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How a government agency is seeding a generation of startups

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The Pentagon agency that brought you the Internet, GPS and drones is setting its sights on an array of highly complex weapons ranging from satellites to undersea platforms in hopes of overwhelming America's potential adversaries.

After nearly four decades of unchallenged supremacy in offensive military capabilities, the U.S. now faces competitors such as China and other technologically savvy nations that have designed vastly effective defenses capable of forestalling American weapons.

Overcoming these obstacles and retaining U.S. military dominance requires a new way of designing and developing weapons, and that's one of the top goals of the Defense Advanced Research Projects Agency (http://www.bizjournals.com/profiles/company/us/va/arlington/defense_advanced_research_projects_agency/1891105) or DARPA, says its director, Arati Prabhakar (/search/results?q=Arati Prabhakar) .

Many companies based in Greater Washington – from giants like Lockheed Martin Corp. (http://www.bizjournals.com/profiles/company/us/md/bethesda/lockheed_martin_corp/3254316) to smaller ones like Aurora Flight Sciences – already play key roles in developing those technologies and may get to reap the long-term benefits of emerging ones.

The U.S. is "powerful but not invulnerable, and so today if you look at the defensive systems that are possible in China but also other parts of the world, it's going to be very hard for our capabilities over time to keep up with what we see developing on the other side," Prabhakar said. "So the question is how you overcome those capabilities?"

There are other agencies within the U.S. defense establishment charged with thinking about future threats and formulating policies. But it's DARPA that's responsible for spotting and developing the emerging technologies that have gone on to underpin weapons that few other nations possess. And it's DARPA that has also seeded the broader economy with advances — the ubiquitous computer mouse, for example — that grew out of research funded by the agency.

The once-secretive agency, housed in a new building in Ballston, is casting a wide net by increasingly turning to academics, entrepreneurs and non-defense contractors to canvass emerging technologies. For small businesses and contractors that get DARPA funding to develop technologies but lack the experience in selling to the Pentagon, the agency has a technology transition and commercialization team to help such firms take their products to market — both to the Defense Department and commercial customers.

The agency was created in 1958 at the height of the Cold War rivalry when the Soviet Union shocked the world by launching a long-range intercontinental ballistic missile as well as placing Sputnik I – the first satellite – in orbit. DARPA was born of the American desire to stay

ahead of adversaries and to never be surprised by a competitor's technological advances.

Even some of the agency's critics acknowledge DARPA's remarkable track record of spawning successful technologies in the last 47 years, but replicating that success in the coming years won't be easy. For starters, there's the uncertainty about future defense spending because Congress and the White House can't reach an agreement on how to cut budget deficits – with Republicans calling for cuts in social spending and Democrats insisting that defense budgets too should pay a price. And there's nowhere near the national determination to beat the Soviets, which characterized DARPA's earlier years. Add political dysfunction and many a lawmaker's disdain for science and the agency's challenges become clear.

But Prabhakar remains sanguine. Although the agency's budget fell 20 percent between 2009 and 2013 after adjusting for inflation, as overall defense spending declined, since then "it has stabilized and I think it's at a healthy, good level," she said. "I want to make sure that we have support for the budget at the level we are at and if we do that, we can do our piece of the job, which is triggering these new capabilities."

Causing enemies pain

The agency's pursuit of over-the-horizon technologies ranges from drones that are designed to lie dormant on ocean floors and shoot up

when triggered – “upwardly fall” in the agency’s parlance – to inexpensive satellite launches from conventional airplanes. Those advances can potentially impose huge costs on adversaries but must be done without bankrupting the U.S., Prabhakar said.

The undersea drone program has a budget of $63 million over four years. The Boeing Co., Global Aerospace Corp., Sparton Electronics, General Dynamics Corp. and Lockheed Martin Corp. have contracts to develop designs for the program.

The way to overcome the kinds of defenses that advanced competitors are putting up against U.S. weapons is “to inflict so much complexity on the adversary that they drown in the sea of what we have,” Prabhakar said, speaking about one agency goal called Rethinking Complex Military systems. “We make

their life so painful! Of course the challenge for us is how do we inflict complexity on them without having it shoot us in the foot?”

