Driving Technological Surprise:
DARPA's Mission in a Changing World

April 2013

Defense Advanced Research Projects Agency

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Joint Meritorious Unit Award

to the

Defense Advanced Research Projects Agency

The Defense Advanced Research Projects Agency distinguished itself by exceptionally meritorious service from February 2009 to July 2011. The men and women of the agency applied a unique warrior spirit characterized by creative intellect and keen expertise to deliver innovative cutting-edge technology to save lives and improve mission success amidst constantly evolving threats. Not satisfied to conduct research from their laboratories far behind enemy lines, they stood side-by-side with our warfighters, engaging with senior military leaders and front-line troops alike to better understand battlefield conditions and the realities of the combat environment. The agency established a permanent presence in Afghanistan, the Defense Advanced Research Projects Agency Forward Cell, and embedded more than 100 employees and contractors in locations throughout Afghanistan to rapidly bring emerging capabilities to bear. Based on urgent needs identified by troops on the ground, they created and fielded a wide range of highly effective tools including the HALOE Light Detection and Ranging sensor which delivered three-dimensional views of the battlespace to operational and intelligence users; the VADER radar pod to track threat vehicles and dismounted personnel; the MAINGATE radio system for interoperable communications and large data transmissions; the BLAST GAUGE detection system to assess blast exposure and medical risk to personnel; and NEXUS-7, a large data analytic framework that provided unique and valuable insights against key strategic and operational questions. By their exemplary performance of duty, the members of the Defense Advanced Research Projects Agency have brought great credit upon themselves and to the Department of Defense.

Given under my hand this 11th day of September 2012

Secretary of Defense

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
675 NORTH RANDOLPH STREET
ARLINGTON, VA 22203-2114

OFFICE OF
THE DIRECTOR

April 2013

Each morning, the people of DARPA come to work in vigorous pursuit of our mission: making the pivotal early technology investments that ultimately create and prevent decisive surprise for U.S. national security. This is our responsibility, and this is our privilege.

We define our portfolio of programs in a framework that puts our enduring mission in the context of tomorrow's environment for national security and technology. Our work is done through deep engagement with the broad technical community – companies, universities, and other parts of government – and with the Military Services and other agencies that use our new capabilities. We wrote this document to share our current framework with all these partners, Congress, and our senior leadership in the Pentagon and in the Administration. Your support of DARPA's mission is vital to our success.

Every dollar our Nation invests in DARPA is an investment in options for a better, more secure future. In an uncertain world with constrained budgets, creating these options is more important than ever. With you, we will deliver a new generation of technologies for our Nation's security.

Arati Prabhakar

Driving Technological Surprise:
DARPA's Mission in a Changing World

DARPA must continue to drive technological surprise and superiority so U.S. security capabilities remain second to none in a rapidly changing world.

We live in a world of complexity and change.

The United States is the largest economy, but other nations have recently grown at impressive rates.

The U.S. military is the largest, best equipped, and most powerful, but other nations, terrorist groups, and even individuals can put us in positions with limited and unacceptable options.

Some existential threats that challenged us in the past have receded, but a plethora of new weapons and techniques in the hands of many types of actors can and do threaten our way of life and endanger our democracy in fundamental ways.

Our research, innovation, and entrepreneurial capacity is the envy of the world, but others are building universities, labs, and companies with vigor and determination, and some are seeking to harm or confiscate our own capacity.

American companies make many of the most advanced technologies, but other components essential to our national defense and infrastructure are made only outside the United States.

Societies, markets, and technology communities that are increasingly connected across national boundaries open tremendous opportunities, but they also introduce new risks and challenges for our Nation.

In 1958, at the height of the Cold War, with a tight focus on a single major adversary and in the wake of the shock associated with the Soviet launch of the world's first satellite, Sputnik, our Nation established the Defense Advanced Research Projects Agency (DARPA) with a mission of *preventing* technological surprise from adversely affecting our country while *creating* surprises for U.S. adversaries. The Second World War was still fresh in our memories, and the atomic capability that marked its end hung heavily over global affairs in that early postwar era. It was a time when the United States was the fastest growing economy in the world. Automobiles and steel were our premier industries. Communications meant a phone call or airmail, while computing meant a slide rule or a room full of vacuum tubes. The integrated circuit was invented and first built that year.

