Three examples of DARPA's space programs are Responsive Access, Small Cargo, Affordable Launch (RASCAL), Orbital Express, and the Space Surveillance Telescope (SST). RASCAL is designed to place small payloads in orbit on a moment's notice by launching them from a high-speed, high-altitude aircraft that eliminates a large and expensive first stage booster. Orbital Express will demonstrate the feasibility of using automated spacecraft to refuel, upgrade, and extend the life of 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 would make our satellites more difficult to track and to evade), 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. This telescope will search for very faint objects in geosynchronous orbit, e.g., new and unidentified objects that suddenly appear with unknown purpose or intent.

DARPA's programs are in full support of the National Aerospace Initiative, including hypersonic flight programs.

3.3. Networked Manned and Unmanned Systems

DARPA is working with the Army, Navy, and Air Force toward a vision of filling the battlespace with unmanned systems that are networked with manned systems. The idea is not simply to replace people with machines, but to team people with robots to create a more capable, agile, and cost-effective force that lowers the risk of U.S. casualties. The recent use of UAVs in Afghanistan has just begun to demonstrate the potential of this idea.

DARPA has been working on this strategic thrust for the past several years. Much, although not all, activity in this area is expected to transition to the Services within the next few years.

Two broad trends have combined to make this thrust feasible. First, there is an increasing appreciation within the Services that combining unmanned with manned systems can enable new combat capabilities or new ways to perform hazardous missions. Second, improved processors and software permit the major increases in on-board processing needed for unmanned systems to handle ever more complex missions in ever more complicated environments.

A prominent program in this area is Future Combat Systems (FCS), which DARPA is conducting with the Army. FCS is catalyzing the Army's transformation to the Objective Force. It will be a networked system-of-systems that includes manned and unmanned ground vehicles, along with various unmanned air vehicles. The goal is to develop Units of Action that have the lethality and survivability of an M1-based heavy force, but with the agility of today's light forces. FCS brigades will be able to deploy anywhere in the world within 96 hours.

DARPA is also conducting three unmanned air combatant programs: the Unmanned Combat Air Vehicle (UCAV) with the Air Force (see Figure 7), UCAV-N with the Navy, and the Unmanned Combat Armed Rotorcraft program with the Army. These aircraft will be teamed with manned systems on the ground and in the air to transform how the Air Force suppresses enemy air defenses, how the Navy suppresses enemy air defenses and conducts extended surveillance, and how the Army conducts armed reconnaissance and attack.

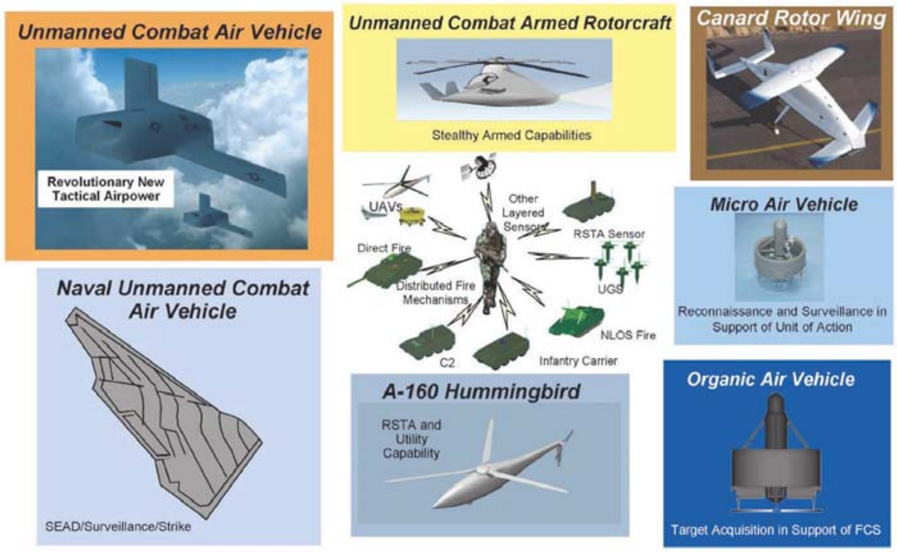

Figure 7: DARPA's Unmanned Systems programs.

3.4. Robust, Self-Forming Networks

The Department of Defense is in the middle of a transformation to what is often termed "Network Centric Warfare." In simplest terms, the promise of network centric warfare is that networked military systems will change the terms of any conflict in the U.S. military's favor. It will allow the U.S. and its allies to go beyond a correlation of local forces by providing them better information and letting them plan and coordinate attacks far more quickly and effectively than the adversary. In essence, networking is using "better brains" to create a more agile and effective brawn.

