.05 billion for S.D.I. research — nearly $13 for every man, woman and child in the country — and the administration has requested $5.3 billion more in Star Wars money for the coming year. Even if Congress succeeds in cutting this sum — both the House and Senate have voted substantial reductions — S.D.I. will still remain an important component of the national budget.

Star Wars research, moreover, gets contributions from many sources besides formal S.D.I. appropriations. The Strategic Defense Initiative Organization is less than three years old, and virtually all the projects now under its aegis began with other government agencies and organizations. Overlapping research objectives and financing persist, and much of the technology developed by the Defense Advanced Research Projects Agency, the Defense Nuclear Agency and other organizations indirectly furthers Star Wars objectives. An insider acknowledged that "Star Wars money has a way of losing its color after passing through many hands."

When the S.D.I.O. needs something to be invented or built, it pays handsomely and apportions the task to many hands. Predictably, the largest S.D.I. contracts have gone to the giants of the aerospace industry. Heading the 1986 list is the Boeing Company, with contracts totaling $131 million. Other top S.D.I. contractors include TRW Inc., $61 million; Hughes Aircraft Company, $40 million; Lockheed Missiles and Space Company, $25 million; Rockwell International Corporation, $24 million; and the Raytheon Company, $17 million. But Star Wars funds are also earmarked for a wide range of small businesses, government laboratories and agencies (including the Central Intelligence Agency), and academic institutions.

The economic impact of S.D.I. money is ubiquitous and potent. A Stamford, Conn., market re-

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rch concern, Business Communications Com-, has estimated that the commercialization of Wars technology will eventually yield private-sector sales ranging between $5 trillion and $20 trillion. The financial inducement for a company to participate in S.D.I. research is so great, in fact, that the S.D.I.O. receives 10 times as many proposals as it can pay for.

Private entrepreneurs can exploit a wide range of inventions and discoveries that grow out of government-sponsored research, and Star Wars technologies are no exception. But the commercial licensing of government processes or inventions is a complex system that sometimes imposes burdensome practical problems. A government agency may be unwilling to grant exclusive long-term rights to the use of an invention or process, for instance, thereby depriving prospective commercial licensees of a competitive edge.

The secrecy of such sensitive military projects also poses a potential problem for the transfer of technology from S.D.I. research to the private sector, but General Abrahamson minimizes its ng-term importance: "Of urse there are technologies in S.D.I. that are vital to our national interests and are classified top secret. However, you'd be amazed how much of our work is nonclassified or only moderately classified. Our secrecy classification system, like the proposed missile defense itself, is organized in layers, and our policy is to permit the maximum freedom of communication consistent with the national interest. That policy shouldn't pose a real problem for anyone."

"I am determined," General Abrahamson said, "that we not miss the opportunity to capitalize on the results of S.D.I. research and apply it across all facets of our economy and society."

THE COMBINATION OF A thick wallet and a gambler's quest for dramatic gains has already led S.D.I. researchers to discoveries with important implications for fields largely unrelated to strategic defense.

Perhaps the most significant of these areas is conventional warfare, where rail guns and other new "hypervelocity weapons" promise to transform the kind of continental-scale armored combat for which the Soviet and American armies have been girding themselves since World War II.

Both the Pentagon and the Kremlin believe that in future land wars, tanks and armored personnel carriers will decide the outcome of battles. Consequently, both sides press their munitions makers to design ever more lethal projectiles, and sturdier forms of armor to stop the enemy's shells, bullets and rockets.

To defeat the next generation of tough-skinned Soviet tanks, Army planners believe, an entirely new class of weapons might be needed: weapons as superior to today's powder-burning guns and rockets as the 15th-century harquebus was to even the best crossbow of the day. And thanks to the Strategic Defense Initiative, the electromagnetic rail gun may provide American armored vehicles with just such a weapon.

In contrast to traditional rockets and shells, which are propelled by expanding gases, the acceleration achieved by a rail gun is not limited by the speed of sound: given enough energy, a rail gun can accelerate objects to speeds comparable to those of meteors. In principle, a rail gun standing on the ground could bombard targets on the moon. A rail-gun projectile might even be made to hit a target hard enough to initiate nuclear fusion — a fact noted by scientists seeking to develop fusion energy as an alternative to the fission process that is used to generate electricity in today's nuclear power plants.

