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Mr. Chairman, Subcommittee Members and staff: I am very pleased to appear before you today to discuss the Defense Advanced Research Projects Agency's (DARPA) Fiscal Year (FY) 2003 activities and our FY 2004 plans to continue to transform our military through technological superiority.

Let me begin by saying a few words about the DARPA.

Since the time of Sputnik, DARPA has had a special mission within the Department of Defense (DoD). Our mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security. DARPA does this by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military uses.

DARPA prevents technological surprise by filling that gap long before our adversaries can, and, at its very best, DARPA also *creates* technological surprise for our adversaries. An example is DARPA's development of stealth – a dramatic technological capability that continues to put our adversaries at a disadvantage.

DARPA fulfills a unique role within the DoD. As a Defense Agency, DARPA reports to the Secretary of Defense and is the Secretary's only research agency not tied to a specific operational mission. DARPA is designed to be the "technological engine" for transforming the DoD, supplying technological options for the entire Department.

This is a unique role within DoD. The Department's operational components focus on nearer term needs at the expense of long-term change because of their emphasis on near-term urgent needs and requirements. Consequently, a large organization like the DoD needs an organization like DARPA whose *only* charter is radical innovation. We try to imagine what a military commander would want in the future and accelerate that future into reality by changing people's minds about what is technologically possible.

DARPA's Eight Strategic Thrusts

Through the years, DARPA has continuously refocused its work in direct response to evolving national security threats and to technological opportunities. DARPA's *Strategic Plan*, which describes how we are pursuing our mission through today's changing circumstances, was submitted to Congress on February 3, 2003.

That report details the eight strategic research thrusts that DARPA is emphasizing today:

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

I want to tell you about these eight thrusts, the forces driving them, and illustrate them with some example programs.

<u>Counterterrorism</u>

Foremost in our minds today is protecting Americans against acts of terror and the networks that perpetrate them. DARPA's counterterrorism strategic thrust has two major elements: Information Awareness and Biological Warfare Defense.

The goal of our Information Awareness programs is to create information technology that America's national security community can use to detect and defeat terrorist networks before they can attack us.

This work has been greatly expanded as a direct result of the September 11th attacks. It includes research in technologies to identify people at a distance, translate written and spoken languages into English, vastly increase the size and searchability of databases, improve decision-making by policy makers, find patterns in scattered data, and predict the behavior of terrorist groups.

One of our Information Awareness programs is Total Information Awareness (TIA), around which there has been much controversy. If I knew only what I read in the press about TIA, I would be concerned too. So I'd like to briefly address some of the main concerns.

No American's privacy has changed in any way as a result of DARPA's Information Awareness programs, including TIA. The Department of Defense *is not* developing technology so it can maintain dossiers on every American citizen. The Department of Defense *is not* assembling a giant database on Americans.

Instead, the TIA program is designed as an experimental, multi-agency prototype network that participating agencies can use to better share, analyze, understand, and make decisions based on whatever data to which they currently have *legal* access. TIA will integrate three broad categories of information technologies from DARPA and elsewhere: advanced collaboration and decision support tools, language translation, and data search and pattern recognition.

The ultimate goal is an interagency network to collaborate, "connect the dots," and prevent terrorist attacks. While the research to date is promising, TIA is, today, a series of experiments. We want to be clear that the DARPA program is an R&D project only. The Omnibus Appropriations Act of Fiscal Year 2003 (P.L. 108-007) requires that before we make major investments in preparation for deployment of a working system, we will need to make our case for deployment and Congress must permit such deployment.

TIA is a program to make new tools. It does not permit any agency access to data that they don't already have, and it in no way alters the authority or responsibilities of those agencies in that regard. Policymakers, particularly Congress, will ultimately determine how TIA tools may be used and on what data.

On February 7, 2003, the DoD announced the establishment of two boards to oversee TIA. These boards, an internal oversight board and an outside advisory committee, will work with DARPA as we continue our research. They will help ensure that TIA develops and disseminates its tools to track terrorists in a manner consistent with U.S. constitutional law, U.S. statutory law, and American values.

In late February, we had our first meeting with the internal board, chaired by the Under Secretary of Defense (Acquisition, Technology and Logistics). We look forward to working closely with both oversight boards as we continue our work on TIA.

The second element of DARPA's counterterrorism strategic thrust is Biological Warfare Defense (BWD). DARPA's BWD program began in the mid-1990s in response to a growing awareness that changes in the strategic and technological environment had sharply increased the biological warfare threat to the United States.

