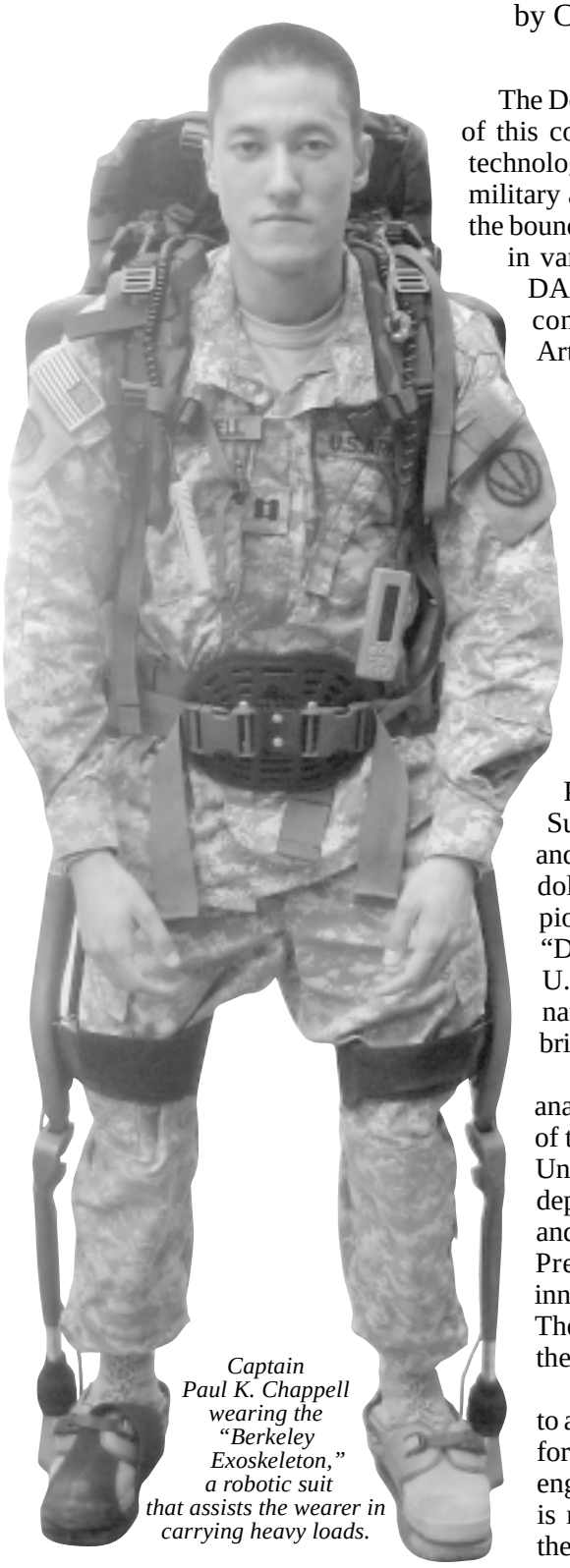
DARPA and the Future of Army Air and Missile Defense

by Captain Paul K. Chappell



Captain Paul K. Chappell wearing the "Berkeley Exoskeleton," a robotic suit that assists the wearer in carrying heavy loads.

The Defense Advanced Research Projects Agency (DARPA) produces some of this country's most high-tech innovations. Both past and present, these technological advances have achieved far-reaching applications in both the military and civilian sectors. In the future, DARPA will continue to explore the boundaries of scientific feasibility in its search for high-payoff discoveries in various fields of technology. Throughout this article, I will describe DARPA's mission and how its discoveries have impacted and will continue to impact the military and civilian sectors—Air Defense Artillery in particular.

From 13 April through 13 July 2006, I served as a DARPA intern on behalf of Air Defense Artillery. My job was to learn about all of DARPA's high-tech programs and report to U.S. Army Training and Doctrine Command which projects were most viable and applicable to the military. DARPA also created this intern program so that the selected service members could serve as liaisons between DARPA and their respective branches as their military careers continue.

DARPA has established an impressive track record. In the past, the agency has been responsible for developing such innovations as the Internet, Global Positioning System, Stealth Fighter, first network firewall, first computer mouse, M-16 rifle, Army Tactical Missile System, Global Hawk, Joint Strike Fighter, Predator unmanned aerial vehicle (UAV), Sea Shadow, Ground Surveillance Radar, Joint Surveillance and Target Attack Radar System, and Saturn Rocket. What makes this possible is DARPA's two-billion dollar annual budget, the many forward-thinkers they employ who are pioneers and experts in their field, and DARPA's mission statement: "DARPA's mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use."

