Strategic Plan

Defense Advanced Research Projects Agency

February 2003

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DARPA's Strategic Plan

1. Introduction and Purpose

This report responds to the requirement in Senate Report 107-151 for the Defense Advanced Research Projects Agency (DARPA) to develop a strategic plan. Its purpose is to describe, in broad terms, DARPA's current top-level strategy to Congress, other elements in the Department of Defense (DoD), the research community, and other interested parties.

2. Overview of DARPA

2.1. DARPA's Mission, Management and Organization

DARPA's strategic plan begins with the Agency's mission:

> *DARPA's mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use.*

DARPA's mission implies one imperative for the Agency: radical innovation for national security. DARPA's management philosophy reflects this in a straightforward way: bring in expert, entrepreneurial program managers; empower them; protect them from red tape; and make decisions quickly about what projects need to be started and what projects should stop.

To maintain an entrepreneurial atmosphere and the flow of new ideas, DARPA steadily rotates program managers in and out of the Agency, with most program managers serving for only four years. The idea is that the best place to get new ideas is new people. New people also ensure that DARPA has very few institutional interests besides innovation, because new program managers are willing to redirect the work of their predecessors – and even undo it, if necessary.

Another notable feature of DARPA's management philosophy is that the Agency has very limited overhead and no laboratories or facilities. Again, the idea is to minimize any institutional interests that might distract the Agency from its imperative for innovation.

DARPA's current technical organizational structure is shown in Figure 1. This chart implies more formal structure than is actually the case at DARPA. In general, the character and mission of DARPA offices change over time as DARPA focuses on different areas. Offices are created and disbanded as DARPA changes direction.[1] The basic purpose of Offices is to create synergy by bringing together experts with similar interests so they can interact with each other. DARPA has found that bringing together people with the same interests can lead to a non-linear generation of ideas. The Office Directors' job is to recruit outstanding program managers and develop the office synergy, while keeping the program managers broadly on-track with the office theme. The Office theme or vision is set by the DARPA Director reflecting his interactions with the Service Secretaries and Chiefs, the Joint Chiefs of Staff and staff, and the Secretary of Defense and his staffs.

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[1] For example, in the past 15 months, two new offices, the Information Awareness and Information Exploitation Offices, were established in response to DARPA's current strategy, the focus of the Information Processing Technology Office was changed, and a DARPA-wide theme in space was created.

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There are two basic DARPA technical offices: technology offices and systems offices. The technology offices are the Defense Sciences Office, Microsystems Technology Office, and Information Processing Technology Office. These offices focus on new knowledge and component technologies that might have significant national security applications. The system offices are the Tactical Technology Office, Special Projects Office, Advanced Technology Office, Information Exploitation Office, and Information Awareness Office. These offices focus on technology development programs leading to products that more closely resemble a specific military end-product, i.e., an item that might actually be in the military inventory. As a practical matter, there tends to be a fair amount of overlap between the two types of offices: the work in the technology offices often shapes the work of the systems offices, and vice-versa.

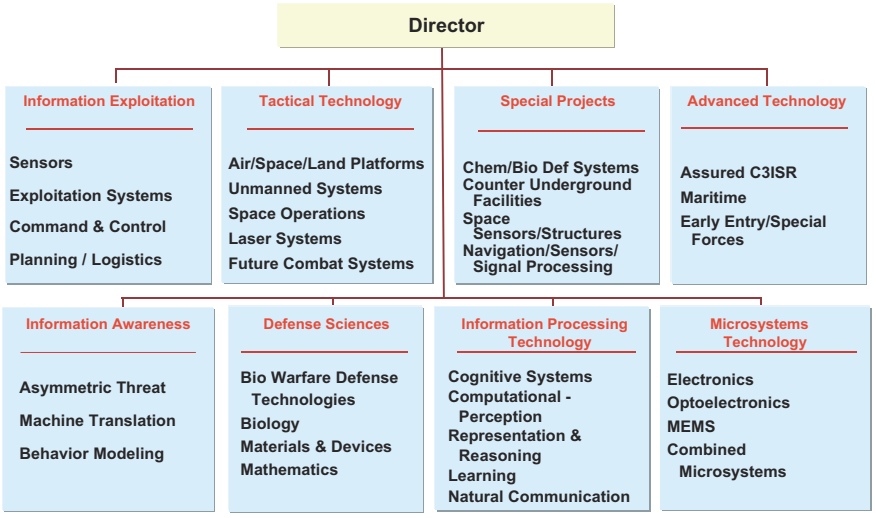

Figure 1: DARPA's organization.

