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SEPTEMBER 2015

# Keeping the Technological Edge

## *Leveraging Outside Innovation to Sustain the Department of Defense's Technological Advantage*

*A Report of the CSIS Defense-Industrial Initiatives Group and the CSIS International Security Program*

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ISBN: 978-1-4422-5896-9 (pb); 978-1-4422-5897-6 (eBook)

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Washington, DC 20036
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## Contents

## Acknowledgments

This report would not have been possible without the support and active engagement of the Office of the Assistant Secretary of Defense for Research and Engineering, and in particular, the Information Analysis Centers.

The authors would particularly like to note the contributions of David Berteau, former director of the CSIS National Security Program on Industry and Resources, who directed this study for much of its duration before leaving CSIS for government service. Mr. Berteau's diligence and thoughtfulness informed many of the findings and recommendations found throughout this report. In addition, the CSIS team would like to recognize the substantive contributions of Gary Powell, who consulted on this project, and Christopher Zember, who was an active participant, as well as sponsor, of this work.

In addition, the CSIS team is grateful for the time and contributions of the many participants and interviewees who were directly involved in the development and vetting of the findings and recommendations found in this report. However, the report's conclusions are those of the authors alone, and participation should not be construed as endorsement of the report's findings. These findings and any errors are the responsibility of the authors alone.

This report was made possible by the generous support of the Information Analysis Centers of the United States Department of Defense (DoD IACs).

## Executive Summary

Technology innovations in the Department of Defense (DoD) have delivered unmatched national security capability for the United States for the greater part of the last seven decades. Federal research and development (R&D) funding is the grain of sand at the heart of the U.S. high-technology pearl. Continuing to push the technology envelope is central to maintaining U.S. preeminence in military capability, because, as Secretary of Defense Ashton Carter made clear in his Silicon Valley speech at Stanford in April 2015, "threats to our security and our country's technological superiority are proliferating and diversifying."[1] The U.S. global lead in defense technology is being actively eroded by potential competitors who themselves are pursuing advanced technologies to develop asymmetric capabilities that challenge the U.S. ability to carry out critical missions.

A strong DoD R&D program remains a necessary foundation for maintaining military technological dominance, but it is no longer sufficient for ensuring future DoD technology superiority. It remains necessary because there will always be military-unique products that have no commercial market and where commercial industry on its own will not invest. Perhaps even more crucially, the federal government makes strategic investments in basic science and technology that lay the foundation for developments critical to both defense and commercial technologies. However, focusing on innovation resulting directly from DoD's R&D program is insufficient today due to the rapid expansion of innovation occurring outside the DoD sphere of influence. In order to harness cutting-edge technology in a world where innovation is increasingly occurring beyond the traditional jurisdiction of government investment, DoD must continue to look beyond traditional industrial and geographic boundaries and proactively leverage outside innovation.

Leveraging outside innovation is a key complement to DoD's R&D program—allowing the rapid incorporation of technology that is being developed outside the jurisdiction of government investment and traditional government interfaces (universities and defense contractors), but which has significant military relevance, into DoD systems. As changes in the nature of the global economic system have made advanced technologies and technical know-how widely available, many key technologies are increasingly commercial in origin and globally sourced. Most of these sources lie outside the traditional sphere of defense technology development, but these technologies are increasingly applicable for military purposes. This new environment requires an expanded set of tools for improving awareness and gaining access to these technologies.

DoD is not ignorant of this challenge, nor is it standing pat. Both Secretary of Defense Carter and his predecessor Chuck Hagel have raised the profile of this problem set. With greater visibility, new initiatives have sprung up around the Department to address this challenge. In spring of 2015, Secretary of Defense Carter announced the creation of the Defense Innovation Unit Experimental (DIUX), to interface with Silicon Valley and connect to the talent and technology resident there, as well as an investment in the In-Q-Tel venture capital initiative to better harness startups. This is in addition to the numerous existing DoD initiatives in emerging/operational capabilities acquisition, rapid acquisition and

[1] Ashton Carter, "Rewiring the Pentagon: Charting a New Path on Innovation and Cybersecurity" (speech, Drell Lecture at Stanford University, Palo Alto, CA, April 23, 2015), http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1935.

support for small business innovation.[2] The third iteration of the Better Buying Power initiatives (BBP 3.0) is centered on "achieving dominant capabilities through innovation and technical excellence,"[3] through commercial technology utilization, open architectures, improved outreach, and others. Each of the military services has developed initiatives focused on addressing the challenges of this new innovation environment, including the Air Force's Bending the Cost Curve initiatives, Army Rapid Equipping Force, and Navy Rapid Innovation Cell. This report seeks to build on that foundation by proposing recommendations to expand and enhance DoD's awareness of and access to outside innovation.

This paper will first explore the context of the global innovation environment that is driving the need for DoD to better connect with the global commercial economy. DoD also faces unique circumstances that make the task of penetrating and leveraging this market even more difficult. The scope, timelines, and responsibilities inherent in the wide variety of critical missions facing DoD present serious challenges to rapid innovation. DoD capabilities often face strict standards, challenging and complicated logistics, and integration challenges. Security of supply, industrial base protection, and technology security concerns also play important roles. And yet, it is clear that to continue to drive innovation in the twenty-first century, awareness and access of outside innovation will only become more important.

The innovation discussed in this paper is technological development that, when coupled with the processes, concepts of operations, and implementation necessary in DoD, provides improved and/or cheaper capability for the U.S. military. There is no doubt that the internal R&D engine of DoD must keep revving, but this report is explicitly targeting the additional exploitation of the proliferating availability of defense-relevant outside innovation. In order to put the importance of outside innovation in context, CSIS developed a taxonomy of centers of innovation, which frames outside innovation in terms of other DoD innovation. The four "centers" of innovation identified encompass the range of global innovators, in reference to 1) their proximity to DoD's existing sphere of influence and 2) the source of requirements driving the innovation. Each of these centers of innovation provides different benefits and challenges, based on the differing levels of responsiveness to or independence from DoD, as well as its understanding of DoD needs, and governing market dynamics. Similarly, maximizing the benefits of each center of innovation requires a different mix of processes. It is in outside innovation that the processes are still least mature and growing, and that is where additional input could help most.

Through an expansive set of interviews with experts, practitioners, and senior officials, the study team developed a set of recommendations, which are described in more detail in the final section of the report. These recommendations are divided into proposals that address the two sets of challenges posed by this new innovation environment: 1) encouraging better awareness of outside innovation, and 2) enabling better access to that outside innovation once it has been identified.

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[2] Including the Rapid Innovation Fund and Small Business Innovation Research (SBIR) program.

[3] Under Secretary of Defense for Acquisition, Technology and Logistics Frank Kendall, "Better Buying Power 3.0," White Paper (Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, September 19, 2014), 2, http://bbp.dau.mil/docs/2_Better_Buying_Power_3_0(19_September_2014).pdf.

Recommendations for expanding awareness of outside innovation:

1. While many parts of DoD are highly conversant with the latest advances in technology, this awareness is not universally shared by critical elements of the acquisition, resource, and requirements communities. DoD should create and share a better knowledge base of emerging technologies and processes across the Department.
2. DoD should more extensively utilize efforts to promote operational innovation and support the use of small "demonstration" projects and operational experimentation to identify and incorporate outside innovation in the field. This includes encouraging and supporting more warfighter-innovator collaboration, and expanded use of field-testing for quicker evaluations of outside innovations.
3. DoD should expand and connect initiatives at OSD and in the military departments that search for specific technology development from outside innovation.

Recommendations for improving access to outside innovation:

1. DoD should develop forcing functions within the warfighter and acquisition communities that identify capability gaps, match available and emerging technologies and concepts with those gaps, and rapidly pull those technologies and concepts into operational use.
2. DoD policy and practice should create and foster requirements flexibility that allows consideration of potential solutions that don't fit existing programs or requirements. This could be enabled by focusing on expanding modularity and use of open systems architectures, which can provide flexibility in approaches to meet specified outcomes.
3. DoD policy should, as part of identifying options to address capability gaps, support consideration of disposability (i.e., planned obsolescence), not updating, as a viable acquisition strategy where circumstances warrant such an approach.
4. DoD must capture and leverage wartime rapid-fielding lessons learned, under which DoD has accepted more risk, accepted commercial/civil solutions for operationally essential capabilities, and enticed commercial and non-U.S. firms to compete.
5. DoD should continue or expand mechanisms for warfighters to fund urgent and emerging operational capability needs, including Joint Urgent Operational Needs/Joint Emerging Operational Needs (JUONs/JEONs) funds, Joint Capability Technology Demonstrations (JCTDs), Emerging Capabilities Technology Development (ECTDs), Rapid Innovation Fund, and others.
6. DoD should expand Better Buying Power goals and encouragement of prototypes to include prototypes for proof of concept, validating requirements, defining requirements, and as a basis for experiments and tests.
7. DoD needs to create separate funding (at appropriate levels) for warfighter initiatives. Warfighters in particular need a way to fund innovation without waiting for the PPBE/S cycle to provide money. DoD needs a limited amount of prearranged set of funds to be available to verify, evaluate, and begin to incorporate outside innovation discoveries.

## The Innovation Imperative

The U.S. Department of Defense (DoD) is the world's largest research and development (R&D) organization and has been responsible for some of the most significant technological breakthroughs of the past century.[1] Technology innovations in DoD have delivered unmatched national security capability for the United States for the greater part of the last seven decades. This dominance has been driven by technology innovations ranging from military-specific innovations like nuclear-powered ships, stealth aircraft, and precision-guided munitions, to public goods like the global positioning system and early versions of the internet. Continuing to push the innovation envelope is central to maintaining U.S. preeminence in military capability, because the U.S. technology lead cannot be assumed to last indefinitely.

Part of this challenge is that innovation comes in many forms. It can be focused on technology, processes, or business practices. It can be evolutionary or revolutionary; sustaining or disruptive; continuous or discontinuous; incremental, differential, radical, or breakthrough. It can be the next linear step in advancing a well-understood problem (e.g., batteries), a pioneering application of an existing technology (microwaves), a process tool for management (Six Sigma), a new concept of operation that changes tactical planning (carrier warfare), or a radical new technology that spurs a paradigm shift in strategy (nuclear weapons). Innovation can result in a new platform that changes the nature of warfare, a single component that upgrades capability or simply a shift in the cost curve that changes the value proposition of a system.

The innovation discussed in this paper is technological development that, when coupled with the processes, concepts of operations, and implementation necessary in DoD, provides improved and/or cheaper capability for the U.S. military. Because it is focused on outside innovation, this study is generally not focused on major weapons systems as candidates for sourcing from nontraditional firms at the system level, although the subsystems and components of these systems would be good candidates for insertion of innovative technology. While someday the nature of the defense-industrial base may change to the point where whole platforms are sourced from predominantly commercial performers, that is not likely in the medium term.

The creators, performers, and builders of U.S. technological supremacy today are a diverse community of innovators, both inside and outside of government. Inside DoD, the military departments drive their own innovation, from the soldiers, sailors, airmen, and marines in the field, to the service laboratories and engineering centers, to innovation-focused agencies like the Defense Advanced Research Projects Agency (DARPA) and the intelligence community. DoD also funds others to develop innovation, including academic institutions like the federally funded research and development centers (FFRDCs), university-affiliated research centers (UARCs), and think tanks, as well as for-profit companies. Relevant for-profit firms include both defense and commercial companies, large and small, from within the United States as

[1] The U.S. Department of Defense spends $65 billion a year on RDT&E activities, which is as much as the top six global companies spend on R&D combined. This also represents 60 percent of the total military budget of China, and nearly 100 percent of Russia's defense spending (per the International Institute of Strategic Studies' *The Military Balance 2014*).

well as international. Most importantly, this resource base has a foundation of global talent drawn to solving national security challenges.