> **Network Centric Warfare**
>
> *An information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision-makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization. In essence, Network Centric Warfare translates information superiority into combat power by effectively linking knowledgeable entities in the battlespace.*
>
> — *Network Centric Warfare*, DoD C^4 ISR Cooperative Research Program

At the heart of this concept are survivable, assured communications at strategic and tactical levels. The intent is a network that degrades softly under attack, while always providing a critical level of service. The basic construct of a Joint Network Centric Warfare network is shown in Figure 8. DARPA continues its revolutionary thrust to ensure that U.S. forces will have secure, assured, multi-subscriber, multi-purpose (e.g., maneuver, logistics, Intel) networks for the future unified forces. This means conducting research in areas including self-forming networks, software programmable radios, spectrum management, and low probability of detection/intercept/exploitation communications.

The Adaptive Joint Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C^4ISR) Node Advanced Concept Technology Demonstration (AJCN ACTD) program is a prime example of DARPA's research activities in network communications. The AJCN ACTD is a multi-purpose, reconfigurable "radio frequency device in the sky." The program, just getting underway, will be a single system that can simultaneously

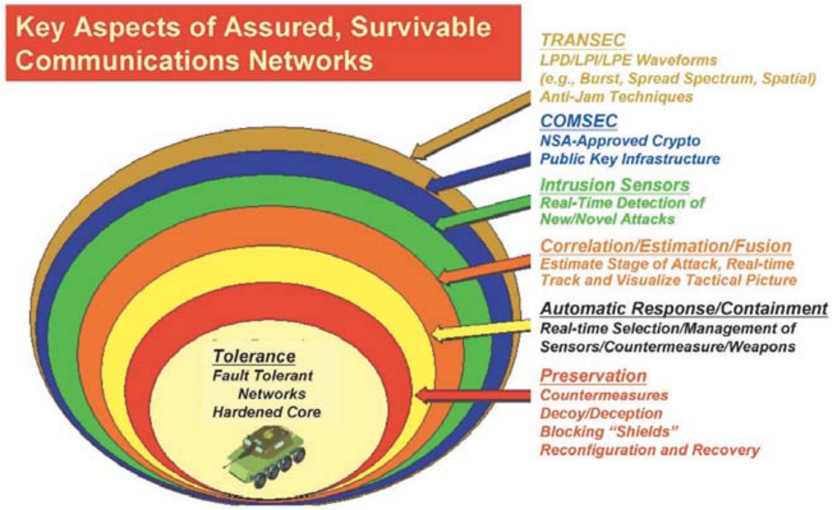

Figure 8: Protection of a Network-Centric Warfare network.

do any and all of the following: link up previously incompatible radios; conduct signals intelligence; conduct electronic warfare; and conduct information warfare.

DARPA's Small Unit Operations Situational Awareness System (SUO SAS) has developed a self-forming, self-healing communication system for dismounted warfighters operating in difficult and complex environments, such as urban and wooded terrains. The SUO SAS network allows the warfighter to covertly and securely communicate with his fellow squad members and automatically reports all squad member position locations, enabling both mission planning and mission execution monitoring. In October 2002 at Fort Benning, GA, the Army conducted a highly successful demonstration of using SUO SAS to help rescue a downed aircrew trying to escape capture in a city – a situation modeled on the events in Mogadishu, Somalia, in 1993.

The TeraHertz Operational Reachback (THOR) program is developing affordable, lightweight, and small high-speed optical communications networks for mobile and expeditionary forces without requiring laying down fiberoptic cable in-theater. THOR's long-term goal is to use emerging commercial technology to achieve data transfer rates of 10 gigabits per second over a 400 kilometer aircraft-to-aircraft link, a 40-fold improvement over current, high-data rate military communication systems.

A final example is the neXt Generation Communications program, which will make 10 to 20 times more spectrum available to the U.S. military by dynamically allocating spectrum across frequency, time, and space (see Figure 9). This capability has been described as "tuning for daylight."

3.5. Detect, Identify, Track, and Destroy Elusive Surface Targets

The Department of Defense has steadily improved its ability to conduct precision strike for many years. As a result, the war in Afghanistan showed that, in the words of the Chairman of the Joint Chiefs, "... the bomb is no longer solely an area weapon, but is going to be used like bullets from a rifle, aimed precisely and individually."[11] Timely, accurate, and precise delivery of bombs and missiles helped the U.S. overthrow a hostile regime in short order with very few American or

[11] Gen. Richard Myers, Chairman of the Joint Chiefs of Staff, Oral Testimony before the Senate Armed Services Committee, February 5, 2002.