DARPA has several special authorities to assist the Agency in carrying out its unique mission in accordance with its flexible management philosophy. For example, DARPA has an Experimental Personnel Authority[2] that allows the Agency to maintain its entrepreneurial edge by hiring expert program managers from industry at competitive salaries, and do it very quickly – much faster than under normal Civil Service rules.

DARPA also pioneered the use of Other Transactions Authorities[3], which allow much more flexible contracting arrangements with firms and universities than would normally be possible under the Federal Acquisition Regulations.

Finally, DARPA has the authority to award prizes to encourage technical accomplishments[4], similar to the prize awarded to Charles Lindbergh for his nonstop transatlantic flight to Paris. DARPA is making use of this authority for the first time to sponsor a race of fully autonomous, unmanned ground vehicles from Los Angeles to Las Vegas in April 2004, with a prize of $1,000,000.[5]

2.2. DARPA's Role in the Department of Defense

DARPA fulfills a unique role within the Department of Defense. As a Defense Agency, DARPA reports to the Secretary of Defense. The Director, Defense Research and Engineering has been

2 5 USC 3104 Note

3 10 USC 2371 and 10 USC 2371 Note

4 10 USC 2374

5 http://www.darpa.mil/grandchallenge

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assigned to be DARPA's Principal Staff Assistant (PSA). DARPA is the Secretary of Defense's only research agency not tied to a specific operational mission. DARPA supplies technological options for the entire Department. DARPA is designed to be the "technological engine" for transforming the Department of Defense.

This unique role is needed because near-term needs and requirements generally force the operational components to focus on nearer-term needs at the expense of major change. Consequently, a large organization like the DoD needs a place like DARPA whose *only* charter is radical innovation. DARPA looks beyond today's known needs and requirements because, as military historians have noted, "None of the most important weapons transforming warfare in the 20th century – the airplane, tank, radar, jet engine, helicopter, electronic computer, not even the atomic bomb – owed its initial development to a doctrinal requirement or request of the military."[6] *None* of them. And to this list, DARPA would add stealth and Internet technologies.

DARPA's approach is to imagine what a military commander would want in the future, and then accelerate that future into being – thereby changing people's minds about what is technologically possible today.

DARPA's Outreach

Among the individuals who have been briefed on major elements of DARPA's current strategy are:

- U.S. Vice President Richard B. Cheney
- Secretary of Defense Donald H. Rumsfeld
- Secretary of the Army Thomas E. White
- Secretary of the Navy Gordon R. England
- Secretary of the Air Force Dr. James G. Roche
- Chairman of the Joint Chiefs of Staff Gen. Richard B. Myers
- Under Secretary of Defense for Acquisition, Technology and Logistics Edward C. "Pete" Aldridge Jr.
- Army Chief of Staff Gen. Eric K. Shinseki
- Chief of Naval Operations Adm. Vern Clark
- Commandant of the Marine Corps Gen. James Jones
- Air Force Chief of Staff Gen John P. Jumper
- Commander, U. S. Strategic Command Adm. James O. Ellis Jr.
- Commander, U.S. Northern Command, Gen. Ralph E. Eberhart
- Commander, U.S. Joint Forces Command, Adm. Edmund P. Giambastiani, Jr.
- Commander, U.S. Special Forces Command, Gen. Charles R. Holland
- Director, Defense Research and Engineering Ronald M. Sega
- Assistant Secretary of the Army for Acquisition, Logistics and Technology Claude M. Bolton Jr., Major General, USAF (Ret.)
- Assistant Secretary of the Navy (Research, Development and Acquisition) John J. Young, Jr.
- Undersecretary of the Air Force Peter B. Teets
- Vice Commander, U.S. European Command, Gen. Carlton W. Fulford, Jr.
- Commander, Air Force Material Command Gen. Lester L. Lyles
- Director, Program Analysis and Evaluation Stephen A. Cambone
- Director, Force Structure, Resources and Assessment, J-8, Joint Chiefs of Staff, and Chairman, Joint Requirements Oversight Council Lt. Gen. James E. Cartwright

Figures 2 and 3 illustrate how DARPA works. These figures show where science and technology (S&T) funding is invested along a notional "time-line" from "Near" to "Far," i.e., indicative of how long it takes for an S&T investment to be incorporated into an acquisition program.