The innovation provided by this traditional national security community has enabled a U.S. military predicated on technical superiority to meet global security commitments, protect U.S. citizens and interests, and execute the national military strategy. However, as Secretary of Defense Ashton Carter has made clear, "threats to our security and our country's technological superiority are proliferating and diversifying."[2] The U.S. global lead in defense technology is being actively eroded by potential competitors who themselves are pursuing advanced technologies to develop asymmetric capabilities that call into question the U.S. ability to carry out critical missions. Changes in the nature of the global economic system have enabled this trend by making advanced technologies and technical know-how widely available. As Secretary Carter has stated clearly, "now much more technology is commercial, and the technology base is global." Most of these technology sources lie outside the traditional sphere of defense technology development, but are increasingly applicable for military purposes. The accelerating pace of technological change and the diffusion of technology and information are precipitating what former Secretary of Defense Chuck Hagel warns will be "an era where American dominance on the seas, in the skies, and in space can no longer be taken for granted."[3]

At the same time, DoD resources for investing in technology are under pressure from a decreasing topline and declining purchasing power.[4] Budget cuts since 2011 have inordinately impacted investment spending (procurement and R&D). In particular, R&D contracts took the largest hit under sequestration in 2013, absorbing a one-year cut of 21 percent across DoD, the largest in any year for which contracting data is available.[5] The downward trend continued in 2014, as R&D contracts fell another 8 percent. This budget pressure can only accelerate the erosion of the U.S. technological lead, especially as competitors like Russia and China ramp up military investment.[6] DoD leaders continue to publicly assert their commitment to protect investment resources under continued budget pressures, but with ongoing operational requirements this will remain exceedingly difficult. Additionally, actions to "batten down the hatches" on R&D can have the unintended consequence of protecting existing stakeholders and entrenched activities, as the money available for new and less traditional activities dries up. And yet, in a declining budget environment, it is these outside-of-the-box solutions, developed away from the military bureaucracy, that may provide the best opportunity for innovation and efficiencies.

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[2] Carter, "Rewiring the Pentagon: Charting a New Path on Innovation and Cybersecurity."

[3] Chuck Hagel, "Remarks by Secretary Hagel and Gen. Dempsey on the Fiscal Year 2015 Budget Preview" (speech, Pentagon Briefing Room, Arlington, VA, February 24, 2014), http://www.defense.gov/Transcripts/Transcript.aspx?TranscriptID=5377.

[4] For discussion of combined effect on DoD purchasing power, see Clark Murdock, Ryan Crotty, and Angela Weaver, *Building the 2021 Affordable Military* (Washington, DC: CSIS, June 2014), http://csis.org/files/publication/140625_Murdock_Building2021Military_Web.pdf.

[5] Jesse Ellman, Gregory Sanders, and Rhys McCormick, *U.S. Department of Defense Contract Spending and the Industrial Base, 2000–2013* (Washington, DC: CSIS, October 2014), ix–x, http://csis.org/files/publication/140929_Ellman_DefenseContractSpending2013_Web.pdf.

[6] Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China: 2014," http://www.defense.gov/Portals/1/Documents/pubs/2014_DoD_China_Report.pdf.

The Department of Defense is fundamentally aware of these trends in both the global innovation environment and DoD, and leaders across the Department are responding. DoD has launched a series of initiatives to address this new world and fight back against rising challenges. The 2014 Quadrennial Defense Review identifies innovation as a "central line of effort" in leveraging new domains of warfare, improving acquisition outcomes, developing warfighting and posture concepts, and changing culture.[7] Deputy Secretary of Defense Bob Work, at the direction of former Secretary of Defense Chuck Hagel, is leading a Defense Innovation Initiative (DII) to underpin a new "offset strategy" directed at evolving the U.S. military-technological edge and "accelerat[ing] innovation throughout the Department,"[8] including efforts focused on personnel management, concepts of operations, wargaming, business practices, and, of course, R&D. Parallel to the DII, Frank Kendall, under secretary of defense for acquisition, technology and logistics, has focused his third iteration of the Better Buying Power initiatives (BBP 3.0) on "achieving dominant capabilities through innovation and technical excellence."[9] Another subset of the DII is the Long-Range Research and Development Plan (LRRDP), focused on identifying high-value technology opportunities to target in the DoD-wide R&D investment strategy.

In spring of 2015, Secretary of Defense Carter announced in a speech at Stanford the creation of the Defense Innovation Unit Experimental (DIUX), to interface with Silicon Valley and connect to the talent and technology resident there. This program will focus on leveraging the "nexus of innovation"[10] in Silicon Valley by increasing partnerships with the business and academic communities and raising the profile of national security issues. In addition, the secretary unveiled an investment in the CIA's venture capital initiative, In-Q-Tel, in order to leverage the existing relationships and infrastructure of that program for DoD needs. These new initiatives are on top of the many existing programs in DoD that were created or have been recently directed toward reaching outside innovation. It includes small business-focused programs like the Rapid Innovation Fund and Small Business Innovation Research program. There are collaboration programs, public-private partnerships, venture capital, and outreach—many of which are identified in Appendix I.

Each of these initiatives acknowledges the changing nature of the global technology environment, and provides guidance for better connecting to outside innovation. However, questions remain about how these initiatives will develop new processes and implement new approaches to conducting business to take the changes introduced by this shifting technology paradigm and leverage them in new ways. Most importantly, the Department must move from ad hoc initiatives to changing the way it does business if it is going to maximize the return from the fount of global commercial innovation. It is clear that even with new initiatives, strategy documents, war games, outreach to industry, speeches, and testimony before the Congress, if the Department does not continue to develop and employ new ways of doing business to access innovation it may not achieve the technological advantage it is seeking.

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[7] Department of Defense, *2014 Quadrennial Defense Review*, March 2014, vi, http://www.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf.
[8] Secretary of Defense Chuck Hagel, "Memorandum: The Defense Innovation Initiative," November 15, 2014, http://www.defense.gov/pubs/OSD013411-14.pdf.
[9] Kendall, "Better Buying Power 3.0."
[10] Carter, "Rewiring the Pentagon: Charting a New Path on Innovation and Cybersecurity."

While today's cutting-edge weapons were built by a combination of the same tried-and-true providers of exquisite weapons platforms that fought back the Soviet Union, the bright minds of the service laboratories and the disruptive thinkers of DARPA, it is far from clear that these avenues will be sufficient to access innovation in the emerging global technology environment because the key technologies of the next three decades are likely to be very different from the breakthroughs of the past. The Department cannot just assume that these new communities and centers of innovation will simply come to DoD of their own accord. DoD needs to improve its *process* for increasing its awareness of and access to the larger global community of innovators in order to leverage the universe of innovation that will be needed to deliver national security capability in the future. This report seeks to help address that question of "how."

## The Global Innovation Environment

The primary force driving the necessity of an evolution in DoD's perspective on innovation derives not from failures of the Department of Defense to deliver cutting-edge technology for national security, but from the changing global innovation environment in which the Department now operates and competes. This new ecosystem is characterized by the diffusion of technology, lower barriers to entry, and wider access to information. These trends benefit the global economy, but undoubtedly undermine historical advantages that DoD has exploited to maintain technological dominance for much of the last seven decades.

Creating new product innovations once required laboratories and universities to develop the technologies, building-sized supercomputers to model them, domestic industry to provide sophisticated, expensive materials, and factories to produce them. New hardware technologies still require each of these steps, but they are now available to nearly anyone at the push of a button and at a fraction of the cost. The supercomputers of the past now fit in an inventor's hand and can be had for hundreds, not millions, of dollars. These same computers can facilitate testing, and greater access to and lower cost of technology means that garages can now be high-tech labs. Materials can be acquired from online global supply networks and then production can be outsourced over the internet to "on-demand" manufacturers. Thus, the immense comparative advantage for DoD of the domestic U.S. resource base, including university researchers, government-sponsored laboratories, sophisticated materials suppliers, and advanced production centers, is diminished.

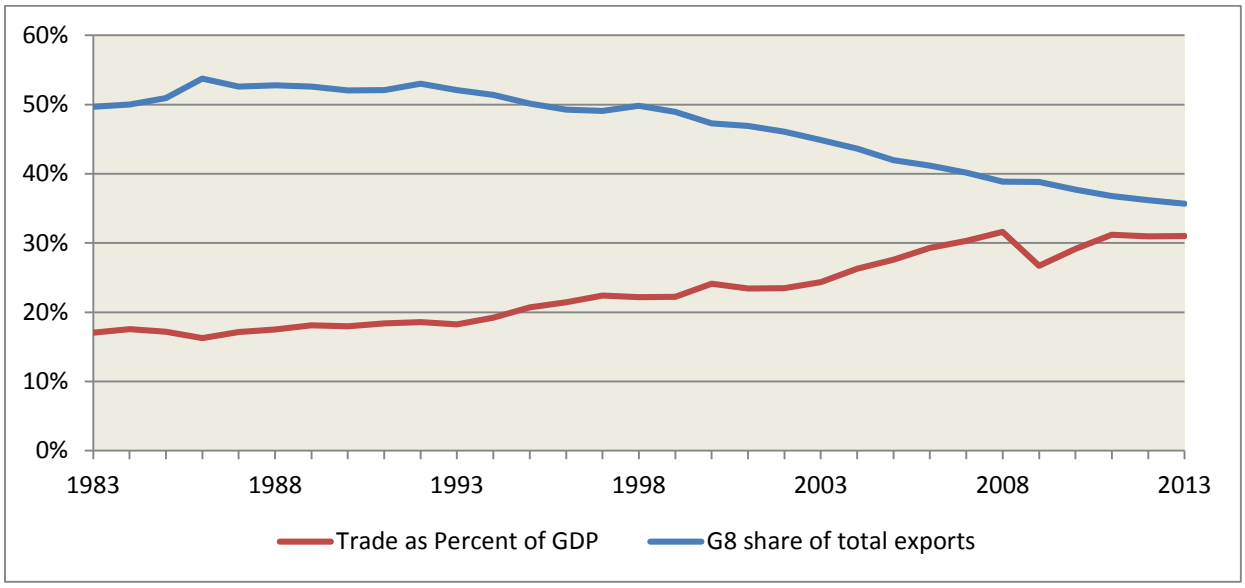
The Department of Defense's current innovation and acquisition systems are predicated on the superiority of the U.S. domestic resource base to stay ahead of the rest of the world. They were optimized for a world where, given enough time and mass, the Department could do anything. While DoD's will and commitment to innovation remain, both time and mass are in increasingly short supply.

While the United States still holds the leading position in military technology innovation, the gap with the rest of the world is shrinking. Four key characteristics of the global innovation environment, globalization, privatization, commercialization, and acceleration, combine to threaten DoD's future technology dominance. Globalization and privatization represent characteristics of the world today, while commercialization and acceleration are traits of technology itself, intertwining to make the global innovation environment.

## Globalization

The profusion of global movement and connectivity in products, services, people, and ideas has fueled a global economic environment that has itself underpinned U.S leadership in the world. The global expansion of free trade, improvement of transportation technology, and rise of information technology has lowered barriers to and costs of the movement of ideas, knowledge, and goods. In the last 30 years, world trade in goods (as measured in imports and exports of all goods and services) has increased by an order of magnitude—half again as fast as world GDP has been growing. As shown by the red line in Figure 1, world trade in goods has doubled as a share of world GDP, so that, today, one in three goods sold or financial transactions made now occur internationally.[11]

**Figure 1: Globalization of the World Economy[12]**




Additionally, the source and composition of this trade has changed significantly. As trade has increased, the role of less established economies in those trade flows has grown significantly. The G8 countries were responsible for over half of all global exports a quarter-century ago; that has now dropped to nearly a third, as shown by the blue line in Figure 1. These same trends that have bolstered global economic prosperity have led to an erosion of the U.S. lead in two core inputs to innovation: manufacturing and research and development.