Many government organizations have explored the possibilities of the rail gun. But both financing and research coordination were lacking until the Strategic Defense Initiative Organization stepped in.

Among the technologists responsible was Jon Farber, a division chief with the Defense Nuclear Agency in Alexandria, Va. Mr. Farber has devoted much of his career to the building of machines that mimic the destructive pulses of electromagnetic energy emitted by nuclear explosions. Like many kinds of Star Wars weaponry, these testing machines require gigantic pulses of power.

"I realized," Mr. Farber recalled, "that the greatest possibility for quick progress toward an anti-missile weapon lay in the rail gun, and I predicted that by working on rail guns we could accelerate all our S.D.I. programs, reducing development times by six to eight years."

Essentially, a rail gun is an electric motor, in which two metal rails running the length of the gun barrel are the main stationary elements and the projectile itself is the moving part. When a massive electric current is made to flow between the rails via an armature at the back of the projectile, the flow generates an electromagnetic force that drives the projectile forward.

One of the main problems with such a weapon is providing it with a suitable supply of electric power. Not only must the source yield a gigantic pulse of power for each shot, but it must recharge fast enough to maintain a reasonable rate of fire.

Ignoring bureaucratic boundaries, Mr. Farber broached his ideas directly to the S.D.I.O.. "To establish my bona fides, I offered to lend them a power supply of the kind we use in our simulated nuclear explosions," he said. "They agreed, and starting in March last year, the S.D.I. people agreed to share costs with us in the building of a capacitor-powered rail gun. Only nine months later we were able to fire the first demonstration shot. We blasted a little plastic cube right through a thick metal plate, and the resulting hole was impressive enough to convince even stubborn skeptics."

Since then, researchers have devoted their efforts to reducing the size of the containers needed to contain the electric power for the rail gun. Within a few years, Mr. Farber predicts, high-power capacitors charged by generators of various kinds will be small enough to fit not only into orbiting space stations, but inside tanks and other fighting vehicles.

"At present we are substantially outnumbered and outgunned by Soviet tanks, whose big guns can open fire before ours come into range," Mr. Farber said. "Rail guns could reverse that situation and change the balance of land forces in our favor."

ANOTHER KEY AREA of Star Wars development is the interface between computer science and applied physics, in which researchers are confronting the need to process extraordinary amounts of information in the shortest possible time. Future large-scale conflicts, whether in space, in the atmosphere, on the ground or at sea, are expected to unfold too quickly for even the most efficient consortium of human minds to control without massive computer assistance. A reliable, lightning-fast system for planning battles is therefore regarded as vital both to a defense against ballistic missiles and to the conduct of war on the earth's surface.

Part of the challenge lies in the realm of applied physics. Physicists are following several routes toward speeding up the microscopic switches that operate logic gates — the components of semiconducting chips that enable computers to calculate. The opening or closing of a switch determines whether its gate is to register a zero or a one — the binary numbers used for all computations.

Contractors working for S.D.I. or related defense technology projects are working on an entirely new type of computer switch: one that operates optically rather than electronically. An optical switch would be used to transmit or block a beam of light rather than an electric current, and thus benefit from the enormous speed at which light travels. The switch itself could be actuated by light signals; matching pulses of light applied to opposite sides of the switch would open it, and mismatching pulses would close it.

A remarkable new material being developed for both optical and electronic computer switching is a synthetic crystal, gallium arsenide, and substantial S.D.I. funds have been appropriated for pushing its development. Gallium arsenide transmits electrons several times faster than does the silicon used in con-

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ventional chips, and can also fun[illegible] as an optical switch.

[illegible]r potential optical sw[illegible]hat has attracted official interest is a plastic called polydiacetylene, under development at General Telephone and Electronics Laboratories Inc., of Waltham, Mass. According to Dr. Mrinal Thakur, a senior member of G.T.E.'s. technical staff, an optical switch based on polydiacetylene could handle up to one trillion operations per second; a conventional silicon switch can manage only about one-thousandth as many in the same time. Optical switches, moreover, would be highly resistant to electronic pulses from nuclear explosions that would disable ordinary chips.