6 John Chambers, ed., The Oxford Companion to American Military History (New York: Oxford University Press, 1999) p. 791

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The gold "bubble" on the Near side of Figure 2 represents most of the work of the Service S&T organizations. Service S&T tends to gravitate towards the Near side because the Services emphasize providing technical capabilities critical to the mission requirements of *today's* warfighter. This is excellent S&T, and it is crucial because it continuously hones such U.S. military capabilities, e.g., improving the efficiency of jet engines. However, it is typically focused on known systems and problems.

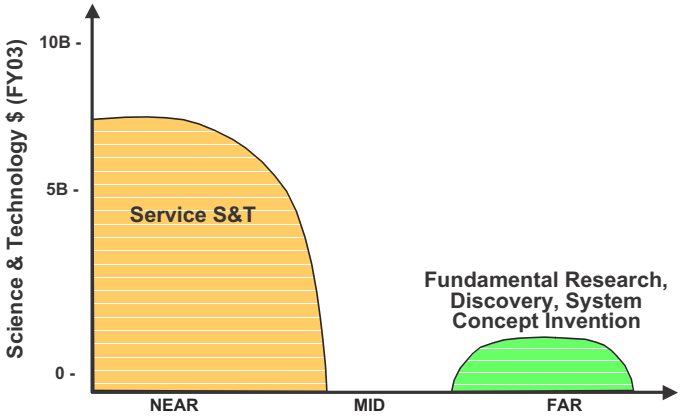

Figure 2: Timelines and investments in science and technology.

The small, green bubble on the Far side of Figure 2 represents fundamental discoveries, where new science, new ideas and radical new concepts typically first surface. People working on "the Far side" have ideas for entirely new types of devices, or new ways to put together capabilities from different Services in a revolutionary manner. But, the people on the Far side have a difficult, sometimes impossible, time obtaining funding from those on the larger Near side because of the Near side's focus on current, known problems.

DARPA was created to fill the gap between these two groups. Its mission, shown by the blue bubble in Figure 3, is to find the people and ideas on the Far side and accelerate those ideas to the Near side as quickly as possible. DARPA emphasizes what *future* commanders might want and pursues opportunities for bringing entirely new core capabilities into the Department. Hence, DARPA mines fundamental discoveries – the Far side – and accelerates their development and lowers their risks until they prove their promise and can be adopted by the Services. DARPA's work is high-risk and high-payoff precisely because it fills the gap between fundamental discoveries and their military use.[7] The inset discussion, "Shaping DARPA's Strategy," provides a more detailed discussion of how DARPA chooses its programs.

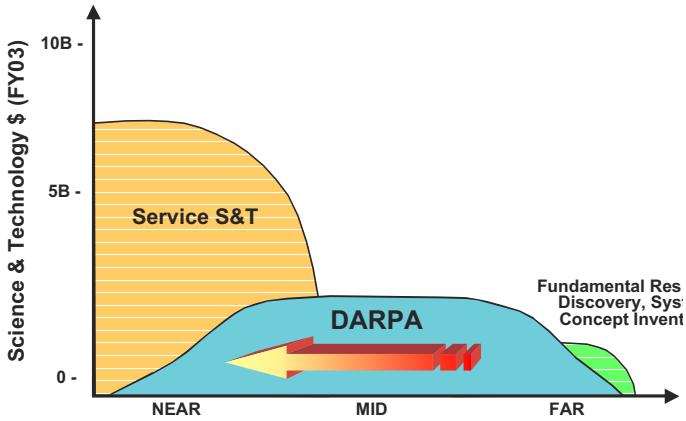

Figure 3: DARPA's role in science and technology.