Our world and technology have changed many times in myriad ways since 1958. Throughout these decades, DARPA has kept a sharp focus on its mission, making the pivotal early investments that led to potent new technologies and capabilities that prevented and created strategic surprise—and often contributed to the major global changes over this period. DARPA created materials science as a field by investing in this cross-disciplinary area in its earliest years. The revolution in information technology traces many of its roots to DARPA's work in the ARPAnet, computing, graphics, integrated circuit design, client/server architectures, artificial intelligence, and communications. DARPA demonstrated positioning from satellites and miniaturized receivers, leading to today's omnipresent global positioning system (GPS) capabilities. Aircraft stealth technology originated in DARPA inspiration and investment, as did unmanned

aerial vehicles (UAVs). In every case, many other organizations—across the private sector, the Military Services, and other agencies—were critical to realizing these technologies and using them to change our world. But in every case, DARPA's early investments explored and showed what was possible and began a revolution in capability.

DARPA represents less than 1 percent of the Nation's research and development (R&D) spending and 4 percent of the Department of Defense (DoD) budget for research, development, test, and evaluation (RDT&E). But our impact has been outsized over many decades. The reason: DARPA plays a unique role in DoD and in the broader technology community. DARPA is a projects agency, and we accomplish our objectives through deep engagement with companies, universities, and DoD and other labs. Our success hinges on having a healthy U.S. R&D ecosystem. Within the DoD Science and Technology (S&T) efforts, our role is to invest in high-payoff opportunities that often require taking significant risk. We work closely with our colleagues in the Service S&T organizations, sometimes building on their early research and drawing on their technical expertise, and often relying on them to help us transition successful results to military use.

To deliver on our mission, we challenge the status quo and think outside of, and well beyond, prevailing perspectives. Our Defense leadership demands this view—thinking in new and disruptive ways—to create better options for the future. DARPA gives the technology community, both inside and beyond the Defense establishment, a way to reach past the conventional organizational constraints that often limit innovation. We encourage a different mindset. Our unique mission—focused on Defense science and technology, but enlisting and empowering the broad community of innovators—drives all our work and lays the foundation for our disproportional effect.

DARPA's Strategy and This Framework

DARPA's investment strategy begins with a portfolio approach. Reaching for outsized impact means taking on risk, and high risk in pursuit of high payoff is a hallmark of DARPA's programs. We pursue our objectives through hundreds of programs. By design, programs are finite while creating lasting revolutionary change. They address a wide range of technology opportunities and national security challenges. This assures that while individual efforts might fail—a natural consequence of taking on risk—the total portfolio delivers.

How do we create this portfolio of programs? One major part of the answer is bottom up: DARPA program managers define and propose new programs they believe promise revolutionary change. This is important for several reasons. An effective DARPA program manager is the person closest to the critical challenges and possible technology opportunities in his or her arena, and the personal inspiration and drive behind a novel idea is the spark needed to start a big fire. More fundamentally, surprise rarely comes from groupthink.

Yet we recognize that our work lives in a context of today's realities and tomorrow's outlook. So a framework for DARPA—an understanding of our enduring mission in the context of the geopolitical and technological environment and its direction—is vital in shaping our portfolio.

We focus on three essential, interdependent strategic objectives to carry out our mission:

- Demonstrate breakthrough capabilities for national security
- Catalyze a differentiated and highly capable U.S. technology base
- Ensure DARPA itself remains robust and vibrant to deliver on its mission today and in the future.

We pursue each of these objectives in the context of our current framework.

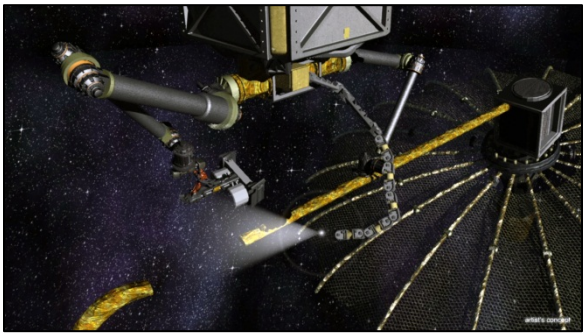
Breakthrough Capabilities for National Security

Two major factors shape our thinking about the next generation of capabilities for national security.

The first is the complex set of real and potential security challenges our Nation faces. Today's issues require a vast range of approaches and capabilities. We are in the process of finishing a counterinsurgency operation and building local security capabilities in Afghanistan. An array of diplomatic, intelligence, and possible military measures are required to address nuclear uncertainties posed by Iran and North Korea. Our Government and private networks deal with the growing onslaught of more capable and frequent cyber attacks from many sources on an ongoing basis. Potential adversaries are deploying sophisticated capabilities to contest our ability to project military power. Our economy is increasingly interdependent with a China that is redefining its own position in global affairs. And a look into the future only adds uncertainty. The proliferation of nuclear, chemical, and biological weapons of mass destruction or terror; the flare-up of tensions among nations in hot spots around the world; growing pressures in the urbanizing developing world; and the globalization of technology and new R&D are all trends we can see. Beyond these are the threats that we perceive only dimly. Taken together, this shifting, un-predictable national security environment demands a wide range of capabilities for the future and the agility to both anticipate and respond to whatever comes.