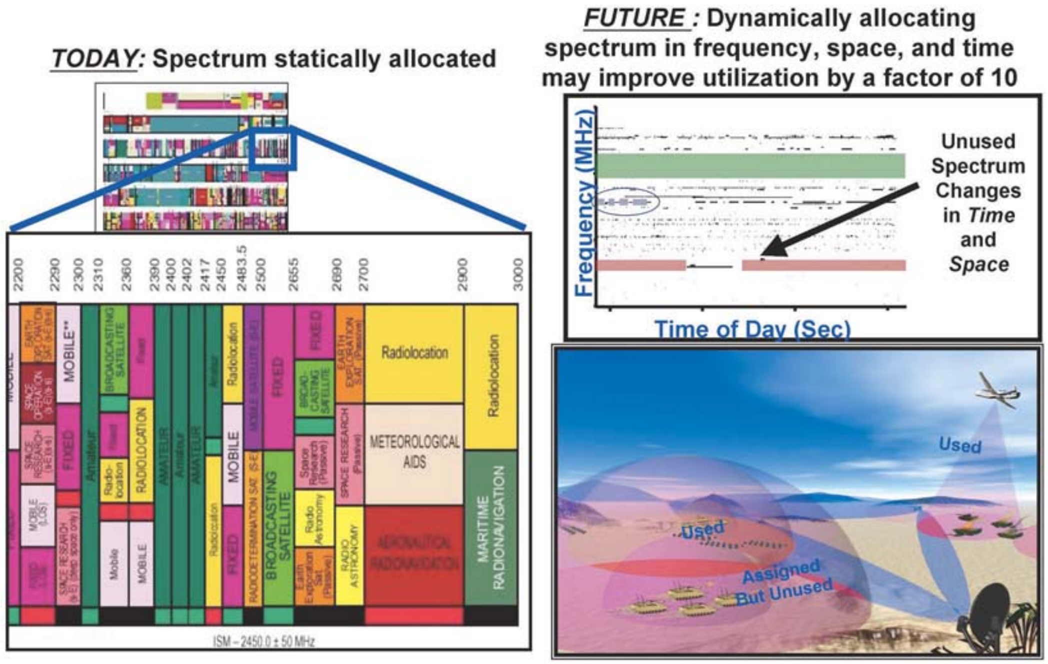

Figure 9: The neXt Generation Communication program

unintended casualties. Yet, experience has also shown that major challenges remain in target detection, identification, and tracking. It is still difficult to strike targets that are hiding, moving, or that require a rapid reaction by U.S. forces in order to be destroyed.

To provide a focused response to these challenges, DARPA established the Information Exploitation Office (IXO) in November 2001. IXO is assembling the sensors, exploitation tools, command systems, and information technologies needed to rapidly find and destroy ground targets in any terrain, in any weather, moving or not, at any time, with minimum accidental damage or casualties. To do this, IXO is working to seamlessly meld sensor tasking with strike operations, leveraging the development of platforms that carry both capable sensors and effective weapons. Of course, this implies blurring or even erasing barriers between the Intelligence and the Operations functions at all levels of command. This is a difficult technical challenge that requires a joint approach with potentially large implications for U.S. military doctrine and organizations – truly a DARPA-hard problem.

IXO is supporting research in four general areas: sensors to find targets; sensor exploitation systems to identify and track targets; command and control systems to plan and manage the use of sensors, platforms, and weapons throughout the battlespace; and information technology to tie it all together and ensure the effective dissemination of information.

A good example of IXO's efforts is the Affordable Moving Surface Targeting Engagement (AMSTE) program. AMSTE is demonstrating (see Figure 10) how, by making only minor modifications to existing and planned systems, U.S. forces can integrate information from multiple radars to precisely and rapidly destroy individual moving ground vehicles with a low-cost, GPS-guided gravity bomb like the Joint Direct Attack Munition (JDAM).

Another example of DARPA's work in time-critical precision strike is the Advanced Tactical Targeting Technology (AT3) program. By sharing the measurement of radar signals, AT3 can leverage non-dedicated platforms, such as fighters, to detect and locate enemy surface-to-air

Figure 10: AMSTE directs a Joint Stand Off Weapon (JSOW) to a direct hit on a moving tank during 2002 field experiments.

radars to an accuracy of 50 meters, from 50 miles away, and within 10 seconds after the enemy's radar turns on – a dramatic improvement over today's capabilities.

IXO is also developing tools to extract precise target identification from many different sources of data. Because many of our recent and potential adversaries invent or modify their weapons, programs such as Exploitation of 3D Data are developing techniques to recognize parts of vehicles (missile launchers, gun barrels, treads) that characterize threats, rather than specific vehicle types.

3.6. Characterization of Underground Structures

Many potential U.S. adversaries are well aware of the U.S. military's sophisticated ISR capabilities and global reach, so they have been building deeply buried underground facilities to hide what they are doing and to harden themselves against attack. These facilities can vary from the clever use of caves to complex, carefully engineered bunkers. Such installations can be used for a variety of purposes, including ballistic missiles, leadership protection, command-and-control, and the production of weapons of mass destruction.

