DARPA Today: Anticipating and Meeting New Challenges

America's national security challenges are in many respects more complex, dynamic and widespread than ever before. For example, no longer does the United States have the luxury of focusing its defenses almost exclusively on a single superpower; today the nation faces multiple real and potential adversaries, including non-nation-states resistant to conventional diplomatic and military pressures. At the same time, sophisticated technologies once accessible exclusively to a few global powers are increasingly available and affordable. And new and serious threats—including those involving cyber and biologics—are emerging and evolving at a rapid pace. These trends demand that DARPA diligently pursue its long-standing mission of creating and preventing strategic surprise.

Challenges that DARPA is working on today, to strengthen national security tomorrow, include:

Harnessing Complexity for Air Dominance

DARPA, the U.S. Air Force (USAF) and the U.S. Navy together are exploring a variety of "systems-of-systems" concepts in which networks of manned and unmanned platforms—including weapons, sensors and electronic warfare systems—would interact to assure success in a contested air battlespace. Such distributed systems offer the potential of unprecedented flexibility and powerful new strategic and tactical options, but they also give rise to new battle management challenges. That would be especially true under conditions in which assets are in operating environments where access to critical communications is degraded or denied. DARPA aims to overcome some of these obstacles through the development and demonstration of novel air-battle-management control algorithms and digital decision-aids. The agency is also exploring the use of reference software architectures to enable robust, scalable and rapidly evolvable airborne communication networks that would dramatically exceed today's capabilities.

Achieving Extreme Hypersonic Flight

Hypersonic flight—which refers to flight velocities of more than five times the speed of sound—offers a number of strategic advantages. Looking beyond the research arena, DARPA is developing hypersonic technology demonstrations for operational capabilities. To harness the power of extreme hypersonics, DARPA is collaborating with the USAF to identify and fill knowledge gaps and overcome remaining technological challenges. The Hypersonic Air-breathing Weapon Concept (HAWC) joint program is pursuing flight demonstrations of technologies critical for an effective and affordable air-launched hypersonic cruise missile. The Tactical Boost Glide (TBG) program, another DARPA/USAF effort, is developing technologies that would enable air-launched tactical-range hypersonic boost-glide systems. The goal is to develop such capabilities in ways compatible with current launch platforms—including, potentially, the Navy Vertical Launch System (VLS).

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DARPA's mission is to make the pivotal early technology investments that create or prevent strategic surprise for U.S. national security

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Owning the Electromagnetic Spectrum

Today, the electromagnetic spectrum is as important a battlespace as air, land, sea and space, essential not only to communications but also to precision timing and navigation. Properly harnessed, the spectrum can serve as a remarkable force multiplier and provide a window into otherwise invisible activities by adversaries. It can also be used to hide U.S. activities from those adversaries and even make "visible" to them phenomena that are not really there. Among other initiatives to fulfill spectrum's strategic and tactical potential, DARPA sponsored a national competition—the Spectrum Challenge—to accelerate the development of advanced radio technology capable of communicating in congested and contested electromagnetic environments without direct coordination or preplanning. DARPA is also working to develop breakthrough component and integration technologies needed to enable a new generation of complex communications and sensing capabilities in the terahertz frontier.

Revolutionizing Satellite Launch and Service

Imagine a world in which getting a satellite into orbit can be as quick and reliable as an aircraft takeoff. DARPA's Airborne Launch Assist Space Access (ALASA) program aims to enable launches of 100-pound payloads for less than $1 million apiece. Equally ambitious is DARPA's goal of making it practical to achieve these launches with just 24 hours' notice. In addition, DARPA's Experimental Spaceplane (XS-1) program is designed to place a 3,000- to 5,000-pound payload into orbit using an expendable upper stage for less than $5 million, or about one-tenth the cost of a comparable launch today. Separately, DARPA's Phoenix program strives to develop and demonstrate advanced technologies to robotically service and maintain satellites in the harsh environment of geosynchronous orbit, approximately 22,000 miles above the Earth.

Strengthening Sophisticated Cyber Defenses

DARPA is pursuing a number of innovative approaches to improve cybersecurity and enhance the survivability of information systems if attacked—including critical systems in unmanned vehicles, weapons systems, satellites, and command and control devices. Recognizing the growing complexity of the cyber defense battlespace, DARPA's Plan X program aims to facilitate real-time situational awareness in the multi-dimensional cyber domain. Other DARPA cyber defense efforts include pursuit of new technologies to enable distributed computer systems to work through attacks; permit trustworthy Internet communications in untrusted environments; and automate the discovery, identification and characterization of new malware.