Computer experts working on projects related to S.D.I. are also streamlining problem-solving hardware and procedures. One of their approaches is to break up a complex problem into many small elements that can be solved simultaneously and then be rapidly reassembled to yield the required result. This technique of "parallel p[illegible]ing" is a feature of s[illegible]vanced machines as the [illegible]arp, a new supercomputer developed at Carnegie Mellon University, and the Connection Machine, a product of Thinking Machines Inc. According to the Defense Advanced Research Projects Agency, which paid for its development, the latter machine recently took only three minutes to complete a computation over which a powerful International Business Machines Corporation mainframe computer had had to labor for six hours.

The computers and programs S.D.I. is helping to bring into being are powerful tools whose civilian counterparts will have incalculable scientific value, experts say. These machines might be used for long-term weather forecasting, for example, and for creating reliable mathematical models of the atmosphere and the oceans. Environmentalists regard such models as essential in making accurate estimates of the effects of human activities on climate.

[illegible]al strategic defense p[illegible] seek to use the computer as an adjunct to the human brain, and the outcome of this work in such "expert systems" is applicable to conventional battlefields and civilian needs as well. Two of the latest Defense A[illegible]vanced Research Projects Agency's computer projects for the Navy not only organize and assess mountains of information but also make recommendations to fleet commanders for solving specific tactical and strategic problems. The machine intelligence behind such recommendations is compounded by its designers from the knowledge of many human experts, and the computer program is capable of adding to its knowledge from its own problem-solving experiences.

Similar programs, many of which are independent of S.D.I. but have benefited from its discoveries, have begun to help physicians diagnose patients and to assist plant managers in spotting problems in production, inventories and quality control.

Computer pattern recognition is another field of great interest to S.D.I. and other defense agencies. A computer capable of recognizing and interpreting patterns can guide a missile equipped with a television eye, singling out the pattern of a target from a background of clutter.

Missiles are not the only beneficiaries of this work. Related computing ability is at the heart of the advanced research agency's Autonomous Land Vehicle, an eight-wheeled driverless truck from which it is hoped a robot fighting vehicle will evolve. Although their capabilities are still quite limited, such robots may foreshadow not only the advent of mechanical soldiers but of surrogate servants, laborers and bodyguards — the creatures of science fiction.

IN MANY AREAS, S.D.I. funds have played an important role not in fostering new projects, but rescuing or reviving old ones. One significant example has been the Nova laser, completed last year at Lawrence Livermore National Laboratory, in Livermore, Calif., at a cost of $187 million and 8 years' construction time. The world's most powerful laser, Nova is yielding experimental data that may contribute both to a beam defense against missiles and to the generation of electric power by hydrogen fusion.

Nova, which fills one of the largest buildings in Livermore's sprawling laboratory compound, was financed by the Department of Energy as a fusion power experiment. The object was to concentrate the combined beams of Nova's many lasers on a pinhead-size target, the implosion of which would initiate fusion in the target's hydrogen core.

But during the last three years, as financing for many fusion experiments has dwindled almost to the vanishing point, defense scientists began using Nova for another purpose: the production and testing of very short-wavelength beams, including X-ray lasers — a type of laser that many experts believe would be peculiarly effective against missiles.

That Nova is being kept active, for whatever purpose, is a source of satisfaction to fusion power advocates. "The present oil glut will be short-lived, and when the crunch comes the energy shortage is likely to be devastating," an engineer at the Electric Power Research Institute said. "Fusion may be our salvation, and Nova may be the route to fusion. If Star Wars keeps Nova alive, it's all to the good."

Besides lasers, beams of charged and neutral particles are under study as possible directed-energy weapons, and these, too, are expected to find civilian applications. The Department of Energy has sponsored experiments using electron beams for sterilizing food and for removing pollutants from industrial smokestack emissions, for instance. Electron beams developed for killing enemy missiles may also serve mankind by fighting cancer.

"The S.D.I.O. is very interested in a potential weapon called the free-electron laser," said Dr. James A. Ionson, a 36-year-old astrophysicist who is in charge of selecting many S.D.I.O. research projects. "And the work that has gone into it shows considerable promise for cancer therapy.