To meet the challenge posed by the spread of these facilities, DARPA has a Counter-Underground Facility program (see Figure 11). The program is developing and using a variety of sensor technologies – seismic, acoustic, electro-optical, radio frequency, and chemical – to characterize underground facilities. The program is working on tools to answer the questions, "What is this facility for? How busy is it now? What are its structures and vulnerabilities? How might it be attacked? Did our attack destroy the facility?" The ability to answer these questions accurately will go a long way towards limiting the threat from underground facilities.

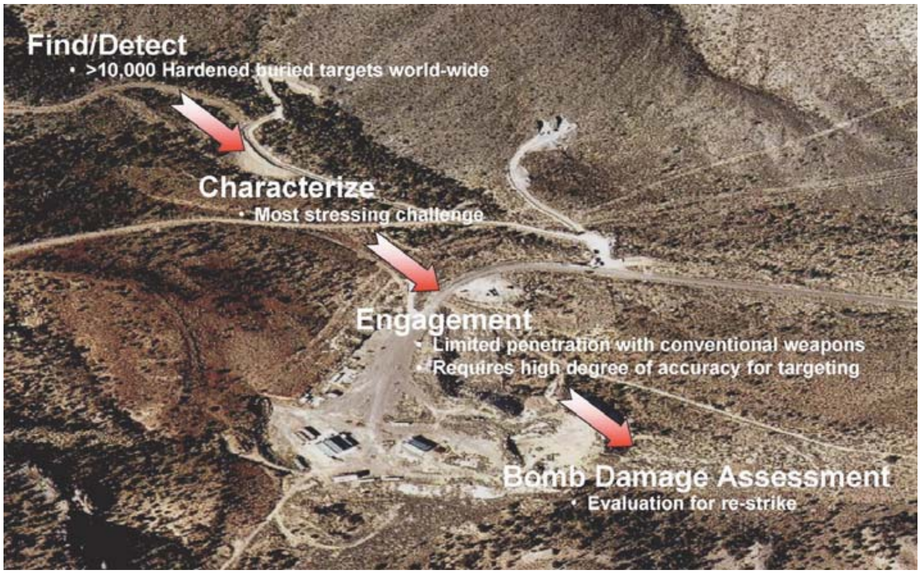

Figure 11: Counter-Underground Facilities program.

3.7. Bio-Revolution

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

First, over the last decade and beyond, the U.S. has made an enormous investment in the life sciences – so much so that it has now become commonplace to say that we are entering a "golden age" of biology. One would be hard-pressed to find a better example of the far right-hand side of Figure 2 than the plethora of fundamental new discoveries being reported every day in the life sciences. DARPA is mining these new discoveries for concepts and applications that could enhance U.S. national security in revolutionary ways.

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

Third, DARPA's programs to thwart the threat of biological attack have brought significant biological expertise into the Agency. This created an impetus and a capability to begin 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 12:

- **Protecting Human Assets** refers to the BWD work described above in the "Counter-terrorism" strategic thrust (Section 3.1). BWD was the seminal activity of the Bio-Revolution at DARPA and, therefore, is also included here.
- **Enhanced System Performance** refers to creating new systems with the autonomy and adaptability of living things by developing materials, processes, and devices inspired by living systems. For example, DARPA-supported researchers are studying how geckos climb walls and how an octopus hides to find new approaches to locomotion and highly adaptive camouflage. The idea is to let nature be a guide toward better engineering.

- **Enhanced Human Performance** is aimed at preventing humans from becoming the weakest link in the U.S. military. The goal is to exploit the life sciences to make the individual warfighter stronger, more alert, more endurant, and better able to heal.
- **Tools** are the variety of techniques and insights on which the other three areas rest.

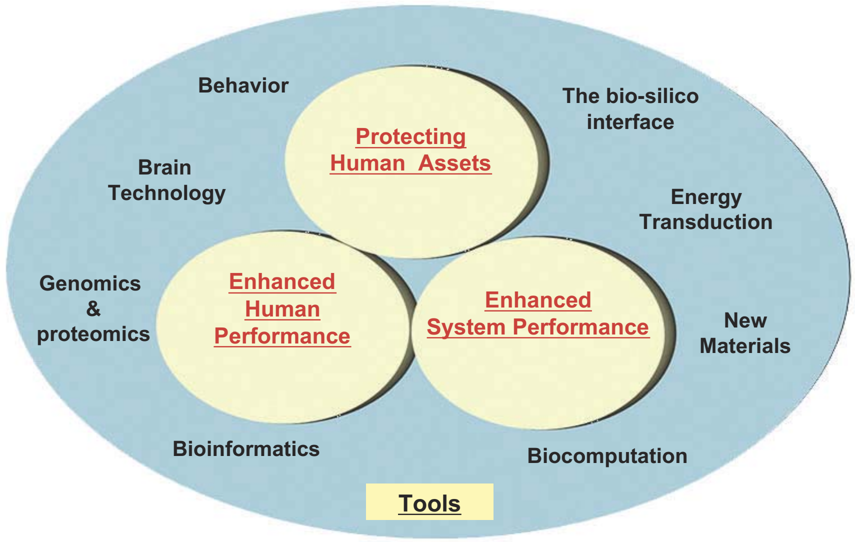

Figure 12: The four elements of DARPA's Bio-Revolution thrust.