Globalization has become synonymous with the shift of manufacturing processes to less developed economies. This shift has been a key driver of the growth of global value chains, with manufacturing centers spreading to countries with lower costs of labor and capital, coinciding with the lowering costs of communicating with and transporting goods from these locales. Figure 2 illustrates the outcome of

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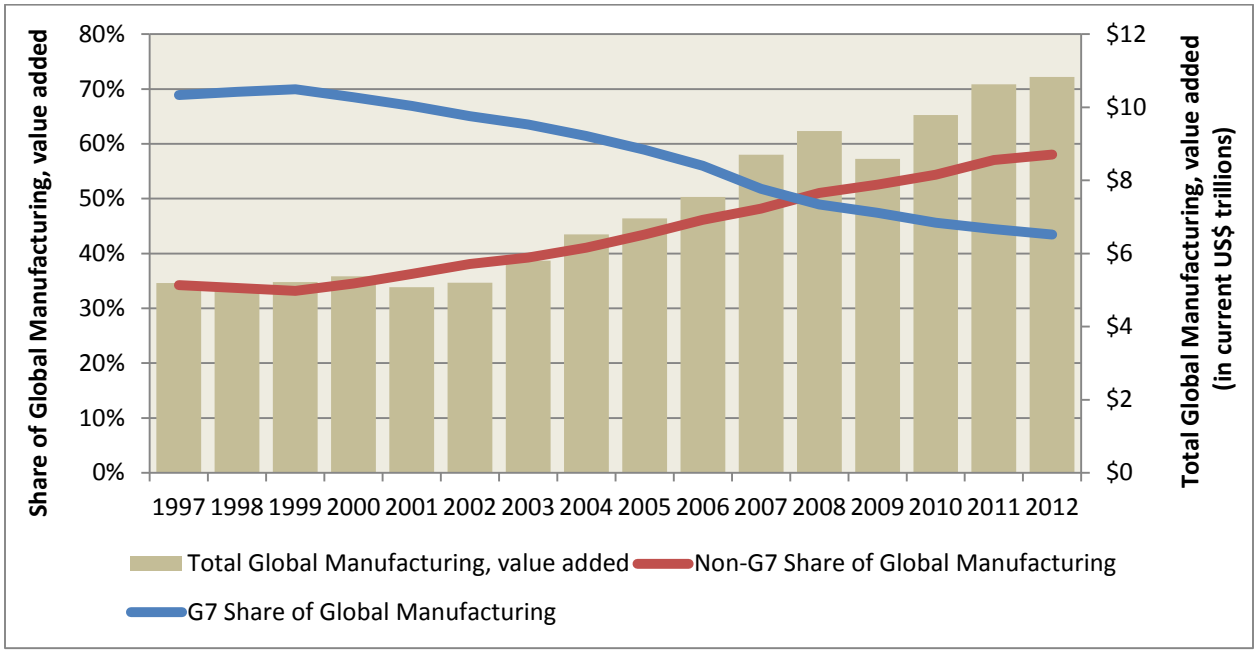
[11] James Manyika, Jacques Bughin et al., *Global flows in a digital age: How trade, finance, people, and data connect the world economy*" (San Francisco, CA: McKinsey & Company, April 2014), 1, http://www.mckinsey.com/insights/globalization/global_flows_in_a_digital_age.

[12] CSIS analysis of UN data. UN Conference on Trade and Development, "Exports and imports of goods and services, annual, 1980–2013," UNCTADstat, http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=25116&IF_Language=eng.

these trends. Under these conditions, global manufacturing has grown from a $5 trillion industry in 1997 to nearly $11 trillion in 2012. In just 15 years (1997–2012), the role of G7 countries in global manufacturing fell from 70 percent (value added) down to just over 40 percent. In 2008, the non-G7 countries overtook the G7, and are now responsible for almost 60 percent of global manufacturing.

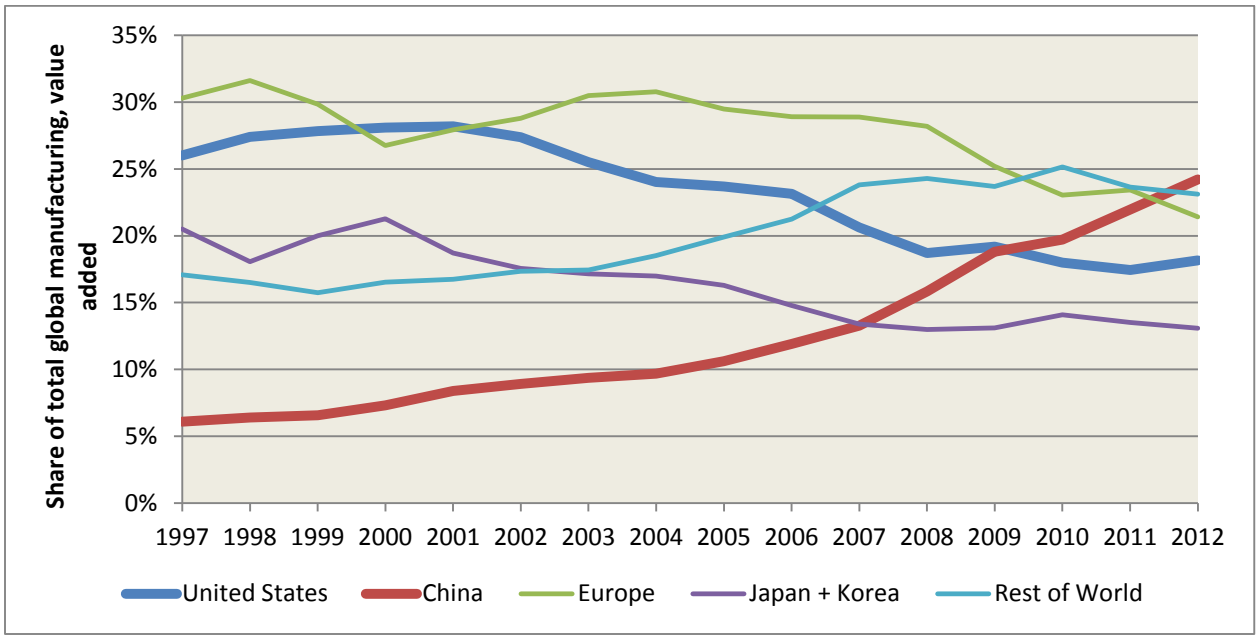
**Figure 2: Changing Global Manufacturing Base**[13]




Unsurprisingly, these trends are mirrored by those in the U.S. and China. As shown in Figure 3, the U.S. manufacturing sector (in blue) has declined in its share of world manufacturing by a third, while that of China (in red) has more than tripled. Similarly, U.S. partners like Japan and the Republic of Korea (combined in the purple line), and the European countries (green), have similarly declined by around a third each, while the rest of the world (excluding those listed above, in teal) has expanded its market share by a third.

[13] Source: World Bank and Organization for Economic Cooperation and Development (OECD) data; CSIS analysis. Data definition (per World Bank): "Manufacturing refers to industries belonging to ISIC divisions 15-37. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs."

**Figure 3: Globalization of Manufacturing by Country/Region**




Manufacturing has been a key source of technology transfer, as well as innovation initiation in developing economies. It has been well-documented by both academic[14] and government[15] sources that manufacturing plays an outsized role in national innovation. As the Defense Science Board highlighted in its review of key developments out to 2030, "the shift of manufacturing capability to a more global base enables new players to learn a technology and improve on it."[16]

While manufacturing represented the last age of globalization, based around the movement of capital- and labor-intensive activities to countries with low costs for these production inputs, the global flows of goods and investments today are increasingly knowledge intensive. Half of global flows are now part of the knowledge economy.[17] Falling costs and shrinking barriers have enabled the spread of research and development from its concentration in the developed world out to the developing world. In 1973, 97 percent of global R&D took place in developed countries, but by 2007, that share had dropped to 75 percent.[18] Figure 4 shows this dynamic, paired with the overall increasing volume of global R&D activity. China is the primary driver of the increase in "developing economies" R&D (as this data set is based on

[14] Richard M. Locke and Rachel L. Wellhausen, eds., *Production in the Innovation Economy* (Cambridge, MA: MIT Press, 2014), 1–16.

[15] Executive Office of the President, *Making in America: U.S. Manufacturing Entrepreneurship and Innovation* (Washington, DC: Government Printing Office, June 2014), http://www.whitehouse.gov/sites/default/files/docs/manufacturing_and_innovation_report.pdf.

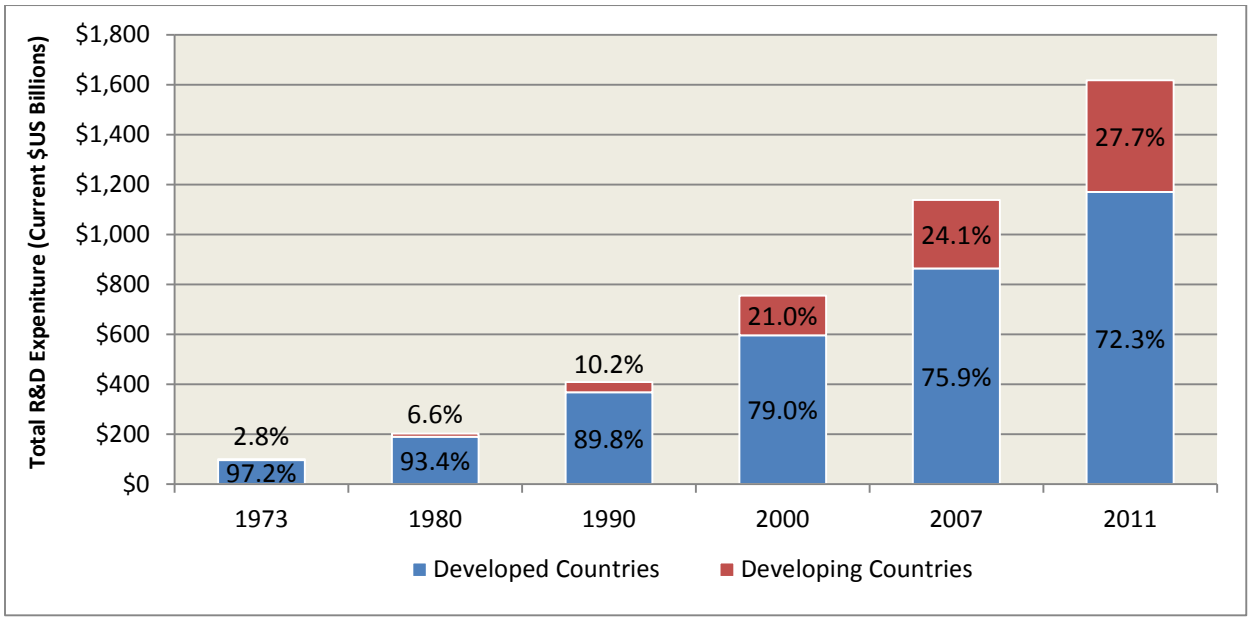
[16] Defense Science Board, *Technology and Innovation Enablers for Superiority in 2030* (Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, October 2013), vii, http://www.acq.osd.mil/dsb/reports/DSB2030.pdf.

[17] Manyika et al., *Global flows in a digital age*.

