CHANGING How We Win

DARPA Technologies That Are Making a Difference Today

DARPA

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Defense Advanced Research Projects Agency

CHANGING WHAT'S POSSIBLE

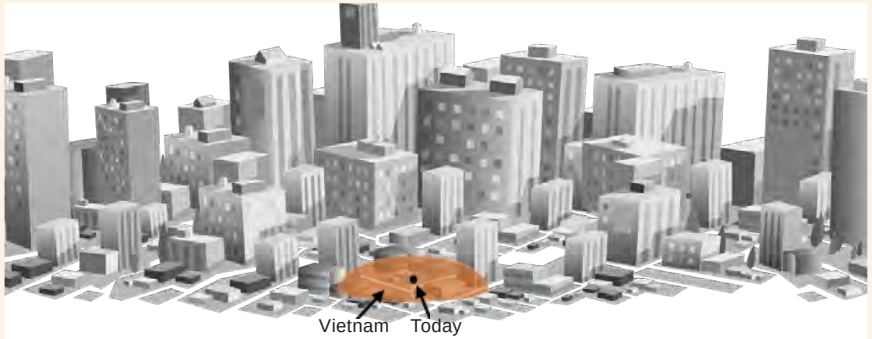
DARPA's mission is to conceive, develop, and demonstrate breakthrough technologies for national security. Our work does not stop there, however. DARPA's mission is complete only when those technologies have transitioned into working capabilities that enable new tactical and strategic possibilities.

Today's warfighters routinely depend on past DARPA transitions. For example, synthetic aperture radar, ground moving target indication, and advanced communications and data networks developed by DARPA in recent decades provide an unprecedented understanding today of **where adversary forces are and how they are moving.** DARPA's development and demonstration of an aircraft with a low radar cross-section—met initially with skepticism from military planners—resulted in a **stealth revolution** that pilots today depend upon to fight and win in contested airspace. And DARPA-developed electro-optical infrared sensors, miniaturized Global Positioning System (GPS) components, microelectromechanical systems,

Intelligence, Surveillance, and Reconnaissance

Stealth

Precision Targeting



and advanced command and control technologies **rewrote the book on military targeting** and catalyzed a historic shift from the traditional metric of "sorties per target" to a modern tally of "targets per sortie." Many of these capabilities had their in-theater debuts in the First Gulf War, where they provided stunning displays of asymmetrical advantage.

The cycle of radical innovation at DARPA continues today—though the Agency's approach to developing breakthrough technologies has evolved with advances in the larger U.S. innovation ecosystem. Increasingly, DARPA is taking advantage of the extraordinary creativity and pace of the private commercial sector and then adding customized Government-developed components to create specialized military tools and capabilities more precise and powerful than anything available elsewhere in the world.

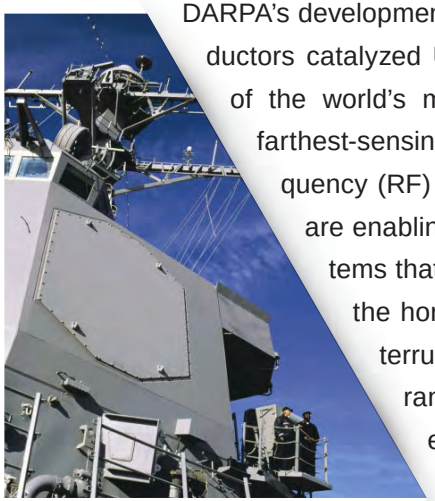
The following pages highlight recent DARPA developments at various stages of transition. Together, these advances represent a portfolio of progress that promises to keep the Nation secure while DARPA's innovators extend the Agency's reach to new and even more exciting technological frontiers.

Long Range Anti-Ship Missile (LRASM)

DARPA's LRASM program was created to address a pressing need for longer-range anti-ship missiles able to counter advanced electronic warfare and related defenses. To ensure that transition to the Services would be as fast and smooth as development of the weapon itself, DARPA stood up a rapid deployment office with the U.S. Navy and Air Force, located within the Agency's headquarters, ensuring a seamless and speedy leap to operational capability. Test flights in close collaboration with the Navy have been completed and the missile system is now on track for early operational deployment in FY18.