DARPA's Continuous Assisted Performance (CAP) program illustrates how the Bio-Revolution is aimed at helping U.S. warfighters. CAP is investigating ways to prevent fatigue and enable soldiers to stay awake, alert, and effective for up to seven days straight without suffering any deleterious mental or physical effects and without using any of the current generation of stimulants.

Perhaps the program that best exemplifies the "revolution" in Bio-Revolution is the Brain Machine Interface program (see Figure 13). This program is finding ways to detect and directly decode signals in the brain so that thoughts can be turned into acts performed by a machine. Essentially, this program is working on ways for machines to synchronize with minds and then act directly on thoughts. This has actually been demonstrated, to a limited degree, with a monkey that has been taught

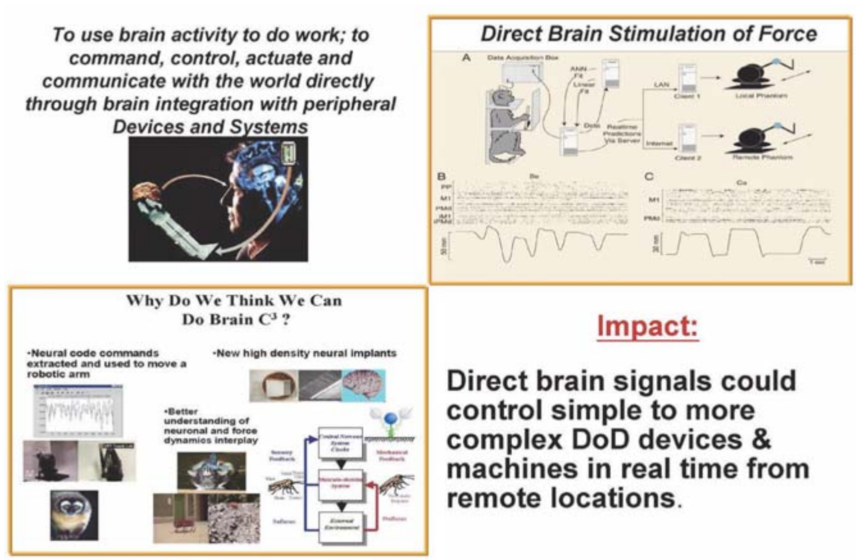

Figure 13: Brain-Machine Interface program.

to move a computer mouse or a telerobotic arm simply by thinking about it. The long-term Defense implications of finding ways to turn *thoughts into acts*, if it can be developed, are enormous: imagine U.S. warfighters that only need use the power of their thoughts to do things at great distances.

3.8. Cognitive Computing

Many elements of the information technology revolution that have vastly increased the effectiveness of the U.S. military and transformed American society – time-sharing, interactive computing, the ideas behind the personal computer, the Internet – were spurred on by the vision of a scientist at DARPA in the 1960s and 1970s, J. C. R. Licklider. Licklider's vision was of people and computers working together symbiotically. His concept was of computers seamlessly adapting to people as partners that handle routine information processing tasks. This frees people to focus on what they do best – think analytically and creatively – and, thereby, greatly extend the powers of their minds, i.e., what they can know, understand, and do.

Despite the enormous and continuing progress in information technology over the years, it is clear that we are still quite short of Licklider's vision. While current information systems are critical to U.S. national defense, they remain exceedingly complex, expensive to create and debug, unable to easily work well together, insecure, 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's Information Processing Technology Office (IPTO) is returning to its "roots" to take on Licklider's vision again in a strategic thrust called "Cognitive Computing." Cognitive computers can be thought of as systems that know what they are doing. Cognitive computing systems will have the ability to reason about their environment (including other systems), their goals, and their own capabilities. They will be able to 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 previous expert systems.

There are a number of reasons to believe the time is ripe for a more successful attempt at completing Licklider's vision. First, artificial intelligence and related disciplines, such as speech processing and machine learning, have made great strides in the last 20 years. Second, continuing rapid improvements in microelectronics are leading to the point where circuits with the complexity of primate brains are actually foreseeable (see Figure 14). Third, the on-going revolution in neural and brain science should provide insights into how people actually think, which can then be applied to computers.

To meet this challenge and opportunity, DARPA will focus on six core research areas over the next few years: computational perception; representation and reasoning; learning, communications and interaction; dynamic coordinated teams of cognitive systems; and robust software and hardware infrastructure for cognitive systems. The theoretical work in these areas will be focused by emphasizing several specific, but different, applications. The strategic thrust of Cognitive Computing will serve as a template to reshape DARPA's enduring foundational work in information technology (see Section 4.3).