The second significant factor is the possibility of a fundamental, long-term shift in public investment for national security. We may be entering a period of constrained Defense spending for science and technology (S&T) investments and for acquisition and operations. How deep any decline may be and whether this spending reduction is cyclic or permanent remains to be seen. But public demand for sustained Government spending on entitlement programs, coupled with an aging demographic and the continuing growth in healthcare costs, creates a tangible possibility that long-term real Defense budgets will decline. We aren't forecasting this future; we are simply recognizing that these realities will have an effect. Because DARPA's prime directive is to prevent strategic surprise and enable U.S. superiority, we must consider what will be required to meet the Nation's security needs even in these circumstances.

The uncertainties we face—threat uncertainties and fiscal uncertainties—do not change the fact that the Nation relies on DoD to deter war and protect the security of our country. Given this environment, several investment themes have become more important and shape our portfolio and programs as we aim to create breakthrough capabilities for future national security.



The Phoenix program aims to show that new space systems can be built in geosynchronous orbit at a greatly reduced cost by cooperatively harvesting and reusing valuable components. This artist's rendition shows a Phoenix satellite detaching an aperture from a retired satellite for reuse.

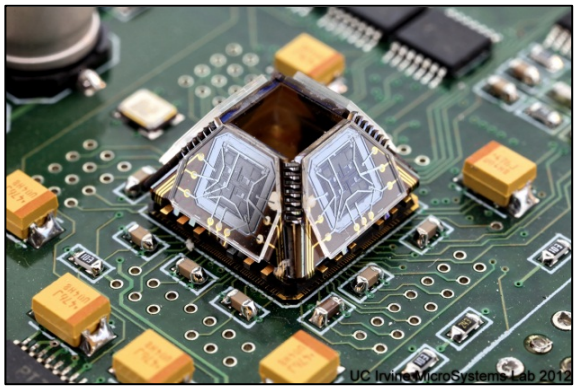
Game-changing new systems technologies. DARPA has a long history of developing and demonstrating new systems capabilities that change what is possible. Today's Warfighters rely on systems from aircraft to navigation to communications that trace their roots to earlier

DARPA work. Looking ahead, these key capabilities may become vulnerabilities, as sophisticated adversaries also understand how critical they are to our ability to fight. So DARPA seeks to create the next generation of new capabilities that once again change the equation in our favor, faster than others can respond.

Layered, multitechnology warfighting concepts. Modern warfare may be too complex for a single new capability to deliver sustained superiority across a variety of scenarios. But combining multiple technology advances by layering and integrating them can lead to a revolution in capabilities. Looking ahead, we can imagine coordinated local position, navigation, and timing (PNT); adaptive electronic warfare; manned and unmanned systems working in harmony; tactical cyber effects; and advanced intelligence, surveillance, and reconnaissance (ISR) – all woven together in ways that create decisive surprise in tomorrow's wars.

Adaptable systems and solutions. Our military engagements of the last 20 years, with a few exceptions, have been fought with systems developed largely for Cold War scenarios. Our Warfighters have adapted for the realities on the ground. Today when we consider future engagements, we can more readily imagine a host of diverse environments and adversaries. In an uncertain world, adaptability is critical. We won't always know exactly what we will need for tomorrow's battle, and our adversaries will change their tactics and technologies over time and in the field. So systems that can be readily upgraded and can adapt in real time to changing surroundings and conditions will play an important role.

Innovation to invert the cost equation. Cost control and affordability constraints are being addressed during the requirements analysis and development phases of programs, but these concepts need to be considered earlier. Today we seek to use innovation to radically invert the cost dynamic. How can we impose more cost on our adversaries and less on ourselves, thereby increasing our deterrent? Can innovative systems architectures, autonomy, adaptability, and new processes offer new possibilities? These approaches may allow us to reinvent development, production, logistics, operations, and maintenance in ways that radically change the cost equation.



The Micro-PNT program is developing technology for self-contained, chip-scale inertial navigation and precision guidance.

Examples. Position, navigation, and timing (PNT) and cyber are two areas of DARPA investment that demonstrate these approaches.