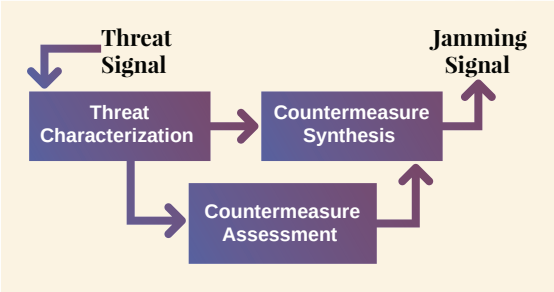
The LRASM program not only bolstered the fleet through its creation of a long-range survivable strike weapon but also demonstrated a rapid acquisition model with potential applicability to other urgently needed capabilities.

High-Performance RF Arrays



DARPA's development of gallium nitride (GaN) semiconductors catalyzed U.S. development and deployment of the world's most powerful, highest-performing, farthest-sensing, and strongest-jamming radio frequency (RF) arrays. These investments in GaN are enabling a new generation of military systems that can scan space for debris, search the horizon for incoming missiles, and interrupt adversary communications at ranges not possible with conventional electronics. DARPA's foresight to invest in this technology when its future value was still uncertain is paying off today by delivering unprecedented capabilities for some of the Nation's most critical military programs, including Space Fence; the Terminal High Altitude Area Defense (THAAD) anti-ballistic missile system; the Surface Electronic Warfare Improvement Program's anti-ship missile warning and protection system; and the Next Generation Jammer airborne electronic warfare system. All of these rely on GaN to provide the Nation with the tactical and strategic edge required to win tomorrow's battles.

Cognitive Electronic Warfare



U.S. military aircraft lack countermeasures against new radar frequencies and waveforms not in their on-board jamming profile library, and it can take months to develop and deploy new profiles and countermeasures. DARPA has developed a completely new way to address this threat: cognitive electronic warfare, in which the on-board system senses across the radio spectrum, uses artificial intelligence to learn in real time what the adversary's radar is doing, and then immediately generates a specific jamming profile to counter it.

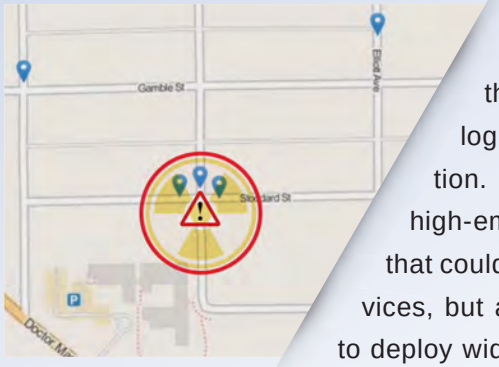
Testing of these systems, developed through DARPA's Adaptive Radar Countermeasures (ARC) program, is underway with U.S. Naval Air Systems Command and the U.S. Air Force, as well as with the Office of Naval Research (ONR) for inclusion in the Next Generation Jammer upgrade. The U.S. Army's Communications-Electronics Research, Development and Engineering Center (CERDEC) is leveraging a related DARPA program, Behavioral Learning for Adaptive Electronic Warfare (BLADE), as CERDEC develops requirements for the Army's next-generation Multi-Function Electronic Warfare program.

Communications Through Jamming

Our adversaries are not only deploying new radar frequencies and waveforms that challenge U.S. jamming capabilities; they are also improving their own jammers and their ability to disrupt U.S. military communications. To address that threat, DARPA's Communications Under Extreme RF Spectrum Conditions (CommEx) program has developed innovative technologies that together have resulted in a powerful, modular upgrade to Link 16—the military's primary tactical data-exchange network that, among other functions, supports air-to-air communication in contested environments. The program's adaptive anti-jam system was recently integrated and tested on Link 16 production radios. Some features have been flight-tested against real jamming systems, and plans are underway for testing of the full system in 2017.