By manipulating a beam of electrons produced by a charged-particle accelerator, researchers have found they are able to "tune" the wavelength, or color, of the resulting beam. Such tuning helps scientists create beams with the short wavelengths deemed effective against missiles, and may also provide the key to a potential new cancer therapy, Dr. Ionson said.

"Electron beams can penetrate tissue to any desired depth, and the depth is determined by the energy of the beam," he said. "An electron beam has very little effect on the tissue through which it merely passes. But when it reaches its penetration depth, it releases most of its energy at that spot. Consequently, a precisely tuned electron beam could be used to hit a malignant tumor with pinpoint accuracy without damaging the surrounding tissue. The technique might be especially valuable in brain surgery."

MANY INDUSTRIES and government researchers are quite comfortable with Star Wars, but the S.D.I.O.'s relations with the nation's academic community is ambiguous. Educators have raised moral and political as well as scientific objections to the attempt to build a missile defense, and many believe it cannot succeed, however much money is pumped into the effort.

Both the Union of Concerned Scientists and the Federation of American Scientists have denounced S.D.I., and some 6,500 scientists and scientific educators have signed petitions pledging not to accept S.D.I. funds.

Still, negative opinions about the strategic merits of the President's program can often be separated from attitudes regarding the broader benefits of S.D.I.-related research. According to a survey conducted last spring by Peter D. Hart Research Associates Inc., two thirds of 549 American physicists polled expressed doubts that S.D.I. could ever defend the entire population of the nation against ballistic missiles, and 62 percent declared themselves opposed to deploying a Star Wars defense.

But despite their general opposition to the development of actual S.D.I. weapons, many American physicists saw merit in the basic research involved; the Hart poll revealed that 77 percent of physicists supported basic Star Wars laboratory research and 21 percent op-

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U.S. Troops Find Weapons Too Complex

By Molly Moore
Washington Post Staff Writer

After a U.S. soldier has carried out the 18 steps necessary to fire a Stinger antiaircraft missile at an enemy jet or helicopter, he must remember one other requirement: to hold his breath to avoid inhaling the noxious fumes the weapon emits.

The Stinger, which an Army study said is "unnecessarily difficult" and too complicated for many soldiers, is but one of many weapons now entering the nation's high-technology arsenal despite being designed with insufficient concern for those who will use the weapons on the battlefield, according to Pentagon documents and defense officials.

For example, a 1985 study by the Army Research Institute, the service's research agency, concluded that "the Army is not developing weapon systems that work well when they get into the field. These problems are going to worsen because weapons are becoming more complex while the supply of capable soldiers is decreasing."

As the Defense Department approaches the $2 trillion mark in its arms buildup, the services confront the problem of manning the battlefields of the 21st century with ordinary soldiers, sailors and airmen who have trouble keeping pace with the high-technology hardware, according to Pentagon studies and some defense officials.

Although the problem of matching troops to equipment has dogged the nation's military for years, the challenge has taken on serious new ramifications with the emphasis on sophisticated weaponry and a dwindling supply of potential young recruits. In recognition of the problem, each of the services has established special programs that officials say will attempt to improve future weapons design and troop training.

"People are concerned about readiness," said Lawrence J. Korb, the Pentagon's manpower chief from 1981 to 1985. "But when you have a weapon that an American high school graduate who's going to be in the Army can't operate and maintain . . . that is a problem."

Military officials are quick to note that, if used properly, many of today's weapons are far more effective than the hardware they have replaced. They acknowledge, however, that many of those new systems have created cumbersome and costly new difficulties.

"There often had been very little consideration given to the human factor during the design of the weapon system," said Dennis Leedom, assistant director of the Systems Research Laboratory at the Army Research Institute. "So often you had fielded or were about to field weapons systems that could not be used by your average soldier."

The Stinger, for example, is a portable, 35-pound missile. Designed to cripple low-flying enemy aircraft, it was built beginning in 1978 as an improved successor to the Redeye missile. Officials now say the Stinger, which the administration reportedly would like to provide to rebels in Angola and Afghanistan, has some of the same problems as the older missile because not enough care was paid to the soldier's capability during development of the weapon.

The research institute's engineering report on Stinger problems cited "aircraft identification, ranging and weapon superelevation as being especially or unnecessarily difficult." The gunner is required to prepare the weapon for firing and sight the target while attempting to determine whether an approaching aircraft is "friend or foe."

