Bridging The Gap

DARPA

Powered by Ideas

Defense Advanced Research Projects Agency

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DARPA's Strategic Plan

1. Purpose

This document describes the Defense Advanced Research Projects Agency's (DARPA) current strategic plan, as required by Section 2352, title 10 of the United States Code. It provides a top-level view of DARPA's activities for Congress, the research community, and various elements of the Department of Defense (DoD).

This strategic plan describes DARPA's mission, the strategy for realizing that mission, and the tactics by which the strategy will be achieved.

DARPA's original mission, established in 1958, was to prevent technological surprise like the launch of Sputnik, which signaled that the Soviets had beaten the U.S. into space. The mission statement has evolved over time. Today, DARPA's mission is still to prevent technological surprise to the US, but also to create technological surprise for our enemies. Stealth is one example where DARPA created technological surprise. A discussion of DARPA's mission appears in section 2.

DARPA's strategy for accomplishing its mission is embodied in strategic thrusts. Over time, as threats and opportunities change, DARPA's strategic thrusts evolve. Today there are eight strategic thrusts, detailed in sections 3 and 4, that are important national security research and development areas. They represent focus areas for DARPA involvement and contain the foundations for innovative joint warfighting capabilities to defeat existing and emerging national security threats.

DARPA executes its strategy by sponsoring specific revolutionary, high-payoff research and development programs. Sections 3 and 4 provide many examples of DARPA-sponsored efforts to pursue its strategy by bridging the gap between fundamental discoveries and their military uses.

2. DARPA

2.1. Mission, Management, and Organization

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 quickly make decisions about starting, continuing, or stopping research projects.

To maintain an entrepreneurial atmosphere and the flow of new ideas, DARPA's strategy is to hire program managers for periods of only 4 to 6 years; the best way to foster new ideas is to bring in new people with fresh outlooks. 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. And, since program managers are not at DARPA for a career, they are willing to pursue high-risk technical ideas even if there is a good chance the idea will fail.

Another feature of DARPA's 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 problems or new technological opportunities. Offices are created and disbanded as DARPA changes direction.

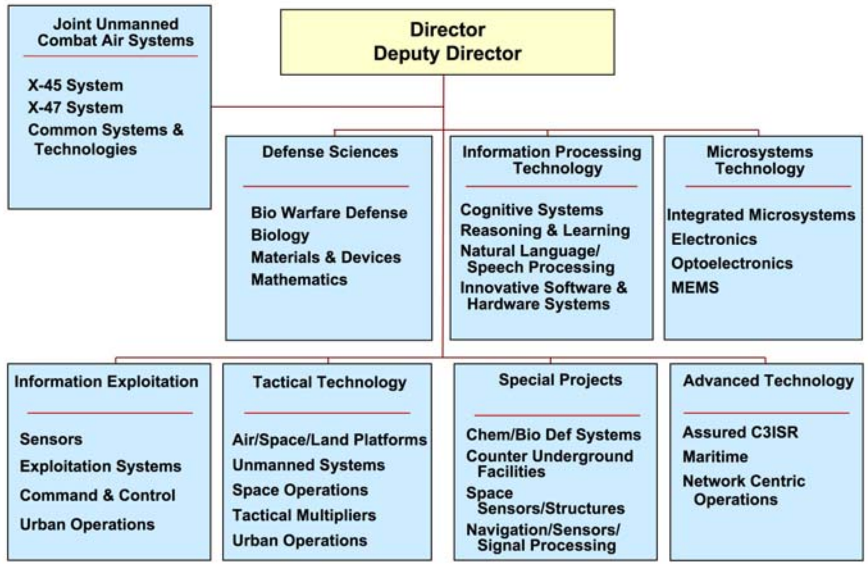

Figure 1: DARPA's organization.

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 combining people with the same interests leads to a nonlinear generation of ideas. The office directors recruit outstanding program managers and develop the office synergy, while keeping the program managers broadly on track with the office theme.

The themes of each office are set by the DARPA Director reflecting his interactions with the Secretary and Under Secretaries of Defense, Chairman of the Joint Chiefs of Staff, Combatant Commanders, Service Secretaries, Service Chiefs, Service units, and the staffs at each DoD level.

There are two basic technical offices at DARPA: technology offices and systems offices. The technology offices focus on new knowledge and component technologies that might have significant national security applications. These offices are the Defense Sciences Office, Microsystems Technology Office, and Information Processing Technology Office. The systems 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. These offices are the Tactical Technology Office, Special Projects Office, Advanced Technology Office, and Information Exploitation Office. As a practical matter, a fair amount of overlap exists between the two types of offices; the work in the technology offices often shapes the work of the systems offices, and vice versa.

In addition, DARPA currently hosts the Joint Unmanned Combat Air Systems (J-UCAS) Office, which is focused on developing a specific set of unmanned combat air vehicles for the Department of Defense.

Congress has granted DARPA 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 that allows it to maintain its entrepreneurial edge by hiring expert program managers from industry at competitive salaries, and do it much faster than under normal Civil Service rules.[1] This authority has been so successful that a DoD-wide authority for hiring highly qualified experts was modeled on it.[2] DARPA intends to start its transition to this new DoD-wide authority in Fiscal Year 2005.

DARPA pioneered the use of Other Transactions Authorities, which allow much more flexible contracting arrangements than normally possible under the Federal Acquisition Regulations. [3]

DARPA has the authority to award cash prizes to encourage and accelerate technical accomplishments, similar to the prize awarded to Charles Lindbergh for his nonstop transatlantic flight to Paris.[4] Based on this authority, in March 2004 DARPA offered a $1 million prize to any individual or team that could build a fully autonomous, unmanned ground vehicle that could travel a significant distance at militarily relevant speeds. *Scientific American* described the event well:

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
- Deputy Secretary of Defense Paul D. Wolfowitz
- Secretary of the Navy Gordon R. England
- Chairman of the Joint Chiefs of Staff General Richard B. Myers
- Acting Under Secretary of Defense for Acquisition, Technology and Logistics Michael W. Wynne
- Under Secretary of Defense for Intelligence Stephen A. Cambone
- Chief of Naval Operations Admiral Vern Clark
- Air Force Chief of Staff General John P. Jumper
- Commandant of the Marine Corps General Michael W. Hagee
- Army Chief of Staff General Peter J. Schoomaker
- Commander, Naval Surface Forces, Vice Admiral Timothy W. LaFleur
- Commander, U.S. Air Force Space Command, General Lance Lord
- Commander, U.S. Joint Forces Command, Admiral Edmund P. Giambastiani, Jr.
- Commander, U.S. Army Training and Doctrine Command, General Kevin P. Byrnes
- Commander, Third Fleet, Vice Admiral Michael J. McCabe
- Commander, U.S. Air Forces in Europe, General Robert H. Foglesong
- Commander, U.S. Special Operations Command, General Bryan D. Brown
- Commander, U. S. Strategic Command, General James E. Cartwright
- Commanding General, Marine Corps Combat Development Command, Lieutenant General James N. Mattis
- Director, Defense Research and Engineering, Ronald M. Sega
- Under Secretary of the Air Force Peter B. Teets
- Vice Chief of Naval Operations Admiral John B. Nathman
- Assistant Secretary of the Navy (Research, Development and Acquisition) John J. Young, Jr.
- Assistant Secretary of the Army for Acquisition, Logistics and Technology Claude M. Bolton, Jr.
- Director, National Security Agency, and Chief, Central Security Service, Lieutenant General Michael V. Hayden
- Director, National Geospatial-Intelligence Agency, Lieutenant General (Ret.) James R. Clapper, Jr.

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1 5 USC 3104 Note

2 5 USC 9903

3 10 USC 2371 and 10 USC 2371 Note

4 10 USC 2374a

> Of the 15 vehicles that started the Grand Challenge … not one completed the 227 kilometer course. One crashed into a fence, another went into reverse after encountering some sagebrush, and some moved not an inch. The best performer, the Carnegie Mellon entry, got 12 kilometers before taking a hairpin turn a little too fast. The $1-million prize went unclaimed. In short, the race was a resounding success. The task that the Pentagon's most forward-thinking research branch … set out was breathtakingly demanding. Most bots can barely get across a lab floor, but DARPA wanted them to navigate an off-road trail at high speed with complete autonomy. The agency had expected maybe half a dozen teams, but more than 100, ranging from high school students to veteran roboticists, gave it a try. The race … has concentrated the minds of researchers, blown open the technological envelope and trained a whole generation of roboticists. They will be out there again next October. [5]

DARPA's second Grand Challenge in October 2005 will offer a prize of $2 million.[6]

2.2. DARPA's Role

DARPA is a Defense Agency with a unique role within DoD. DARPA is not tied to a specific operational mission: DARPA supplies technological options for the entire Department, and is designed to be the "technological engine" for transforming DoD.

Near-term needs and requirements generally drive the Army, Navy, Marine Corps, and Air Force to focus on those needs at the expense of major change. Consequently, a large organization like DoD needs a place like DARPA whose *only* charter is radical innovation.

DARPA looks beyond today's known needs and requirements. As military historians note, "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."[7] *None* of them. And to this list, DARPA would add unmanned systems, stealth, global positioning system (GPS) and Internet technologies.

DARPA's approach is to imagine what capabilities a military commander might want in the future and accelerate those capabilities into being through technology demonstrations. These not only provide options to the commander, but also change minds about what is technologically possible today.

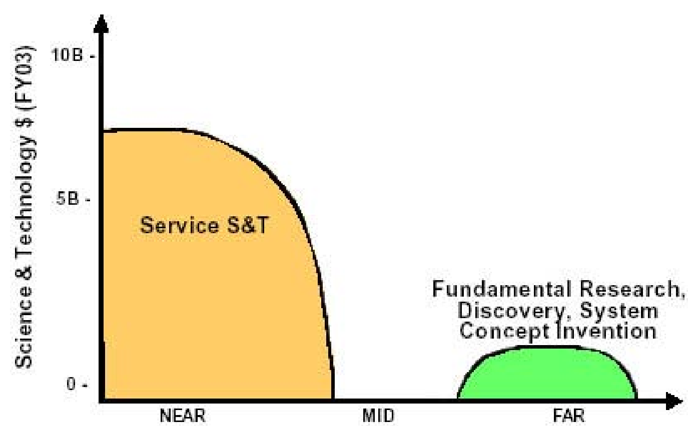

Figure 2: Timelines and investments in science and technology.

Figures 2 and 3 illustrate how DARPA works. These figures show where science and technology (S&T) funding is invested along a notional timeline from "Near" to "Far," which is indicative of the "time to go" for an

5 *Scientific American* **291**, 6, p. 6 (December 2004).

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

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

S&T investment to be incorporated into an acquisition program.

The Near bubble in Figure 2 represents most of the work of the Service S&T organizations. Service S&T tends to gravitate toward 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 U.S. military capabilities, e.g., improving the efficiency of jet engines. However, it is typically focused on known systems and known problems.

The Far bubble in 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 improvements against current, known problems.

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 they could not obtain the resources to execute their ideas. The Soviets beating the U.S into space with Sputnik in 1957 is a prime example. Sputnik motivated President Eisenhower to create DARPA in 1958 to bridge the gap between these two groups.

DARPA's mission, shown 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.

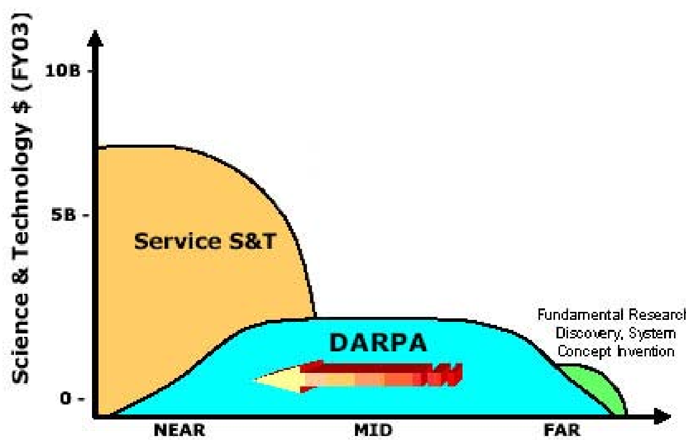

Figure 3: DARPA's role in science and technology.