In addition, building upon technologies investigated under the COmmEx program, the Agency's Computational Leverage Against Surveillance Systems (CLASS) program is developing new ways to protect U.S. military signals from increasingly sophisticated adversaries by means of enhanced waveform complexity and interference exploitation. In collaboration with CERDEC, DARPA in 2016 conducted TRL-6 testing of CLASS in a set of exercises at Ft. Dix, N.J. The technology is also being integrated into a new CERDEC project aimed at securing Army radios against jamming threats.

Finding Nuclear and Radiological Threats

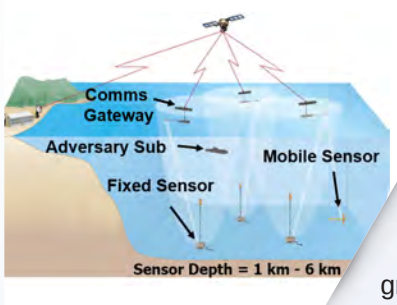


Perhaps no domestic security threat today exceeds that of a nuclear or radiological ("dirty bomb") detonation. Current sensors can detect high-emitting radiological materials that could signal such mass-terror devices, but are too large and expensive to deploy widely to fully protect an urban area or major transportation hub.

DARPA's SIGMA program has successfully created high quality, handheld radiological sensors at a fraction the cost of today's devices. SIGMA developed not only that hardware but also the software to monitor thousands of those mobile detectors in real time—an essential capability to discern the movement of nuclear materials before they can be incorporated into a terrorist's weapon.

In collaboration with officials in the Washington, D.C., metropolitan area and the Port Authority of New York and New Jersey, DARPA in 2016 tested the devices and networking system at critical transportation hubs and on a city-wide scale involving 1,000 detectors, and will oversee final testing and transition to appropriate authorities for urban deployments in 2017.

Submarine Detect and Track



Enemy submarines pose a growing asymmetric threat in terms of their low cost and consequential growth in numbers. In addition, these submarines have trended toward lower acoustic signature levels and have grown in lethality. DARPA's Distributed Agile Submarine Hunting (DASH) program is working to defuse this threat through the development of advanced standoff sensing from unmanned systems. The program has already developed two prototype systems—a fixed passive sonar node and an unmanned underwater vehicle that conducted successful deep dive testing in 2016. The Navy is supporting continued field trials of this essential technology with a path to full program deployment.

Highly Autonomous Unmanned Ship

The United States in 2016 took its first step towards long-range, highly autonomous vehicles for maritime operations when DARPA unveiled the technology demonstration vessel it developed and built through the Agency's Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV) program.

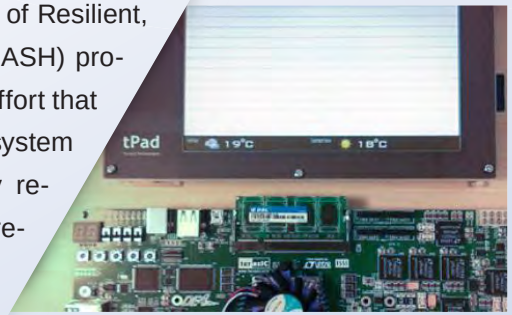
The 132-foot ship, christened Sea Hunter, is not remotely piloted, but rather is designed to operate over thousands of kilometers of open ocean with only sparse supervisory oversight, all while adhering to international rules for navigation and collision avoidance. These capabilities mean that future autonomous vessels could patrol large areas at a fraction of the cost of a crewed ship and potentially engage in such dangerous tasks as submarine tracking and mine clearing without posing any risk to Sailors. Sea Hunter began open-water testing off the California coast in 2016, under joint leadership of DARPA and ONR. Transition to the Navy is anticipated in 2017.