When President Dwight D. Eisenhower convened a commission to analyze why the Soviet Union had beaten us into space with the launch of the Sputnik—the world's first artificial satellite—he learned that the United States possessed the technical expertise and ability to successfully deploy the first space satellite, but that the country lacked the attention and concern necessary to make this a reality. To remedy this problem, President Eisenhower created DARPA, which pursued high-tech innovation and handled all space research prior to the creation of NASA. The paragraph below, extracted from DARPA's strategic plan, describes the agency's unique charter.

DARPA is the Secretary of Defense's only research agency not tied to a specific operational mission. DARPA supplies technological options for the entire department. DARPA is designed to be the "technological engine" for transforming the Department of Defense. This unique role is needed because near-term needs and requirements generally force the operational components to focus on nearer term needs at the expense

of major change. Consequently, a large organization like the DoD needs a place like DARPA whose only charter is radical innovation. DARPA's approach is to imagine what a military commander would want in the future, and then accelerate that future into being—thereby changing people's minds about what is technologically possible today.

The effectiveness of DARPA's strategic approach can be seen in the many innovations that the agency has developed that will greatly impact how air and missile defense will someday be waged. In the near future, air threats will consist primarily of low-flying UAVs, increasingly affordable cruise missiles and tactical ballistic missiles, and technologically superior anti-radiation missiles. Due to these innovations in air power, the U.S. Air Force will experience a decreased ability to guarantee protection of U.S. ground forces through air superiority alone. Not only will tactical ballistic missiles continue to threaten U.S. ground forces, but low-flying UAVs and cruise missiles will become more available and affordable to our adversaries, thus allowing them to effectively deploy chemical, biological, nuclear, or conventional munitions. Eventually, the cost of these weapons delivery platforms will become so inexpensive that developing countries will be able to afford low-flying UAVs and cruise missiles in addition to chemical and biological agents.

Lieutenant Colonel Edward Tovar, a DARPA intern, poses with a prototype of "Big Dog," an unmanned ground vehicle that the Marine Corps plans on fielding within the next six years.

Within the next several decades, the trend in air power will evolve toward unmanned air systems and long-range standoff strike capabilities. The industrialized countries of this world will develop unmanned aerial hunter-killers that will replace traditional fighter and bomber aircraft. Without a cockpit, human beings, and life support systems, these aircraft will be more versatile and survivable. For example, these hunter-killers will be able to perform incredible maneuvers in flight that a human being would not be able to withstand due to overwhelming g-forces.

A DARPA project named Joint Unmanned Combat Air Systems (JUCAS) is an example of the direction in which our industrial adversaries will inevitably evolve their air-to-surface capabilities. JUCAS, which exists as a prototype that has been successfully flight tested, consists of multiple aircraft that are autonomously controlled without direct human intervention. Once a target is selected for the system, the JUCAS aircraft determines the best flight path to their objective. The JUCAS aircraft, which can work in groups ranging from two to a dozen autonomous planes, will then conduct their mission upon the objective. Like a swarm of robots from a science fiction movie, these aircraft will overwhelm the target by jamming enemy radars, bombing air defense systems, and destroying the intended asset. The JUCAS aircraft will decide amongst themselves which aircraft are within ideal jamming range and optimal intercept range, and which plane falls within the best conditions to destroy the target of interest. All of this is approved by a human in the loop who is located at a safe location, but it is the aircraft themselves that think and decide how to best destroy their target.

Air power will become more threatening in the near future, ranging from affordable low-end systems amongst our adversaries in developing countries to advanced autonomous systems amongst our industrial adversaries. Fortunately, DARPA is working on programs that will improve our air defense capabilities. Where short-range air defense is concerned, DARPA is considering developing technology for a Multi-Modal Missile that will replace both Stinger and Javelin. The Multi-Modal Missile will be a shoulder-fired ground-to-surface missile that can be mounted on a Predator UAV or a Bradley Fighting Vehicle, or can be carried by an individual Soldier. The Multi-Modal Missile will have a single warhead. By operating a simple switch, a Soldier will be able to change the warhead discharge so that it can optimally penetrate ten inches of reinforced concrete in an opposing bunker position, or allow the warhead to effectively destroy an enemy UAV, low-speed cruise missile, or ground armored vehicle. Since future air power will consist of UAVs that can fly nap-of-the-earth to avoid detection by ground radar and air force assets, short-range air defense will play an increasingly critical role throughout this century.

