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## Assessing High-Risk, High-Benefit Research Organizations: The “DARPA Effect”

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**D**efense innovation requires strong leadership coupled with a framework of supporting universities, research organizations, and contractors to focus on developing new capabilities through fundamental discoveries. The most frequently-discussed model for such a system is the United States’ DARPA—an organization that stimulates innovative ideas for the military. The “DARPA effect” is the ability of an organization to manage and drive high-risk research that might lead to highly inventive and innovative ideas with potential defense application. Although no country has replicated the DARPA structure, most have a process to inspire and fund innovative research and development (R&D) that presents opportunities to improve defense capabilities through fundamental (disruptive) changes in the nature of future warfare. This brief provides an overview of worldwide defense S&T approaches to creating a culture of high-risk research that results in high-benefit output for the military.

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One of the critical stages of a defense research, development, and acquisition (RDA) system is to develop and integrate innovative technological capabilities with new or existing military programs. Innovation leaders are likely to establish defense-owned/defense-oriented or commercial organizations dedicated to generating new science and breakthroughs in technology development that ultimately contribute to the advancement of new concepts for the military. For this study, international commercial and defense concepts of high-risk research were examined to answer this question: How do leading developers approach high-risk innovative research?

## DEFINING RESEARCH AND DEVELOPMENT

Given the slow-moving bureaucracy of defense S&T and RDA systems, radical technology developments are more likely to occur in the civil apparatus. Although commercial products are likely to be more readily available and less costly to acquire, governments may continue to turn to defense contractors for more sensitive needs, such as seen in the development and application of stealth technology. R&D, especially blue-sky research, requires a high degree of risk as a technology is taken from the lab and into a defense program, possibly to redefine capabilities for the future. Defense R&D focuses on the value to military capabilities; however, much of the global defense industry is struggling to redefine and assess financial risk (costs) against military needs (national security). Given the 10 to 25 years it may take to see the benefit of high-risk investment, it may be more important to consider how countries with developing defense R&D capabilities may approach radical innovation than to identify a replicated DARPA organization.

## LOOKING FOR HIGH-RISK, HIGH-BENEFIT ORGANIZATIONS

The RDA process analytic framework suggests a process to identify the existence of DARPA-like structures or organizations that drive advanced R&D on behalf of military programs. For this study, the author examined the culture of high-risk research and the organizations that play a role in the transition of fundamental research to defense programs. The study sought to identify any organizations that attempt to replicate the effect of a DARPA-like program and are responsible for stimulating R&D that will benefit the military.

## DARPA AS A MODEL FOR HIGH-RISK, HIGH-REWARD R&D

The United States remains the leader in radical defense technology innovation, in large part because of government-led organizations such as DARPA and innovative industrial organizations like Lockheed Martin's Advanced Development Program, (also known as Skunk Works). DARPA has been described as a non-hierarchical organization whose primary role is to oversee creative research conducted in short programs that typically run four to six years. It describes its role as that of "sponsoring revolutionary, high-payoff research bridging the gap between fundamental discoveries and their military use." Under its current structure, DARPA has six technology program offices with an investment strategy in which program managers define the programs that might lead to revolutionary change. DARPA's overall objectives are to "demonstrate breakthrough capabilities for national security" and "catalyze a differentiated and highly capable U.S. technology base." To this end, DARPA solicits and reviews pro-

posals with the military services and awards grants for basic and applied research with the most innovative potential.

DARPA serves as a catalyst for developing disruptive capabilities, with support from the upper echelon of the defense acquisition community. DARPA-run programs have the ability to reach into various sectors of industry by funding the creation of new ideas—although some programs can quickly become classified or 'black' because of the high payoffs to the military. DARPA's success rests largely in its ability to create pathways for high-payoff research to transition new concepts and technology breakthroughs to military programs.

The F-117 program models a successful collaboration between a government-led organization (DARPA) and a private-led organization (Lockheed's Skunk Works). Skunk Works is known for its ability to move technology breakthroughs from a laboratory concept to developmental programs. In 1974, DARPA set forth a series of proposals for a stealth aircraft, although Lockheed was not initially invited to participate in the competition because of the sensitive nature of the program. Skunk Works' lead director, drawing from his experience of developing secret technology for the SR-71 spy plane, approached DARPA with a new design that would reflect electromagnetic radiation. Lockheed eventually demonstrated the unique features of its discovery and was awarded a contract to develop two prototypes for a program that was quickly moved into top secret channels to protect the technology breakthroughs. At that point, oversight for the program shifted from DARPA to the U.S. Air Force Special Projects Office. Skunk Works continued to drive the development of supporting technologies and systems, relying on off-the-shelf hardware and borrowing concepts for other successful programs.