PNT Without GPS

GPS has revolutionized the all-important ability to know exact current location and heading, but the Defense Department's growing dependence on it also constitutes a vulnerability in the event of a system breakdown or attack. That's why DARPA developed and is now testing advanced PNT systems that can take advantage of alternative sources—such as repurposed signals intelligence (SIGINT) information—to serve as external position fixes, and feature advanced inertial measurement units that require fewer fixes while minimizing navigational drift.

This potentially liberating system is undergoing operational testing with the Navy, and DARPA continues to push PNT technologies to new horizons with novel algorithms and reconfigurable architectures that can be customized to particular mission needs.

Protection from Cyberattacks



DARPA's Clean-slate design of Resilient, Adaptive, Secure Hosts (CRASH) program was a basic research effort that designed new computer system components that are highly resistant to cyberattack. The results have quickly made their

way into both commercial and military applications. One university performer on the program started a company based on CRASH research, which led to an announcement from HP in 2015 that its new line of printers would feature this security-enhancing software to help prevent those devices from serving as inadvertent system portals for hackers.

Within the Defense Department, the Naval Surface Warfare Center is using CRASH technology to protect shipboard control systems from cyberattack; CRASH software is also being used by the Defense Information Systems Agency and is being incorporated into a number of Defense Department command and control servers. The Department of Homeland Security and the Air Force Research Laboratory have also been working together to test and evaluate CRASH technology in multiple devices. Each of these transitions is contributing to the Nation's cybersecurity by taking entire classes of threats off the table.

Cyber Operations

Plan X gives cyber operators the tools to understand what's happening in their complex, obscure, and fast-morphing domain, facilitating the planning and execution of their operations as well as assessments of mission effects—essential to making the increasingly important cyber domain a tractable one for military operations. Plan X technology is transitioning to U.S. Army Cyber Command and will be used by Cyber Protection Teams to support decision makers and defend networks at the tactical edge.

Assessment of Information Operations

Influence operations in the information domain have already proven integral to campaigns being waged by the Islamic State of Iraq and Syria (ISIS) and Russia, and are anticipated to be an increasing part of future conflicts. Yet little is known about the elements that contribute to successful information campaigns, or how best to counter those campaigns. Through its Quantitative Crisis Response (QCR) program, DARPA is delivering to operational partners newly developed tools that provide information operators the first capability to understand on a strategic scale what is happening in the online information environment and to predict the impacts of adversaries' information operations.

Rapid Diagnosis of Infectious Diseases

Today's diagnostic tests for infectious diseases can take a week or more to provide definitive results from the field—far too long when the disease in question is a fast-moving scourge such as Ebola or Zika. DARPA's Mobile Analysis Platform is a simple, rugged, handheld, battery-operated instrument that rapidly identifies a range of infectious diseases and can easily accommodate new modules as needed to address novel or unanticipated pathogens. It enables low-cost and robust molecular diagnostics within 30-45 minutes in locations without traditional laboratories or secure pharmaceutical logistics chains. Instant wireless transmission of test results and location data produces invaluable real-time epidemiological analyses at the pace of outbreaks themselves.

DARPA conducted testing with the U.S. Marine Corps Warfighting Laboratory during the 2016 Rim of the Pacific military exercises and is now testing the device with the U.S. Naval Health Research Center and the U.S. Military HIV Research Program in the United States and in Africa.

Space Situational Awareness

Space is increasingly congested and contested, with valuable satellites and various manmade and natural orbital debris all tracing paths above the Earth. The U.S. Space Surveillance Network, operated by U.S. Air Force Space Command, is tasked with tracking the hundreds of thousands of known objects in Earth orbit to ensure the safety of U.S. assets, and is now enjoying the added assistance of the newest DARPA-developed addition to that network: the Space Surveillance Telescope (SST).

In 2016, SST transitioned from a DARPA-led design and construction program to ownership and operation by the U.S. Air Force, which plans to operate the telescope in Australia jointly with the Australian government. There, SST will provide key space situational awareness from an area of the geosynchronous belt that is currently only sparsely observed.