"The lower mental category soldiers constituting a large portion of the current population of gunners cannot operate Stinger," the report stated.

Lt. Gen. Robert M. Elton, chief of personnel for the Army, said, "The Stinger was a great improvement . . . . It still needs to improve some more."

Although the Army has no shortage of soldiers capable of operating the Stinger, Elton said, it was forced to reassign smart soldiers to units using the weapon.

In addition to weapons that are too complex, some systems designed to reduce the number of people needed to operate them actually resulted in larger crew requirements, according to Pentagon personnel officials.

In other cases, poor planning forced the military to restructure units using the new hardware. And in some instances, training was so inadequate that unprepared forces either refused to use or misused their sophisticated equipment, according to Pentagon officials and several 1984 military weapons engineering reports. For example:

- Equipment designed to make maintenance of the M1 tank easier by electronically identifying malfunctions "is so unwieldy, difficult to transport and difficult to connect to the tank that it actually discourages its use by maintenance personnel," according to a 1984 institute study.
- When the military discovered that the M1 fault-finding devices also were too difficult to operate, officials began updating training and technical manuals. But, according to the report, the manuals were revised so frequently that they were outdated by the time they reached the field, and troops frequently ignored them.
- The Navy's Spruance-class destroyer, designed to be one of the most efficient in the service, required 32 percent more sailors than was intended, according to Navy officials. Engineers had designed a ship for a streamlined crew of high-technology specialists, leaving most of the routine maintenance to be performed when the ship was in port. The Navy later discovered the idea was impractical, officials said.

"It's an excellent theory," said Vice Adm. Dudley L. Carlson, the Navy's chief of personnel. "But we couldn't implement it."

- The research institute's 1984 study of the Blackhawk helicopter found that the Army severely underestimated the number of people required to maintain and operate the transport. Estimates of the number of mechanics needed for each platoon servicing the helicopter varied from four to 19, depending on which Army source was

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posed it.

To counter the anti-Star Wars lobbying of several professional organizations, scientists favoring S.D.I. research recently organized the Science and Engineering Committee for a Secure World. Among the group's members is Dr. Martin I. Hoffert, chairman of the department of applied sciences at New York University, who describes himself as a political liberal and an opponent of nuclear arms. "When I first heard of S.D.I., I had no real interest in it," he said. "But I was interested in almost any opportunity for ridding the world of nuclear weapons, and I came to believe that S.D.I. might give us a chance."

Some two dozen major educational institutions are now receiving S.D.I. funds, among them the University of California (Los Angeles and Berkeley), the Massachusetts Institute of Technology and Johns Hopkins University. Besides these, many colleges and universities are recipients of second-hand Star Wars money transmitted through various prime contractors.

Highly qualified physicists are sometimes drawn to Star Wars projects by an inducement at least as potent as remuneration: access to the laboratories, equipment and staffs that can take on research programs far beyond the financial reach of even the richest university.

The cumulative impact of such an influx of funds and assistance on the broader course of American science will, of course, be impossible to measure for many years. But scientists and technical experts both inside and outside the strategic defense program agree that the systems, materials and devices brought into being in the name of S.D.I. will leave a profound legacy. One defense physicist (who asked to remain unidentified) put it this way:

"Some say we've made Faustian deals with the Devil, and there's an element of truth in it, if you happen to look at national defense as the Devil, which I do not. I'm being paid to work in a lab that's more exciting than a toy store. I'm given all the fancy hardware I need for my work, which has to do with very short-wavelength lasers. Do you realize what magnificent scientific tools such lasers will one day give us? We could use them to make holographic movies of the interaction of molecules in living cells, catalyzing the whole field of cancer research. X-ray or gamma-ray lasers will help us understand the nature of life at its most basic level.

"Sure, we're working on weapons, and we hope they'll be very good weapons. But the biggest payoff for many of us is the thrill of personal scientific achievement — achievement that in many cases would be impossible without Star Wars tools." ■

SPACE COMMERCE AND STRATEGIC DEFENSE

Searching beyond NASA, the SDI organization provides the means for a government/industry partnership to aid commercial space development.