DARPA emphasizes what *future* commanders might want and pursues opportunities for bringing entirely new core capabilities into DoD. 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 bridges the gap between fundamental discoveries and their military use.[8] Even though much of DARPA's work takes years to reach payoff, DARPA's flexibility and ability to change direction quickly allow it to react swiftly to emerging threats during a conflict. The inset discussion, "Shaping DARPA's Strategy," provides a more detailed discussion of how DARPA chooses its programs.

DoD's overall goal is to invest three percent of its topline in science and technology. This funding level is consistent with industry levels in healthy, well-run companies. In addition, these

8 Approximately five percent of DARPA's research is basic research (budget category 6.1). Basic research is inside the Far side bubbles and is primarily supported by the Service S&T organizations (with the Office of Naval Research having a primary role), and organizations like the National Science Foundation, the National Institutes of Health, and the Department of Energy. Basic research creates new *knowledge*, whereas DARPA creates new *capabilities* for national security by accelerating that knowledge and capacity into use.

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 and about 140 technical program 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 larger 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. 2) This process includes:

- Specific assignments from the Secretary of Defense, Under Secretary for Acquisition, Technology and Logistics, or Director, Defense Research and Engineering;
- 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 Geospatial-Intelligence Agency, the Defense Information Systems Agency, and the Defense Logistics Agency;
- Discussions with intelligence community agencies 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 allocates funds for exploring highly speculative technology that has far-reaching military consequences.

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

- Their own technical communities;
- Suggestions from DoD advisory groups, such as 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 Agency Announcements or open industry meetings such as DARPATech;
- Surveys of international technology;
- Breakthroughs in DARPA or other research programs; and,
- Small studies and projects used to flesh out ideas, often referred to as "seedlings."

DARPA's strategy and budget is reviewed thoroughly by the Under Secretary for Acquisition, Technology and Logistics and Director, Defense Research and Engineering.

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 program 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 interim technical milestones required to prove the hypothesis?
- What is the transition strategy?
- How much will it cost?
- Are the programmatic details clear?

companies typically spend about three-quarters of the three percent on improving their current products (Near side) and one-quarter on new products and technology (Far side). This split is deliberate and allows companies to maintain their current capability, while keeping an eye out for the unknown future so they can respond quickly to new products and markets.

By mining the Far side and bridging 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.

2.3. Shaping Programs

When considering which technologies to pursue, DARPA is mindful of its unique role and mission and searches for what are called "DARPA-hard" problems, i.e., technical challenges that, if solved, will be of enormous benefit to U.S. national security – even if the risk of technical failure is high. DARPA's senior management meets regularly with civilian and military leaders throughout the DoD to understand their problems, discuss with them what DARPA is working on that might help, and ask them the classic question, "What problems keep you up at night?" (See inset above, "DARPA's Outreach.") These discussions, coupled with constantly monitoring the "Far side" for potential solutions, keep DARPA's strategy matched with DoD's hardest technical problems and greatest technical opportunities (see inset, "Shaping DARPA's Strategy").

In addition, to keep current with the real-life facts-on-the-ground, several times a year DARPA's senior leadership and technical program managers visit military bases, commands, training centers, and other facilities to talk with warfighters and get a sense of their problems.

2.4. Major Accomplishments

Over the past four decades, DARPA and its management methodology have been very successful at "bridging the gap."[9]

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 1957 also launched DARPA, so all the Agency's initial projects were 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.

A new mission emerged to counter a new threat: intercontinental ballistic missiles. From approximately 1960 to 1970, DARPA was a driving force behind the United States' technology advancements in ballistic missile defense. In 1968, the Army Ballistic Missile Defense Agency was created, and the ballistic missile defense mission was transferred from DARPA.

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

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9 In 2003, the Institute for Defense Analysis released its report (www.darpa.mil/body/pdf/P-3698_Vol_1_final.pdf) documenting the major contributions DARPA system projects made to the revolution in military affairs.

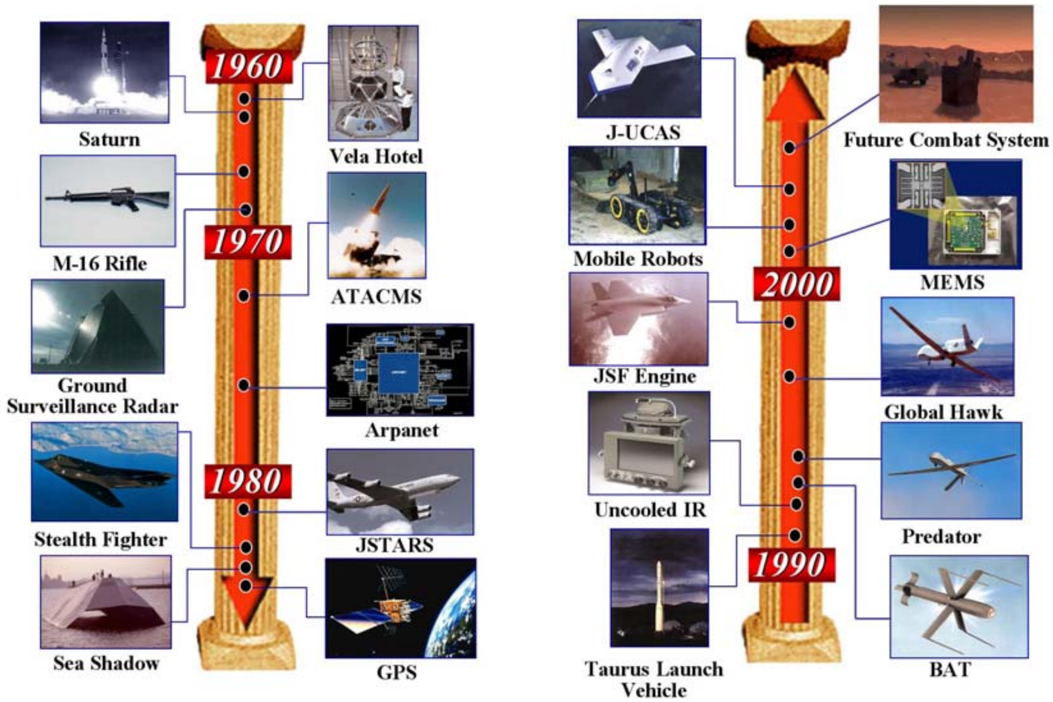

Figure 4: Key DARPA accomplishments spanning more than four decades.

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 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 (UAVs) have been prominent in Operation Enduring Freedom in Afghanistan and Operation Iraqi Freedom. DARPA started on the concept of a high altitude, long-range, extended loiter unmanned system in the 1970s with the TEAL RAIN program. After a number of significant technical breakthroughs, the Global Hawk high altitude endurance UAV transitioned from DARPA to the Air Force in 1998. 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-1990s.

The most well known of all DARPA technologies 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 DoD, the Federal Government, the U.S. industry, and the world.

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

2.5. Transitioning 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.

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 a Service acquisition program necessarily having decided on it *per se*. This means the key component 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 radical new technology.

Figure 5 is an illustration of DARPA's strategy to transition technology to the warfighter.

Figure 5: DARPA transition methods.

The first bar illustrates the majority of DARPA's transition activities. DARPA invests about 98 percent of its funds at organizations outside DARPA, primarily at universities 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 becomes sufficiently confident of the capability, value and technical maturity of a new technology for a predictable cost and schedule. It will then be willing to propose the technology to DoD users or acquisition programs. DARPA's investment reduces 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 DoD.

However, companies will not propose a new technology to a Service if they are not confident the Service 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 70 percent of its funding through the Services. That is, a Service organization serves as DARPA's agent, signing the contracts with the research performers and monitoring the day-to-day technical work. This investment 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 it can build a technology and a Service is willing to accept it, the technology transitions and DARPA's role in the development is, typically, forgotten.

DARPA occasionally builds prototypes 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 it will get a new and cost-effective capability. However, without proper planning such programs can run into a 2-year funding gap between the time the Service is convinced it wants the system and when the DoD financial system can effectively respond. To prevent these and other problems, DARPA tries to ensure transition of prototypes by negotiating a memorandum of agreement (MOA) with the Service adopting the system, such as the one for the Falcon rapid response launch vehicle. The earlier the MOA is negotiated, the better it works since it is easier to plan the needed outyear funding, instead of trying to find it later. In general, for its Advanced Technology Development (i.e., "6.3") programs, DARPA requires that an MOA or a transition strategy be negotiated with a Service, not before a program starts, but at some predetermined point during its development in order to proceed to its later stages.

DARPA has two other initiatives that help transitioning technology, the Service Chiefs Program and Operational Liaisons. DARPA's Operational Liaisons and Service Chiefs Program also help maintain strong institutional links and open communications with the Services and other elements of DoD and promote a cadre of officers who understand DARPA.

DARPA's *Service Chiefs Program* is a joint program between DARPA's Director and the Chief of Staff of each Service. Under the program, each Service details young, talented officers to DARPA as interns on a 2 to 3 month basis to give them an in-depth look at DARPA's programs and way of doing business. The interns also help DARPA's program managers better understand existing military capabilities and combat operations. Over the last two years, over 45 officers from all the Services have participated in the program, which has proven valuable in transitioning DARPA technology to the Services. However, the real value of the program is long-term. As these young officers progress through their careers, being exposed to DARPA at an early stage should make them more open to new technology and hence be even more valuable to U.S. national security.

Working with SOCOM

Over the last several years, DARPA has forged a close working relationship with Special Operations Command (SOCOM) based on the good strategic fit and synergy between the two organizations. SOCOM has sophisticated operators who face difficult problems that might be solved with advanced technology, and who can use experimental equipment in small quantities. DARPA is well-placed to supply that technology, and is interested in getting feedback on its work. In the short term, this relationship offers a good opportunity to test new technical solutions to difficult problems; in the longer term, it shapes SOCOM's view of what is and will be technically possible, and it influences what technology DARPA pursues.

To strengthen the systematic transition of its technology to SOCOM, DARPA has two representatives detached to the Command. Both are posted at SOCOM and work to bring SOCOM and DARPA together across a range of programs. This can vary from co-investing in a program, to SOCOM testing DARPA technology, to getting SOCOM's views on pending DARPA programs. SOCOM is a partner or participant in over 25 DARPA programs and has endorsed or influenced over 50 more.

Among the recent fruits of this relationship are portable water purification and language translation devices, improved language training tools, and an improved portable mission planning tool.

Operational Liaisons from each Service are assigned to the Director's Office at DARPA. Their everyday job is to maintain DARPA's connection to the real-life problems of the Services while, at the same time, helping transition DARPA technology to the Services. These individuals are usually very senior both in rank and experience, come with a great set of contacts within their Service and help reinforce the day-to-day linkages between DARPA's research programs and the needs and opportunities of the Services. (See Section 6.2 for contact information.)

The current DARPA Operational Liaisons are COL Gasper Gulotta, U.S. Army; CAPT Christopher R. Earl, U.S. Navy; Col Jose A. Negron, Jr., U.S. Air Force; Col Otto Weigl, U.S. Marine Corps; Dr. Young Suk Sull, National Geospatial-Intelligence Agency.

In addition, DARPA has detailed its own representatives to the Special Operations Command (SOCOM) in Tampa, FL. Their purpose is to maximize the flow of new technology to our special forces with a minimum of bureaucracy, an approach that has worked extremely well. DARPA's SOCOM representatives are Ms. Kathy MacDonald and Dr. Joe Mitola.

3. Current Strategic Thrusts

Strategy is 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 United States.

DARPA currently emphasizes research in eight strategic thrusts:

- Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets
- Robust, Secure Self-Forming Tactical Networks
- Networked Manned and Unmanned Systems
- Urban Area Operations
- Detection, Characterization, and Assessment of Underground Structures
- Assured Use of Space
- Cognitive Computing
- Bio-Revolution

3.1. Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets

The Department of Defense has steadily improved its ability to conduct precision strike against both stationary and moving ground targets. The timely, accurate and precise delivery of bombs and missiles has given the U.S. military tremendous advantages. Yet, experience shows that major challenges remain in target detection, identification, and tracking. It is still difficult to strike targets that are hiding, use evasive tactics such as frequent starts and stops, or that require a rapid reaction by U.S. forces in order to be destroyed.