[18] Elisa Around and Martin Bell, *Trends in the Global Distribution of R&D since the 1970s: Data, Their Interpretation and Limitations*, STEPS Working Paper 39 (Brighton, UK: STEPS Centre, 2010). Due to the difficulty of finding longitudinal R&D data, the "developing"/"developed" country construct is used here to match the data sets back to 1973. The breakdown is based on the UNESCO Institute for Statistics.

data originally compiled in 1973), with India, Korea, Taiwan, Singapore, and Brazil also contributing significantly to this increase.

**Figure 4: R&D Expansion and Globalization**[19]




The U.S. economy still dominates the global R&D market, with the U.S. public and private sectors comprising 30 percent of global R&D. But with the global increase in R&D spending, the sheer volume comprised of that other 70 percent is far larger—$1.1 trillion worth of non-U.S. R&D activity. Economic analysis by researchers at the National Defense University suggests that by 2050, U.S. share of global science and technology (S&T) will decline to 18 percent of the world total.[20]

With the rapid expansion of the global innovation base, DoD is increasingly a smaller player, with less influence on, awareness of, and access to the profusion of new technologies. By limiting its focus to only U.S. government-funded R&D (including that financed by government and performed by industry), DoD dismisses 95 percent of global R&D activity.[21] At the same time, other nations have increasing access to this same globalized well of innovation, without the barriers that once protected U.S.-developed technology.

[19] Data for 1973–2007 from Around and Bells, *Trends in the Global Distribution of R&D since the 1970s*. Data for 2014 aggregated to match STEPS data, from National Science Foundation, "International comparisons of gross domestic expenditures on R&D and R&D share of gross domestic product, by region/country/economy: 2011 or most recent year," Science and Engineering Indicators 2014, National Science Foundation, 2014, http://www.nsf.gov/statistics/seind14/index.cfm/overview.

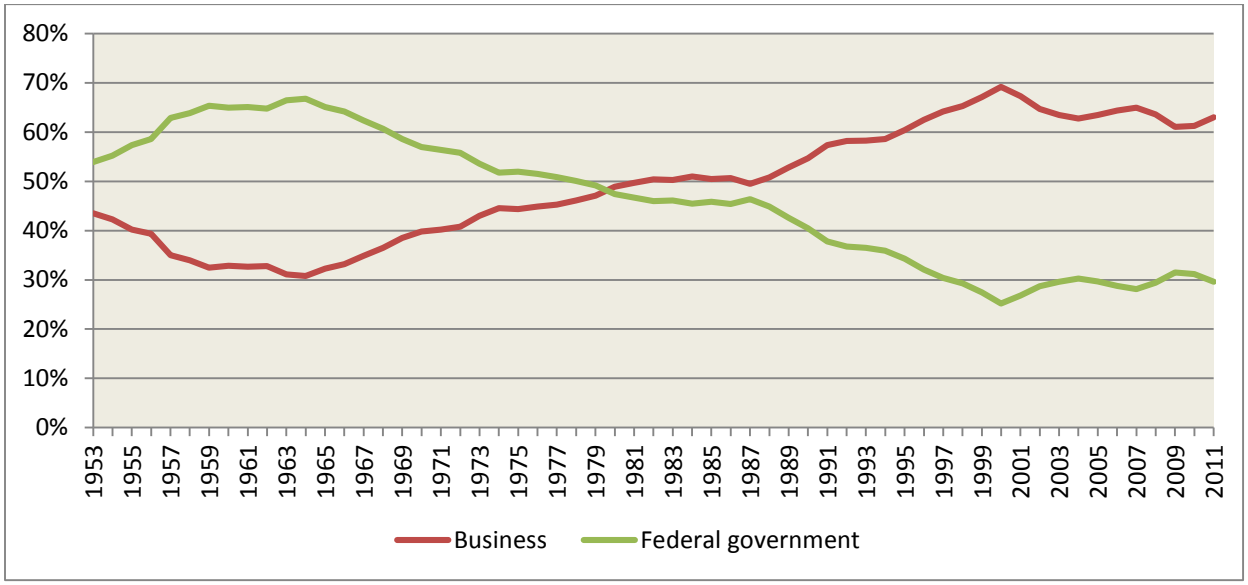
[20] Timothy Coffey and Steven Ramberg, *Globalization of S&T: Key Challenges Facing DOD* (Washington, DC: National Defense University, February 2012).

[21] Martin Grueber, Tim Studt et al., "2014 Global R&D Funding Forecast," *R&D Magazine*, December 2013, http://www.battelle.org/docs/tpp/2014_global_rd_funding_forecast.pdf.

## Privatization

The dispersion of the loci of innovation globally presents one set of challenges, but the shift from public sector to private presents another. National governments have always played a primary role in driving innovation through research and development, particularly focused on the research side of the equation. The lowering costs and barriers to technology and growing global markets have driven a profusion of R&D spending in the private sector, fundamentally changing the value proposition for firms. As shown in Figure 5, in the 1960s, U.S. federal spending on research and development was double that of the U.S. private sector.[22] Government R&D actually increased sixfold over the 60-year period displayed (accounting for inflation), but business R&D multiplied twentyfold. So, today the private-public role in U.S. R&D has flipped, with almost two-thirds of U.S. R&D funding coming from the business sector. Just the top six global R&D companies combined now spend as much on R&D as the whole of DoD.[23]

**Figure 5: Privatization: Source of Funds for R&D in the United States, Percent Share of Public and Private Sector[24]**




As a microcosm of this shift, the time when only DoD had their hands in the development of the major game-changing technologies, like microprocessors, the Global Positioning System, and the internet, is passing. While DoD is still involved in the cutting edge of key technologies, commercial firms are increasingly challenging the Department for primacy.

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[22] Congressional Budget Office, *R&D and Productivity Growth: A Background Paper* (Washington, DC: Congress of the United States, June 2005), 5, http://www.cbo.gov/sites/default/files/06-17-r-d.pdf.

[23] Michael Casey and Robert Hackett, "The 10 biggest R&D spenders worldwide," *Fortune*, November 17, 2014, http://fortune.com/2014/11/17/top-10-research-development/. Note: The Top 6 in 2014 were Volkswagen, Samsung, Intel, Microsoft, Roche, and Novartis.

[24] Source: National Science Foundation, *Science and Engineering Indicators 2014*, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series), Table 4-6, http://www.nsf.gov/statistics/seind14/content/chapter-4/chapter-4.pdf.

## Commercialization

At the same time, the key technologies that are being developed in the commercial world have greater military significance than possibly any previous period. With the opening up of new domains of warfare, the increasing role of networking and communication, and the development of new concepts of training and operations, military might is becoming less and less tethered to the tanks, aircraft carriers, and fighter planes that only exist for military purposes. Instead, new advantages are being found through information—sensing, big data, simulation, computing, networking, and communications—all areas where the global commercial market is at the cutting edge of technology. As the director of DARPA, Arati Prabhakar, asserts, the most promising innovations are "typically not found in the established defense industries."[25]

The commercial market is increasingly developing technology with military significance. As DoD works to build and integrate information system architectures across the enterprise, the commercial market is putting sophisticated IT systems into the palms of consumers' hands. IT systems and data are now at the heart of both advanced commercial and military technology. The sophistication and applicability of commercial products has changed the fundamental value proposition of commercial technology for DoD. As Al Shaffer, the Pentagon's lead research executive (principal deputy assistant secretary of defense for research and engineering), has made clear, "many technologies of importance to the Department's capability developments are driven by the commercial sector, and have become a global commodity."[26]

As the commercial sector takes an increasing role in key technology areas, DoD has to shift the way it interfaces with these firms and technologies. In some cases, like microelectronics, these technologies have their origins inside of DoD labs, but have flourished in the commercial environment to the point where DoD is now lagging the market. In cases like this, DoD is relatively aware of the major muscle movements in commercial industry, but cycle times are much shorter than defense design cycles. Additionally, some firms may see working with DOD as incompatible with their commercial interests. In a well-publicized series of events, Google acquired a significant number of the largest robotics firms in the country, including some like Boston Dynamics with DoD contracts. However, the tech giant has made clear that they do not plan to look for continued work with DoD after those contracts are completed.[27]

The bigger challenge is those technologies that have developed either wholly or largely outside of the DoD purview, where DoD does not have the in-house knowledge base to leverage the technology. Even more troubling than these new technologies that DoD may not have expertise in are those technologies incubating beyond DoD's eyes, companies that the chief information officer at the Defense Intelligence

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[25] Arati Prabhakar, "Global Security Forum 2014: Military Innovation and Changing Ways of War" (speech, Center for Strategic and International Studies, Washington, DC, November 12, 2014).

[26] Alan R. Shaffer, principal deputy assistant secretary of defense for research and engineering, testimony before the Committee on Appropriations, Subcommittee on Defense, U.S. Senate, 113th Congress, May 14, 2014, http://www.appropriations.senate.gov/sites/default/files/hearings/Written%20Statememt%20Mr%20%20Shaffer.pdf.

[27] William J. Lynn, "The End of the Military-Industrial Complex: How the Pentagon Is Adapting to Globalization," *Foreign Affairs* 93, no. 6 (November/December 2014): 107.

Agency says, “really don’t know much about the way that we do business and we don’t know they exist.” The problem, as he lays it out, is that “it turns out the biggest source of the best ideas is ‘non-traditional performers,’” companies with no prior federal contracts.[28] Additionally, even where those in DoD may have knowledge of these developments (e.g., specialists in the labs), this information may not actually spread to those in decisionmaking or warfighting roles where it can be leveraged to inform decisions.

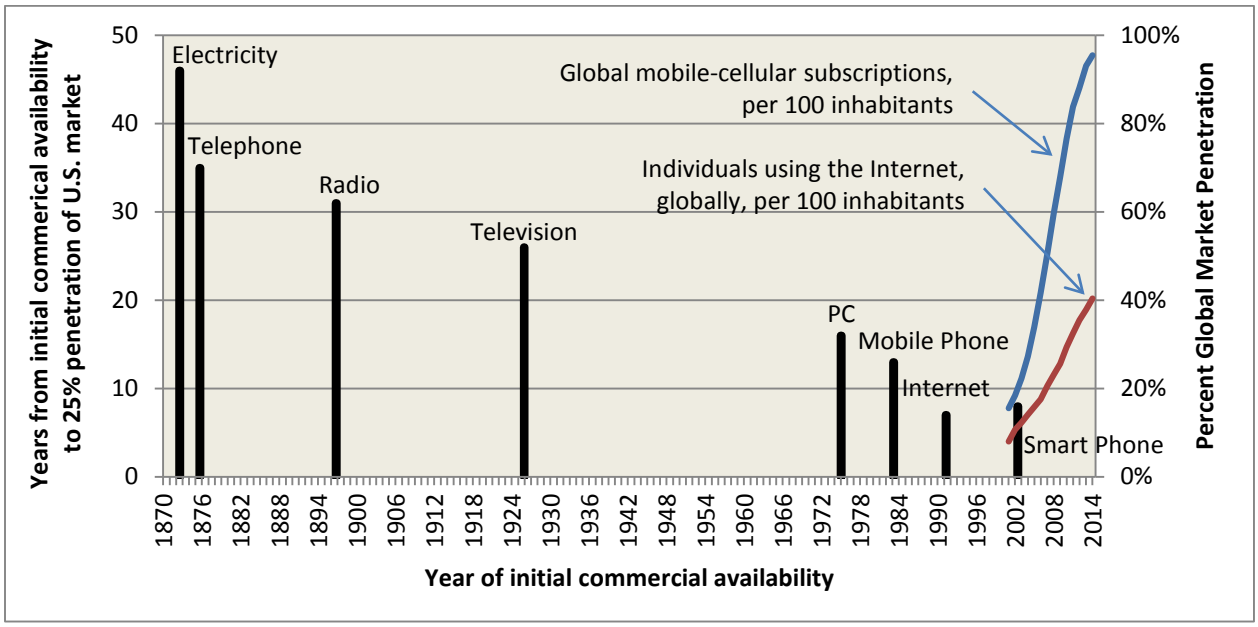
## Acceleration

The compression of time and space by the information and transportation technology revolutions, combined with the growing private sector and multiplying loci of innovation, have produced an innovation ecosystem where the pace of technology change is accelerating. While there is no one simple way to demonstrate the pace of technology change, indicators of computing power, technology adoption, information production, and many others are growing in exponential fashion. This technological acceleration has significant impact on DoD’s ability to remain on the technological cutting edge and outpace global threats.