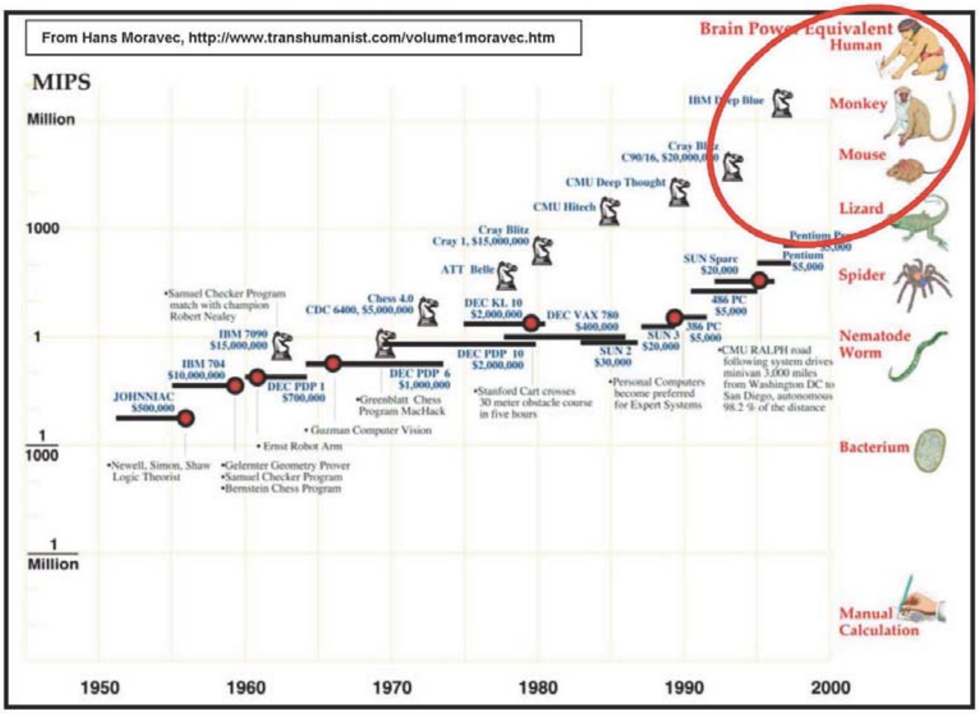

Figure 14: Microelectronics circuits as complex as primate brains are foreseeable.

If DARPA succeeds in this strategic thrust, just now getting underway, then in another 10 to 20 years, much of Licklider's vision may finally be realized, sparking a second powerful revolution in information technology.

4. Enduring 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 independently of current strategic circumstances. These "Enduring Foundations" are the investments in fundamentally new technologies, particularly at the component level, that historically have been the technological feedstocks enabling quantum leaps in U.S. military capabilities. DARPA is sponsoring 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. And information technology is the enabling technology for Network Centric Warfare, discussed in Section 3.4.

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

With this in mind, over 40 percent of DARPA's budget can be considered as devoted to high-risk, high-payoff component technologies. This figure is consistent with a goal established by the Undersecretary of Defense (Acquisition, Technology and Logistics) that at least 40 percent of DARPA's research be for "core technologies."

4.1. Materials

The importance of materials technology to Defense systems is often underestimated. In fact, 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 computation and memory.

In keeping with this broad impact, DARPA has maintained a robust and evolving materials program. DARPA's approach is to push those new materials opportunities and discoveries that might change way the military operates. In the past, DARPA's work in materials has led to such technology revolutions as new capabilities in 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 is building on this heritage of major contributions.

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

- **Structural Materials –** low-cost, ultra-lightweight structural materials and materials designed to accomplish multiple performance objectives in a single system;
- **Functional Materials –** material with a non-structural function such as advanced materials for semiconductors, photonics, magnetics, and other electronic materials;
- **Mesoscopic Machines –** materials that can be used for air or water purification and harvesting water from the environment;
- **Smart Materials and Structures –** materials that can sense and respond to their environment; and
- **Power Generation and Storage –** materials focused on novel ways to generate and store electric power, e.g., advanced fuel cells and materials to extract energy 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. As a result of this microstructure, SAM alloys have unique and previously unobtainable combinations of hardness, strength, damage tolerance and corrosion resistance. Possible uses for SAM alloys include corrosion-resistant, non-magnetic hulls for ships; lightweight alloys for aircraft and rocket propulsion; and self-sharpening penetrators. DARPA's Initiative in Titanium aims to develop revolutionary processes for low cost extraction of titanium metal from oxide ores. The approaches include electrolytic processes that are similar to those developed for aluminum and which reduced its cost from that of a precious metal to an everyday material.

One more example is the Morphing Aircraft Structures program, which is developing technologies aimed at building air vehicles that can radically change their shape in-flight. This would allow a plane to fundamentally and dynamically vary its flight envelope, much like a bird does, so that a single air vehicle could perform multiple, radically different missions.