DARPA's BWD program is comprehensive and aggressive. It covers sensors to detect an attack, technologies to protect people in buildings and manage the response to an attack, vaccines to prevent infection, therapies to treat those exposed, and decontamination technologies to recover the use of an area. I discussed our work in this area in some detail in testimony before this subcommittee on March 19th, so I won't repeat that today.

Assured Use of Space

The national security community, generally, and the U.S. military in particular, use space to provide warning, intelligence, communications, and navigation. These orbiting assets are one of the great advantages the U.S. military has over potential adversaries. And American society relies on space for everything from communications to weather reporting, making space assets a vital element of the U.S. economy and our way of life.

This military advantage and civil dependency have not gone unnoticed by our adversaries, and there is no reason to believe that they will remain unchallenged or untested forever. When I became the Director of DARPA, the Secretary of Defense 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 assets from attack.

There are five elements in DARPA's space strategic thrust:

- *Access and Infrastructure:* technology to provide rapid and affordable access to space
- *Situational Awareness:* the means for knowing what else is in space and what that "something else" is doing
- *Space Mission Protection:* methods for protecting U.S. space assets from harm

- *Space Mission Denial:* technologies that will prevent our adversaries from using space to harm the United States or its allies
- *Space-Based Engagement:* technologies for space-based sensing, communications, and navigation to support military operations on earth

Four examples of DARPA's space programs are Responsive Access, Small Cargo, Affordable Launch (RASCAL); Space Surveillance Telescope; Orbital Express; and Innovative Space-Based Antenna Technology.

RASCAL is designed to place small payloads in orbit on a moment's notice by launching them from a high-speed, high-altitude, reusable aircraft that eliminates a large and expensive first stage booster. RASCAL is aimed toward a system to place 50- to 130-kilogram satellites and commodity payloads into low earth orbit at any time, at any inclination, and with a launch cost that is less than a third of current capabilities for the dedicated micropayload size.

The Space Surveillance Telescope program is developing a ground-based, wide-aperture, deep field-of-view optical telescope to search for very faint objects in geosynchronous orbit. It will enable us to identify and assess unidentified objects that suddenly appear in orbit with unknown purpose.

Orbital Express will demonstrate the feasibility of using automated spacecraft to refuel, upgrade, and extend the life of on-orbit spacecraft. It will lower the cost of doing business in space and will provide radical new capabilities for military spacecraft, such as high maneuverability to make our satellites more difficult to track and evade, autonomous orbital operations, and satellites that can be reconfigured as missions change or as technology advances. Orbital Express just announced a launch date of March 2006, and we look forward to updating you on our progress in the coming years.

The Innovative Space-based Antenna Technology (ISAT) program is developing revolutionary large antenna technologies that could one day enable large, yet affordable, space-based radar (SBR) systems capable of operating at medium earth orbit (MEO). MEO-based SBR enables persistent, continuous coverage of ground mobile targets with far fewer satellites than that required with constellations based in low earth orbit.

ISAT successfully completed its Phase I feasibility study. Contractors completed mechanical testing on critical, lightweight, space-qualified structures that enable over 100 to one volumetric compression for stowing large antennas for launch. Phase II just commenced and focuses on additional antenna structures testing and detailed designs for a space-based demonstration, with a planned launch in 2009.

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. Improved processors and software have enabled the major increases in onboard processing needed for unmanned systems to handle ever more complex missions in ever more complicated environments.

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. There is an increasing appreciation within the Services that combining unmanned and manned systems can enable new combat capabilities or new ways to perform hazardous missions. The use of unmanned air vehicles (UAVs) in Afghanistan began to demonstrate the potential of this idea.

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, an aggressive and far-reaching program that will profoundly change how the Army fights, trains, equips, and sustains 21st century operations. FCS is a networked system of systems that includes advanced manned combat vehicles as well as unmanned ground and air systems. The goal is to develop brigade-sized formations called "Units of Action" that have the lethality and survivability of an armored, heavy force, the deployability of an airborne force, and the tactical agility of an air-assault force.

DARPA has been at the forefront of the aggressive FCS initiative. We are conducting demonstrations of advanced prototypes, including unmanned ground reconnaissance and attack platforms; low-cost tactical precision munitions; small UAVs that support operations in urban and mountainous environments; and sensors that can detect vehicles camouflaged under dense foliage. A Defense Acquisition Board scheduled for May could allow FCS to enter System

Development and Demonstration under Army management this year. This will enable the Army to field an FCS Unit for operational testing in FY 2008, with the first Unit of Action ready for operational deployment by 2010.

DARPA is also conducting three unmanned air combatant programs: the Unmanned Combat Air Vehicle (UCAV) with the Air Force, 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.