The speed at which technology changes erodes the efficacy of the long-lead research, development, procurement, and fielding process for DoD “inventions.” Major defense acquisition programs can spend 15 to 20 years in development, and another 50 or more years in procurement and in service. With the speed of technology change today, the long timelines from development of requirements, through proposal, contract award, development, and initial procurement of a product can lead to generational gaps in technological components. Figure 6 shows a proxy for this challenge—the speed of penetration of technology into the market. Electricity first became commercially available in the United States in 1873 and took 46 years to penetrate 25 percent of the U.S. market. With each major new technology, this penetration rate has increased. By contrast, mobile phones only took 13 years to go from initial commercial availability to 25 percent adoption in the United States. In fact, looking at the line on the right hand side of Figure 6, now, after only 32 years, there are 95 mobile phone subscriptions for every 100 people *on the planet*. Near complete global adoption of mobile phones has taken a third less time than it took for electricity to gain 25 percent adoption in just the United States.

[28] Dan Doney, speech at Armed Forces Communications and Electronics Association’s “Defense Acquisition Modernization Symposium,” August 5–6, 2014, Ronald Reagan Building, Washington, DC.

**Figure 6: Accelerating Penetration of Technology**[29]




As the rate of technology change speeds up, it accelerates both the speed at which an organization must adopt it to remain in front and the competitive response of adversaries' technologies. Additionally, due to the same explosion of digital connectivity and information access, the ability to use innovation is no longer coupled to the ability to innovate. In his "The Diffusion of Military Power," Michael Horowitz notes that "inventing technologies or even being the first to use them does not guarantee advantage in international politics."[30] He goes on to theorize that the spread of military innovation is centered on the financial intensity and organizational capital required to assimilate that technology, which he refers to as adoption-capacity theory. While Horowitz's analysis focuses on major military innovations, it has applicability to the broader set of evolutionary innovations we are seeing now in information technology, networking, etc. The speed of technology change and its more commercial nature has markedly decreased the financial intensity required to adopt many new innovations, making them more conducive to rapid diffusion. The challenges remain in the difficulty of adoption for organizational purposes. One could argue that the speed of change makes adoption more difficult as the incubation time for an organization to understand and assimilate a technology is reduced. On the other hand, as these technologies more closely relate to the technologies in our everyday lives (i.e., the "commercialization" of military-relevant technology), it may be that organizational barriers to adoption may decrease.

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[29] For more discussion of this topic, see the work of futurist Raymond Kurzweil, in particular Kurzweil, *The Singularity Is Near: When Humans Transcend Biology* (New York: Penguin Books, 2005). Data for electricity, telephone, radio, television, PC, mobile phone, and internet all come from Kurzweil's published data at Singularity.com. Smartphone data comes from ASYMCO. Global cellular and internet data comes from the International Telecommunication Union (ITU).

[30] Michael C. Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton, NJ: Princeton University Press, 2010), 2.

The key to the acceleration issue is the impact on the decision calculus for technology first-movers, a position the United States has traditionally held and plans to continue to do so. As the cycle times for technology change and diffusion increase, there is an erosion of first-mover advantages for new technologies. The nexus of military diffusion and commercialization of technology and its impact on first-movers is an area that requires more study and will be critical for DoD as it prioritizes its limited innovation-focused resources. This erosion has been exacerbated and sped up by cyber theft and industrial espionage, which increase the rate of diffusion to adversaries. The impact of this systemic mass-theft of intellectual property is something that industry and the Department are still trying to come to grips with, and its impact cannot be understated. The scale and speed of the transfer of key technologies and engineering design secrets to competitor nations is unprecedented. So, in a world where technology may spread from first-movers to fast followers before the original innovator has organizationally assimilated the technology, what is the benefit to trying to maintain the leading edge in all domains? This is a question that has broader implications beyond the scope of this study, and it is not intended to suggest that DoD should abandon R&D and give up the objective of technology dominance, but the next-order consequences of these issues require further consideration.[31]

Despite these challenges, it is not sufficient for DoD to minimize the harm of this feature of the global innovation environment; DoD's approach needs to focus, not on minimizing damage, but on maximizing opportunity. That is the focus of this paper: identifying opportunities for the Department of Defense to develop new processes and tailor old ones to realize the gains of the ongoing global technology innovation revolution underway today.

## The Imperative for a New DoD Approach

The Department of Defense is not the first organization to face a world that is changing around it, forcing uncomfortable changes and facing challenging new dynamics. In fact, the challenge driven by this new global innovation environment is one that has caused upheaval and disruption throughout the commercial market over the course of the last two decades. In his seminal book, *Open Innovation*, Henry Chesbrough analyzes the causes and implications of the tectonic shift in the innovation landscape from a system that rewarded *closed innovation*, to a new paradigm that disrupted this system and imposed an environment where *open innovation* thrives. The relatively stable workforce and tight capital markets that characterized the mid-twentieth century rewarded significant investment in internal research and development and putting high walls around the organization, resulting in the primacy of this closed innovation model. As technology, talent, and capital become more mobile, flexible, and available in the new global innovation environment outlined above, the open innovation paradigm is gaining dominance, incentivizing lower barriers between an organization and the global market to better harness the R&D investments occurring outside of the organization.

The innovation model that drove the Cold War offset strategy in the Department of Defense under Secretary of Defense Harold Brown and Under Secretary of Defense for Research and Engineering Bill

[31] For further discussion of these issues see Horowitz, *The Diffusion of Military Power*, as well as Peter Singer, *Wired for War: The Robotics Revolution and Conflict in the Twenty-First Century* (New York: Penguin Press, 2009), and Max Boot, *War Made New: Technology, Warfare, and the Course of History, 1500 to Today* (New York: Gotham Books, 2006).

Perry was a classic example of the closed innovation model that predominated at the time. It was a research and development program that targeted specific technologies and leveraged new research occurring in-house in places like the Advanced Research Programs Agency (ARPA). This model leveraged the benefits of the closed innovation paradigm, including the ability to retain the top talent, limited competing sources of investment capital, and high barriers to entry, to develop and bring to market the game-changing technologies that revolutionized conventional warfare.

In launching his initiatives for a new offset strategy in the fall of 2014, Secretary Hagel recognized the collapse of the paradigm that had driven the success of previous strategies, stating, "we cannot assume—as we did in the 1950s and 70s—that the Department of Defense will be the sole source of key breakthrough technologies."[32] The inference to this statement is that there will be other sources of key technologies, and that DoD must be able to access them to successfully execute such a strategy. Understanding the shifting innovation paradigm is key to ensuring that access.

Chesbrough identifies four key factors in the global innovation environment that have eroded these benefits that undergirded the logic of the closed innovation paradigm.[33] First, the increasing availability and mobility of skilled workers—made possible by lower barriers to cross-border mobility and increased availability of higher education—provided a greater pool of talent and knowledge. This widened talent pool in turn had more opportunities for growth outside of their institutions, thus diffusing the know-how learned in these internal organizations out to other new firms, competitors, and start-ups. This trend interacted significantly with the second factor, the growth of the venture capital market, which financed the spinning off of this talent to new ventures, increasing the risk of investing in internal R&D talent. Similarly, for the third factor, firms now ran a much higher risk of losing out on any concepts they did not bring quickly to market, as talent could find their own avenues to market and commercialize these concepts. Finally, the growing availability and capability of external suppliers enabled those with fewer resources to still be able to bring ideas to market quickly.

[32] Chuck Hagel, "Defense Innovation Days Opening Keynote" (speech at Southeastern New England Defense Industry Alliance, Newport, RI, September 3, 2014), http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1877.

[33] This section draws heavily from Henry Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology* (Boston, MA: Harvard Business School Press, 2003).

**Case Study: Private-Sector Response to the New Imperative**

One example that highlights the necessity of an open innovation approach in this changing global innovation environment is found in an influential *Harvard Business Review* study of Proctor & Gamble's (P&G) structural overhaul of their R&D enterprise, termed the "Connect & Develop" strategy. In the late 1990s, the firm found their R&D productivity stagnating, and the innovation success rate dropped by over a third, as the market changed around the firm. A collapse of the company's market value in 2000 precipitated an executive change and a fundamental reevaluation of the business model. The new CEO identified the closed innovation model as untenable and ineffective for meeting the company's annual growth requirements, and set a goal of 50 percent of innovations coming from outside the company, up from 15 percent at the time. At its core, the calculus for this decision wasn't just based on declining productivity and marketing failures, but also the fact that there were only 7,500 scientists and engineers at P&G, and approximately 1.5 million talented individuals of relatively equivalent capability worldwide that they were not utilizing.

A key culture change had to shift the mindset from "not invented here" to "proudly found elsewhere." The rewards system was structured so that product success led to the same recognition and reward, whether internally or externally derived. In fact, because time to market was an important metric for success, often development of external products led to *greater* reward. Success required leveraging both proprietary and open networks, thus continuing to utilize the in-house talent, while also vastly expanding the reach of the enterprise. Proprietary networks, including senior technology entrepreneurs in the organization and supplier networks, allowed P&G to better leverage expertise through established information-sharing pathways. At the same time they pursued new open network avenues to reach innovators outside of their established pathways. Utilizing services and organizations including NineSigma, InnoCentive, Yet2, and YourEncore, P&G connected to problem-solvers, inventors, consultants, and partners that would historically have been outside of their purview.

Source: Larry Huston and Nabil Sakkab, "Connect and Develop: Inside Procter & Gamble's New Model for Innovation," *Harvard Business Review*, March 2006.

Each of these four factors—talent, capital, opportunity, and supply chains—challenges the Department of Defense today. There is no doubt that, as DoD asserts in its most recent *Annual Industrial Capabilities Report to Congress*, "the base upon which the Department [of Defense] relies is more global, commercial, and financially complex than at any time in our Nation's history." And yet, it still significantly lags industry in both the implementation of changes in recognition of this fact, as well as cultural permeation of the tenets of this global innovation reality.

Talent: The Department of Defense has slowly shifted from being the sole home for aerospace and nuclear scientists and engineers, to being the primary supporter of many fields of science and engineering talent, to being the preferred (but no longer dominant) employer, to being on par with commercial technology firms, to being out-competed for top talent. Once, the most promising talent

flocked to the defense sector to work with the best equipment on the most cutting-edge projects. Now, DoD must compete more with commercial firms that offer cutting-edge work, first-class facilities, and high wages, while the Department itself is hamstrung by lower wages, the byzantine federal hiring process, and security clearance requirements that wall off large swaths of the best talent. This shift is exacerbated by the impending retirement of the baby boom generation that has manned the aerospace and defense sector. Two of the largest defense firms, Lockheed Martin and Northrop Grumman, have warned that half of their workforce will be eligible to retire in the next 5 to 10 years, and replacing those workers will not be easy.[34]

Capital: DoD can no longer rely on the gravitational pull of its budget to draw in the universe of technology that is relevant to defense applications. In a world of exploding global commercial high technology, DoD is just another planet, exerting force on those objects closest to its orbit but unable to reach many others. Venture capital, hedge funds, and private equity firms at home and abroad have vastly increased the available capital for start-ups, spin-offs, and small firms. The headaches of defense procurement and government oversight are an obstacle that actively deters these firms from seeking out business with DoD.