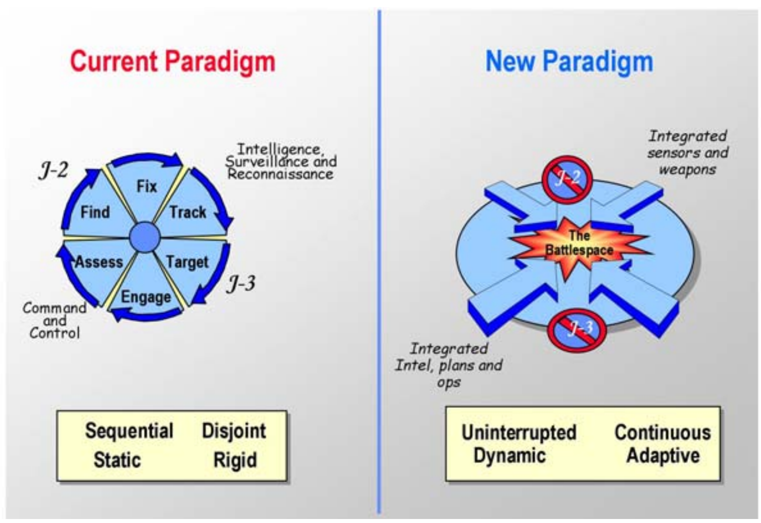

Figure 6: Our goal: eliminate barriers between Intelligence (J-2) and Operations (J-3).

To provide a focused response to these challenges, DARPA is assembling sensors, exploitation tools, and battle management systems to rapidly find and destroy ground targets in any terrain, in any weather, moving or stopped, with minimum accidental damage or casualties. To do this, we must seamlessly meld sensor tasking with strike operations to use platforms or a network of platforms that carry both capable sensors and effective weapons. This implies blurring or even erasing conventional barriers between the intelligence and operations functions at all levels of command (see Figure 6). This is a difficult challenge requiring technical and organizational innovations to achieve a joint approach to striking ground targets.

Our strategy to address this mission anticipates network-centric warfare arriving in two stages. In the first stage, networks will connect more and more sensors, platforms, and weapons with a variety of communications links (Figure 7). In the second stage, computers and commanders will take advantage of the massive amounts of data available to increase the speed, accuracy, agility, and capability of our combat forces.

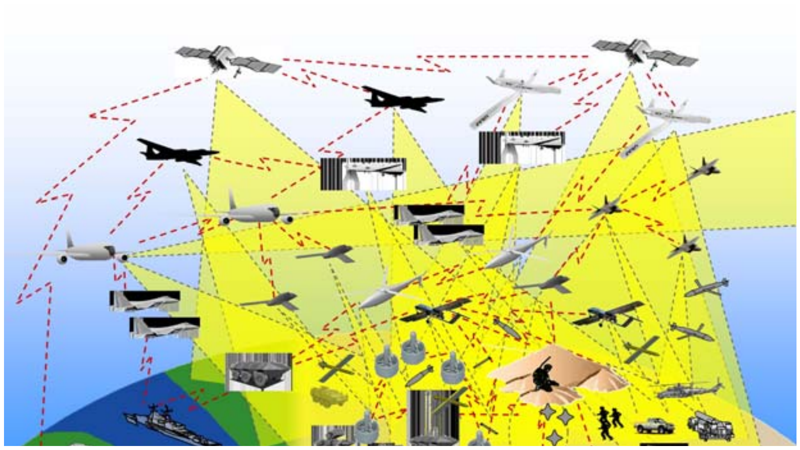

Figure 7: Networked operations.

For example, changes in images generated by DARPA's foliage-penetrating radar can be used to engage elusive targets. The radar itself operates at frequencies that penetrate the forest's canopy. Algorithms, run either on an aircraft or by the network at a ground station, compare images taken at different times to detect changes that signify either departures or arrivals. Because radars operate in all weather and at long ranges, this technique can discover the location of potential targets over very wide areas.

Then, to identify targets in response to these cues, DARPA's ladar sensors can obtain exquisitely detailed, 3-D imagery. Figure 8 shows a ladar image of a tank beneath forest cover. By flying the ladar over a potential target, photons can be collected from many different angles. Those that pass through gaps between leaves, however few, can be collated together into a full image. New computational methods can match these data against 3-D geometric models of a variety of target types, even identifying gun barrels, rocket launchers, and other equipment that unambiguously indicate the military nature of the vehicle. (Figure 8 depicts actual data from field tests.)

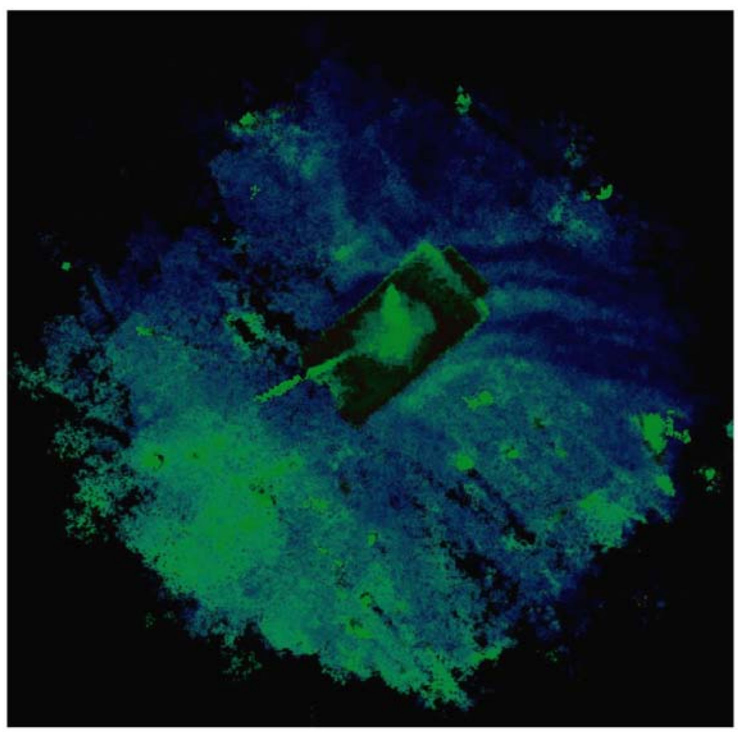

Figure 8: A composite image of a tank under trees formed from observations by a ladar sensor.

DARPA is developing software tools to "stitch-together" information obtained from a variety of tactical sensors (e.g., moving target indicator radar, synthetic aperture radar, optical, video, and acoustic sensors), and then cue the sensors to obtain more information (Figure 9). For example, the change detections obtained from radar could cue the ladar sensor to watch a new arrival.

Conversely, if Predator video lost a target because it entered a forest, the radar could be cued to search for the vehicle when it stops.

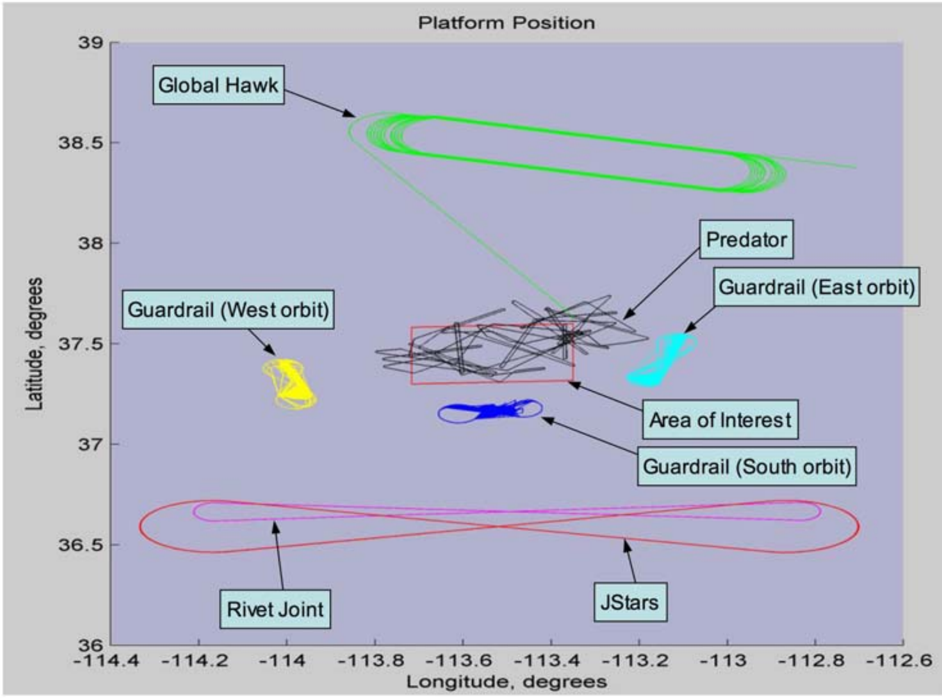

Figure 9: Decision aids help manage and adjust sensor routes to cover moving targets.

3.2. Robust, Secure Self-Forming Tactical Networks

The DoD is in the middle of a transformation to what is often termed "Network-Centric Operations" (see Figure 10). In simplest terms, the promise of network-centric operations is to turn information superiority into combat power so that the U.S. and its allies have better information and can plan and conduct operations far more quickly and effectively than any adversary.

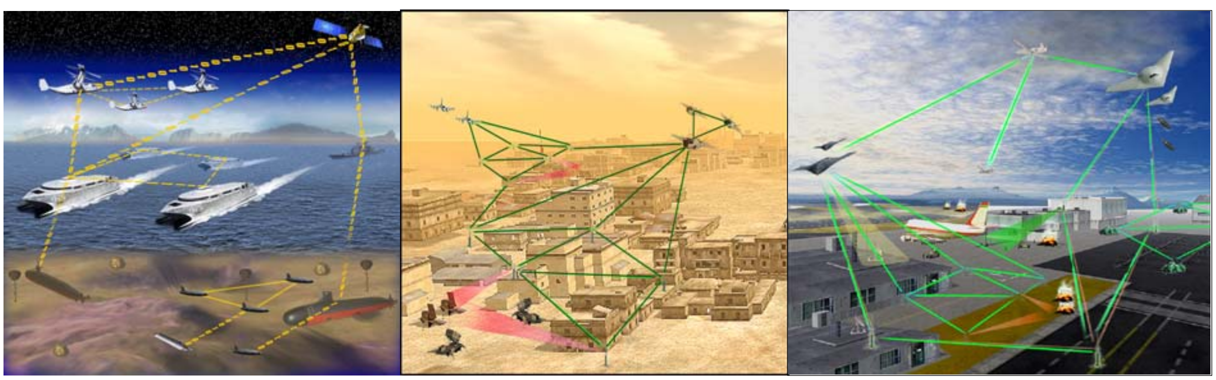

Figure 10: Future network-centric operations – anti-littoral access, urban operations, and expeditionary assault.

At the core of this concept are networks – networks that must be as reliable, available, and survivable as the platforms they connect. They must distribute huge amounts of data quickly and precisely across a wide area. They must form themselves without using or building a fixed infrastructure. They must withstand attempts by adversaries to destroy, disrupt, or listen in on them. These challenges must be met, as networks are becoming at least as important as our weapons platforms.

DARPA is working to ensure that U.S. forces will have secure, assured, high-data-rate, multi-subscriber, multipurpose (e.g., maneuver, logistics, intelligence) networks for future forces. This means conducting research in areas that include mobile *ad hoc* self-forming networks; information assurance and security; spectrum management; heterogeneous networks; and anti-jam and low probability of detection/intercept communications.

An example of DARPA's work in self-forming networks is the Small Unit Operations Situational Awareness System (SUO SAS) program. SOU SAS developed a self-forming, self-healing communication system for dismounted warfighters operating in difficult and complex environments, such as urban and wooded terrains. It allows warfighters to covertly and securely communicate with fellow squad members, and automatically reports all squad member locations, enabling both mission planning and mission execution monitoring. SOU SAS technology and capabilities transitioned to the Army, which is making the technology more compact and portable.