Whenever there have been technological surprises, the people typically surprised are on the Near side. There are always a few people on the Far side who knew that something could be done, but

[7] In line with DARPA's mission, only about 5 percent of DARPA's research is basic research. Basic research is inside the green bubbles and is primarily supported by the Service S&T organizations, with ONR having the primary role, and organizations like the National Science Foundation, the National Institutes of Health, and the Department of Energy. Basic research creates new knowledge and technical *capacity*, whereas DARPA creates new *capabilities* for national security by accelerating that knowledge and capacity into use.

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Shaping DARPA's Strategy

Basic Challenge and Focus: A basic challenge for any military research organization is matching military problems with technological opportunities, including the new operational concepts those technologies make possible. Parts of this challenge are extremely difficult because: (1) some military problems have no easy or obvious technical solutions; and (2) some emerging technologies may have far-reaching military consequences that are still unclear. DARPA focuses its investments on this "DARPA-hard" niche – a set of technical challenges that, if solved, will be of enormous benefit to U.S. national security, even if the risk of technical failure is high. Other factors also shape DARPA's investments:

- DARPA emphasizes research the Services are unlikely to support because it is risky, does not fit their specific role or missions, or challenges existing systems or operational concepts;
- DARPA focuses on capabilities military commanders might want in the future, not what they know they want today;
- DARPA insists that all programs start with good ideas and good people to pursue them; without both these things, DARPA will not start a program.

Notable Features: DARPA's decision-making process is somewhat unusual for a government agency. It is informal, flexible, and yet highly effective because it focuses on making decisions on specific technical proposals based on the factors discussed above.

There are two reasons for this. DARPA is a small, flat organization rich in military technological expertise. There is just one porous management layer (the Office Directors) between the program managers and the Director. With less than 20 senior technical managers, it is easy to make decisions. This management style is essential to keeping DARPA entrepreneurial, flexible and bold. DARPA's management philosophy is to pursue fast, flexible, and informal cycles of "think, propose, discuss, decide, and revise." This approach may not be possible for most government agencies, but it has worked well for DARPA.

The Basic Process: DARPA uses a top-down process to define problems and a bottoms-up process to find ideas, involving the staff at all levels. DARPA's upper management and program managers identify "DARPA-hard" problems by talking to many different people and groups. (See "DARPA's Outreach" on p. 3) This process includes:

- Specific assignments from the Secretary of Defense or Under Secretary for Acquisition, Technology and Logistics;
- Requests for help from the Service Secretaries and Chiefs, Joint Staff, and Unified Combatant Commands;
- Discussions with senior military leaders on "What are the things that keep you awake at night?";
- Research into recent military operations to find situations where U.S. forces have limited capabilities and few good ideas;
- Discussions with Defense Agencies such as the Defense Threat Reduction Agency, the National Imagery and Mapping Agency, the Defense Information Systems Agency, and the Defense Logistics Agency;
- Discussions with the intelligence community such as the Central Intelligence Agency and the National Security Agency; and
- Discussions with other government agencies or outside organizations such as the National Science Foundation and the National Academy of Sciences.
- Visits to Service exercises or experiments.

During DARPA's program reviews, which occur throughout the year, DARPA's upper management looks for new ideas from program managers (or new program managers with ideas) for solving these problems. At the same time, management budgets for exploring highly speculative technology that have far-reaching military consequences.

Program managers get ideas from many different sources, such as:

- Their own technical communities;
- Suggestions from DoD-wide advisory groups, including the Defense Science Board and Service science boards;
- Suggestions from DARPA-sponsored technical groups, including the Information Science and Technology Study Group and the Defense Science Research Council;
- Suggestions from industry or academia, often in response to published Broad Area Announcements or open industry meetings such as DARPATech; and
- Breakthroughs in DARPA programs and/or U.S. or international research

Vetting a Program: During reviews of both proposed and on-going programs, DARPA's assessment is often guided by a series of questions. These seemingly simple queries help reveal if a program is right for DARPA.

- What is the project trying to do?
- How is it done now and what are the limitations?
- What is truly novel in the approach that will remove those limitations and improve performance? By how much?
- If successful, what difference will it make??
- What are the midterm exams required to prove the hypothesis?
- What is the transition strategy?
- How much will it cost?
- Are the programmatic details clear?