Opportunity: Just as DoD can no longer rely on the size of its budget to draw in the universe of defense-relevant technology, it also can no longer rely on the uniqueness of its high-technology needs to corner the market. Where once the defense sector drew the most cutting-edge products by virtue of having the highest-end requirements, the commercial sector now drives demand for the highest-end components in many sectors. For example, commercial demand for microelectronics is multiple generations ahead of what is going into even the newest platforms being built by DoD today. In many cases, the commercial demand for electronics, computers, networks, and sensors is now on a generational par with what is used in DoD, but the electronics products market is a $2 trillion market,[35] while total U.S. defense contracts for products (everything from uniforms to ships) totaled only $127 billion in 2014.[36]

Supply Chains: The global commercial market has leveraged the productivity and innovation gains enabled by the rise of global value chains to democratize access to materials, devolve non-core competencies to suppliers, and decouple production from design. While defense firms today are undoubtedly global businesses, they face difficult hurdles and significant costs in seeking to fully utilize this global system. DoD and its suppliers face significant statutory, regulatory, and bureaucratic constraints that hamper efforts to tap into these global networks. Notably, the defense technology control framework, encompassing export controls and Buy American Act provisions among others, fails to accommodate this new reality. Similarly, security of supply, cybersecurity, supply chain security, and domestic production requirements complicate access. Therefore, the Department and its prime contractors are hamstrung in their ability to fully leverage the benefits of global value chains.

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[34] Joelle Tessler, "Aerospace, defense sectors brace for brain drain as Cold War workers retire," Associated Press, March 10, 2008.
[35] Stephanie S. Shipp et al., *Emerging Global Trends in Advanced Manufacturing* (Washington, DC: Institute for Defense Analyses, March 2012), https://www.wilsoncenter.org/sites/default/files/Emerging_Global_Trends_in_Advanced_Manufacturing.pdf.
[36] CSIS analysis of data from the Federal Procurement Data System, available at FPDS.org.

These realities of the global innovation environment drive to only one conclusion: that while a strong DoD R&D program remains a necessary component to maintaining military technological dominance, this internal program is no longer sufficient for future DoD needs or technology superiority. It remains necessary because there will always be military-unique products that have no commercial market and where commercial industry on its own will not invest. Perhaps even more crucially, the federal government makes strategic investments in basic science and technology that lay the foundation for developments critical to both defense and commercial technologies. In order to harness cutting-edge technology in a world where innovation is increasingly occurring beyond the traditional jurisdiction of government investment, DoD must expand its horizon and look beyond industrial and geographic boundaries and proactively leverage outside innovation.

## The *Outside* Innovation Imperative

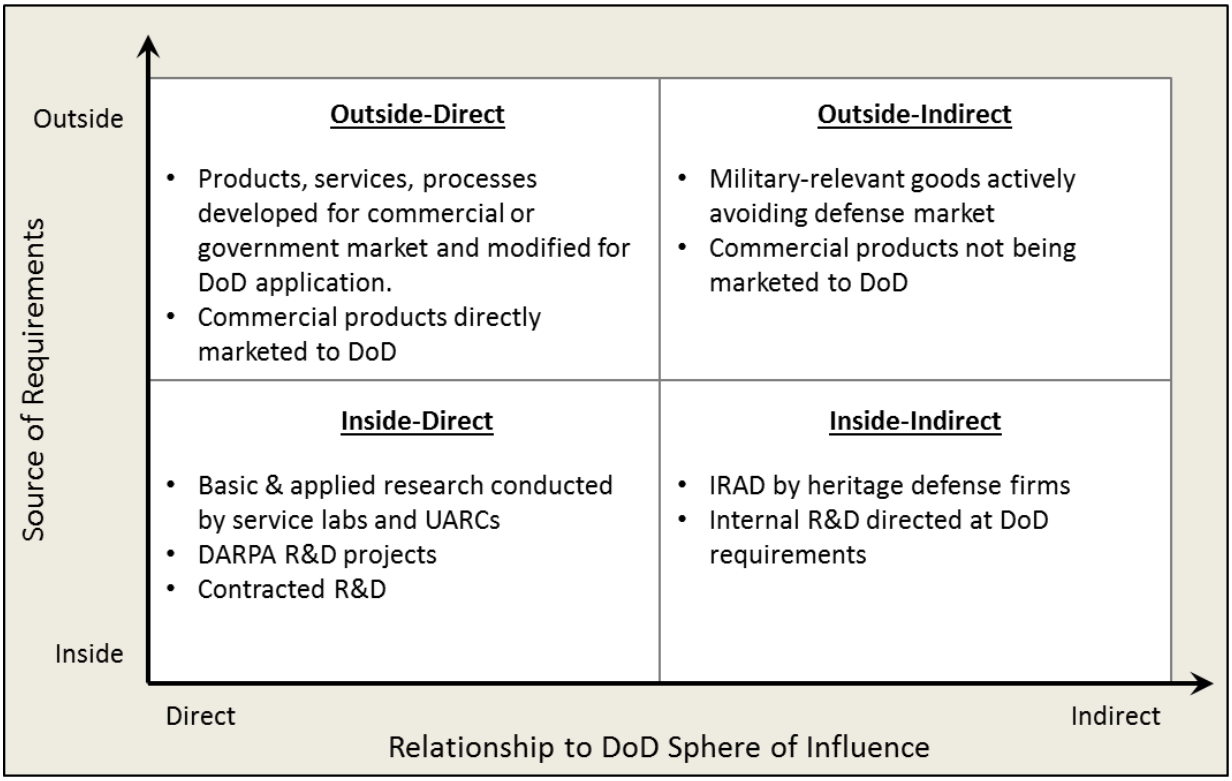
The weight of these changes in the global innovation environment demands a new approach to facilitating and leveraging innovation in the Department of Defense. The open/closed innovation paradigm espoused in the business world is useful for describing defense innovation, but incomplete. CSIS has expanded this notion with a new taxonomy for categorizing the universe of innovation from a DoD perspective, as pictured in the matrix in Figure 7.

The four categories, or "centers," of innovation identified encompass the range of global innovators, in reference to 1) their proximity to DoD's existing sphere of influence, and 2) the source of requirements driving the innovation. Each quadrant of the taxonomy is discussed individually below, but the concept is focused on delineating centers of innovation that require different processes to be optimized for access by DoD.

CSIS developed this taxonomy over the course of nearly 100 interviews with experts inside and outside of government, as the team discussed DoD's innovation efforts. The dividing lines between the four quadrants are far murkier than depicted in Figure 7 and these categories are on a continuum. Each of these centers of innovation provides different benefits and challenges, based on the differing levels of responsiveness to or independence from DoD, as well as its understanding of DoD needs, and governing market dynamics. Similarly, maximizing the benefits of each center of innovation requires a different mix of processes.

Inside innovation is where DoD's requirements have driven the development of the innovation. Whether it is work by labs and DARPA or by contractors that have a close relationship with DoD, this innovation is directed predominantly, if not solely, for DoD consumption. This is the part of the market where DoD really is the dog, and the market is the tail. It is a monopsony market (or possibly an oligopsony if you consider sales to international partners), where DoD is the primary, if not the sole, market for these products. These baskets of innovation require little effort for DoD to be aware of and stay abreast of developments in, as they are the primary target and customer. Access to this innovation can still be a challenge, but DoD is set up to maximize this kind of innovation best. Alternatively, outside innovation has been derived from non-DoD requirements, due to the needs of the global commercial market or the anticipated needs of the developer. Both awareness and access are challenges for DoD to harness outside innovation.

**Figure 7: Center of Innovation Matrix**

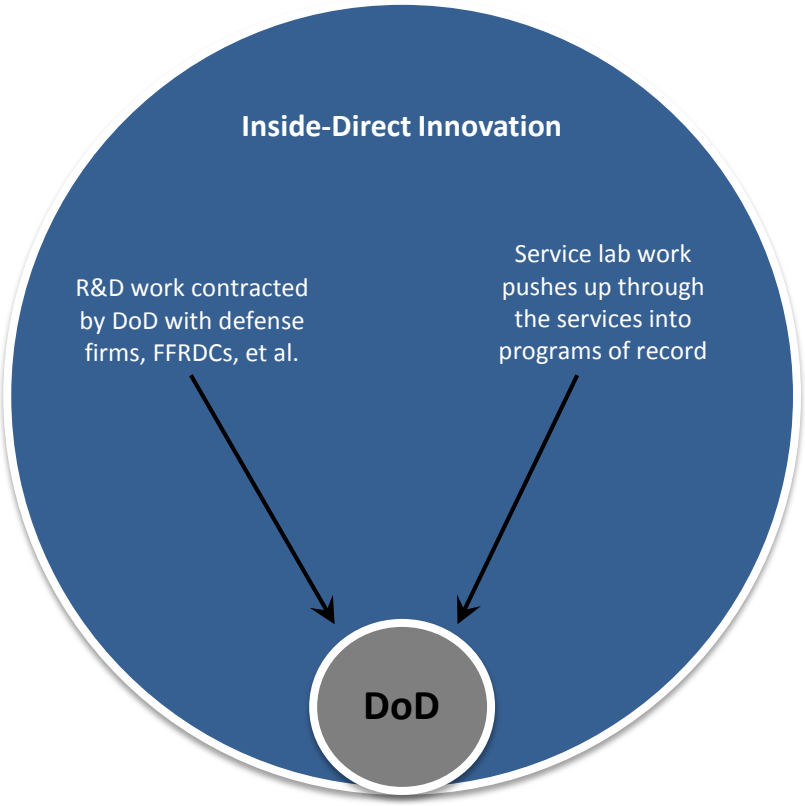



Source: CSIS analysis.

## Inside Innovation

*Inside-Direct Innovation* is modeled after the closed innovation paradigm and represents the core of what most people, both inside and outside of the Department, think of when DoD innovation is discussed (Figure 8). This category centers on innovation done under direct funding and management from DoD. It includes science and technology research undertaken by internal civilian and military personnel, by federally funded R&D centers (FFRDCs), by university-affiliated research centers (UARCs), and by contractors under direct contract. It also includes funded research by DoD entities like the Defense Advanced Research Projects Agency (DARPA) under alternative arrangements such as cooperative agreements and Other Transaction Authority (OTA).

**Figure 8: Inside-Direct Innovation**




Funding for inside-direct innovation derives mostly from the Congressional Research, Development, Test & Evaluation (RDT&E) appropriations, including R&D for Major Defense Acquisition Programs (MDAPs), and science and technology through the 6.1 (basic research), 6.2 (applied research), and 6.3 (advanced technology development) budget activities. The requirements driving this innovation derive from service requirements and department policymakers. DoD "pushes" internal work up through the bureaucracy as developed by military, civilian, and contractor personnel in the dozens of governmental or quasi-governmental institutions operated under DoD management. DoD also actively "pulls" in work from the closely held defense industry and defense research community, with which there are high levels of interaction, through direct contracting mechanisms, where DoD statements of work and evaluation criteria govern the activity undertaken and the contractor is responsible for delivering outcomes under that contract directly back to DoD. The intellectual property derived typically belongs to DoD.

These activities and funding streams represent the core science and technology competency residing in the direct purview of the Department. Inside-direct innovation makes up nearly the entirety of the RDT&E appropriation, which was approximately $63 billion in 2014. Of this $63 billion, $26 billion in 2014 was contracted R&D—research and development directed and funded by DoD, but performed by contractors.