The heart of many networks is a common clock time. In many cases, this is provided by GPS. Hence, if an adversary jammed GPS, they might be able to take down the network. DARPA's Chip-Scale Atomic Clock program will cope with this vulnerability. Microelectro-mechanical systems (MEMS) technology will be used to place an entire atomic clock onto a single chip, reducing its size and power consumption by factors of 200 and 300, respectively (Figure 11). These wrist-watch-sized atomic clocks will greatly improve the mobility and robustness of military communication and navigation devices by providing a network clock if the GPS signal is lost.

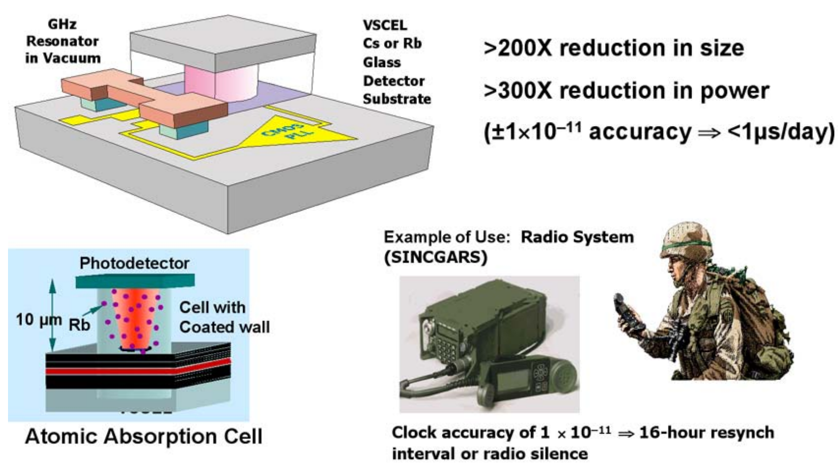

Figure 11: Chip-Scale Atomic Clock: Ultra-miniaturized, low-power, atomic time and frequency reference units.

To help provide bandwidth, the Optical and Radio Frequency Combined Link Experiment program (Figure 12) will combine large-bandwidth, free-space optical communications with radio frequency communications to demonstrate compact, robust, high bandwidth mobile communications for the military. This hybrid of optical and radio frequency technologies will provide more reliable high-data-rate communications than either could achieve on its own.

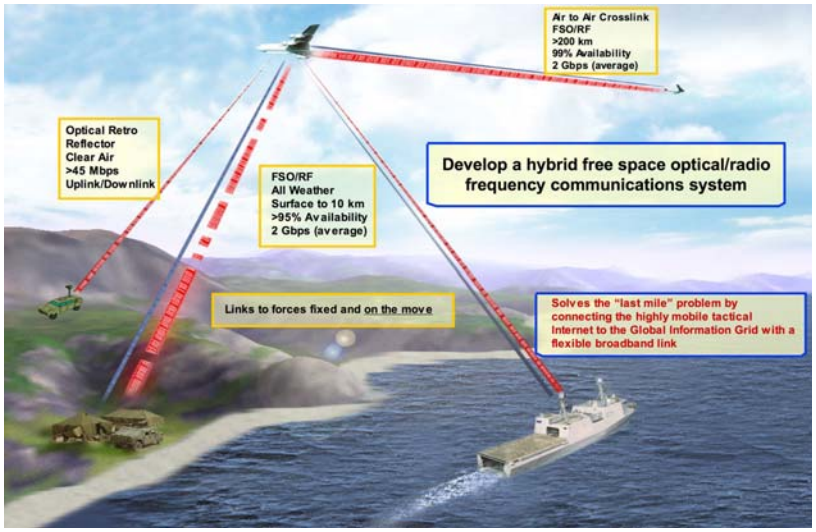

Figure 12: Optical and Radio Frequency Combined Link Experiment.

Spectrum is a valuable resource. The neXt Generation (XG) Communications program will increase spectrum availability and utility for the U.S. military 10 to 20 fold by dynamically allocating spectrum across frequency, time, and space without interfering with use by the spectrum owner (Figure 13). XG will allow networks to be set up much more quickly, without waiting for someone to allocate spectrum, and has been described as "tuning for daylight."

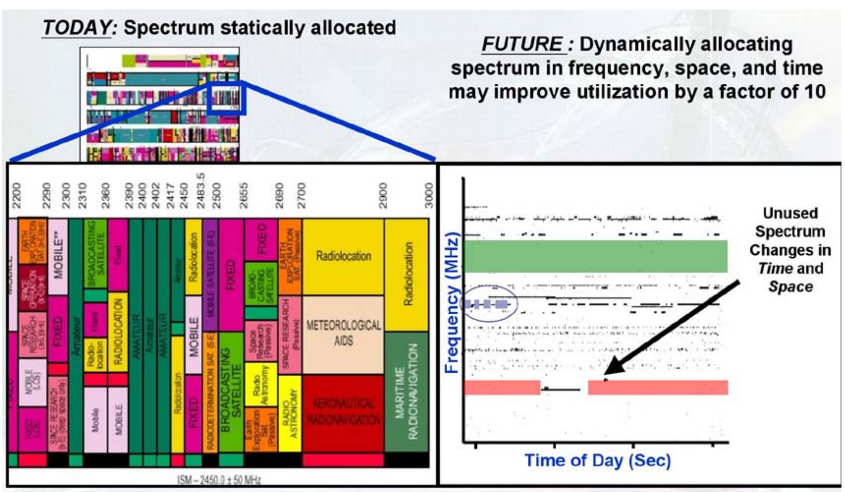

Figure 13: XG Communications program.

In the area of information assurance, the threat to military networks from computer worms that have never been seen before, and that exploit previously unknown network vulnerabilities ("zero-day worms"), has exceeded commercial industry's ability to mount an adequate defense. DARPA's Dynamic Quarantine of Worms program will develop an integrated system of detection and response devices to quarantine zero-day worms and stop them from spreading until other parts of the network can be protected.

3.3. Networked Manned and Unmanned Systems

DARPA is working with the Army, Navy, and Air Force toward a vision of a strategic and tactical battlespace filled with networked manned and unmanned systems. The goal is not simply to replace people with machines, but to team people with autonomous platforms to create a more capable, agile, and cost-effective force capable of achieving its mission with significantly lower risk of U.S. casualties. The use of unmanned aerial vehicles (UAVs) in Afghanistan and Iraq is a first step showing the transformational potential of this concept.

Several broad trends have made this strategic thrust feasible. There is an increasing appreciation within the Services that combining unmanned and manned systems can enable new combat capabilities and new ways to perform hazardous missions. Improved computers and software are permitting the dramatic increases in onboard processing required for unmanned systems to handle increasingly complex missions in ever more complicated environments (Figure 14). Networking manned and unmanned systems in combat will improve our knowledge of the battlespace, enhance our targeting speed and accuracy, increase the survivability of the *network* of vehicles, and allow greater mission flexibility. A network of collaborating manned and unmanned systems will be far more capable than the sum of its individual components.

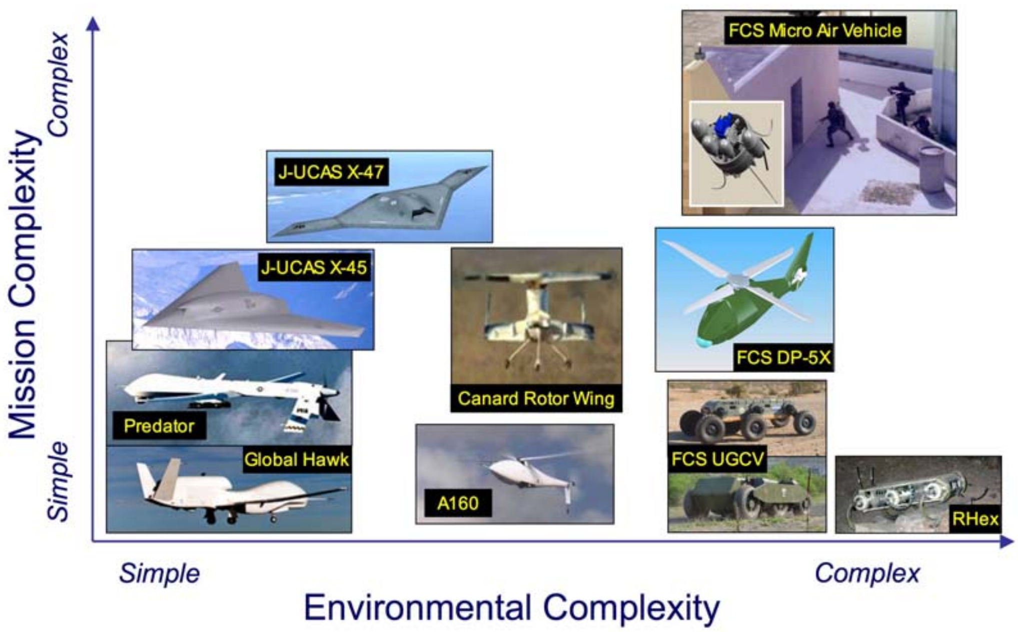

Figure 14: Unmanned Vehicles – the increasing challenge of autonomy.

For FY 2005 DARPA is hosting the Joint Unmanned Combat Air Systems (J-UCAS) program, which the Office of the Secretary of Defense established in late 2003 and is currently funding to accelerate DoD's progress towards making networked unmanned combat air vehicles a reality for suppressing enemy air defenses, precision strike, and persistent surveillance. J-UCAS is a joint Air Force and Navy program that builds on DARPA's earlier work on unmanned combat air vehicles for the Air Force (X-45) and the Navy (X-47). For FY 2006, funding for the program will move to the Air Force's budget. There will also be management changes that, as of this date, are under discussion. The program will develop new air vehicles, but the heart of the J-UCAS system will be its Common Operating System (COS), which will manage its network services and other system resources (e.g., sensors, weapons, communication links) to achieve specific missions. The combination of the air vehicles, control stations, and the COS, in conjunction with other manned and unmanned systems, will create an entirely new and powerful type of fighting force.

A prominent program in this area, Future Combat Systems (FCS), has been developing collaborative manned and unmanned Army units that have the *lethality* and *survivability* of our current heavy force, but the *agility* of our current light force. The Army assumed leadership of the FCS program from DARPA in FY 2003. Since the Army is using a spiral development approach in FCS, DARPA is continuing to develop and transition enabling technologies for the program. These efforts include the Micro Air Vehicle, which is a backpackable intelligence, surveillance, and reconnaissance (ISR) system suitable for dismounted soldiers, the Unmanned Ground Combat Vehicle (UGCV) for fire support, and several other platforms for ISR and tactical strike.

Working with the Army

The senior leadership at DARPA and the U.S. Army meet regularly, with a special focus on how they can continue to work together on Future Combat Systems (FCS), the centerpiece of the Army's transformation away from a threat-based force and toward a capability-based force. FCS will fundamentally change the way the Army fights, making it a network-centric force that achieves the lethality, mobility, and survivability of the current heavy force with a lighter, more rapidly deployable force.

DARPA and the Army have been working together on FCS since FY 2000. DARPA led the program in its earliest stages, and in 2003 DARPA transitioned the FCS program management lead to the Army. DARPA continues to work on supporting technologies to make future spirals of FCS even more capable, and currently has 18 programs with the Army to develop FCS component technologies, including the Micro Air Vehicle, the Organic Air Vehicle, the A160 Hummingbird, and the Electromagnetic Mortar.

In a near-term example, the Army is using mobile, distributed, collaborative command and control technology from DARPA's Command Post of the Future program in Iraq today.

3.4. Urban Area Operations

Intelligence analysts report that the world's urban areas are increasing in size; by 2025 nearly 60 percent of the world's population will live in urban areas. Given this growth, it is prudent to assume U.S. forces will continue to be deployed to urban areas for combat and post-conflict stabilization operations for the foreseeable future. Unstable and lawless urban areas give terrorists sanctuary to recruit, train, and develop asymmetric capabilities, including the possibility of chemical, biological, and radiological weapons of mass destruction (WMD). Historical evidence shows that urban area operations can be the most chaotic, dangerous, and costly type of operations.