It’s precisely because some U.S. weapons have become so expensive, threatening to eat up large chunks of the Pentagon’s budget while struggling to keep pace with technological advances, that DARPA is embarking on finding ways to redesign such systems.

“Just look at how hard it is to get an upgrade on the next generation of semiconductor technology into, for example, the F-35,” she said. “That’s a multiyear undertaking, incredibly costly, costing hundreds of millions of dollars.”

The F-35 Joint Strike Fighter, made by Lockheed Martin, is the costliest U.S. weapon ever developed, at an estimated cost of about $391 billion.

Slow and expensive electronics upgrades means “at any moment in time our systems are not using the full power of the underlying technology,” Prabhakar said. That’s because of how such weapons are designed, making them difficult to upgrade unlike many commercial electronics products, she said.

Drones from sea

DARPA is also trying to get beyond technologies that emerged from its own labs in the past and revolutionized the world, such as global positioning systems and drones. GPS technology delivers accurate location information from a constellation of satellites. What began as a tool used only by the military, GPS is now so common that its continued use by the Pentagon could become a “strategic vulnerability,” according to the agency.

With the U.S. military’s decisive advantage in conventional warfare dependent on precision location and timing, the emergence of technologies capable of blocking GPS signals pose a threat, according to the agency’s annual report sent to Congress in March. DARPA is now turning to solutions like self-calibrating gyroscopes to avoid excessive reliance on GPS.

The CIA and the U.S. military both fly drones that can linger over targets for hours and drop missiles on command from remote operational centers. Such armed unmanned aerial vehicles, which have become the weapon of choice in President Barack Obama’s administration to take out high-value terrorists from Africa to Pakistan, weren’t welcomed with enthusiasm when DARPA began investing in the technology in the 1960s.

As the agency’s annual report notes, back then “the concept of using UAVs engendered widespread skepticism within military circles.”

To expand the use of such drones, many of which need a small runway to take off and land, DARPA is examining the feasibility of designing a launch and recovery arm that can be mounted even on small naval vessels like the U.S. Navy’s littoral combat ship to enable a fixed-wing drone to operate from sea.

Aurora Flight Sciences received a contract to develop the first phase of the program called SideArm, while the second phase contract went to Northrop Grumman Corp. and AeroVironment Inc.

Beyond the military

Not all of DARPA’s research priorities are aimed at delivering technologies with obvious military applications. On June 6, the agency held the DARPA Robotic Challenge in Pomona, California, which was won by a joint team from South Korea and the University of Nevada, Las Vegas. DARPA created the contest in the aftermath of a meltdown at the Fukushima Daichi nuclear plant in Japan that was hit by a tsunami in March 2011. The goal is to design robots that can work in disaster conditions where humans can’t operate.

The technology for the general purpose mechanical robots that competed in the contest is still in its infancy, Prabhakar said. Operating in post-disaster areas and doing things like driving a vehicle, walking about, and operating valves or opening doors – activities that constitute an automatic repertoire of skills for humans – is “the hardest environment for those mechanical creatures,” she said. The agency also is studying and evaluating academic research in the area of synthetic biology that could someday yield advances like walls made from biologically engineered material capable of self-healing after suffering damage, Prabhakar said.

The ability to engineer microbes or re-engineer them to produce new chemistries may also help with reducing dependence on fossil fuel-based materials and lead to more corrosion-resistant coatings or better de-icing on airplane wings.

A better understanding of how to manipulate biological materials could also help down the road in containing bio-terrorism threats, she said.

Avoiding the 'valley of death'

While DARPA's budget nurtures research that's bubbling around the world, the real payoff only comes when the fruits of that investment get incorporated into the U.S. arsenal. And that worries Prabhakar. "My bigger concern is whether our new technological capabilities become new operational capabilities," she said.

The slowing pace of adoption by the Pentagon of new technologies incubated by DARPA also worries Peter Singer, a senior fellow at the New America Foundation and author of "Wired for War," a 2009 book that explores the high-tech revolution in warfare.