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they could not obtain the resources to execute their ideas. By mining the Far side and plugging the gap between what might be done and what is done, DARPA prevents technological surprise for the U.S. and creates technological surprise for our adversaries by bringing forth technology that revolutionizes U.S. capabilities.

2.3. Some Major DARPA Accomplishments

Over the past four decades, DARPA and its management methodology have been very successful at "filling the gaps" in Figure 3.[8]

Figure 4 illustrates some of DARPA's preeminent accomplishments since the early 1960s.

DARPA was borne of the space age. The launch of Sputnik in 1958 also launched DARPA, so the Agency's initial projects were all space-related. However, the Agency nearly ceased to exist when DARPA's space programs were transferred over to the National Aeronautics and Space Administration and the National Reconnaissance Office.

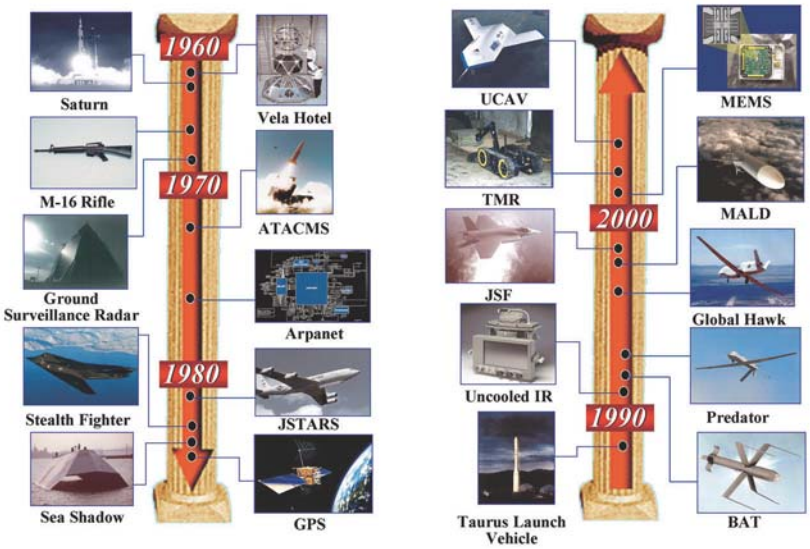

Figure 4: A summary of key DARPA accomplishments spanning more than four decades.

But a new mission came along to counter a threat that no Service or agency was tackling: ICBMs. From approximately 1960 to 1970, DARPA was the driving force behind the U.S.'s technology advancements in Ballistic Missile Defense. In 1968, the Army Ballistic Missile Defense Agency (ABMDA) was created and the ballistic missile defense mission was moved from DARPA to ABMDA.

In the 1960s, DARPA's Project AGILE pursued a modification of the Colt AR-15 rifle to develop what is now known as the M-16 assault rifle, the standard-issue shoulder weapon in the U.S. military.

DARPA began developing the technologies for stealthy aircraft in the early 1970s under the HAVE BLUE program, which led to prototype demonstrations in 1977 of the Air Force's F-117 tactical fighter that proved so successful in Operation Desert Storm. After the successes of the DARPA HAVE BLUE Stealth Fighter program, DARPA launched the TACIT BLUE Technology Demonstration, which contributed directly to the development of the B-2 bomber deployed by the Air Force. DARPA's stealth technology has also gone to sea: the SEA SHADOW, built in the mid-1980s, employs a faceted shape similar to that of the F-117 to

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8 In Spring of 2003, a forthcoming Institute for Defense Analysis report will document the contribution DARPA system projects made to the Revolution in Military Affairs.

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achieve reduced radar cross section, while the twin hull construction contributes to wake reduction and increased sea-keeping capabilities.

The Global Hawk and Predator Unmanned Aerial Vehicles have been prominent in Operation Enduring Freedom in Afghanistan and other parts of the world. DARPA began working on Global Hawk in the 1970s as the TEAL RAIN program; the Global Hawk high altitude endurance unmanned aerial vehicle (UAV) transitioned from DARPA to the Air Force in 1998. Development of Predator began in 1984 as DARPA's AMBER program. The Tier 2 Predator medium-altitude endurance UAV evolved directly from DARPA's AMBER and Gnat 750-45 designs, and was operationally deployed in the mid-90s.