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The development of a vigorous and profitable American commercial space industry is dependent upon many variables—including availability of capital, maturity of technology, ability to insure risk investments, etc.—but the primary determinant of success in this industrial sector is, of course, the presence of a sufficient market, or return on investment, for commercial space operations and applications. Although the theoretical marketplace for numerous space businesses has been estimated, [1] to date, despite the investment of well over $100 million in entrepreneurial space ventures since the late 1970s [2], no new "space" business has been able to demonstrate a sufficient return on initial investment to meet standard investment criteria [3].

Commercial Space Potential

Does this absence of sufficient return demonstrate, as some argue, that "commercial space" has been oversold as a significant future market sector for the U.S. economy? Such a conclusion may at first appear warranted, however, before national policymakers and industrial leaders turn their backs on this arena of international competition, perhaps they should review a recent report issued by the Business Higher Education Forum, "whose members include some of the nation's most prestigious businesses and universities." [4] A *Washington Post* description of this report concludes, "There is a risk that the 1990s will be recalled as the decade when this country lost its leadership in space." [5]

There is mounting evidence for commercial space applications and operations possibilities—for example, the ability of a privately marketed commercial expendable launch vehicle (Ariane) to capture more than 40 percent of the free world's satellite launch business, the recent launch of the European SPOT remote sensing satellite, the entry of the People's Republic of China into the space transportation business, and the establishment of an 82-company Japanese consortium, under the direction of the Mitsubishi Corporation. The last is called the "Society for Studying Space Commercialization." These all provide indications for profit potential on the space frontier. [6]

Government Supported Space Programs

Each of the aforementioned programs combines governmental support with a commercial orientation in an attempt to generate successful commercial space activity. While an analysis of the advantages and disadvantages of each structure is beyond the scope of this article, it should be noted that without the national government as an active, supporting partner none of the programs would likely exist.

In the U.S., building such a government/industry cooperative program for developing a viable commercial space sector has been, at best, fitful. While many policy statements have been released [7], and some agencies (notably NASA and NOAA) have attempted to commercialize—or in their terms, "privatize"—existing governmentally-developed space systems, (NASA has even attempted to encourage additional investment in space by offering assorted inducements, including free launches on the Space Shuttle) none of these federal efforts have been targeted at market development. Yet, each of our foreign competitors have chosen this mechanism as a principal method of competition. For instance, at least 40 percent of the payloads flown on the Ariane originate from European governments, not commercial entities. [8]

'The single most effective method to encourage growth in space ventures is through federal procurement.'

Why is the U.S. government reluctant to assist its commercial space industry through market development? Many reasons can be listed, such as a "free market" philosophy and competition from federally-operated space systems—including the Space Shuttle, the Global Positioning Satellite system, and, until recently, LANDSAT. It should be noted that this reluctance continues to exist despite a presidential proclamation in 1984 which committed the term contracts with new space companies if the government has a need for the service and the purchase would be cost effective." [9]

Congressional Hearings on Federal Procurement for Space Ventures

There is a growing consensus within the commercial space community that the single most effective method to encourage further growth in the American private sector for space ventures is through federal procurement. Hearings held before the House Science and Technology Committee last year brought together representatives from four leading commercial space ventures—Geostar Corporation, Orbital Sciences Corporation, Space Industries Incorporated, and Space Services Incorporated of America—to address this issue. [10]

In a letter to a NASA administrator, Committee Chairman Don Fuqua states, ". . . the creative use of procurement authority would appear to offer one of the most potentially effective methods by which NASA could promote the growth of privately developed spaceware and services." [11] Similar thoughts were echoed by Orbital Sciences Corporation President, David Thompson, "Market uncertainty presents the dominant business risk facing most new space enterprises. The federal government is the largest established market for space ventures: it purchases over 90 percent of the space hardware and services provided by U.S. industry." [12]

'The federal government purchases over 90 percent of the space hardware and services provided by U.S. industry.'