*Inside-Indirect Innovation* covers technology or process innovation undertaken by DoD contractors or other related entities not under direct DoD management, but falling within the close purview of DoD (Figure 9). We often refer to these contractors as "heritage defense firms" although it is an amorphous

concept and one that shifts as firms change their market strategies. For purposes here, we focus on a company-by-company delineation, as opposed to by industry segment. The firms we are talking about here have a preponderance of their revenue coming from their defense segments and have close working relationships with DoD.

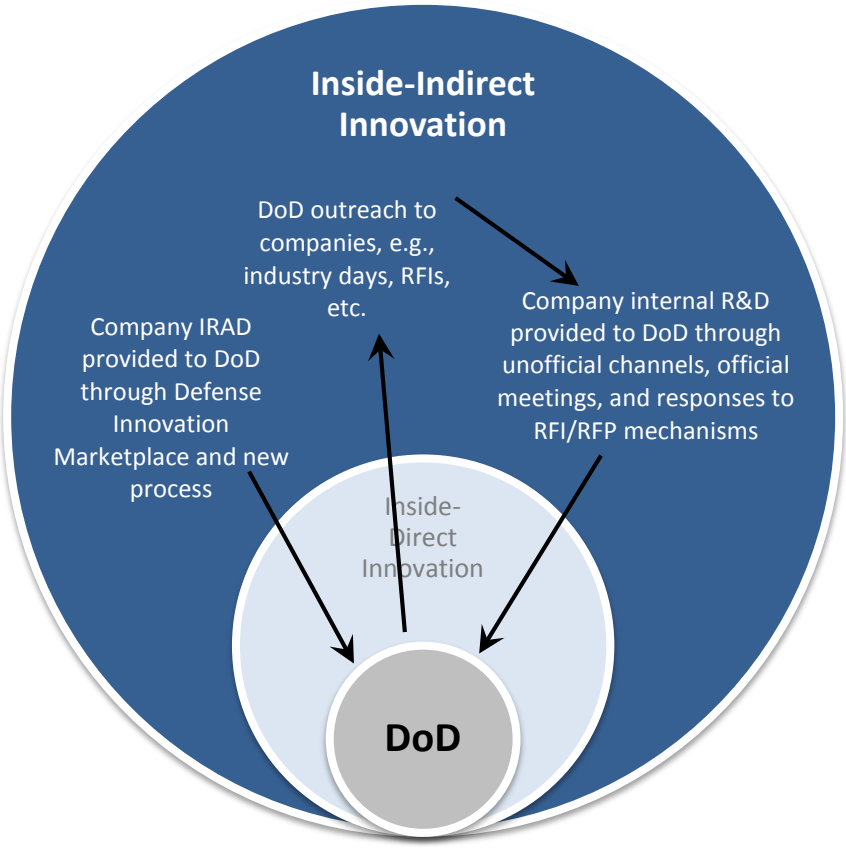
For the sake of clarity it is important to understand the different types of contractor R&D. The first type is contracted R&D (or CR&D), which can be found in the inside-direct innovation bucket. In this case, DoD needs a particular project undertaken with a specific goal and funded at a certain level, and the work is governed by a contract holding the contractor responsible for specific outcomes. Independent R&D (often called IRAD) is a specific type of R&D set in regulation in the DoD context (in a Defense Federal Acquisition Regulation Supplement rule). IRAD is work that is independently undertaken by the contractor (not at the direction of or through direct funding by the government), but fits certain criteria that make it eligible to have some of the cost reimbursed by DoD. This exists to encourage and subsidize R&D on military technologies outside of just government-directed work. Finally, internal R&D is contractor research and development that is not reimbursable. Internal R&D is contractor funded but not reimbursed. For heritage defense contractors, this R&D is often funded from DoD contract profits and is generally development intended for future DoD sale.

Reimbursed IRAD amounts to about $4 billion per year in total unclassified funding.[37] Interviews conducted as part of this study suggested there may be another $4 billion in reimbursed IRAD via classified funding and bid and proposal costs that are really IRAD. Even though funding ultimately originates in DoD, by definition this is R&D that is not being directed or managed by the Department, but instead by the contractors. Even though the funding is indirect, the goals of the innovation are aimed at current or future DoD projects and requirements. Internal R&D is hard to get a fair accounting of, as companies each count their R&D differently (include or exclude IRAD, etc.). Using publicly available financial data for 15 defense-centric firms, we get about $8 billion of non-CR&D in these largest firms.[38] The other hallmark of this segment of the innovation taxonomy is that because of their proximity to DoD, these firms are generally tailoring their work based on knowledge of the DOD ecosystem and requirements.

[37] Cheryl Pellerin, "New DOD Rule Supports Independent Research, Development," Armed Forces Press Service, February 6, 2012, http://archive.defense.gov/news/newsarticle.aspx?id=67068.

[38] From the CSIS Defense Index, which comprises only publicly held companies that derive over 50 percent of sales from defense segments, and in 2013 included: Raytheon, Northrop Grumman, Lockheed Martin, General Dynamics, Boeing Defense, Space, and Security (as a business unit separate from the rest of Boeing), BAE Systems, Thales, Finmeccanica, L-3 Communications, Elbit Systems, Exelis, Rockwell Collins, Cubic Corp, and Alliant Techsystems.

**Figure 9: Inside-Indirect Innovation**




There is less connectivity between the Department and the innovators in this case, as DoD may or may not actually be aware of the ongoing technology development until the contractor responds to a "Request for Information," comes to an industry day, or somehow seeks to move the technology into a DoD program or pipeline. Nonetheless, the close relationship between the customer and the innovator ensures information exchange and awareness on the part of DoD to the technology being developed. Greater information exchange surrounding ongoing IRAD is being encouraged by DoD through online systems like the Defense Innovation Marketplace. Better Buying Power has also emphasized increased communication of needs from the government side for more productive IRAD and the draft BBP 3.0 initiatives include more involvement with industry over requirements definition early in the requirements process.

Inside innovation—both direct and indirect—benefits from a massive cohort of stakeholders in the military departments, in the defense agencies, and in the defense contracting community. Whether being directly funded and managed by the Department or indirectly funded, all inside innovation is focused on eventual use by the Department of Defense, often to the exclusion of all others. DoD's requirements, acquisition, and contracting structures are currently optimized to best leverage inside innovation—the innovation that emerges from efforts that already have high-degree connectivity to the Department. This is the innovation that sustained DoD throughout much of the last 70 years. This

innovation is not going away—in fact it remains critical for military-unique requirements—but the global innovation environment is putting significant pressure on these centers of innovation.

## Outside Innovation

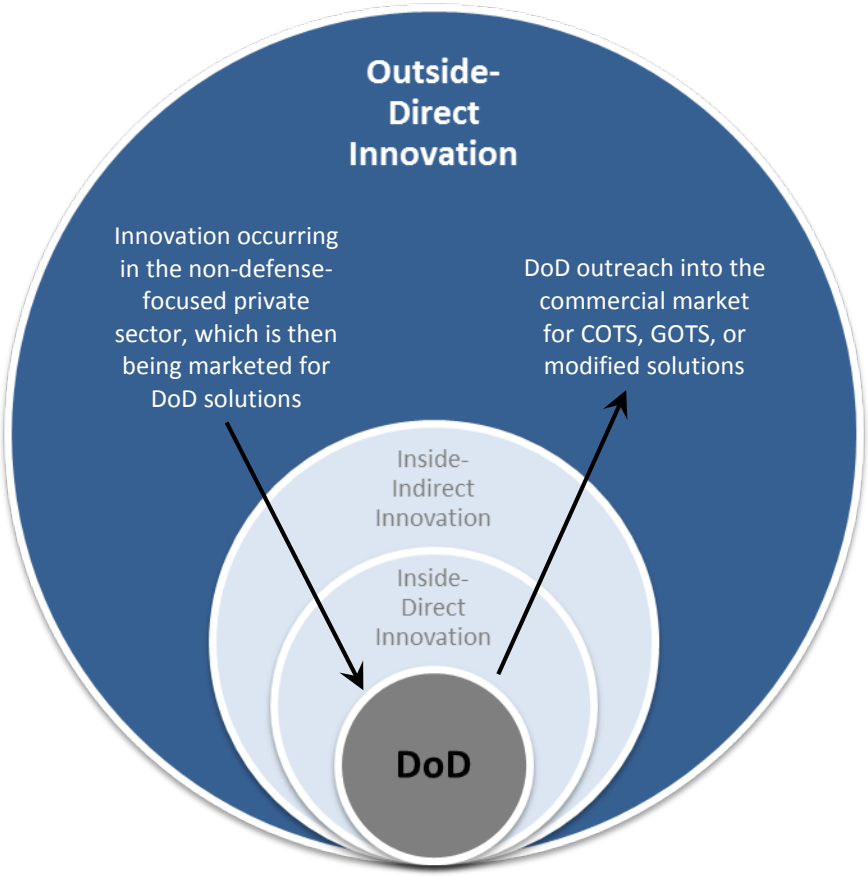
It is the innovation coming out of the global innovation ecosystem that is untethered from DoD that provides the biggest challenges and opportunities for the Department today. This outside innovation comes from nontraditional performers outside of the direct sphere of influence that DoD exerts. These firms range from Google and Apple to small Indian software designers and Israeli drone-makers. Some may be avidly seeking to sell their solutions to the defense market, while others may actively avoid the pitfalls of defense procurement, and still others may be unaware of the defense application of their work. It is these centers of innovation that DoD must improve its capability to interact with and access in order to successfully assimilate cutting-edge and/or cost-saving outside innovation.

*Outside-Direct Innovation* includes processes and technology developed by commercial vendors who identify DoD entities as a potential customer (Figure 10). Outside-direct innovation has been an increasingly important part of the DoD procurement environment since Secretary of Defense Bill Perry initiated structural reforms to the acquisition process that minimized the role of "MilSpec," the standardization of specifications for military items, and began relying on commercial standards for the many commodities and commercially produced items purchased by DoD. With the convergence of commercial and military-relevant technology, particularly in the information technology space, outside-direct innovation is rapidly expanding from parts and commodities to information technology solutions and even platforms.

As in the previous categories, there are both push and pull aspects to DoD's relationship with outside-direct Innovation. There are many commercial firms that see the monolithic defense market as an area ripe for marketing their commercial solutions. IT solutions for project and process management, ranging from internal needs like human resources and data management to more operational requirements like data processing and fusion, are common in-roads for commercial products. Medical devices, communications technologies, and energy solutions have also found second homes in DoD due to the active engagement by firms seeking out new markets. Responding to RFIs and RFPs, and participating in industry days and search activities, are all ways that commercial firms move themselves into DoD's orbit.

DoD has also increasingly reached out to commercial markets to find ready-made fixes to Department challenges. This outreach may be to access other government solutions at work in other agencies or well-known commercial technology available to be overlaid on existing defense technology. Often innovation in this category may be something that DoD is made aware of by either the innovator of the technology or the network of individuals that make up the inside innovators (scientists in the labs, academics in the UARCs, professional contacts through the defense industry, etc.). The origin of the products derives from expected commercial demand and the global market, which increasingly have DoD applications. This includes commercial items being modified for sale to DoD from outside the cadre of heritage defense firms.