The UCAV program has been conducting flight demonstrations with two X-45A demonstrators at NASA Dryden Flight Research Center at Edwards Air Force Base in California. The first block of flight demonstrations was successfully completed February 28th, with a total of 16 flights and nearly 13 flight hours on the two vehicles.

The final Block 1 demonstrations verified safe operation of the weapons bay door at altitudes of 35,000 feet and speeds up to Mach 0.75, the maximum planned altitude and speed for the demonstrator vehicles. By the end of this year, we plan to use both X-45A demonstrators to work cooperatively in a simulated attack on a surface-to-air missile site, including dropping an inert munition.

To help arm tactical platforms, the High Energy Liquid Laser Area Defense System (HELLADS) program is developing a new high energy laser (HEL) tactical weapon system whose unique cooling system might allow the system to be 10 times lighter, significantly smaller, and approximately half the cost of current developmental HEL systems.

The HELLADS design goal of less than 5 kilograms per kilowatt would enable, for the first time, high energy lasers that could be integrated into several air and ground tactical platforms, including unmanned combat armed rotorcraft (UCAR), UCAV, Predator B, the F/A-18, and future ground combat systems. HELLADS could protect fixed installations or population centers from attack, patrol a border, or patrol a demilitarized zone with the capability to react to hostile actions and engage tactical missiles, rockets, or artillery at the speed of light.

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 military organizations and systems can be seamlessly networked to change the terms of any conflict to favor U.S. and coalition forces. It will allow the United States and our 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 our adversaries.

At the heart of this concept are survivable, assured, spectrum-agile communications, encompassing both the strategic and tactical levels. The goal of this work is a high capacity network that degrades softly under attack, while always providing a critical level of service.

DARPA is conducting research in areas including self-forming, *ad hoc* networks; high capacity, multiband, multimode communications systems; ultra-wideband communications; spectrum sharing; information assurance; and low probability of detection/intercept/exploitation communications.

The Adaptive Joint C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) Node Advanced Concept Technology Demonstration (ACTD) program is a prime example of DARPA's research in multiband, multimode communications. The program, just getting underway, will focus on a single system payload that can provide a gateway for connecting previously incompatible radios into a network, while conducting signals intelligence, electronic warfare, and information warfare. The ACTD is a joint DARPA, Army, Air Force, Office of the Secretary of Defense, and U.S. Joint Forces Command effort to assess the military utility of a multirole radio frequency system and to develop an optimal concept of operations with the users.

DARPA's Small Unit Operations Situational Awareness System (SUO SAS) has developed a self-forming, self-healing *ad hoc* 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, Georgia, DARPA and the Army conducted a highly successful demonstration of SUO SAS enabling the rescue of a “downed” aircrew trying to “escape capture” in a city—a situation modeled on the events in Mogadishu, Somalia, in 1993.

DARPA transitioned SUO SAS technology to the Army Communications and Electronics Command (CECOM), where it is being integrated into the Soldier, Biological and Chemical Command’s Objective Force Warrior program. CECOM is also leveraging the SUO SAS radio and networking technologies to accelerate the networking of DARPA’s NETFIRES program, unattended sensors, intelligent munitions, communications relay, and robotic systems into the Army’s transformation into the Objective Force.

Borne out of the need for rapid and efficient utilization of the shrinking military bandwidth, the neXt Generation (XG) Communications program will make 10 to 20 times more radio frequency communication spectrum available to the U.S. military by dynamically sharing unused spectrum across frequency, time, and space. It turns out that, on average, only a small portion of the commercial spectrum is actively used at any given moment, even though most of the spectrum is licensed for assumed 100 percent use. The key technology question becomes whether an XG system can exploit underutilized spectrum without interfering with the original licensee.

Detect, Identify, Track, and Destroy Elusive Surface Targets

The Department of Defense has steadily improved its ability to conduct precision strike for many years. Timely, accurate, and precise delivery of bombs and missiles helped the United States overthrow a hostile regime in Afghanistan in short order with very few American or unintended casualties. However, our experience shows 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.

Providing a focused response to these challenges, DARPA is assembling the necessary sensors, exploitation tools, command systems, and information technologies 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, we are 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 way of operating 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 and has potentially large implications for U.S. military doctrine and organizations—truly a DARPA-hard problem.

A good example of DARPA's efforts is the Affordable Moving Surface Targeting Engagement (AMSTE) program. AMSTE is demonstrating how, by making only minor modifications to existing and planned systems, U.S. forces can, for the first time, integrate information from multiple radars to precisely and rapidly destroy individual and multiple moving surface targets.