Referring to the aforementioned presidential commitment to facilitate long-term contracts with new space ventures, Space Services Inc., Chairman David Hannah, Jr. believes, "This simple action, if implemented throughout the federal government, in my view, could have an enormously positive effect on several new space companies, including SSI." [13] Federal contracts attorney Matthew S. Simchak offered numerous suggestions for possible adoption by Congress which would effectively meet the goal of increasing private space companies' role in federal contracting. Furthermore, he feels, "Enhancement of competition for the government's needs in space is a highly desirable objective." [14]

The committee hearings focused on NASA's role in using procurement to enhance space commerce. Unfortunately, from the perspective of private space ventures, NASA administrator James Beggs concludes, "It would appear that existing procurement authority does not permit a preference for commercial venturers or the 'encouragement' thereof. . . . We believe the Space Act authority to be sufficient to meet our basic commercialization objectives." [15]

While the validity of this interpretation of existing procurement law may be questioned, (Note: The Competition in Contracting Act of 1984 permits agencies to direct contract awards in order to create a second source of supply and to make awards based on valid unsolicited proposals) the intent of NASA is clear. Furthermore, while NASA's efforts to create a U.S. commercial space sector can also be questioned, it is, perhaps, more productive to search for other agencies within the federal government that might offer opportunities for new space companies. It is at this juncture that the Strategic Defense Initiative (SDI) must be considered.

Strategic Defense Initiative Opportunities

One of the challenges inherent in the President's SDI is finding innovative methods of rapidly and inexpensively moving research, technologies, and systems from concept through testing and, if appropriate, to deployment. The most efficient and advanced technical solutions to problems encountered in the SDI program will be of little value if they are too costly or take too long to implement.

The SDI organization, because of its structure and separate identity within the Office of the Secretary of Defense, recognizes the need for innovative, fast-track approaches by both industry and government. Moreover, through the creation of the Educational and Civil Applications Office within the SDI organization, the potential to transfer certain technologies, systems, and methods to broader civilian applications and markets is also being explored. This would result in increased private sector/SDI interaction. In meeting its requirements, new private sector space companies may offer significant opportunities to SDI, while simultaneously expanding the civil and commercial application of SDI-related technologies and programs.

In meeting its requirements, new, private sector space companies may offer significant opportunities to SDI.'

These entrepreneurial space ventures are developing products and services which span a broad range of technologies, including Shuttle upper stages, precise navigation and positioning systems, manned orbital platforms and power generation systems, materials processing of gallium arsenide crystals and other exotic materials, remote sensing and surveillance systems, and commercial expendable launch vehicles. In almost every instance, these start-up space ventures use the existing industrial base as subcontractors to actually produce the proposed product or service. Yet, in each case the business approach and management philosophy employed by these "general contractors" has resulted in significant cost and schedule savings over competing products offered by traditional aerospace companies and/or the federal government. [16]

Nontraditional Space Companies

Consequently, entrepreneurial space companies offer products and services potentially useful to SDI launch systems, surveillance systems, orbital platforms and related infrastructure, and advanced materials. Typically, these companies blend entrepreneurial business practices, private capital, and established defense and aerospace subcontractors to produce

w-cost, schedule-sensitive, technically-sound space systems.

If these are potentially useful products and services to SDI, then it should consider the best methods, which do not jeopardize speed and efficiency of nontraditional business approaches, to obtain them. Potential SDI benefits from this include both meeting its requirements in a cost-effective manner, and also the successful creation of a new tier of qualified competitors for future DOD/SDI procurements. Benefits to the new space companies are obvious. As companies begin to develop a customer base and performance record, more commercial business in space becomes possible. Investors can see an income stream and may be attracted to other commercial space ventures.

'Investors can see an income stream and may be attracted to other commercial space ventures.'

The advantages to new space companies and their investors are stated in a recent report entitled "Star Wars Profits in Space," published by KCI Communications: "No forward-looking investor, large or small, can afford to ignore the opportunities that are now emerging. Even if the Star Wars program ultimately falls short of its ambitious objectives, the research that will have been lavished on it is likely to generate sufficient spin-offs to fuel innovation and advances in other fields well into the 21st century." [17]

In short, the SDI may become the "Apollo program" of the 1980s and 1990s. Since over 10,000 small businesses participated in Apollo, new space ventures obviously will not overlook the possibilities for a "kick-start" inherent in SDI. The U.S. should include SDI in its efforts to assist space commerce.