Recent operations show that adversaries seek to fight in urban areas as a way to counter U.S. Forces' superior precision detection and strike capabilities that work so well against fixed and mobile targets in open and semi-concealed terrain. By hiding in urban areas, adversaries hope to force the U.S. to commit more ground troops and suffer more casualties, and to undermine U.S. goals by increasing the likelihood of collateral damage as U.S. forces seek and destroy targets in urban areas.

Urban areas offer adversaries opportunities to conceal movement, weapons, and activities. Finding and identifying elusive targets in the severe clutter in urban areas is difficult: the number and diversity of structures that sensors must search and categorize within a relatively confined area present a serious challenge to existing capabilities. Adversaries will also seek to hide their activities and weapons by blending in with the larger society. Enemy installations look like civilian installations, and the equipment used to fabricate unconventional weapons, such as improvised explosive devices or weapons of mass destruction (chemical, biological, or radiological), also have civilian applications in areas such as biotechnology, chemical engineering, food processing, and energy production.

DARPA programs in Urban Area Operations seek new urban warfare concepts and technologies that would make a smaller U.S. force conducting combat operations in an urban area more effective, suffer fewer casualties, and inflict less collateral damage. The objective is to make U.S. operations in urban areas as responsive, flexible, and successful as U.S. precision strike operations in open and semi-concealed areas, while minimizing the number of U.S. ground forces required.

For pre- and/or post-conflict stabilization operations, DARPA seeks advanced concepts and technologies to give U.S. forces capabilities to quickly and accurately understand and deal with changing social and environmental circumstances that could undermine a combatant commander's objectives. Capabilities are needed that rapidly prepare soldiers for missions in new cultural environments; improve command, control, communications, intelligence, surveillance, and reconnaissance in stabilization operations; and improve U.S. Forces' situational awareness of changing social and environmental circumstances. Combined, these efforts will enhance stabilization by enabling a limited number of U.S. Forces to achieve operational objectives through virtual force multiplication.

Working with the Marine Corps

The Commandant of the Marine Corps and the DARPA Director met several times to discuss the warfighting needs of the Corps, and DARPA responded with several quick-reaction programs. For example, U.S. convoys in Iraq frequently find themselves under attack by small arms. DARPA worked with the Marine Corps Warfighting Laboratory to develop the Boomerang shooter detection system, and 40 prototype Boomerangs have been deployed to Iraq. The Marine Corps had an urgent need for beyond-line-of-sight communications, and DARPA began the Marine Airborne Retransmission System to link line-of-sight radios using a tactically transportable aerostat with a self-contained mobile ground station. DARPA teamed with the Marine Corps Systems Command to mature and deploy two Reconnaissance, Surveillance, and Targeting Vehicles to Iraq to assess their operational capability, marking the first time a hybrid electric vehicle will be used by our Armed Forces in a combat theater.

In other programs, DARPA is developing an Optically Directed Attack Munition specifically for the Marine Corps to retrofit mortar rounds into precision-guided weapons. DARPA provided the Marines with Command Post of the Future (CPOF) equipment to allow them to become familiar with the technology and enhance their ability to operate with the Army as it deploys CPOF systems. Looking toward the future, DARPA is beginning a USMC Future Capabilities Study to look broadly at the operational concepts and technologies needed to make "Distributed Operations" a reality for the Marines, including how to fight an enemy that uses asymmetric warfare.

DARPA is investigating the feasibility of technical ideas in a number of areas and plans to pursue those showing the most promise. Technical areas being investigated include:

- *System Architecture and Integration* to develop novel integrated concepts of operation tailored to the challenges of urban warfare. The goal is system-level approaches that address the challenges of planning and executing urban operations and are as responsive, flexible, and successful as other aspects of U.S. warfighting – before and after major combat operations.

- *Improved Intelligence, Surveillance, and Reconnaissance* to vastly improve U.S. capabilities to detect adversaries hiding in civilian-type buildings and other structures and to find hidden explosives or WMD. This work includes: systems to detect adversaries, explosives, and WMD in open areas and in severe urban clutter; flying/perching machines for communications and sensor payloads; and systems to distinguish combatants from noncombatants in crowds and buildings.

- *Tagging, Tracking and Locating Capabilities* to persistently monitor targets or equipment of interest; tag, track and locate enemy activities; track and detect weapons fabrication and movement; and precisely discriminate threat from non-threat entities against severe background clutter. Tagging systems will be covert and able to be queried by handheld systems at close ranges, and by platform sensors at significant ranges, with a low probability of detection. Information retrieved from tagging systems will be integrated with network sensor, command and control, and information technology systems to enable tracking and location of a significant number of targets over a wide area. Equipped with advanced tagging, tracking and locating technologies, U.S. Forces would have capabilities to quickly identify threatening situations, precisely focus response operations, and reduce the potential for collateral damage.

- *Weapons for Urban Operations* to develop ultra-precise, beyond-line-of-sight infantry weapons for use in congested urban areas. One goal is weapons whose effectiveness can be varied from lethal to nonlethal and prevent collateral damage, enabling "blue-safe" regions to be maintained.

- *Urban Access with Minimal Infrastructure Disruption* to develop technologies that enhance urban mobility, including novel communications for individual soldiers; technologies to negate urban obstacles and move faster than the enemy without being detected; and vertical mobility for infantry. One goal is innovative approaches to vertical mobility that offer individual warfighters and unmanned systems the potential to shift facets of the force-on-force ground battle to the third dimension – above the city – giving U.S. forces a unique capability for countering the advantages of an enemy embedded in an urban environment.

- *Asymmetric Warfare Countermeasures* to develop technology to detect, prevent, or mitigate asymmetric attacks, such as suicide bomber attacks, improvised explosive device (IED) attacks, and WMD attacks – including radiological dispersal devices. For example, DARPA is embarking on a program to develop advanced biomedical technologies that minimize the warfighter's vulnerability to radiation exposures that would otherwise be lethal. The first component of this program will exploit recent advances in human molecular biology to vaccinate soldiers against radiation injury. The program's second component will focus on the development of novel antidotes that enhance the body's normal radiation protective mechanisms. DARPA is closely following the 2005 Defense Science Board Study on Integrated WMD Defense for more ideas.

  A recent example of a DARPA effort to counter asymmetric insurgency operations implemented in Iraq is the Boomerang shooter detection system (Figure 15). The Boomerang system is designed to determine the direction from which shots are fired at a moving vehicle to allow an appropriate response. DARPA is also exploring technologies to detect or neutralize IEDs.

Figure 15: Boomerang

- *Pre- and Post-Conflict Capabilities* to model and understand social indicators that precede the onset of hostility and conflict, coupled with tools to develop strategies to stabilize an urban area and assist U.S. civil affairs units.

- *Command, Control, and Intelligence (C2I) for Urban Warfighting* to develop new approaches to all-echelon C2 and new intelligence analysis tools specifically suited for urban operations. The goal is a collaborative environment that allows warfighters to see and understand what is happening throughout the urban battlespace in real time. One example is the mobile, distributed, collaborative command and control used in the Command Post of the Future (CPOF) (see Figure 16). CPOF technology shifts C2 from specific physical locations to a virtual command post by allowing remote access to a common planning tool from wherever the commanders are located, so they can collaborate in planning, coordinating, and executing operations in real time. The Army uses this technology today in Iraq. Another example of how DARPA is contributing to C2I in Iraq is technology from the Translingual Information Detection, Extraction and Summarization (TIDES) program. TIDES is used by various U.S. organizations in Iraq to obtain more accurate and timely translations of Arabic speech and text.

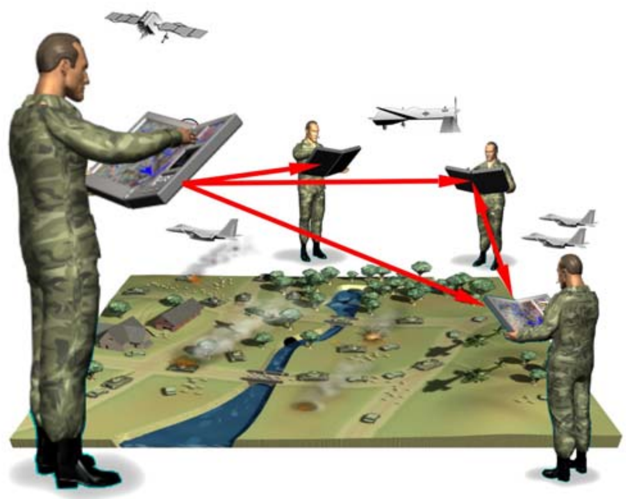

Figure 16: Command Post of the Future.

- *Modeling and Simulation* tools are being developed to prepare warfighters to manage stabilization operations, based on current knowledge of the terrain and environment, and enhance their sensitivity to local noncombatants through the use of large, multiplayer games tailored to the region.

3.5. Detection, Characterization, and Assessment of Underground Structures

Our adversaries are well aware of the U.S. military's sophisticated intelligence, surveillance, and reconnaissance assets and the global reach of our strike capabilities. In response, they have been building deeply buried underground facilities to hide various activities and protect them from attack.

These facilities can vary from the clever use of caves to complex and carefully engineered bunkers in both rural and urban environments (see Figures 17 and 18). They are used for a variety of purposes, including protecting leadership, command and control, hiding artillery and ballistic missiles launchers, and producing and storing weapons of mass destruction.

To meet the challenge posed by the proliferation of these facilities, DARPA's Counter-Underground Facility program is developing a variety of sensor technologies and systems – seismic, acoustic, electromagnetic, optical, and chemical – to find, characterize, and conduct post-strike assessments of underground facilities. The program is working on tools to answer the questions, "Where is the facility? What is this facility's function? What is the pace and schedule of its activities? What are its layout, construction, and vulnerabilities? How might it be attacked? Did an attack destroy or disable the facility?"

Figure 17: Cave entrance.

Figure 18: Underground facility.

To provide answers, DARPA is developing ground and airborne sensor systems with two-orders-of-magnitude improvement in sensor performance, combined with advanced signal processing for clutter rejection in complex environments. Underground facility detection, localization and characterization in multiple proof-of-concept tests and prototype demonstrations using these advanced systems began in Summer 2004.

3.6. Assured Use of Space

The national security community, including the U.S. military, uses space systems to provide weather data, warning, intelligence, communications, and navigation. These satellite systems provide our national security community with great advantages over potential adversaries. American society as a whole uses space systems for many similar purposes, making them an integral element of the U.S. economy and way of life.

These advantages – and the dependencies that come with them – have not gone unnoticed, and there is no reason to believe they 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

Working with the Air Force

DARPA and the Air Force have a strong working relationship, including quarterly meetings with the Air Force Chief of Staff and a particularly close and productive relationship with the Air Force Space Command. This has led to several new DARPA programs in space, targeting, and in-flight data exchange. As the Executive Agent for Space, the Air Force continues to integrate its operational missions with DARPA's technology development. These efforts are tackling the most difficult challenges to ensure that the U.S. maintains unhindered access to space, and that U.S. space assets are protected from attack.

To improve our ability to strike moving targets, DARPA and the Air Force are developing fast, precision-strike technologies to prosecute time-critical targets and perform battle damage assessment. In supporting the work in precision strike, DARPA is currently working on technology to vastly improve the exchange of data in-flight – technology that was first operationally validated in Afghanistan in 2001.

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 the Soviet Union had seized "the ultimate high ground." Over time, U.S. space systems have become a key to our military advantage. DARPA is again taking a major role in this important technological area.