AMSTE tracks the moving target from long range and uses this tracking information to continuously redirect a modified, low-cost global positioning system (GPS)-guided gravity bomb like the Joint Direct Attack Munition (JDAM) to attack the target. In September, an F-14 flying at 20,000 feet over the Naval Air Warfare Center Weapons Division in China Lake, California, delivered two AMSTE-configured JDAMs to two different targets within a convoy 6 miles away moving at 18 miles per hour.

That same day, an F/A-18 launched a single, AMSTE-configured Joint Stand-Off Weapon from 30,000 feet and scored a direct hit on a single M-60 tank, 35 miles away, that was moving at 15 miles per hour in traffic with a convoy progressing in the opposite direction.

These demonstrations—that AMSTE can precisely engage moving targets at stand-off ranges using modified low-cost inventory weapons—offer a powerful transformational capability to U.S. warfighters. The Air Force is examining several of the technologies inherent in the AMSTE concept.

The Air Force has placed requirements for AMSTE technology into its next-generation intelligence, surveillance and reconnaissance (ISR) and weapons assets by requiring moving target engagement capabilities resident on both the Global Hawk and the MC2A platforms. The requirement also exists in the Navy and the Air Force to have a weapon with data links for the purpose of attacking moving targets.

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. Such installations can be used for a variety of purposes, including hiding ballistic missiles, protecting leadership, command and control, and producing weapons of mass destruction.

DARPA's Counter-Underground Facility program is meeting the challenge posed by the proliferation of these facilities. We are developing and demonstrating seismic, acoustic, electro-optical, radio frequency, and chemical sensor technologies to characterize underground facilities. The program activities will enable the warfighter to answer the questions: "What is this facility for? How busy is it now? What are its internal structures and vulnerabilities? How might it be attacked? Did our attack destroy the facility?"

Bio-Revolution

DARPA's strategic thrust in the life sciences, dubbed "Bio-Revolution," is a comprehensive effort to harness the insights and power of biology to make U.S. warfighters and their equipment safer, stronger, and more effective.

Over the last decade and more, the U.S. has made an enormous investment in the life sciences—so much so that we frequently hear that we are entering a "golden age" of biology. DARPA is mining these new discoveries for concepts and applications that could enhance U.S. national security in revolutionary ways.

There is a growing recognition of synergies among biology, information technology, and micro/nano technology. Advances in any one area often benefit the others, and DARPA has been active in information technology and microelectronics for many years. DARPA also is able to bring other disciplines together with biology in ways that enhance the multidisciplinary exploitation of biology.

DARPA's Bio-Revolution thrust has four broad elements:

- *Protecting Human Assets* refers to the Biological Warfare Defense work mentioned earlier.
- *Enhanced System Performance* work is developing new systems with the autonomy and adaptability of living things by developing biologically inspired materials, processes, and devices embodied in systems such as biorobotics.

- *Enhanced Human Performance* is aimed at preventing humans from becoming the weakest link in the U.S. military by exploiting 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.

Let me give you some example of our work here.

To find new approaches to locomotion and highly adaptive camouflage, researchers in our Enhanced System Performance programs are studying how insects run over rough terrain, geckos climb walls, flies avoid capture and how an octopus hides. Why? Imagine if our soldiers and equipment could use some of these same techniques.

Our Continuous Assisted Performance (CAP) program is investigating ways to prevent fatigue and enable soldiers to stay awake, alert, and effective for up to 7 consecutive days without suffering any deleterious mental or physical effects and without using any of the current generation of stimulants.

In a recent series of studies, a new class of drugs, ampakines, has been identified that appears to be effective in eliminating the negative effects of sleep deprivation. Monkeys deprived of sleep for 30 hours showed complete recovery from cognitive, brain electrical signal, and brain metabolism defects when given the drug. We are aggressively pursuing development of these drugs as replacements for current stimulants.

Another exciting effort is in the area of blood platelets. Platelets are tiny constituents of the blood that promote clotting and wound healing; platelets are our body's own "internal bandage." Obviously, it would be very helpful to have platelets on hand in theaters of war to treat our wounded soldiers.

Unfortunately, platelets are very fragile and perishable; they last only about five days, even under ideal refrigerated storage conditions. Researchers have tried for years to extend the storage life of platelets, to no avail. So, to date, platelets have not been readily available to military field hospitals.

DARPA's Metabolic Engineering program has funded research that combines a freeze-drying process for platelets with a sugar called trehalose. Just this winter, we have demonstrated that mouse platelets processed in this way can be stored for up to 18 months in their desiccated state and then successfully rehydrated for use. If this technology works for human platelets, and tests are beginning, it could eventually make blood platelets available on the battlefield to save the lives of our wounded soldiers.