With its numerous breakthroughs in telescope design and camera technology, SST provides unprecedented imaging quality to spot small, faint objects across an extraordinarily wide field of view and the ability to take thousands of pictures per night. It also boasts revolutionary image analysis software that enables much faster discovery and tracking of previously unseen or hard-to-find small space objects.

OVERCOMING TODAY'S NON-TRADITIONAL ADVERSARIES

The innovations highlighted above are anticipated to play critical roles in the years ahead against the growing threats posed by peer adversaries. They will complement a number of DARPA innovations from the past decade that are already in use—many of them applied in recent years against non-traditional adversaries, including insurgents who are posing challenges in tightly contested, low-resource environments. Among the most notable:

High-Value Tactical Information

DARPA's Command Post of the Future (CPoF) was an early experimental effort to adopt sophisticated commercial technologies and add unique military features to produce game-changing tools specifically for sharing situational awareness.

CPoF succeeded, providing an unprecedented, real-time common operational picture in addition to deep collaboration capabilities for ground commanders, and was adopted by the U.S. Army as its command and control system for use in Iraq and Afghanistan. Following a similar approach, DARPA's TransApps program, launched in 2010, delivered to Soldiers an array of secure mobile applications functional in austere environments, making it instantly popular and widely used among ground troops in Afghanistan.

Taking this approach even further, DARPA's Persistent Close Air Support (PCAS) program developed and deployed a tablet-based targeting and communications system that gives on-the-ground Joint Terminal Attack Controllers the power to ensure precision air strike. The technology was demonstrated on U.S. Air Force A-10 Thunderbolt II aircraft and on U.S. Marine Corps MV-22 Osprey in 2015, and the prototype system is now in testing for use with Army ground forces and unmanned strike aircraft.

Deep Data Analysis for Stability Operations

A recent, intensive, multi-year investment in revolutionary data-analysis tools for processing and analyzing large, imperfect and incomplete datasets identified billions of dollars of previously invisible terrorist financing. These tools, developed under the Agency's XData program, generated a number of other information threads that have similarly provided specific opportunities to intervene, as well as deep and invaluable insights into security and stability dynamics in conflict zones.

Unmanned Aerial Vehicles

DARPA's work in this domain began in the 1980s, when the Agency integrated the technologies needed to fly an unmanned aerial vehicle for hundreds of hours, including digital flight controls, composite materials, microprocessors, and satellite navigation. But as is sometimes the case, transition was not immediate. Game changing though this new capability was, the resulting aircraft were of limited practical value to the Air Force for years until world events made them a core weapon against violent extremism and insurgent groups.

TRANSITION AT DARPA

DARPA's work is not done until the new and extraordinary technologies it develops are making a difference. That's why, even before a program launches, DARPA starts developing strategies for transitioning anticipated results into applicable, real-world domains.

The transition from research to demonstrable impact can take a variety of paths. In some cases, a DARPA program will result in a near-term military capability and move directly to a program of record in one or more of the Services. In other cases, new DARPA-enabled technologies will transition first to the civilian sector, where commercial forces and private capital may drive further technical advances and cost efficiencies that can facilitate subsequent incorporation into military systems. In still other cases, DARPA's role may be even more fundamental, proving the realistic potential of a capability previously believed impossible and setting the stage for others to pursue that exciting glimmer of novelty and surprise.

By design, not all DARPA efforts transition upon their conclusion. Some programs simply fail—positive evidence that the Agency is staying true to its mission of extreme ambition. Some succeed but the resulting capability is so disruptive that, in the short term at least, it cannot be introduced into existing systems or strategies. In those cases, years may pass before a DARPA-supported advance gets the opportunity to make its mark—perhaps because related technologies have matured or because geopolitical or economic contexts have evolved in ways that have made the advance more practicable or more critically needed.

DARPA is committed to ensuring that its achievements are ultimately put to use to keep our Nation safe.

The Defense Advanced Research Projects Agency

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