In 2001, the Under Secretary of Defense for Acquisition, Technology and Logistics directed DARPA to begin an aggressive effort to ensure that the U.S. military retains its preeminence in space by maintaining unhindered U.S. access to space and protecting U.S. space capabilities from attack. Figure 19 depicts DARPA's space strategic thrust with five elements:

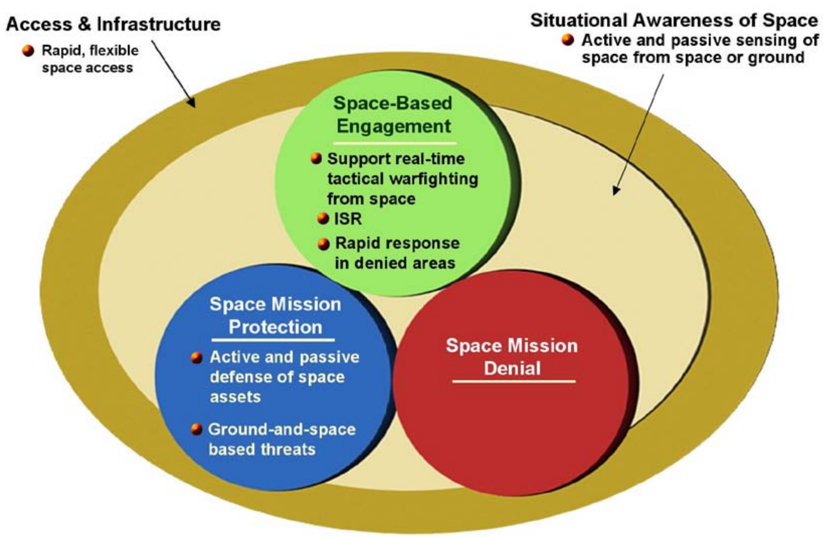

Figure 19: DARPA's space thrust.

- *Access and Infrastructure* refers to rapid and affordable access to space.
- *Situational Awareness of Space* refers to knowing what else is in space and what that "something else" is doing.
- *Space Mission Protection* refers to protecting U.S. assets in space from harm.

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

- *Space Mission Denial* refers to preventing adversaries from using space assets to harm the U.S. or its allies.
- *Space-Based Engagement* refers to reconnaissance, surveillance, communications, and navigation to support military operations on earth.

DARPA focuses most of its efforts on the first four thrusts, while the work in space-based engagement emphasizes technology to significantly improve tactical warfighting, complementing the strategic focus of the National Reconnaissance Office.

Examples of DARPA's space programs are Orbital Express, Space Surveillance Telescope (SST), and Falcon. Orbital Express will demonstrate the feasibility of using automated spacecraft to refuel, upgrade, and extend the life of appropriately designed on-orbit spacecraft. This will lower the cost of doing business in space and will provide radical new capabilities for military spacecraft, such as high maneuverability (which will make our satellites more difficult to track, hide from, or attack), autonomous orbital operations, and satellites that can be reconfigured as missions change or as technology advances. The SST program is developing a ground-based, wide-aperture, deep field-of-view optical telescope. It will search for very faint objects in geosynchronous orbit, e.g., new and unidentified objects that suddenly appear with unknown purpose or intent.

Figure 20: Falcon program's Hypersonic Cruise Vehicle.

Falcon (Figure 20) is designed to vastly improve the U.S. capability to reach orbit or almost anywhere on the globe promptly from bases in the continental U.S. This will improve the military's ability to quickly position intelligence, surveillance, and reconnaissance payloads while reducing its reliance on forward and foreign basing. Falcon will proceed in stages, including a small, low-cost launch vehicle; hypersonic test vehicles; and, eventually, a hypersonic vehicle. The technology required for Falcon will drive major progress in achieving low-cost, responsive access to space.

3.7. Cognitive Computing

Many elements of the information technology revolution that have vastly improved the effectiveness of the U.S. Forces and transformed American society (e.g., time-sharing, personal computers, and the Internet) were given their impetus by J. C. R. Licklider, a visionary scientist at DARPA some 40 years ago. Licklider's vision was of people and computers working symbiotically. He envisioned computers seamlessly adapting to people as partners that would handle routine information processing tasks, thus freeing the people to focus on what they do best – think analytically and creatively – and greatly extend their cognitive powers. As we move to an increasingly network-centric military, the vision of intelligent, cooperative computing systems responsible for their own maintenance is more relevant than ever.

Despite the enormous progress in information technology over the years, information technology still falls well short of Licklider's vision. While computing systems are critical to U.S. national defense, they remain exceedingly complex, expensive to create, insecure, frequently incompatible, and prone to failure. And, they still require the *user* to adapt to *them*, rather than the other way around. Computers have grown ever faster, but they remain fundamentally unintelligent and difficult to use. Something dramatically different is needed.

In response, DARPA is revisiting Licklider's vision as its inspiration for the strategic thrust, "Cognitive Computing." Cognitive computers can be thought of as *systems that know what they're doing*. Cognitive computing systems "reason" about their environments (including other systems), their goals, and their own capabilities. They will "learn" both from experience and by being taught. They will be capable of natural interactions with users, and will be able to "explain" their reasoning in natural terms. They will be robust in the face of surprises and avoid the brittleness and fragility of expert systems.

The benefits from this cognitive computing thrust will be profound. The increasing complexity of military systems means that the level of expertise needed to maintain them is also increasing – as are the staffing requirements for virtually every military function that uses computing and communications technology. By creating systems that know what they are doing, and that can configure, maintain, and adapt themselves, we will be able to drastically reduce the staff needed for operations centers, forward command posts, and even in support of small dismounted units and special operations teams. Cognitive computing technology will also help us to deal with the increasing tempo of operations and the complexity of plans, such as Air Tasking Orders and joint hostage rescue operation plans, by allowing computers to tap into the accumulated knowledge of past experience on behalf of their human partners.

Along these lines, DARPA's Personalized Assistant that Learns (PAL) program will create intelligent personalized assistants for many tasks, such as a commander's assistant, an intelligence analyst's assistant, or a decision-maker's executive assistant. These assistants will interact with their human partners by accepting direct, naturally expressed guidance to learn their partners' preferences and procedures. Then, they will be able to anticipate the human's needs and prepare materials to be ready just in time for them. These new and unprecedented artificial helpers should reduce military staffing needs in many key places and will help ensure decisions are made in a timely fashion and with the best possible preparation.

To meet these challenges and seize these opportunities, DARPA has structured its work in cognitive computing to catalyze innovative work in single cognitive systems, collaborative teams of cognitive systems, and collective cognition from large numbers of small non-cognitive elements (Figure 21). Each area will demonstrate the power

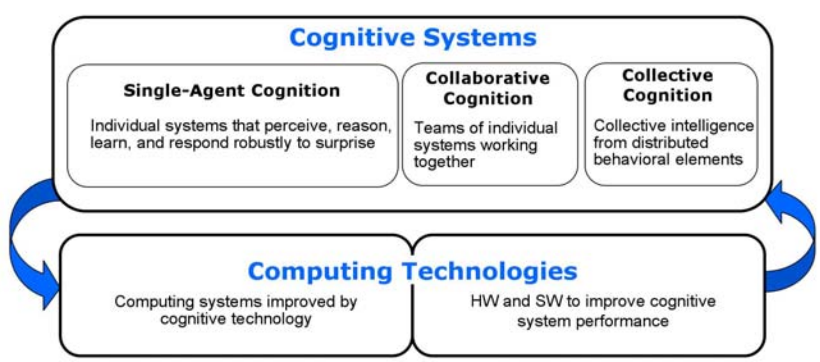

Figure 21: Cognitive Computing at DARPA.

of merging reasoning, learning, perception, and communication technologies. These areas will be supported and complemented by broad-based technology efforts in the hardware, software, and integration techniques needed.

The strategic thrust of cognitive computing is a template shaping DARPA's core technology foundation work in information technology (see Section 4.3).

3.8. Bio-Revolution

DARPA's strategic thrust in the life sciences, called Bio-Revolution, is a comprehensive effort to harness the insights and advances of modern biology to make U.S. warfighters and their equipment safer, stronger, and more effective. This thrust stems from several developments.

For more than a decade, the U.S. and many other nations have made enormous investments in the life sciences – so much that it has become commonplace to say that the world is entering a "golden age" of biology. One would be hard-pressed to find a better example of the Far side than the plethora of fundamental new discoveries in the life sciences reported every day. DARPA is mining these new discoveries for concepts and applications that could enhance U.S. national security in revolutionary ways.

This has been coupled with a growing recognition of synergies among biology, information technology, and micro-/nano-technology. Advances in one area often benefit the other two, and DARPA has been active in information technology and microelectronics for many years.

DARPA's programs to thwart the threat of biological attack brought significant biological expertise into the Agency. This expertise led towards a major exploration of the national security potential of cutting-edge research in the life sciences.

The Bio-Revolution thrust has four broad elements, as shown in Figure 22:

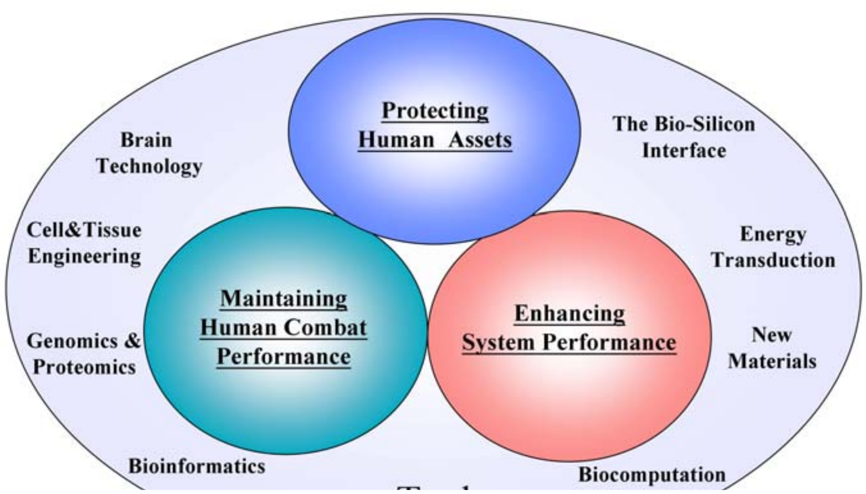

Figure 22: DARPA's Bio-Revolution thrust.

- *Protecting Human Assets* refers to DARPA's work in biological warfare defense (BWD). DARPA's comprehensive and aggressive BWD program began in the mid-1990s in response to a growing awareness of the biological warfare threat to the U.S. It covers sensors to detect an attack, technologies to protect people in buildings, vaccines to prevent infection, therapies to treat those exposed, and decontamination technologies to recover the use of an area. Advances in this area will protect the warfighter not only from biological warfare agents, but also from the infectious diseases they regularly encounter when deployed.

- *Enhancing System Performance* refers to creating new mechanical systems with the autonomy and adaptability of living things by developing materials, processes, and devices inspired by living systems. This is yielding legged robots (Figure 23) that can outperform wheeled vehicles in unplanned terrain, new optics based on eyes, and room temperature infrared sensors inspired by insect sensors that are lighter, more sensitive, and less costly than conventional sensors. The idea is to let nature be a guide toward better engineering.

Figure 23: Bio-inspired hexapod, RHex, emulates cockroach-like locomotion to traverse difficult terrain.

- *Maintaining Human Combat Performance* is aimed at ensuring that the warfighter is better able to maintain peak physical and cognitive performance once deployed, despite extreme battlefield stresses that include environmental extremes (e.g., heat and altitude), prolonged physical exertion, sleep deprivation, and a lack of sufficient calories and nutrients. The goal is for the warfighter who deploys in peak physical condition to stay at peak physical condition.

- *Tools* are the variety of techniques and insights on which the other three areas rest.

DARPA's program in preventing cognitive degradation as a result of sleep deprivation illustrates how the Bio-Revolution will help our troops. This program is investigating ways to mitigate fatigue so soldiers can stay alert and effective for extended periods without suffering deleterious mental or physical effects and without using any of the current generation of stimulants. Other Bio-Revolution programs are developing ways to:

- Eliminate acute pain through strategies that are more effective than narcotics, but do not affect a soldier's mental status or cognitive skills,

- Preserve platelets and other blood products so they are readily available in extremely isolated battlefields, and

- Increase the survival of wounded soldiers who are bleeding on the battlefield.

This research is tailored to dealing with the specific, uniquely difficult environments our troops encounter in combat. All new medical therapies would be required to undergo extensive clinical testing and comply with Food and Drug Administration rules and procedures.

Perhaps the program that best exemplifies the "revolution" in Bio-Revolution is Human Assisted Neural Devices. This program is finding ways to detect and directly decode signals in the brain so that the brain's motor signals can be turned into acts performed by a machine. This capability has been demonstrated, to a limited degree, with monkeys taught to move a computer cursor and telerobotic arm simply by intending to do so (Figure 24).