DARPA's recent PNT programs originally sought to take GPS-like capability to the places where GPS currently does not operate, such as underwater or underground. As concerns surfaced about our critical dependence on GPS, those initial investments are starting to create GPS alternatives, as well as new enablers for future military systems. We have developed micro-PNT technologies and are transitioning them to use. We are developing new inertial measurement units (IMUs) and clocks that use atom interferometry for very long duration missions, as well as techniques that use available signals—from television, radio, cell towers, or even lightning—to augment or replace the location information that GPS

currently provides. And in keeping with the drive for adaptability, our new approach to full navigation systems integration will provide rapidly configurable solutions for the many types of platforms that require advanced PNT.

Cyberspace is an emerging operational domain that is redefining the rules of warfighting. The same information technology systems that have revolutionized our commercial, personal, Government, intelligence, and military endeavors themselves pose a potential vulnerability that nation states, groups, and individuals are starting to exploit. Cyber is an extraordinary example of the importance of changing the cost equation. In this new domain, threats range from self-trained individuals, who can sometimes go up against costly, sophisticated systems, to the concerted efforts of nation states.

DARPA's cyber programs tackle two aspects of this broad challenge. One is to create the capabilities that will allow us to move beyond the "detect and patch" approach we currently employ to a more fundamental defense of our cyber systems. These technologies aim to provide cybersecurity and survivability solutions that enable DoD information systems to operate correctly and continuously even when they are attacked.

The second aspect of our cyber efforts focuses on cyber effects in tactical warfighting scenarios. We can readily imagine a future in which cyber warfare is fully integrated with kinetic warfare—and there is no doubt that our potential adversaries can see this future as well. DARPA's cyber offense efforts aim to create the tools that bridge these domains, for example by providing simulations of cyber effects, battle-damage assessments, and layers of authority and control.

Other DARPA systems programs also reflect one or more of our investment themes for breakthroughs in national security capabilities. These include programs in advanced aircraft, space systems, squad-enabling technologies, undersea systems, electronic warfare systems, communications, ISR, and air dominance.

Transition: Recent Successes in Moving from Concept to Reality

The journey from showing what's possible to changing the world is almost always a circuitous and lengthy undertaking. Planning and working toward a transition that will take our successful efforts forward—and as quickly as possible—is an essential part of DARPA programs right from their start.

Our diverse technology capabilities move forward in many different ways. A DARPA program that demonstrates a military system might move into a program of record in one or more of the Military Services. A component technology like a new material or electronic device is likely to get to the Warfighter when a prime contractor incorporates it into a weapon system development contract. In some cases, the component vendor will also develop commercial applications for the same technology, making it more readily available and less costly to DoD. Our more research-oriented efforts sometimes move to other R&D organizations for continuing development that later makes those technologies available to a wide variety of future Defense systems.

Transition to Program of Record: Tactical Ground Reporting (TIGR) System. TIGR is an application that runs on laptops or a handheld and gives our Warfighters the ability to visualize, share, and exploit the vast amount of data available on the battlefield. Information gathered in daily patrols about events, people, and places is combined with intelligence products such as locations of suspicious activities and anticipated attacks, making TIGR a valuable tool for battlefield awareness for the Soldier on the ground. TIGR's intuitive map-based user interface and bandwidth-efficient distributed data architecture provide a powerful, compelling user experience to our Warfighters even in their constrained and austere environment. Because TIGR is a flexible platform, Warfighters are adapting usage to reflect a changing operational environment, generating new information from dynamic data flows. DARPA first introduced TIGR in Iraq 2007 and, by 2010, all deployed Army Brigade Combat Teams in Iraq and Afghanistan, Special Forces, and NATO elements were using the system. DARPA and the Department of the Army signed a memorandum of agreement to transition TIGR in early 2009. TIGR was formally transitioned to the Army Force XXI Battle Command Brigade and Below program in October 2011.

When a friend shared a link about TIGR, an Army lieutenant had this to say:

From: A
Date: September 5, 2012 1:10:57 AM MDT
To: L
Subject: Re: info sharing in the Army

YEESSSS!!!! I had a sneaking, dark, and wildly unreasonable hope that this was going to be about TIGRnet.

I [*******] love TIGR. Love, love, love it. I was a TIGR updating fiend downrange. We uploaded all sorts of excellent stuff to it - patrol-perspective photos of cave systems, fighting positions we found and posted before they were ever used against us and were therefore plugged into indirect fire systems for quick reference later. One of my favorite TIGR projects was something i worked on for a couple months, systematically attaching a landowners portrait, name, and crop of choice to geospatially-divided (on TIGR) plots of land all along our main routes (ended up being over 250 acres worth), so we knew exactly who owned the land adjacent to every meter of road we would typically drive (great for crop incentive schemes and IED post-blast investigations). Whats great about this is that it rolls over to the new unit coming in, so there's no transfer issues or loss of continuity. I used TIGR every mission of every day for my map imagery and briefing slides. It was so good.