To combat future air threats, DARPA is developing innovations in sensor and radar technology as well. The Integrated Sensor is the Structure is a powerful sensor that consists of an integrated radar deployed on a high-altitude airship. This airship will hover at seventy thousand feet, tracking UAVs, cruise missiles, ground vehicles, and even people within an area of three hundred kilometers. This technology, when coupled with other DARPA programs such as Low-Cost Cruise Missile Defense, will provide the United States with an integrated UAV and cruise missile defense capability for homeland defense and major combat operations abroad.

DARPA is also developing innovations in medium- to long-range air defense. The most dramatic breakthrough will come in the form of solid-state lasers. The advantage of an air defense system based upon laser technology is that the directed beam, traveling at the speed of light, can impact and destroy an incoming missile almost instantaneously. With this comes a level of accuracy, speed,

and precision that the missiles of today cannot achieve. However, the disadvantage of laser technology is that the laser beam's strength becomes diluted in poor weather such as rain, fog, or dust storms. A future air defense perimeter will most likely consist of solid-state lasers as the primary line of defense, due to laser systems' unparalleled accuracy, speed, and precision, while an advanced missile system will serve as the secondary method of protecting defended assets in case of poor weather. DARPA is working on a variety of laser systems that have already reached the prototype stage of development. I was able to witness the test firing of such a prototype, and once the power and heat-management issues inherent to solid-state lasers are resolved, this interceptor of science fiction will become a reality of science fact. DARPA is currently developing the High-Energy Liquid Laser Area Defense System (HELLADS), a liquid-cooled solid-state laser that will, for the first time, allow this technology to become applicable on the battlefield.

Located in Arlington, Virginia, DARPA is a civilian organization with more than 250 employees. With only one Army member, a colonel, on its staff, DARPA presents a diverse and unique work environment that allows interns—drawn from all ranks of the military services and pay grades of federal agencies—to witness a wide array of interactions between various government agencies.

During my internship, I listened to briefings that Dr. Anthony J. Tether, the DARPA director, gave to the deputy secretary of defense, secretary of the Navy, British Royal Air Force chief of staff, director of the National Geospatial-Intelligence Agency, and commanders of the U.S. Army's Training and Doctrine Command, U.S. Army South, and Joint Forces Command. Also during my internship, DARPA sent interns to many of their laboratories and research centers in U.S. cities, including Los Angeles, San Diego, San Francisco, Denver, Tampa, Albuquerque, and Boston.

Given full access to all DARPA programs and program managers, the other interns and I witnessed remarkable projects such as a robotic exoskeleton, air defense laser systems, a thought-controlled bionic arm, robots shaped like dogs, autonomous robot vehicles that successfully navigated 132 miles of desert terrain without human intervention, high-tech autonomous aircraft, morphing-wing aircraft that can alter their wing shapes to perform a variety of missions, a device that can detect a human hiding behind a wall or in a room, a UAV the size of a small bird, and a holographic sand-table display.

DARPA's entire mission is to transform technologies that seem impossible into realities that can benefit the military. Because DARPA's innovations are so revolutionary, the agency's work also impacts the civilian sector. The Internet, Global Positioning System, and first computer mouse are examples from the past, but in the future, DARPA will continue to innovate and bring futuristic technologies to the present.

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Since Air Defense Artillery is such a highly technical branch, it is one of DARPA's primary beneficiaries. There are no cease-fires in the war for technological supremacy, and DARPA will continue to provide the branch with new technologies, enabling us to stay ahead of advances in threat technologies and accomplish our missions on future battlefield.

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SCANNING

DARPA Interships

The Army participates in two internship programs with the Defense Advanced Research Projects Agency (DARPA). One program is the Service Chief's Program (SCP), which is available to all services. The Army tasks Forces Command for officers to participate in the SCP program. The Army began participating in the SCP in 2003. Army participation was formalized in March 2004, when the DARPA director signed a memorandum of understanding with the director of the Army Staff. The other program that enables Army officers to participate in DARPA internships is based on a private agreement between DARPA and the commander of the U.S. Army Training and Doctrine Command. This program, which has also been in effect since 2003, continues under a verbal agreement.

Interns are selected differently for the two programs. For the SCP program, Forces Command conducts an internal selection in response to SCP tasking orders. The tasking is for one officer, per three-month rotation, for a total of four participants per year. Training and Doctrine Command conducts its own selection board to pick two officers for two-month rotations, with a total of 12 participants per year. At these rates, the Army sends sixteen interns to DARPA per year. DARPA hosts about 44 interns per year from all participating organizations. These other organizations include the Air Force (eight interns), Marines (four interns), Navy (six interns), National Geospatial-Intelligence Agency (four interns), and Joint Forces Command (six interns).