## CREATING THE DARPA EFFECT

An organization designed to create a DARPA effect would have the ability to fund research that is not tied to a specific military requirement, understanding that not all research programs will yield viable results. DARPA-like organizations would have strong program managers who interact with academia, military, and private research organizations, and non-traditional researchers. Such an organization would also have the ability to take on high-risk research and have the vision to recommend integration into defense programs. In the future, these breakthroughs are likely to focus on cross-cutting technologies and capabilities that more than one service may find useful. These new technologies will require a broad understanding of a country's overall military requirements and how to spread breakthroughs across services.

To create a "DARPA effect," it is necessary to stimulate potentially highly innovative and inventive ideas and to drive the ones that show real promise to the earliest exploration. The DARPA effect, however, is not always readily evident and the lack of immediate applications for technology breakthroughs often results in scrutiny and funding cuts during budget allocation cycles. Even as other countries consider creating DARPA-like organizations to stimulate defense R&D, some in the United States are questioning DARPA's relevance.

## GLOBAL APPROACHES TO HIGH-RISK R&D

A review of journals, government publications, and interviews identified various government approaches to high-risk, high-benefit defense R&D practices. No organization reviewed is directly comparable to DARPA however, the organizations discussed here represent the approach many countries take to identify, stimulate, or conduct innovative research.

### **Europe**

The European Defense Agency (EDA) is considered by some commentators the DARPA equivalent for Europe because it serves as a forum to promote cooperative defense R&D projects. EDA claims to have the unique role of bringing together planners, researchers, program managers, and developers to "meet the needs of the military tomorrow." A key concept behind EDA is to create synergy by creating R&D pools. Within this framework, a steering board ensures that projects support improving defense capabilities.

EDA's four R&D directorates work collaboratively for future defense capabilities. EDA also considers dual-use technologies, especially in the areas of IT, communications, and command and control capabilities. EDA, however, lacks the network of experts and financial backing to stimulate fundamental research throughout Europe and at one point was considering how to emulate DARPA under the EDA umbrella.

### **United Kingdom**

The role of the Defense Science and Technology Laboratory (dstl) is to "provide independent high quality scientific and technological services to MoD, the UK Armed Forces, and wider Government in those areas inappropriate for the private sector," according to an Ministry of Defence (MoD) study. One of the challenges for the United Kingdom is keeping pace with or ahead of the rapid changes in the application of technologies by their adversaries. Dstl's responsibility is to anticipate and prepare for emerging challenges through defense S&T based R&D. Fundamentally, the United Kingdom wants to have world-class S&T capabilities and plans to invest in developing those skills in the university structure and industry. The U.K. leadership has set in motion a plan to "fast track" basic R&D and to accelerate proof of concept demonstrations, allowing for the earliest exploitation of technical advances.

The United Kingdom established QinetiQ, a publicly-held research company that works with dstl, the research arm of the MoD, in 2001. Its goal is to broaden access to technologies with potential military application. Government leaders claimed that the driving force behind the creation of QinetiQ was to replicate elements of DARPA while maintaining its strong network of government-owned research organization. QinetiQ manages a wide range of collaborative research programs that incorporate research from private organizations as well as a network of university programs for the MoD. QinetiQ comes closest to emulation of DARPA.

### **Germany**

Although there is no organization in Germany with the responsibility to stimulate and improve defense capabilities, the German Research Foundation (Deutsche Forschungsgemeinschaft—DFG) is one example of a self-governing organization that sponsors grants for new high-risk programs. For example, the Koselleck Project funds basic research by German researchers or other nationals who are conducting what it considers high-risk or innovative research in a German research institute. All findings from this project are to be made available to the public. DFG also provides advice to Germany's parliament and government officials on general scientific issues. It receives most of its funding from the federal government. Like DARPA, it has a network of German research universities, non-university research institutions, scientific associations, and the Academies of Science and the Humanities, from which it draws scientific cooperation.

### **France**

France does not have a DARPA equivalent organization; however, in 1977, France established a research organization known as the Directorate for Research, Studies, and Techniques

(DRET) which was to mirror DARPA. DRET's role was to coordinate defense-related research in private and public sectors with military programs. It would fund medium- and long-term research programs at two government-supervised laboratories and award contracts to industrial labs and universities. One of its primary functions was to monitor internal and foreign technology development and make relevant research known within the French Ministry of Defense (DGA).