4.2. Microsystems

Microsystems – microelectronics, photonics, and microelectromechanical systems (MEMS) – are key technologies for the U.S. military, enabling it to see farther, with greater clarity, and better communicate information in a timely manner.

DARPA is building on these accomplishments by shrinking ever-more-complex systems into chip-scale packages – integrating the three core hardware technologies of the information age into “systems-on-a-chip.” It is at the intersection of microelectronics, photonics, and MEMS 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 the U.S. military to think and react more quickly than the enemy and create information superiority by improving how warfighters collect, process, and manage information.

A good example of DARPA’s current work in microsystems is the Chip-Scale Atomic Clock, which is using MEMS technology to place an entire atomic clock onto a single chip, reducing its size and power consumption by factors of 200 and 300, respectively (see Figure 15). Chip-scale atomic clocks will greatly improve the mobility and robustness of military communication and navigation devices. Frequency references from atomic clocks will improve communications channel selectivity and density. Atomic clocks will also enable ultra-fast frequency hopping for improved security, jam-resistance, and data encryption. In GPS receivers, they will greatly improve the jamming margin and help continuously track positions and quickly reacquire a GPS signal. In surveillance, atomic clocks will improve the resolution of Doppler radars and locate radio emitters.

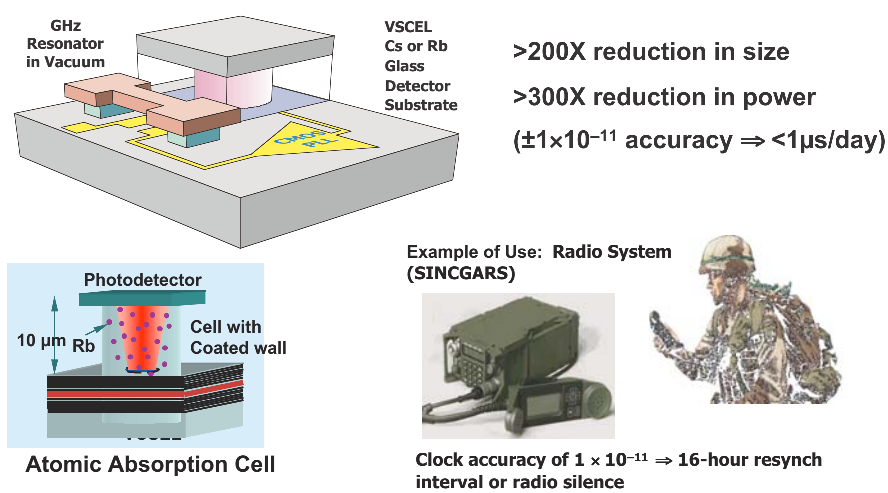

Figure 15: The Chip-Scale Atomic Clock: ultra-miniaturized, low-power, atomic time and frequency reference units.

Another example is the Molecular Electronics program. Within 10 to 15 years, today's dominant computer switch technology, CMOS[12] transistors, will reach its lower size limits and no longer advance according to Moore's Law. Anticipating this, the Molecular Electronics program is seeking to replace CMOS transistors with *molecular* switches that are 100 to 1000 times smaller and have the potential to reach a trillion switches per square centimeter. This development will reduce the size, weight, and power of these processors and increase their performance, allowing greater computing power to be packed into ever smaller volumes, increasing the "smarts" of military systems while lightening the soldiers' load. There has been solid progress towards this goal: in FY 2004, DARPA expects to demonstrate the first 16 kilobit memory based on molecular switches.

4.3. Information Technology

DARPA's strategic thrust in Cognitive Computing is significantly reshaping the Agency's enduring foundation in Information Technology. The six core Cognitive Computing research areas mentioned in Section 3.8 are setting the directions for DARPA's information technology research. These efforts will result in a new class of computational systems that will be responsible for their own operation and able to cope with unforeseen events. These systems will possess the ability to *reason* in a variety of ways, using substantial amounts of appropriately represented knowledge; they will *learn* from experiences and improve performance using accumulated knowledge; they will be able to *explain* themselves and *accept naturally expressed guidance and direction*; they will be *aware* of their own behavior; and most importantly, they will *respond* in a robust manner to surprises. DARPA envisions cognitive systems that possess *imagination* - the ability to invent interesting scenarios and plan for and predict novel futures.

DARPA's efforts build on traditional and revolutionary computing environments and strive to provide such things as improved device/system control, human-robot and robot-robot collaboration, and enhanced human cognition. Among our programs we have the following:

- DARPA's Software for Distributed Robotics (SDR) program is developing robot behavior and software to enable very large groups of very small, very inexpensive robots to perform useful tasks. SDR will allow human operators to control robot "swarms" without having to consider what each individual robot may be doing.