Transition (continued)

Fielded to Warfighters: Blast Gauge. Under a DARPA contract, the Rochester Institute of Technology (RIT) developed the Blast Gauge, a small device worn by Warfighters to measure blast exposure and cue medics for initial response, in just 11 months and for a total development cost of approximately $1 million. As field tests began, and design refinement and larger production quantities were required, RIT researchers formed BlackBox Biometrics, a small business to commercialize and manufacture the Blast Gauges. As of February 2013, more than 11,000 personnel deployed in combat are wearing DARPA Blast Gauges. We are using the data compiled from these devices to understand blast propagation, potentially minimizing exposure in some situations. In addition, Blast Gauge data are giving us new insights into sources and causes of traumatic brain injury.

Transition to Another DoD Agency for Continued Development: Vehicle and Dismount Exploitation Radar (VADER). DARPA initiated the VADER program in collaboration with the Joint Improvised Explosive Device Defeat Organization to create a radar system deployed in UAVs or small manned aircraft. Developed by Northrop Grumman Electronic Systems, VADER provides synthetic aperture radar and ground moving target indicator data to detect, localize, and track vehicles and dismounts. In February 2011, VADER's success led the Air Force to initiate the Dismount Detection Radar (DDR) program to develop and integrate VADER-like capabilities onto UAV Reapers. In July 2012, Raytheon was selected as lead DDR program developer. A subcontract to BAE Electronic Systems calls for development of the DDR's radar command, control, processing, exploitation, dissemination, and mission planning modules—an extension of the VADER Exploitation Ground Station.

More transitions…

NEXUS-7, an analytic framework program for big data, is helping to answer key strategic and operational questions for, and provide unique and valuable insights to, the Drug Enforcement Agency, U.S. Army Intelligence and Security Command, and Defense Threat Reduction Agency.

The ***Robust Automatic Transcription of Speech (RATS)*** program—which automatically detects speech, identifies the language, and can spot key words in high-noise environments—is being deployed at the 55th Wing at Offutt Air Force Base, Nebraska, and at the Patrol and Reconnaissance Wing at Naval Air Station Whidbey Island, Washington.

The ***Persistent Close Air Support (PCAS)*** program provided 500 tablets running a situational awareness application to the 2nd and 3rd Marine Aircraft Wings in Afghanistan, providing Warfighters with added capabilities such as digital gridded reference graphics, digital terrain and elevation maps for mission planning, and in-flight GPS tracking enabling pilots to see aircraft position relative to ground forces.

Currently under review by the Food and Drug Administration for commercialization, the ***Revolutionizing Prosthetics*** program successfully transitioned a prosthetic arm system to the Veterans Affairs' Rehabilitation Research and Development Service for continued study and workforce training.

A Differentiated U.S. Technology Base

U.S. technology leadership has been a cornerstone of national security for many decades, and today's military and deterrent capabilities are critically reliant on core technologies such as materials, electronics, and information technologies. Technology differentiation—our ability to create and use technologies more effectively than others—in these and other fields will continue to be vital to our national security. But, here too, the landscape is shifting in ways that shape our work.

Many technology sectors grew out of a virtuous cycle between Defense needs and commercial opportunities. In semiconductors, for example, DoD invested in early research in materials and devices with an eye to electronics miniaturization for military systems. As the research base grew, entrepreneurs started new companies, and established companies opened new lines of business. DoD was an early customer for these businesses. As new commercial applications in computing and communications blossomed, these fledgling businesses grew and flourished, creating a stable and healthy industrial base on which DoD could rely. At the same time, the industry globalized as U.S. companies sought new markets and production and design capabilities, and as Japanese, South Korean, Taiwanese, and mainland Chinese firms entered the market with strong support from their governments. Today, the semiconductor industry generates more than $300 billion in revenues, with half generated by U.S.-headquartered companies. Although DoD's use of semiconductor components has grown to $3 billion, its share of the market has dropped from nearly 100 percent in the early days to 1 percent today.

This globalization has important implications for national security. Because many commonly used semiconductor types, such as field-programmable gate arrays, are manufactured outside the United States, DoD systems necessarily include components that are part of a global supply chain. This introduces potential vulnerability in both the assurance of supply and the security of the supply chain. At the same time, other players—our allies but also our adversaries and potential adversaries—have the same access to this supply of highly capable components, and many have used them to quickly develop weapons systems with highly advanced capabilities. This pattern of invention, growth, globalization, wide availability, and growing vulnerability pervades most of the core technologies upon which our defense systems rely.