Plumbing the Web's Deepest Resources

Conventional Web searches use a centralized, one-size-fits-all approach that searches the Internet with the same set of tools for all queries. Although useful for conventional purposes and successful commercially, that strategy fails to capture potentially useful information in the "deep Web," which is not indexed by standard commercial search engines. It is also incapable of identifying potentially significant links among pages that clandestinely share information. DARPA's Memex program seeks to develop domain-specific search technologies capable of overcoming these shortcomings, which could revolutionize the discovery,

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organization and presentation of search results critical to national security. The initial focus is on human trafficking, a Web-enabled enterprise with multiple connections to other illicit activities relevant to military, law enforcement and intelligence interests.

Speeding Recovery for Injured Brains and Bodies

DARPA's portfolio of brain research aims to dramatically deepen knowledge of the dynamic functions of the brain and demonstrate breakthrough neurotechnologies based on these insights. In particular, the Agency is developing and assessing revolutionary interfaces to the brain and peripheral nervous system that have the potential to provide high-resolution insights into neural circuits; lower the need for and impacts of invasive surgery; bolster immune function without inducing medication-related side effects; and improve neurocognitive and medical outcomes for wounded warriors and others diagnosed with traumatic brain injury or other neuro-psychiatric conditions.

Finding Synergies at the Intersection of Biology and Engineering

Researchers in the fledgling field of synthetic biology—a hybrid discipline linking biology and engineering—are already cultivating customized bacteria to catalyze new chemistries and produce novel medicines. With foundational toolsets now becoming established in the field, these pioneers are beginning to apply their skills to a more diverse array of applications including the development of bio-based materials with unconventional mechanical, optical and electrical properties. DARPA seeks to speed the development of next-generation tools and technologies to ensure the reliability, stability and safety of engineered biological systems, while compressing the biological design-build-test cycle.

Enabling Rapid Biological Threat Assessment and Response

Whether the result of a natural outbreak or the work of bioterrorists, biological threats pose significant national security challenges. Current technologies for assessing emerging biothreats remain slow relative to the speed with which they can spread, leaving U.S. forces and populations in the United States and abroad vulnerable. DARPA supports a number of programs to speed the identification of and responses to biothreats. One aggressive goal is to demonstrate technologies that can map the complete molecular mechanism through which a novel threat agent alters cellular processes within 30 days of a human cell first being infected by that agent. Such an advance would facilitate rapid development of medical countermeasures and significantly shift the cost-benefit calculus for adversaries considering the use of chemical or biological weapons.

Finding, Tracking and Trailing Submarines

DARPA is developing several affordable, unmanned submarine tracking and trailing alternatives that could transform today's reliance on more resource-intensive manned systems while greatly increasing the number of submarines tracked. One approach under development aims to create underwater satellite-like systems (or "subullites") that would operate from the ocean floor to provide a wide-area view of submarine threats passing overhead. Fixed subullites could passively detect and track passing subs for hours, while mobile versions could intercept those subs to extend tracking time until more capable platforms are able to prosecute the threat.

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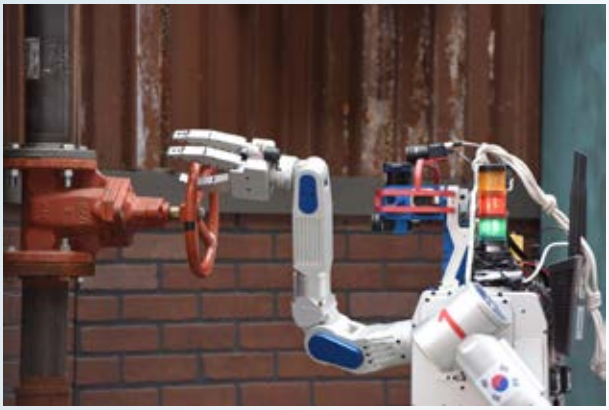
Advancing Capabilities in Ground Robotics

Notwithstanding the admirable creativity and imagination of science fiction authors and Hollywood directors, the field of ground robotics remains very much in its infancy. The DARPA Robotics Challenge aimed to accelerate the maturation of this promising technology sector with a focus on the development of robots capable of providing humanitarian assistance and disaster relief. The Challenge, which gave rise to communities of engineers and software designers from universities, industry and government labs, spurred remarkable advances in robotic agility, perception, power and processing. The final competition was held in June 2015. The Agency continues to invest in programs that aim to move robotics from an expensive, niche field into the mainstream.



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