And the most famous of all of DARPA's technology development programs is the Internet, which began in the 1960s-1970s with the development of the ARPANet and its associated TCP/IP network protocol architecture. DARPA's development of packet switching is the fundamental element of both public and private networks, and it spans the Department of Defense, the federal government, the U.S. industry, and the world (see Section 3.8).

A crucial characteristic to note about several of these accomplishments, which holds true for many DARPA programs, is that it took a long time from when the idea was first conceived to when it actually bore fruit and was used by the U.S. military. DARPA has shown itself very willing to tackle hard technical problems repeatedly, even in the face of previous failure, if the technology offers revolutionary new capabilities for national security. Patience and persistence are required attributes for those who pursue high risk technology, but they are often rewarded with extremely large payoffs.

2.4. Transitioning DARPA Technologies

Transitioning technology – getting technology from research and into use – is a difficult challenge, partly because so many different types of organizations may need to be involved, i.e., S&T organizations like DARPA, the acquisition community, the warfighting/requirements community, and the firms that actually produce the product. And the very nature of a technology strongly shapes how it transitions.

For example, a component technology, like a new material or microchip, is likely to get to the warfighter when a prime contractor incorporates it into a system, without the Service acquisition program necessarily having decided on it *per se*. This means the key decisions are made by industry – prime contractors and subcontractors. On the other hand, a large system development program, such as Global Hawk, requires the warfighting community to establish a formal requirement for the system, thereby charging the acquisition community with actually purchasing it. New systems simply do not "diffuse" their way into military use, like a new material might.

The transition challenge is exacerbated for DARPA because its focus is on high-risk, revolutionary technologies and systems, which may have no clear home in a Service, are Joint, or threaten to displace current equipment or doctrine. All these factors tend to create resistance, or at least barriers, to the use and adoption of a new technology.

Figure 5 is a simplified illustration of three methods DARPA uses to transition technology to the warfighter.

The first "bar" illustrates a significant part of DARPA's strategy. DARPA invests about 90 percent of its funds at organizations outside the federal government, primarily at universities

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and in industry. Over time, this investment leads to new capabilities in industry and steadily reduces the risks of the underlying technology. At some point a company finally becomes confident enough of its ability to make a new technology for a predictable cost and schedule that it will propose the technology to someone other than DARPA. DARPA's investment reduced the risk of a technology to the point where firms themselves are willing to make it, use it, or otherwise bid it back to the rest of the DoD.

Figure 5: DARPA transition methods.

However, companies will not propose a new technology to a Service customer if they are not confident that the Service customer will accept it. The second bar in Figure 5 shows how DARPA removes this impediment. To build potential Service customers for DARPA technology – someone to whom these companies can bid with confidence – DARPA deliberately executes about 80 percent of its funding through the Services. That is, a Service organization acts as DARPA's agent and is the organization that actually signs the contracts with the research performers and monitors the day-to-day technical work. This creates a cadre of people inside a Service who are familiar with a DARPA technology, who can vouch for it, and who can shepherd it into a Service acquisition program. Once the company is confident that it can build a technology and a Service is willing to accept it, the technology then transitions and DARPA is, typically, forgotten.

DARPA occasionally builds prototype of a large, integrated system such as Global Hawk. Such programs reduce the risks in a new system to the point where the warfighting community can be confident that it will get a new and cost-effective capability. However, without proper planning such programs can run into a two-year "funding gap" between the time when the Service is convinced it wants the system and the time when the DoD's financial system can effectively respond. To prevent these and other problems, DARPA tries to ensure transition of prototypes by negotiating a Memorandum of Agreement with the Service adopting the system. The earlier the Memorandum of Agreement is negotiated, the better it works, since it is easier to plan the needed outyear funding ahead of time instead of trying to find it later.

In addition, to strengthen its connections with the Services, DARPA has military officers on staff who serve as "operational liaisons." These liaisons keep DARPA informed about what the Services might want, and they keep the Services informed about what DARPA is developing.