The globalization of all aspects of technology—design, production, supply chains, next-generation research, training and education, and the technologists themselves—is an inevitable and in many ways even a healthy fact of modern life. Our challenge is to create an edge for U.S. national security purposes in this environment. Two investment themes shape our efforts.

Exploiting and transcending commercially available technologies. We seek to be the best user of globally available technologies, to use them with greater creativity to solve problems more quickly, efficiently, and flexibly. This means novel systems architectures as well as integrating specialized niche technologies with commercially available components to create unique solutions.

Catalyzing new national technology capabilities. Entirely new technologies open the door to national security applications that can't even be imagined beforehand. We recognize that many of these technologies will also globalize. But the time advantage to the United States if we pursue them first can be substantial and make all the difference. We approach this challenge from three related perspectives:

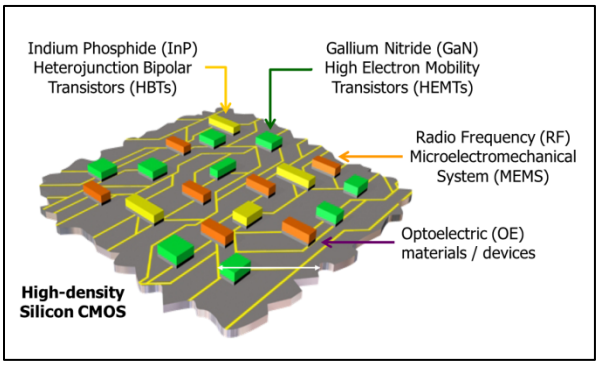
- *Exploring new technology possibilities from fertile basic and interdisciplinary research.* Universities, government labs, and private R&D organizations are bubbling with intriguing new research across many disciplines and new interdisciplinary fields. Some of these research efforts hold the seeds for the next technology revolution. We actively search for these promising activities and explore where their new insights might lead.

- *Building radical technology infrastructure and communities.* DARPA has a long history of building technology infrastructure that becomes the foundation for wide arrays of applications. Today, we are using the same approach in new fields. Our programs create the tools, techniques, and communities that scale well beyond the period of our investment.

- *Demonstrating the new capabilities that technology enables.* Changing minds about what's possible rarely happens only by writing papers and reports. Projects that build prototypes show how technical breakthroughs enable new capabilities.

Examples. Three DARPA technology areas – heterogeneous electronics, engineering biology, and big data – show how these investment approaches lead to impact. They also demonstrate the wide variety of technologies that will be critical for our future national security.

Commercial applications have driven silicon integrated circuit technology so aggressively that billions of transistors are now available in chips that cost only a few dollars for memory and logic functions. But to build highly capable systems, DoD also needs other sophisticated component technologies: optoelectronics for data links, radio-frequency components for electronic warfare and communications, microelectromechanical systems for a wide range of sensor and actuation applications, and power devices for energy conversion. The solution is to combine the niche defense components with globally available silicon. The result is a technology that leverages the massively capable economics of silicon while preserving the outstanding performance of the non-silicon electronics. DARPA's Diverse Accessible Heterogeneous Integration (DAHI) program seeks to enable and improve this process, including the necessary tools and manufacturing expertise, to make this hybrid technology available to the U.S. military.

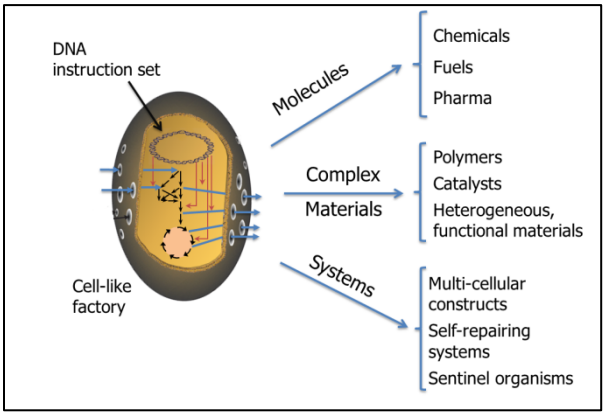


The Diverse Accessible Heterogeneous Integration (DAHI) program is developing processes to intimately combine advanced devices with high-density silicon technology, enabling new capabilities drawn from the best of both worlds.