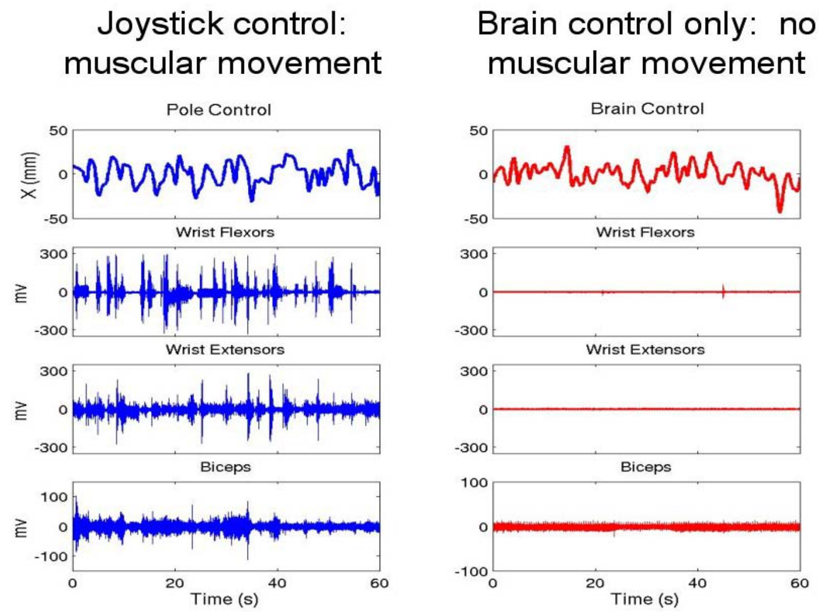

Figure 24: Electromyograms comparing monkey's control of telerobotic arm via joystick and brain control only.

The near-term benefit of this technology will be to injured veterans, who would be able to control prosthetics far more naturally than ever before by having their brain learn to use a prosthesis in much the same way it learned to use a natural limb. This work, coupled with DARPA's work in microelectronics, materials, power, and actuation, will form the basis for dramatically improving the current capabilities in prosthetics. The vision is simple but bold: to drastically improve the quality of life for amputees by transforming current limb prostheses into biologically integrated, fully functional limb replacements that have normal sensory abilities. The goal is for amputees to return to a normal life, with no limits whatsoever, with artificial limbs that work as well as the ones they have lost. This includes not only regaining fine motor control, such as the ability to type on a keyboard or play a musical instrument, but also the ability to sense an artificial limb's position without looking at it, and to actually "feel" precisely what the artificial limb is touching. DARPA is working closely with the Department of Veterans Affairs to make this a reality.

4. Core Technology Foundations

While DARPA's eight strategic thrusts are strongly driven by national security threats and opportunities, a major portion of DARPA's research emphasizes areas largely independent of current strategic circumstances. These core technology foundations are the investments in fundamentally new technologies, particularly at the component level, that historically have been the technological feedstocks for new systems enabling quantum leaps in U.S. military capabilities. DARPA sponsors research in materials, microsystems, information technology and other technologies that may have far-reaching military consequences.

In fact, these technologies often form enabling chains. Advanced materials have enabled new generations of microelectronics, which, in turn, have enabled new generations of information technology, which is the enabling technology for network-centric operations (see Section 3.2).

DARPA's support of these foundations naturally flows into its strategic thrusts with a fair amount of productive overlap. For example, some of the work under the Bio-Revolution thrust could be considered part of the materials work, and the information technology work is being reshaped by the Cognitive Computing thrust.

4.1. Materials

The importance of materials technology to Defense systems is often underestimated. Many fundamental changes in warfighting capabilities have sprung from new or improved materials. The breadth of this impact is large, ranging from stealth technology, which succeeds partly because materials can be designed with specific responses to electromagnetic radiation, to information technology, which has been enabled by advances in materials for electronic devices.

In keeping with this broad impact, DARPA maintains a robust and evolving materials program. DARPA's approach is to push new materials opportunities and discoveries that might change how the military operates. In the past, DARPA's work in materials has led to such technology revolutions as high-temperature structural materials for aircraft and aircraft engines, and the building blocks for the world's microelectronics industry. The materials work DARPA is supporting today builds on this heritage.

Working with the Navy

DARPA has a solid relationship with the Navy that has included regular visits by the Chief of Naval Operations to DARPA, and vice versa. One result of the regular conversations between the senior leadership of DARPA and of the Navy is that, over the past two years, DARPA has worked with the Navy's submarine community to focus on technology that will reduce the size and cost of the next-generation of submarines after the Virginia Class. The first step in this process was the Submarine Design Study – Phase 1, a 6-month task funded by DARPA and the Navy to develop two submarine concepts, each with the goal of significantly reduced cost compared to a VIRGINIA Class submarine. Taking the results of that study, DARPA and the Navy started the TANGO BRAVO program to jointly conduct research and development in five specific areas: (i) shaftless propulsion; (ii) external weapons stow and launch; (iii) hull-adaptable sonar array; (iv) radical ship infrastructure reduction; and (v) reduced crew/automated attack center.

DARPA also has signed Memoranda of Agreement with the Navy to develop solid-state power conversion technology and jet blast deflectors made from advanced materials to reduce the weight and maintenance on the next new aircraft carrier. If successful, the advanced jet blast deflector could be retrofit on all carriers currently in the Fleet.

DARPA's current work in materials includes the following areas:

- *Structural Materials and Components*: low-cost, ultra-lightweight structural materials and multifunctional materials designed to combine, in a single material, structure with other functions, such as power generation;
- *Functional Materials*: advanced materials with a nonstructural function for applications such as electronics, photonics, magnetics, and sensors;
- *Smart Materials and Structures*: materials that can sense and respond to their environment; and
- *Power and Water*: materials for generating and storing electric power and harvesting water from the environment.

For example, DARPA's Structural Amorphous Metals (SAM) program is advancing a new class of bulk materials with amorphous or "glassy" microstructures that have previously unobtainable combinations of hardness, strength, damage tolerance and corrosion resistance. Possible uses for SAM alloys include corrosion-resistant, nonmagnetic hulls for ships and self-sharpening penetrators that could replace depleted uranium. DARPA's Titanium Initiative aims to develop revolutionary processes for the low-cost extraction of titanium metal from oxide ores. The approaches include electrolytic processes similar to those that reduced the cost of aluminum from that of a precious metal to an everyday material. Progress in multifunctional materials promises to yield new structures for micro air vehicles, as well as lightweight blast protection for Navy ships.

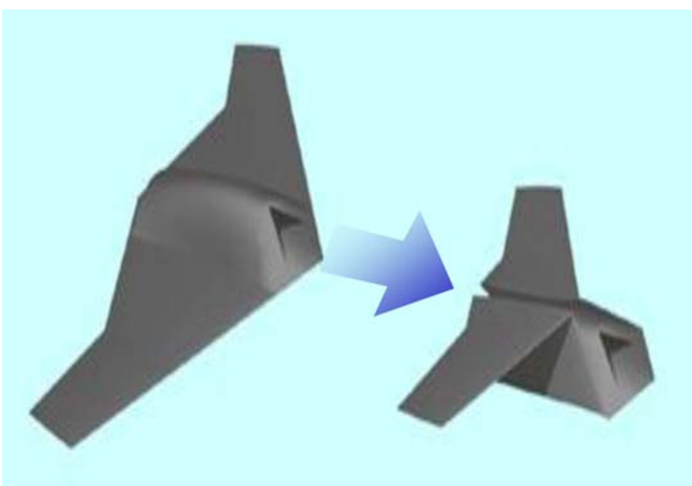

Figure 25: Morphing Aircraft.

Progress in smart materials and devices has provided the fundamental technologies that are making possible the construction of an external skeleton that will work unobtrusively and in concert with a soldier to support a 100-pound backpack. And it is enabling morphing aircraft structures that can radically change their shape in flight (Figure 25). This would allow a plane to dynamically vary its flight envelope while flying, much like a bird, so a single air vehicle could perform multiple, radically different missions.

Other programs are developing materials that will lead to fuel cells that reduce the weight of batteries carried by reconnaissance units from more than 200 pounds to less than 20 pounds, and novel approaches for generating water from air.

4.2. Microsystems

The U.S. military has enjoyed an asymmetric advantage over its adversaries by exploiting advanced microelectronics, photonics, and microelectromechanical systems (MEMS) technology to produce ever more capable platforms that can see further with greater clarity. The rapid progress in these microsystems technologies will remain a key enabler for the DoD in the future. DARPA is extending this technological edge by moving beyond conventional, 2-D, single-technology approaches to launch a new revolution in 3-D, multi-technology integrated microsystems.

DARPA is shrinking ever-more-complex systems and enabling new capabilities into chip-scale packages, integrating microelectronics, photonics, and MEMS into "systems-on-a-chip." It is at the intersection of these three core hardware technologies of the information age that some of the greatest challenges and opportunities for DoD arise. Examples include integrating MEMS with radio frequency electronics and photonics; integrating photonics with digital and analog circuits; and integrating radio frequency and digital electronics to create mixed signal circuits.

The model for this integration is the spectacular reduction in transistor circuit size under Moore's Law: electronics that once occupied entire racks now fit onto a single chip containing millions of transistors. As successful as this progress has been, the future lies in increasing the level of integration among a variety of technologies to create still-more-complex capabilities. DARPA envisions intelligent microsystems that enable systems with enhanced radio frequency and optical sensing, more versatile signal processors for extracting signals in the face of noise and intense enemy jamming, high-performance communication links with assured bandwidth, and intelligent chips that allow a user to convert data into actionable information in near-real-time.

Taken together, these capabilities will allow U.S. Forces to think and react more quickly than the enemy and create information superiority by improving how the warfighter collects, processes, and manages information.

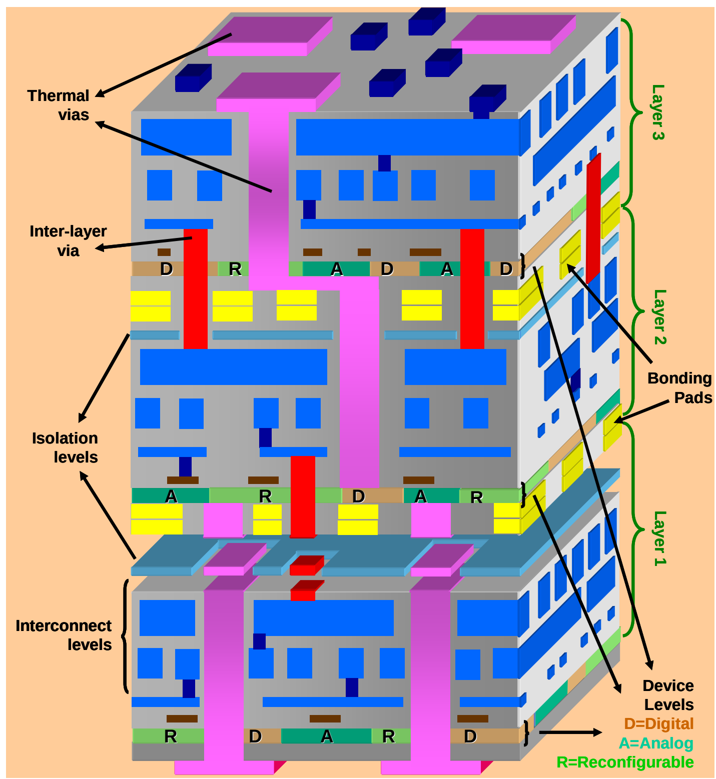

Figure 26: Schematic of 3-D circuit employing advanced functionality in each layer and reducing the length of critical signal paths.

An example of the move to integrated microsystems is the 3-D Electronics program. Conventional 2-D circuits are limited in performance by the long signal interconnects across ever larger circuits and by existing circuit architectures. By moving to three dimensions (Figure 26), we can shorten the signal paths and introduce additional functions in each layer of 3-D stacked circuits that will change the way designers can exploit circuit complexity.