3. Current Strategic Thrusts

"Strategy" can be described as "the evolving pursuit of a central mission through changing circumstances." Consequently, over time, DARPA changes much of what it is doing in response to the different national security threats and technological opportunities facing the U.S.

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As a result of this constant strategic reassessment, DARPA is emphasizing research in eight strategic thrusts. They are:

- Counter-terrorism
- Assured Use of Space
- Networked Manned and Unmanned Systems
- Robust, Self-Forming Networks
- Detect, Identify, Track and Destroy Elusive Surface Targets
- Characterization of Underground Structures
- Bio-Revolution
- Cognitive Computing

The following sections contain brief descriptions of each thrust and the forces driving it, along with some example activities within the thrust.

3.1. Counter-terrorism

Protection against acts of terror and the networks that perpetrate them is foremost in everyone's mind today. DARPA has a counter-terrorism strategic thrust with two major elements.

One element, Information Awareness, has been greatly expanded as a direct result of the September 11th attacks. Its goal is to create information systems that America's national security and law enforcement communities can use to detect and defeat terrorist networks – perhaps preventing a terrorist attack and even eliminating the need for a major military operation.

IAO is *not* building a "supercomputer" to snoop into the private lives or track the everyday activities of American citizens. Instead, IAO is developing and integrating information technology that largely consists of three parts – advanced collaborative and decision support tools, language translation technologies, data search and pattern recognition technologies. Together, these three parts effectively comprise the Total Information Awareness (TIA) project.

The collaborative reasoning and decision-support technologies will solve existing coordination problems by enabling analysts from one agency to collaborate effectively with analysts in other agencies. A major challenge to terrorist detection today is the inability to quickly search, correlate and share data from databases maintained legally by our intelligence, counterintelligence, and law enforcement agencies. The collaborative reasoning and decision-support technologies will punch holes into these "stovepipes."

The language translation technologies will enable the rapid translation of foreign language speech and text and give analysts from intelligence, counterintelligence, and law enforcement agencies the ability to quickly search for clues about emerging terrorist acts. The intelligence community believes it can find evidence of terrorist activities in open source foreign language publications and broadcasts. The rapid translation technologies will help analysts search a significant amount of material in a much shorter period than is possible today.

The research into data search and pattern recognition technologies is based on the idea that terrorist planning activities or a likely terrorist attack could be uncovered by searching for patterns indicative of terrorist activities in vast quantities of data. Terrorists must engage in certain transactions to coordinate and conduct attacks against Americans, and these transactions leave signatures (form patterns) that may be detectable. For this research, the TIA project will only use data that is legally obtainable and usable by the U.S. Government.

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If the project is successful, the national security community and the Department of Homeland Security will consult with Congress to determine whether the TIA technology should be implemented for domestic use. The DoD will consult with Congress on how best to implement TIA technology for protection of U.S. forces overseas.

The DoD recognizes American citizens' concerns about privacy invasions. The Department has safeguards in place to ensure the TIA project will *not* violate the privacy of American citizens. As part of the TIA effort, IAO will research and develop privacy protection and other technologies to prevent abuses and external threats and ensure that data is protected and used only for lawful purposes.

Some individuals have questioned the role of the DoD and DARPA in this area. In its 44-year history, DARPA has undertaken numerous high-risk research efforts that led to significant capabilities. Many existing information technologies – including the Internet – started as advanced DARPA research projects. DARPA has had in the past joint programs with the FBI and the US Customs developing technology that could be used for detecting explosives and drugs at Airports and Sea Ports.

IAO follows a similar path of technical innovation with its research into advanced information capabilities that will give the United States a decisive edge in the global war on terrorism. All Americans share the frustration associated with vague warnings of terrorist threats. It is believed that IAO and its TIA project will help the U.S. Government reduce those generic reports to advance notice of specific threatening acts.

The second element of DARPA's counter-terrorism strategic thrust is Biological Warfare Defense (BWD). DARPA's BWD program began in the mid-1990s in response to a growing awareness that changes in the strategic and technological environment had sharply increased the biological warfare threat to the United States. DARPA's BWD program is comprehensive and aggressive. It covers sensors to detect an attack, technologies to protect people in buildings and manage the response to an attack, vaccines to prevent infection, therapies to treat those exposed, and decontamination technologies to recover the use of an area.