Risks for SDI

While many potential benefits to SDI, entrepreneurial space ventures, and the nation as a whole may accrue from efforts to mesh space commerce and strategic defense, some observers have quickly pointed out that there are substantial risks to the government and the private sector. Moreover, others are uncomfortable with the government utilizing SDI to assist commercial space companies, claiming that such an effort smacks of "industrial policy" and is inconsistent with a free-market economy.

To the latter objection, the best response is that faced with increased international competition and the failure of a purely free market approach to space commerce to date, governmental action seems the only means for ensuring U.S. development of a viable commercial space economic sector. Such an approach is consistent with past history. For example, the Union Pacific Act of 1862 provided for a loan of $60 million in 30-year five-percent U.S. bonds to construct a railroad to the Pacific. One hundred years later, the Communications Satellite Act of 1962 established COMSAT as a government-chartered corporation to develop the communications satellite industry. Of more relevance, the development of commercial air transportation would probably not have occurred in the time frame it did without federal airmail contracts. More recently, the purchase of transponder capacity by the U.S. Navy was instrumental in COMSAT's decision to develop the first maritime communications satellite, MARISAT. [18]

There are indeed risks to both SDI and new space companies in a program for meshing the two. SDI reliance on a start-up venture lacking experience as a federal contractor may increase the risk for company nonperformance. Government program managers may decide to exercise increased control—possibly negating the cost and schedule advantages which originally attracted SDI to the new space venture. While this may not be a real risk, (Remember in order to raise the substantial sums of risk capital needed for entry into the aerospace business, new ventures must convince investors of their ability to effectively meet schedule, cost, and performance constraints.) the perception of it might be minimized by carefully selecting those overall program elements which will be open to the new space ventures. Many of the efforts within SDI may be multiple source, others may not have such a high priority that they cannot afford to take some risks, others may be so cost or schedule constrained that they must choose the lowest cost or quickest program even if they are offered by start-up ventures.

Risks to New Space Ventures

From a business perspective,. the risks for new space ventures appear to be far less. The principal reason for entering the SDI field is to acquire initial customers. Considering this, all other risks appear to be secondary. Still, some analysts disagree. A recent review of space law and commercial use published by the National Legal Center for the Public Interest warns:

> A potential danger exists that commercial space exploitation by the private sector will be substantially channeled into the Strategic Defense Initiative. This will require the establishment of a government contract relationship that can create corporate economic stability, but at the same time, turns established companies into nonbasic research product developers for the government. It also may serve to suppress the creative genius of small private entrepreneurs. [19]

Although this danger may exist, new space companies are not obligated to serve the SDI market. This choice will only be available to them, however, if they survive to the point of commercial take off for their space technologies. In order to reach this plateau, new space companies must actively seek all legitimate business opportunities available to them, especially those within the SDI.

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Notes

1. See, for example, "The Race for Profits In Space," *Financial World*, March 4, 1986. pp. 20-33.
2. Author's assessment, including most major new space ventures. Excludes the tra-

ditional aerospace and communications satellite industries.
3. Excluding ground-based satellite processing ventures.
4. Reported in the *Washington Post*, April 3, 1986, E1.
5. Ibid.
6. A nonexclusive list. Other commercial ventures include, interestingly, the USSR with its Proton launch vehicle.,
7. "National Policy on the Commercial Use of Space," the White House. July 20, 1984.
8. P.V. Nedervelde, "Europe's Place in Space," *Astronomy*, May, 1986.
9. See 7.
10. Hearings before the Space Science and Applications Subcommittee, September 11, 1985.
11. Letter from Don Fuqua to James Beggs, February 4, 1985.
12. Statement of David W. Thompson, OSC, September 11, 1985.
13. Statement of David Hannah, Jr., SSI, September 11, 1985.
14. Statement of Matthew S. Simchak, September 11, 1985.
15. Letter from James Beggs to Don Fuqua, August 19, 1985.
16. This is the essence of the entrepreneur's advantage in the aerospace business. The conclusion is based on the author's direct experience in the field.
17. Cited in *Financial World*, See 1.
18. Thompson, see 12.
19. Robinson and Meredith, "Domestic Commercialization of Space: The Current Political Atmosphere." *American Enterprise, the Law, and the Commercial Use of Space*, Vol. 1, 1986, p. 27.

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