Many a DARPA project has succumbed to the "valley of death," failing to make the transition from labs to a real weapons program, Singer said.

Undersea robots and driver-less cars — things DARPA championed and turned into successful prototypes in the last decade — have failed to translate into a Pentagon program, he said. Mercedes and Ford are more likely to put driver-less cars "on highways before the Pentagon takes it on roadways inside bases," he said.

Unlike the late 1950s, when DARPA was set up in the aftermath of the Sputnik satellite launch, the sense of "oh my goodness, we were surprised by that and we never want to be surprised" that pervaded Washington then doesn't exist now, Singer said.

The Soviet space advances led the U.S. to widespread changes in university curriculum and scholarships for American students to pursue science programs. By contrast, today foreign students dominate science and technology programs and return to their home countries after graduating, he said.

Then there's the overall decline in the country's scientific culture, exemplified by many lawmakers denying the science behind climate change and global warming.

But one of the most important differences in what DARPA faces now compared with its earlier years is the nature of competition.

Unlike the Soviet Union, which cut off itself from the rest of the world both politically and economically by trading only with like-minded communist states, China is open to ideas from all over the world and has a strong economy that pays for scientific research, Singer said.

"China already has matched the European Union in its research and development spending and is on track to match the U.S. in five years," Singer said. China has invested heavily and is working hard on developing, for example, the world's fastest super-computer and has carried out more "hypersonic weapons tests" than DARPA has. While China often is seen as buying old Russian planes and ships, it's also investing in cutting-edge science that makes it a "very different competitor," than the Soviets, Singer said.

"Those are the challenges that DARPA faces," Singer said. "Can they succeed? I hope they can," because "they're not an organization I'd ever bet against."

The agency's success stories

A look at some of the major pockets of DARPA research and what became of them.

Stealth technologies: In the 1970s, when U.S. air dominance was being challenged by adversaries deploying advanced radar that could pick out and shoot American warplanes in the sky, DARPA began studying ways to reduce the vulnerability of U.S. pilots and planes. The work led to the creation of new materials used in making and painting airplanes, curved as opposed to angled surfaces on planes, and redesigned inlet and exhaust vents on jet fighters, among other technologies. The advances resulted in a new class of jet fighters, bombers and helicopters that can penetrate enemy airspace while avoiding radar detection.

Makers of stealthy airplanes:

- Lockheed Martin Corp. (F-117 Nighthawk, F-22 Raptor and F-35 Joint Strike Fighter airplanes)
- Northrop Grumman Corp. (B-2 bomber)

Drones: DARPA's research on unmanned aerial vehicles began as early as 1962, when the agency developed a drone helicopter flying off a ship that could drop torpedoes on enemy submarines. The agency's research on engines, airplane designs, sensors, radar, communications, and autonomous systems have led to a revolution in how the U.S. fights modern wars.

Makers of unmanned aerial vehicles:

- Northrop Grumman Corp. (Global Hawk surveillance plane; Fire Scout surveillance helicopter; X-47B combat airplane flying off aircraft carrier)
- General Atomics Aeronautical Systems (Predator and Reaper aircraft)
- Lockheed Martin Corp. (Sentinel stealth drone; K-MAX cargo helicopter)

Precision guided weapons

Starting in the 1960s and 1970s, DARPA began looking for ways to neutralize the Soviet's numerical strength in tanks that could overrun Western Europe. While tactical nuclear weapons were an option, the agency began studying non-nuclear technologies that could be lethal

without causing widespread civilian deaths. Twenty years later advances in lasers, electronic and electro-optical sensors, GPS and others led to a new class of weapons called precision-guided munitions that can be launched from airplanes or ground-vehicles and can be guided to precise locations and targets.

Makers of precision weapons:

- Boeing Co. (maker of Joint Direct Attack Munition guidance kit used for air-launched missiles)
- Lockheed Martin Corp. & Raytheon Co. joint venture (Javelin portable anti-tank guided missile)
- Raytheon Co. (Advanced Medium-Range Air-to-Air Missile or AMRAAM; TOW anti-armor missile)