- Our High Productivity Computing Systems (HPCS) program is focusing on the *productivity* or *value* of a system, instead of its raw, theoretical computing speed, in order 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 that include weather and ocean forecasting, cryptanalysis, and computing the dispersal of airborne contaminants.

- Our Augmented Cognition program looks to directly (but non-invasively) measure human cognitive load so that information can be presented to the warfighter or commander in a way that does not overload human cognition when mental processes are pressed to the limit, and that takes advantage of spare mental "processing power." This will make those working under high-pressure circumstances much more effective, and will fundamentally change the nature of the human-machine interface, finally creating interfaces that adapt to the user rather than the other way around.

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[12] Complementary Metal Oxide Semiconductor

- DARPA's new Enduring Personalized Cognitive Assistant (EPCA) program will launch the creation of intelligent personalized assistants for many tasks (it imagines the potential for a commander's assistant, an intelligence analyst's assistant, and a decision-maker's executive assistant). These assistants will learn about preferences and procedures by observing their partner humans, but will also accept direct, naturally-expressed guidance. They will anticipate the human's needs and prepare materials to be ready just in time for their use. These new and unprecedented artificial helpers will help reduce staffing needs in many key places and will help make sure decisions are made in a timely fashion and with the best possible preparation. Successful implementation of an EPCA will help finally realize Licklider's vision of human-computer symbiosis.

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

5. DARPA's Strategic Thrusts and QDR Operational Goals for Transformation

In the Quadrennial Defense Review (QDR), the Secretary of Defense established six critical operational goals for transforming the Department of Defense.[13] Figure 16 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	**Counter-terrorism**
Assuring information systems in the face of attack and conducting effective information operations	**Robust, Self-Forming 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** **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	**Detect, Identify, Track and Destroy Elusive Surface Targets** **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, Self-Forming Networks** **Cognitive Computing**

Figure 16: Mapping DARPA's strategic thrusts into QDR operational goals for transformation.

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

In a broader perspective, going beyond DARPA's eight strategic thrusts, approximately 90 percent of DARPA's investments can be mapped into the six QDR goals as shown in Figure 17. The remaining 10 percent of DARPA's budget is largely allocated to basic research and Small Business Innovation Research.

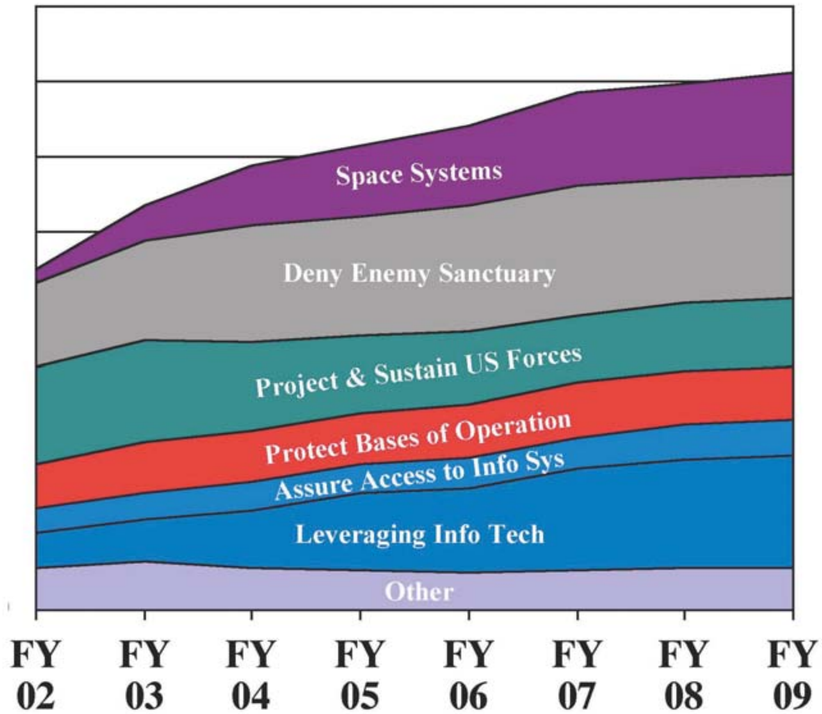

Figure 17: DARPA's budget by QDR transformation goals, FY 2002 - FY 2009.

6. Where To Find More Information

For information on DARPA's Offices and programs, please visit DARPA's website, www.DARPA.mil.

The DARPA Director's April 10, 2002, testimony to the Subcommittee on Emerging Threats and Capabilities, Committee on Armed Services, U.S. Senate, may be found at http://www.darpa.mil/body/NewsItems/pdf/DARPAtestim.pdf.

A fact file has been assembled as a ready reference for those interested in DARPA's research portfolio. This fact file contains short summaries of selected DARPA programs in FY 2003, and it may be found at http://www.darpa.mil/body/NewsItems/darpa_fact.html. This document will be updated for FY 2004.

DARPA has four Military Operational Liaisons who serve as points of contact for each Service:

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