DGA abandoned DRET during a 1977 defense reorganization, and it has not attempted to recreate the structure. France will likely continue to look at the potential for EDA to drive innovative research in Europe. Although abandoned by the French government, DRET may serve as a model for other countries as they consider approaches to similar research programs.

### **Canada**

According to its website, Defence Research and Development Canada (DRDC) is under the Department of National Defence and provides support to the Canadian Forces on security and technological advances. Within DRDC are eight centers performing research and considering the future of technologies, in collaboration with industry, other governments, academia, and domestic government departments. DRDC's main objective is to ensure that its military is technologically prepared and capable of interoperability with its allies. The centers focus on a range of areas considered critical to future Canadian Forces capabilities. Interviews with S&T analysts in Canada suggest there is no equivalent DARPA organization in Canada.

### **Australia**

The Australian Research Council (ACR) provides advice on global S&T innovation that might benefit the Government of Australia. Through its National Competitive Grants Program

(NCGP), ACR provides funding for selected research projects. The Defence Science and Technology Organization (DSTO) is led by the country's Chief Scientist and provides S&T support for current and future defense capabilities and operations. It works collaboratively with government organizations and industry to provide advice on how best to support Australia's defense needs. Interviews with S&T experts suggest there is no DARPA equivalent organization in Australia.

### **Russia**

Russia may be addressing some of its past problems with innovative S&T through the recently formed Defense Ministry's Future Research Fund that was launched in April 2013. The goal of the fund is to "promote military research and development projects," similar to the United States' DARPA. The fund will select projects for R&D and bring forward viable proposals to the Defense Ministry. If successful, the program could bring together industry, design bureaus, academic research centers, and defense organizations to develop revolutionary technological breakthroughs. It is too early to determine if Russia will be successful in bringing all these pieces together to create the culture in which a DARPA-like organization will accelerate innovative R&D.

### **China**

China's S&T and defense research architecture is evolving and the government has established a number of programs that might have the intended role of funding and stimulating cutting-edge technology research. Although on the surface the programs support innovative research, they lack the structure and responsibilities of a DARPA and it is unclear who drives the transition of fundamental research into defense programs.

- The State Key Labs are viewed as one mechanism to build innovation in China. The Key

Labs are built around the concept of team collaboration.

- The National Basic Research Program—also known as the 973 Program—is a Ministry of Science and Technology-administered program that began in 1997 to encourage original innovation.
- The 863 Program was initially launched in 1986 as a government-funded plan to close China's technology gap through research at its state-sponsored institutes. The Ministry of Science and Technology (MOST) has primary responsibility for developing and implementing S&T policy while the China Academy of Sciences oversees China's primary academic research and state-controlled research institutes.

A review of Chinese journals suggests an interest in examining the concepts of a DARPA or Skunk Works-like organization. For example, Guangdong Province was considering a government-level organization that would adopt the principles of DARPA. They point to DARPA's accomplishments and the use of small teams to create innovative breakthroughs. Guangzhou is considering new principles for innovative research, including new regulations to promote the introduction of innovation teams to close the technology gap and to push the area into the development of cutting-edge technologies.

Additionally, the defense division of the Aviation Industry Corporation of China was created to accelerate R&D and break previous patterns of redesign while looking at ways to better integrate design and production. The program should improve production through independent trial-production centers modeled after Skunk Works. The hope for China is that this new process will lead to new breakthroughs in areas such as unmanned aircraft, drones, and other progressive weapons for the PLA Air Force and Navy.

## CONCLUSION

This brief examined a handful of programs whose mission it is to conduct or facilitate high-risk R&D that might spur innovative breakthroughs for the military. DARPA's imperative is to create opportunities for radical innovation for national security by bringing together technical experts and entrepreneurial program managers. DARPA's mission stands out from most other similar organizations because it accepts that the pursuit of high-risk technical ideas has a reasonable chance of failing.

Although most defense acquisition leaders and experts point to the phenomena created by DARPA as the most efficient means to stimulate high-risk, high-benefit research, few countries have adopted a structure or process similar to the United States. However, each has a unique approach to creating a process to stimulate fundamental research with a potential military application. Additional research is necessary to discern the pathways countries like China will take to anticipate, prepare, and meet distant challenges for innovative

breakthroughs, and to expand the analytic framework to recognize the DARPA effect.

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