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 envisioned people and computers working symbiotically. He imagined the potential of computers seamlessly adapting to people as partners that handle routine information processing tasks. Thus people would be free 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, hard to integrate with each other, 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.

DARPA’s Enduring Foundations

While DARPA’s 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 “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.

These technologies often form enabling chains. Advanced materials enable new generations of microelectronics that, in turn, enable new generations of information technology. And information technology is the enabling technology for network centric warfare, which I discussed earlier.

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, more than 40 percent of DARPA’s budget is devoted to high-risk, high-payoff component technologies, consistent with a goal established by the Under Secretary of Defense (Acquisition, Technology and Logistics).

<u>Materials</u>

DARPA maintains a robust and evolving materials program. Our approach is to emphasize those new materials opportunities and discoveries that might change way the military operates. In the past, DARPA’s work in materials 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. Today, our materials work builds on this heritage and includes:

- *Structural Materials*: low-cost, ultra-lightweight structural materials and materials designed to accomplish multiple performance objectives in a single system

- *Functional Materials*: materials with a nonstructural 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
- *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.

We have designed, built, and flown a micro-UAV with a truly multifunctional wing. The vehicle is capable of carrying visible and infrared cameras, chemical and biological hazard detectors, and communications packages. The 13-inch wingspan, 170-gram vehicle, named "Wasp," is the first of its kind in which the load-bearing wing structure is also the battery powering the motor and sensor package. In its maiden flight last August, WASP flew continuously at 30 mph for 1 hour, 47 minutes. In comparison, the baseline normal wing vehicle, powered by a conventional primary cell battery, has an endurance of just 30 minutes.

A final example is the Morphing Aircraft Structures program, which is developing technologies to create adaptive wings for air vehicles, enabling them to radically change their shape in flight. These technologies would allow an air vehicle to fundamentally and dynamically vary its flight envelope (much like a bird does) to perform multiple, radically different roles.

Thus, we are developing a lightweight, actively controlled system of sensors ("nerves"), actuators ("muscles"), and structures ("skin and bones") that mimic the ability of animals to adapt to widely changing environments and threats. The vision is to transform military air vehicles from large expensive systems of piloted aircraft to smaller systems of autonomous aircraft with multiple roles (such as locating and destroying targets) combined into a single aircraft, rather than requiring a large number of individual, single-role aircraft.

Microsystems

Microelectronics, photonics, and microelectromechanical systems (MEMS) are three core 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.

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.

A good example is the Molecular Electronics program. Within 10 to 15 years, today's dominant computer switch technology, CMOS (complementary metal oxide semiconductor) 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 1,000 times smaller and have the potential to reach a trillion switches per square centimeter. This development will reduce the size, weight, and power of processors and increase their performance, allowing greater computing power to be packed into ever smaller volumes, increasing the "smarts" of military systems while reducing the soldiers' load.

There has been solid progress toward this goal: in FY 2004, DARPA expects to demonstrate the first 16-kilobit memory based on molecular switches.

Information Technology

In the fall 2002, using technology developed under DARPA's Mobile Autonomous Robot Software (MARS) program, a robot was deployed roughly 30 meters into an abandoned Pennsylvania coal mine and generated a three-dimensional map of the mine's rugged interior in real-time as the robot moved through the tunnel.

The flooded mine had been flooded and was partially drained in the days before the experiments. The ground was still covered with toxic mud and oxygen levels were too low for humans to breathe. When integrated onto a hardened robotic platform, this MARS volumetric mapping technology could be applied for detailed, robotic exploration of caves, such as those that U.S. warfighters encountered in Afghanistan.

Our Augmented Cognition program will directly, but noninvasively, measure the mental effort ("cognitive load") of the human user using advanced, near-infrared optical sensors to measure brain activity. The computational system will know and support the actual state of the user, rather than just infer the user's state or intentions.

This information will allow us to manipulate or vary the load so information can be presented to the warfighter in ways that reduce information overload and will take advantage of spare mental processing power. This technology will greatly enhance performance under high-pressure circumstances and fundamentally change the nature of the human-machine interface.

We will also create interfaces that adapt to the warfighter rather than the other way around, moving a long ways toward the interactive adaptations originally envisioned by Licklider.

I hope my remarks today have given you a sense of our programs, as well as a sense of our vision and ambitions, of which I am equally proud. Thank you for this opportunity to appear before the subcommittee today. I would be happy to answer any questions you have.