An excellent example of this work is the Unconventional Pathogen Countermeasures (UPC) program. The UPC program is working to create vaccines and therapies effective against any biological warfare threat, known or unknown, natural or engineered. In work that was accelerated because of the anthrax attacks on the Congress, the UPC program has supported what promises to be a major breakthrough in treating anthrax by using lysins, a development featured on the cover of *Nature* earlier this year[9].

3.2. Assured Use of Space

The national security community, generally, and the U.S. military, in particular, use space to provide warning, intelligence, communications, and navigation. These orbiting assets are one of the great advantages that the U.S. military has over potential adversaries. American society also uses space for similar purposes, making space assets an important element of the U.S. economy and way of life.

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9 *Nature* Issue 6900, August 22, 2002, Volume 418

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This military advantage and civil dependency has not gone unnoticed, and there is no reason to believe that it will remain unchallenged or untested forever. As the Rumsfeld Commission explained, "An attack on elements of U.S. space systems during a crisis or conflict should not be considered an improbable act. If the U.S. is to avoid a 'Space Pearl Harbor,' it needs to take seriously the possibility of an attack on U.S. space systems."[10]

DARPA began as a space agency, when the shock of Sputnik caused Americans to believe that the United States' Cold War adversary had seized "the ultimate high ground." DARPA once again is investing in that arena.

In FY 2002, the Secretary of Defense directed DARPA to begin an aggressive effort to ensure that the U.S. military retains its pre-eminence in space by maintaining unhindered U.S. access to space and protecting U.S. space assets from attack. Figure 6 depicts a conceptual framework for DARPA's space strategic thrust with five elements:

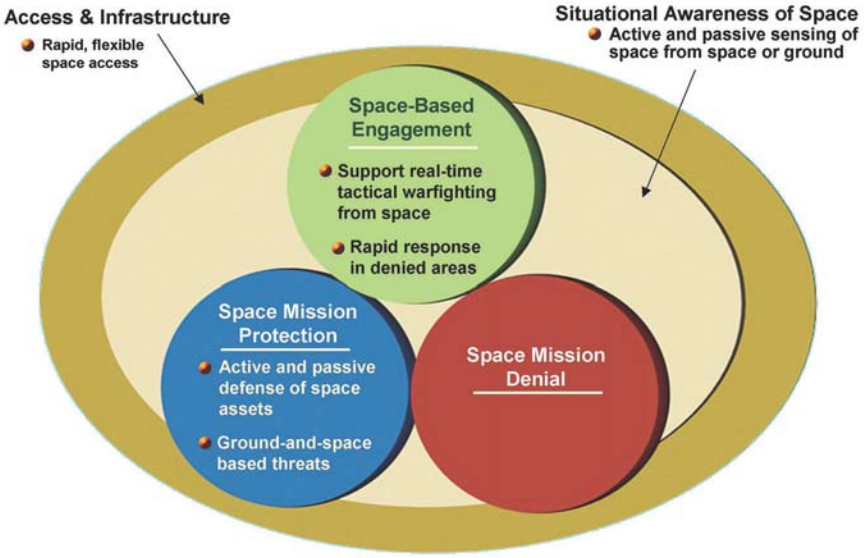

Figure 6: The five elements of DARPA's space program.

- **Access and Infrastructure** refers to rapid and affordable access to space;
- **Situational Awareness** refers to knowing what else is in space and what it is doing;
- **Space Mission Protection** refers to protecting U.S. assets in space from harm;
- **Space Mission Denial** refers to preventing adversaries from using space to harm the U.S. or its allies; and
- **Space-Based Engagement** refers to sensing, communications, and navigation to support military operations down on earth – extending what the U.S. does so well today.

DARPA is focusing most of its efforts on the first four of these thrusts, while the efforts in Space Based Engagement are emphasizing technology complementary to research being done by the Air Force and National Reconnaissance Office.

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10 *Report of the Commission to Assess United States National Security Space Management and Organization*, Hon. D. H. Rumsfeld, Chairman (January 11, 2001)

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