The Societal Implications of New Technologies

Because our programs push the leading edge, they are sometimes society's first encounter with the dilemmas associated with new technologies. We pursue these technologies because of their promise, but we understand, that in this pursuit, we might be working in areas that raise ethical, legal, security, or policy questions. How does the ability to approach and interact with satellites in orbit change international space policy? What are the privacy considerations in using public data? How can we guard against misuse of new synthetic biology capabilities, intentionally or accidentally? In dealing with these issues, our job is twofold: We must be fearless about exploring new technologies and their capabilities; this is our core function, and our Nation is best served if we push these frontiers ahead of other countries. At the same time, we must raise the broader societal questions and engage those who can address them. We work rigorously within the law and regulations and with the appropriate organizations where legal and policy frameworks already exist. In new and uncharted territory, we seek a variety of experts and stakeholders with different points of view and engage them in exploring these dimensions of new technologies. In many instances, technology solutions can be part of the answer to new concerns. But we recognize that, at their heart, these are societal questions that require a broader community be engaged as we explore the technological frontier.

Engineering biology is emerging as a new field as researchers across multidisciplinary labs have started to design and construct genetic pathways, networks, and systems to harness the powerful synthetic and functional capabilities of biology. With them, we can see the potential to develop new and trans-formative materials, sensing capabilities, and therapeutics. But, synthetic biology today is still a multi-year, ad hoc, trial-and-error process constrained to a limited number of simple products. DARPA's investments are developing the tools and technologies to create a new engineering practice, speeding the biological design-build-test cycle and the rate at which we realize novel products and capabilities. Drawing upon and building on the research base, these efforts will begin to create the foundational infrastructure for engineering biology. Some of the first outputs may include new materials and medicines such as antifungals, lubricants, and energetic materials. Beyond these are a new generation of products with properties we can only imagine today.

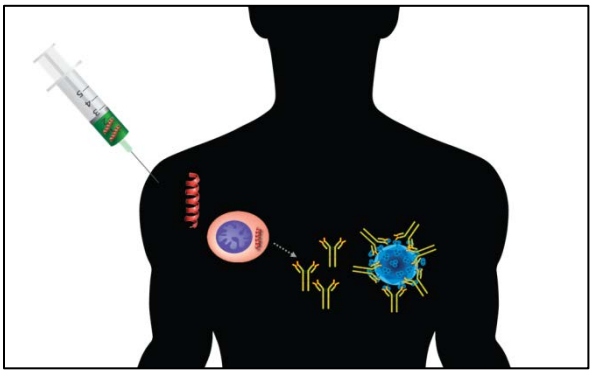


The Living Foundries program is creating tools and processes to rapidly, predictably engineer microorganisms to produce materials with new properties.

Advances in information technology have given us an explosion in data. But how do we find information and, ultimately, knowledge in this massive volume of heterogeneous data? This is a unique opportunity for discovery and insight. DARPA's big data programs strive to bring meaning to these vast amounts of data through analytics at massive scale and visualization techniques that allow users to interact with data in revolutionary ways. The tools, techniques, and communities that come out of the

program very likely will form an important foundation for a host of applications.

A wide array of other DARPA technology programs also reflects our investment approaches for catalyzing the future U.S. technology base for national security. They include programs in robotic systems, advanced prosthetics and the brain-machine interface, innovative manufacturing technologies, adaptable sensor systems, unconventional computing platforms, and rapid countermeasures for biological agents. More broadly, we also invest in early-stage research efforts across physics, materials science, mathematics, and interdisciplinary fields with the potential for future technological applications.



DARPA's program in Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) aims to accelerate immune response to bio threats with nucleic acid-encoded antigens and antibodies.

Managing for Results

The ultimate objective of our work is revolutionary capabilities that result in positive national security outcomes. While keeping this long-term goal in mind, we actively manage our work to maximize our chances of delivering those results.

Because DARPA is a projects agency rather than a laboratory or institution, our work is executed in programs with defined start and end dates. When a program ends, we may move to another area that is more fruitful, or we may continue with a new project in the same field if we see high potential. But in every case, this is a conscious and deliberate decision, not an automatic default to perpetuate work in any one area.

Within each program, the DARPA program manager sets clear milestones according to the objectives for that effort. For a systems demonstration program, typical milestones include design reviews and tests at increasing levels of maturity. For a more research-oriented program, appropriate milestones are often first-of-a-kind lab experiments or meeting increasingly challenging performance criteria. As programs unfold, program managers work closely with their performer communities. They assess results and then redirect or eliminate less productive work and accelerate efforts that are making great progress.

Similarly, DARPA's technical leaders—technical office directors and deputies and the DARPA Director and Deputy—regularly weigh the progress of each program in the context of our overall portfolio. Programs that are on track continue. Those that are not meeting expectations are rescoped or stopped. Those that are showing unexpected promise may be expanded to pursue new possibilities. Lessons are learned and integrated into our ongoing and future programs.