As an example of how this integration approach is impacting system architecture, the Vertically Interconnected Sensor Array program is revolutionizing how focal plane arrays are coupled to their readout electronics by putting the electronics directly behind each pixel. New wafer-level processing technology makes it possible to construct these 3-D stacks, which will dramatically increase the performance and reduce the footprint of the focal plane.

Advanced materials are important drivers in developing new, advanced microsystems. An example is the progress being made in wide bandgap semiconductor devices for ultraviolet emitters, microwave sensors, and high power electronics. The ultraviolet emitters are being integrated into a compact, low-cost, biosensor based on multi-wavelength fluorescence for a new class of early warning systems. The microwave sensors will extend the performance of future radar, electronic warfare, and communications systems, while the advanced power electronics will reduce the size and weight of the power conversion station in future aircraft carriers or enable tactical electromagnetic weapons.

4.3. Information Technology

The DoD is undergoing a transformation to network-centric operations to turn information superiority into combat power. Supporting this, DARPA's information technology programs are building on both traditional and revolutionary computing environments to provide the kind of secure, robust, efficient, and versatile computing foundation that our network-centric future requires. We will also create radical new computing capabilities to make the commander and the warfighter more effective in the field. Our programs strive to provide such things as peta-scale computing, more robust and secure software systems, autonomous vehicle navigation, personalized and intelligent device/system control, human-robot and robot-robot collaboration, and enhanced human cognition.

- The High Productivity Computing Systems program focuses on the productivity or value of a system, instead of its raw, theoretical computing speed, to improve by a factor of 10 to 40 the efficacy of high-performance computers for national security applications. This program will maintain information superiority for the warfighter in areas such as weather and ocean forecasting, cryptanalysis, and computing the dispersal of airborne contaminants.

- The aim of the Improving Warfighter Information Intake Under Stress program is to directly and noninvasively measure human cognitive load so information can be presented to the warfighter in a way that does not overload human cognition when mental processes are pressed to the limit. This capability will enable the warfighter working under high-stress conditions to be more effective, and will fundamentally change the nature of the human-machine interface by finally creating interfaces that adapt to the user, rather than the other way around.

- DARPA continues to push significant improvements in the machine translation of natural languages. DARPA's handheld, one-way speech translation device was used in Operations Enduring Freedom and Iraqi Freedom. In at least one instance, its use led to the discovery of a large cache of weapons and the location of enemy forces. More generally, the performance of machine translation technology on Arabic news feeds has vastly improved from essentially garbled output to nearly edit-worthy text, often understandable down to the level of individual sentences. This work points the way to unprecedented capabilities for exploiting huge volumes of speech and text in multiple languages.

Information technology at DARPA has been instrumental in many crucial developments: the computer mouse, firewalls, asynchronous transfer mode, synchronous optical networks, packet-switching (including TCP/IP), search engines, and natural language processing. Twenty years from now, today's research will have enabled a new and scarcely imaginable legacy of network-centric operations, robotics and cognitive systems (See Section 3.7).

5. Strategy and Programs in Context

In the Quadrennial Defense Review (QDR), the Secretary of Defense established six critical operational goals for transforming the Department of Defense.[11] Figure 27 maps DARPA's eight strategic thrusts against those six goals to show how DARPA's current strategy continues to be a technological engine for transformation in the Department of Defense.

QDR Operational Goals for Transformation	DARPA's Strategic Thrusts
Protecting critical bases of operations (U.S. homeland, forces abroad, allies, and friends) and defeating chemical, biological, radiological, nuclear, and enhanced high explosive (CBRNE) weapons and their means of delivery	**Bio-Revolution**
Assuring information systems in the face of attack and conducting effective information operations	**Robust, Secure Self-Forming Tactical Networks**
Projecting and sustaining U.S. forces in distant anti-access or area-denial environments and defeating anti-access and area-denial threats	**Networked Manned and Unmanned Systems** **Urban Area Operations** **Bio-Revolution**
Denying enemies sanctuary by providing persistent surveillance, tracking, and rapid engagement with high-volume precision strike, through a combination of complementary air and ground capabilities, against critical mobile and fixed targets at various ranges and in all weather and terrains	**Detection, Precision ID, Tracking and Destruction of Elusive Surface Targets** **Urban Area Operations** **Location and Characterization of Underground Structures** **Bio-Revolution**
Enhancing the capability and survivability of space systems and supporting infrastructure	**Assured Use of Space**
Leveraging information technology and innovative concepts to develop an interoperable, joint C4ISR architecture and capability that includes a tailorable joint operational picture	**Robust, Secure Self-Forming Tactical Networks** **Cognitive Computing**

Figure 27: Mapping DARPA's strategic thrusts into QDR operational goals for transformation.

Approximately 90 percent of DARPA's investments can be mapped into the six QDR goals as shown in Figure 28. The remaining 10 percent of DARPA's budget is largely allocated to basic research and Small Business Innovation Research.

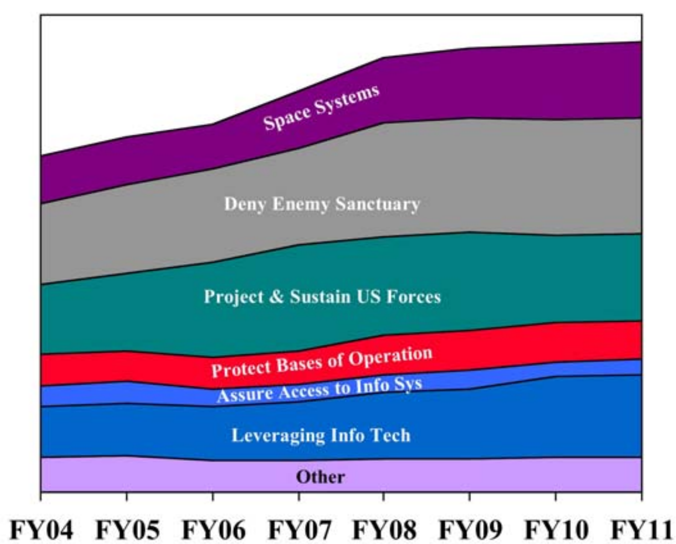

Figure 28: DARPA's budget by QDR transformation goals, FY 2004 – FY 2011.

An overview of how DARPA's programs support its Strategic Thrusts and Core Technology Foundations is shown in Figure 29. The table shows the principal DARPA offices supporting each area; please refer to the websites of those offices for information on their programs. The table also shows the Budget Program Elements (PE) and Budget Project Numbers[12] principally funding each area. Details on

[11] *Quadrennial Defense Review Report*, p. 30 (September 2001)

[12] Budget Project Numbers refer to a subset of programs grouped together under each PE to provide a somewhat finer level of financial detail. It does not mean "project" in the normal sense of the word.

individual programs can then be found by reading those sections of DARPA's FY 2006 Budget Estimates[13].

Strategic Thrusts			
Strategic Thrust	**Principal Office(s)**	**Principal Budget Program Elements**	**Principal Budget Project(s)**
Detection, Precision ID, Tracking, and Destruction of Elusive Surface Targets	IXO ATO SPO	Information and Communications Technology (0602303E)	IT-01
		Tactical Technology (0602702E)	TT-13
		Command, Control and Communications Systems (0603760E)	CCC-01, CCC-02
		Sensor Technology (0603767E)	SEN-01, SEN-02
Robust, Secure Self-Forming Tactical Networks	ATO MTO	Information and Communications Technology (0602303E)	IT-03
		Tactical Technology (0602702E)	TT-06, TT-13
		Electronics Technology (0602716E)	ELT-01
		Command, Control and Communications Systems (0603760E)	CCC-02
Networked Manned and Unmanned Systems	TTO J-UCAS ATO SPO	Tactical Technology (0602702E)	TT-03, TT-04, TT-06, TT-07
		Advanced Aerospace Systems (0603286E)	AIR-01
		Land Warfare Technology (0603764E)	LNW-03
		Network-Centric Warfare Technology (0603766E)	NET-01, NET-02
		Guidance Technology (063768E)	GT-01
		Joint Unmanned Combat Air Systems Advanced Component and Prototype Development (0604400D8Z)*	
		Joint Unmanned Combat Air Systems Advanced Technology Development and Risk Reduction (0603400D8Z)*	
		Joint Unmanned Combat Air Systems Advanced Technology (0603400F)*	
		Joint Unmanned Combat Air Systems Advanced Component and Prototype (0604400F)*	
Urban Area Operations	ATO DSO IPTO IXO SPO TTO	Information and Communications Technology (0602303E)	IT-04
		Tactical Technology (0602702E)	TT-04, TT-06, TT-13
		Command, Control and Communications Systems (0603760E)	CCC-01, CCC-02
		Land Warfare Technology (0603764E)	LNW-01
		Network-Centric Warfare Technology (0603766E)	NET-01
		Sensor Technology (0603767E)	SEN-01
Detection, Characterization, and Assessment of Underground Structures	SPO	Sensor Technology (0603767E)	SEN-01
Assured Use of Space	SPO TTO	Tactical Technology (0602702E)	TT-07
		Space Programs and Technology (0603287E)	SPC-01
Cognitive Computing	IPTO	Defense Research Sciences (0601101E)	CCS-02
		Cognitive Computing Systems (0602304E)	COG-01, COG-02, COG-03
Bio-Revolution	DSO SPO	Defense Research Sciences (0601101E)	BLS-01
		Biological Warfare Defense (0602383E)	BW-01
		Materials and Biological Technology (0602715E)	MBT-02

Core Technology Foundations			
Core Technology Foundation	**Principal Office**	**Principal Budget Program Elements**	**Principal Budget Project(s)**
Materials	DSO	Defense Research Sciences (0601101E)	MS-01
		Materials and Biological Technology (0602715E)	MBT-01
Microsystems	MTO	Defense Research Sciences (0601101E)	ES-01
		Electronics Technology (0602716E)	ELT-01
		Advanced Electronics Technologies (0603739E)	MT-12, MT-15
Information Technology	IPTO	Information and Communications Technology (0602303E)	IT-02
		Electronics Technology (0602716E)	ELT-01

*Details regarding these non-DARPA Budget Program Elements may reached via http://www.defenselink.military/comptroller

Figure 29: DARPA's Strategic Thrusts, the principal offices supporting those thrusts, and the Program Element and Project numbers in the Descriptive Summaries for FY 2006.

[13] Available online at http://www.darpa.mil/body/budg.html

6. Additional Information

6.1. General

Additional information on DARPA's offices and programs is available at www.darpa.mil. In-depth information is contained in DARPA's budget requests at http://www.darpa.mil/body/budg.html.

A listing of current DARPA solicitations may be found at http://www.darpa.mil/baa/. Of special interest to small businesses may be DARPA's Small Business Innovation Research (SBIR) program; more information may be found at http://www.darpa.mil/sbir/.

The DARPA Director's March 25, 2004, testimony to the Subcommittee on Terrorism, Unconventional Threats and Capabilities of the House Armed Services Committee may be found at http://www.darpa.mil/body/NewsItems/pdf/darpa_hasc_32504_final.pdf.

Updates to all these documents, as well as news releases about DARPA programs, can be found at http://www.darpa.mil/body/news.html.

6.2. DARPA Operational Liaisons and Representatives

DARPA's operational liaisons serve as points of contact for the Services. Service representatives with technical questions or needs are encouraged to contact the liaisons or a DARPA program manager working the area closest to a particular area of interest.

Army: ....COL Gasper Gulotta (571) 218-4477,
ggulotta@darpa.mil
Navy:...CAPT Christopher R. Earl (571) 218-4219,
cearl@darpa.mil
Air Force:..Col Jose A. Negron, Jr. (703) 696-6619,
jnegron@darpa.mil
Marines: ....Col Otto Weigl (703) 696-4209
oweigl@darpa.mil
National Geospatial-Intelligence Agency......Dr. Young Suk Sull (571) 218-4597
ysull@darpa.mil

The operational liaisons may also be contacted via SIPRNET at [username]@darpa.smil.mil.

In addition, DARPA has representatives located at the U.S. Special Operations Command:

USSOCOM ....Ms. Kathy MacDonald (813) 828-9366
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jmitola@darpa.mil