We balance the need to give our programs and performers the time and resources necessary to make progress toward our extremely challenging objectives with the need to curtail or redirect efforts that are not productive. These are judgment calls informed by data and direct interactions with the people doing the work. Our overall success lies in striking this balance across the broad portfolio of DARPA programs.

Keeping DARPA Robust and Vibrant

To meet our first two broad objectives, DARPA must be vigorous, healthy, and able to execute on our mission today and in the years ahead. Our third framework objective is to ensure a highly functional environment and the foundation for a strong culture, to keep DARPA robust and vibrant. The starting point is to recognize the critical elements of DARPA's operating model.

Stellar program managers. Program managers are the core of the Agency. Each is a leader who brings to DARPA an adventurous spirit and a deep conviction that his or her technology vision will change the world. They come to DARPA because this is the place that gives them the opportunity to take breakthrough technologies to fruition. Our program managers generally serve 3 to 5-year terms, leading to a constant flow of new people and fresh views.

A program manager may come from industry, universities, or another part of government. He might be at any stage in his career. But each has a set of distinguishing characteristics. He has strong engineering and scientific credentials and excellent judgment about both technology and technologists. He navigates seamlessly from deep science to systems to capabilities. He is driven to have an impact- to make a difference. He strives for confidence without arrogance, recognizing that our success comes from working effectively with others.

The essence of the program manager's role is to define and execute a program that leads to new capabilities for our Nation. A great program manager does this by joining her own ideas with what she learns by listening to those who understand real-world challenges and those who are directly engaged with new research and ideas. She gets out of her office and meets with people where they innovate and work, in companies, universities, and other labs, to better understand their perspectives. From these inputs, she synthesizes a vision for a program that can have significant effect. Once she gains funding for the program, she projects this vision to a technical community that often sees the goals as nearly impossible, even though they themselves may have been part of the inspiration. When the performers are engaged and work is underway, she actively manages the program, driving down the risk inherent in reaching for bold impact and building the community into something greater than the sum of the individual parts. As the program generates results, she works tirelessly to engage potential users and encourage transition, ensuring that our success turns into real capability for the Nation. This process is cultivated and repeated time after time, day after day at DARPA.

Technical leadership to empower program managers and manage the portfolio. Our technical management team composes and oversees the overall DARPA program portfolio. The program approval and oversight process starts in our five technology offices. Office directors and their deputies are responsible for charting their offices' technical directions, hiring and coaching program managers, and overseeing program execution. The DARPA Director and Deputy Director approve each new program and review ongoing programs, while setting Agency-wide priorities and ensuring a balanced investment portfolio. DARPA's technical management team shares program information across the offices and helps to inform judgments about when to lean forward and when to pull back. This group's most important jobs are to bring in great program managers and get them the resources needed to drive their programs to success.

Support functions for effective execution. Vigorous pursuit of mission is equally engrained in DARPA support functions, creating a productive environment around our program

managers that enables them to take bold technology leaps despite their short tenures. Security and legal staff ensure we have a solid foundation, and contracting, finance, and human resources operate with the speed and flexibility that our diverse portfolio demands. Statutes providing specialized hiring authorities and alternative contracting vehicles have proven critically important.

Active engagement with the technical community and users. DARPA's success hinges on our ability to work with a broad technical community—from tiny companies to universities and major contractors to labs of every stripe—and the users of our results across DoD. The inspiration for our programs often comes from these organizations and individuals, including our Warfighters. Execution and transition always happens here. Because the work we fund and its ultimate use take place outside our walls, active engagement is an essential part of delivering on our mission.

The DARPA culture. When these core elements of our operating model come together and work effectively, they allow us to build the most important ingredient in keeping DARPA healthy and robust: our culture. The relentless drive for off-scale impact. The willingness to take risk in pursuit of that impact. The honor in serving our Nation by creating a more secure and better future. We reinforce these values in every action, from major decisions about people and programs to the passing comment in the hallway. And while national security threats have come and gone and returned in new forms, while technologies have transformed our lives, while the world around us has changed and changed again over 5 decades, the DARPA culture remains the quintessence of our continued success.

DARPA Today

- Estimated budget of $2.865 billion in FY 2013 [estimated budget of $2.663 billion in FY 2013 under sequestration]
- 210 Government employees, including 95 technical program managers
- 250 programs across 5 technology offices
- 2,000 contracts, grants, and other agreements with companies, universities, and DoD and other labs

For additional information about DARPA and our programs, please see **www.darpa.mil**.