**Figure 10: Outside-Direct Innovation**[39]



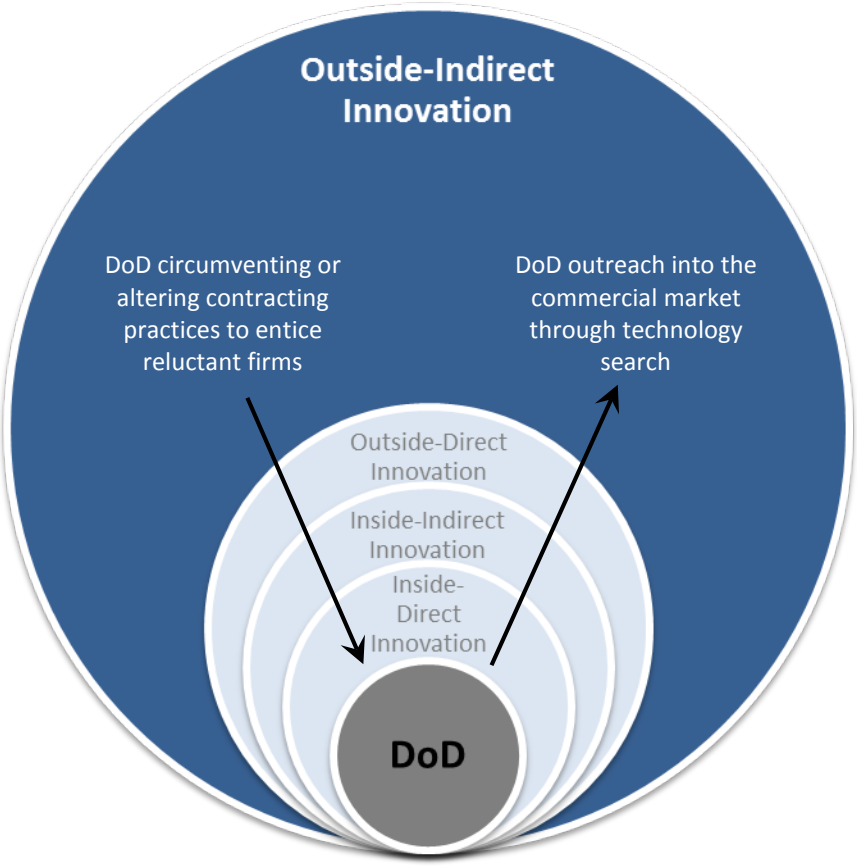

DoD has challenges assimilating outside direct innovation for both cultural and structural reasons. Culturally, there is a "not invented here" syndrome that discounts technology and solutions that do not derive directly from DoD needs. Interviews suggested that there is a belief in many places in the Department that military and Departmental needs are so unique that only purpose-built approaches are appropriate. Structurally, the contracting practices required to pull in commercial technology may prove too onerous or take too long to keep the commercial firm involved due to the shorter time horizons expected in the commercial space. In some cases, the contracting mechanisms may be available, but workforce risk aversion or workforce training gaps

*Outside-Indirect Innovation* includes processes and technology developed by commercial vendors that are not seeking to sell to DoD and in some cases may actively resist such sales (Figure 11). This is the most challenging center of innovation in the matrix, as well as the one that may offer the greatest possible rewards if DoD better optimizes its process to harness it. It is so challenging because the players are so disparate, the technologies are so varied, and the tools to reach them are nascent or limited. But it is important because the world of outside innovation is so vast. The worlds of inside-direct, inside-

[39] COTS refers to "commercial-off-the-shelf" and GOTS refers to "government-off-the-shelf" products that are not being separately developed for DoD-specific requirements.

indirect, and outside-direct innovation encompass, at its largest possible expanse, $150 billion in R&D inputs and another $115 billion in procurement. The global R&D enterprise drives $1.6 trillion in R&D and $11 trillion in manufacturing production. While input metrics like spending levels do not account for R&D productivity differences or risk of failure, with this order-of-magnitude difference, it is clear that DoD should organize itself to continue to better leverage this outside innovation.

**Figure 11: Outside-Indirect Innovation**




With the proliferation of technology that has relevance to defense applications, as discussed previously, there is also an increasing chance that technology innovation is occurring whose developers or sales departments or scientists do not even think of DoD itself or the defense market in general as a potential customer. This can happen in basic and applied sciences or in simple commercial products. An illustrative example is that of touchscreen gloves. Two combatant commands (COCOMs) had identified a requirement for gloves that could interact with touchscreens, which they had not filled. This was a problem that was already being solved in the commercial market, but had not yet turned into a product for DoD. Then a DoD tech scout encountered a startup at a New York City Technology Day that was selling winter-weight touchscreen gloves that could fill this requirement.

This problem of trying to bridge unconnected industries with defense needs is exacerbated by the translation problem DoD faces. Often their requirements require clearances to access, which inherently keep out outsiders. And even when needs statements are made public, they often use defense-centric jargon to describe their problem instead of explaining the core problems they are trying to solve. One

interviewee used the example of a requirement to “improve precision fires” for the Marines Corps, which, at its core, is a sensors and networking challenge. Hypothetically, it is possible that the fundamental science and technology behind “smart home” technologies could apply to this problem set, but those commercial developers would never equate their work to something about “precision fires.”

The flip side of this challenge is that it is equally difficult for DoD to pay attention to the wide variety of technologies and sciences occurring globally and commercially, and then make the intellectual leaps around how these innovations might apply to DoD. In order to be aware of and then harness this array of innovation, DoD must engage in extensive outreach activities, including horizon scanning and technology search to identify possible candidates. The inside innovators also play a crucial role in technology matchmaking through their own connections into the global innovation marketplace. These connections can come through lab-based scientists with academic connections or defense contractors with a diverse set of suppliers. Leveraging these networks to share information and improve awareness across the pockets of innovation in DoD is crucial.

The other challenge for accessing outside innovation is that there is a subset of businesses that are very aware of the defense applications of their products and technologies, but are skeptical of doing business with DoD or the government due to the perception of the burdens that come with it. The common example today is Google, which has made significant acquisitions of robotics companies, including those that currently are under contract with DoD. It has been reported that Google intends to allow these contracts to finish out, but does not intend to seek new government business in the field. One concern for these companies is the cost burdens of government pricing and cost accounting standards, which often require that contractors develop a whole second set of cost and financial accounting tools in order to satisfy government requirements. Frustration over these and other federal requirements can drive companies away from doing business with DoD. Another concern is over control of their technology, including export controls, which can limit sales of the underlying technologies once they have been sold to DoD or incorporated into a defense program, and control of intellectual property.

The processes required for optimization is different for each “center” of innovation. Depending on the type of innovation, there are different actions that DoD would need to take to identify defense-relevant technologies and to then access those technologies.

**Case Study: Government-Sector Response to the New Imperative**

One example that highlights a government attempt at adoption of an open innovation approach in this changing global innovation environment is a new 2014 *Harvard Business Review* study of NASA's initiative to rethink its innovation architecture. In 2005, the Space Life Sciences Directorate (SLSD) at NASA lost nearly half of its R&D budget, then in 2010, the massive Constellation project was cancelled, taking another hit to the NASA innovation enterprise. Nonetheless, SLSD still found itself responsible for solving vexing and complex problems that had life or death repercussions. Leadership recognized a need for a fundamental reevaluation of how they accomplished their mission.

A dedicated team launched pilot projects to prove the concepts of open innovation to an intransigent and skeptical organization. NASA's culture bred an insular innovation environment of rocket scientists that believed that they had all the answers. And yet, in surveys, these same scientists and engineers affirmed the necessary role that collaboration played in their own ability to innovate and find solutions. The challenge for the leadership team was to bridge this gap.

Using three open innovation networks, TopCoder, InnoCentive, and Yet2, they successfully demonstrated how crowdsourcing and challenge models could amplify and assist the work already happening at NASA. They also launched an internal network for sharing information across NASA to limit work duplication and encourage collaboration. Results-wise, the challenges were a real success. For example, one challenge to improve the prediction of solar flares resulted in an algorithm from a retired engineer that provided an orders-of-magnitude improvement over the existing capability, and a significant improvement over even the challenge target metrics. Nonetheless, leadership continues to battle the "not-invented-here" condition and other cultural preferences, as reaction from the rank-and-file was muted and skeptical.

Source: Michael Tushman, Hila Lifshitz-Assaf, and Kerry Herman, "Houston, We Have a Problem: NASA and Open Innovation," *Harvard Business Review*, May 5, 2014.

## Resolving Challenges and Exploiting Opportunities in Leveraging Outside Innovation

Altering the closed innovation model that DoD has followed for 70 years is not just a matter of will; it is a matter of process. While institutional will is crucial, and top-down buy-in is necessary, it is not enough. The entire acquisition, R&D, testing, and contracting bureaucracy has been built up to support the model in place, a model predicated on internal development, monopsony market control, and a captive industry.

Secretary Hagel was absolutely clear in defining the problem that DoD faces in today's global innovation environment: [40]

> ***Many, if not most, of the technologies that we seek to take advantage of today are no longer also in the domain of DoD development pipelines or traditional defense contractors. We all know that DoD no longer has exclusive access to the most cutting-edge technology or the ability to spur or control the development of new technologies the way we once did.***

Given this growing divergence between the Department's internal development and the global base of innovation and technology, this study explored how to develop processes for DoD to better identify, set requirements for, fund, and access innovation developed outside traditional pathways and loci of innovation. Through 18 months of interviews, workshops, and research, the study team identified a wide variety of findings and recommendations, discussed below.

While the study identified many challenges facing the Department in harnessing outside innovation, there is one key finding that serves as a launching pad for recommending steps to better identify, access, adopt, and disseminate outside innovation: *There **are** places in DoD focused on outside innovation, and there are others providing examples that DoD could learn from.* Appendix I lists just the initiatives that crossed the study team's path and is not intended to be an exhaustive list. In fact, this is likely the tip of the iceberg of initiatives across the department.

Two broad classes of issues arose out of the study that offer significant current challenges as well as future opportunities for growth: awareness and access (Figure 12). Awareness impacts DoD's ability to reach out and touch the world of innovation going on beyond its immediate sightlines. Access impacts the Department's ability to then pull that technology and utilize it. The CSIS findings and recommendations are arrayed against these problem areas, recognizing that any given finding may encompass more than one problem area.

[40] Chuck Hagel, "Reagan National Defense Forum Keynote" (speech, Ronald Reagan Presidential Library, Simi Valley, CA, November 15, 2014), http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1903.

**Better Buying Power 3.0**

The Better Buying Power 3.0 initiatives provide promise for deeper commitment from DoD on these issues. At time of release, these initiatives were still in draft form as seen in a White Paper released in September 2014, and available for comment by industry and outside experts. A final report is expected soon. There are innovation-related initiatives that will bear tracking as they are implemented.

1. *Remove barriers to commercial technology utilization.* This initiative looks to break down some of the barriers discussed in this paper to make it easier for those commercial firms that want to do business with DoD, as well as to make it more attractive for those firms that are skeptical of doing business with DoD to buy in. An important aspect of this will be how to reduce the barriers on the prime contractors that are major providers of outside innovation for the department and serve as important network hubs to access a broader community of resources.

2. *Improve technology search and outreach in global markets.* Technology is key for commercial technology, but also for accessing global players. This initiative also highlights the importance of better integration with both the development efforts of global partners and allies through cooperative research, co-development, and co-production and the industrial base options that can complement that at home.

3. *Increase small-business participation, including more effective use of market research.* Small businesses are a key source of innovation, but can also be some of the hardest firms to reach as they are dispersed and may not have departments devoted to following government requirements. DoD outreach mechanisms will be key to accessing these players.

4. *Increase the use of prototyping and experimentation*. Prototyping and experimentation provides high productivity low-cost learning opportunities and ways to understand new technologies.

5. *Emphasize technology insertion and refresh in program planning*. Due to the speed of technology change, DoD must adjust its acquisition approaches to account for both the needs to upgrade systems as they are developed and go into production or to account for technology refresh by understanding that some systems will need to be replaced wholesale on faster timelines than in previous eras.

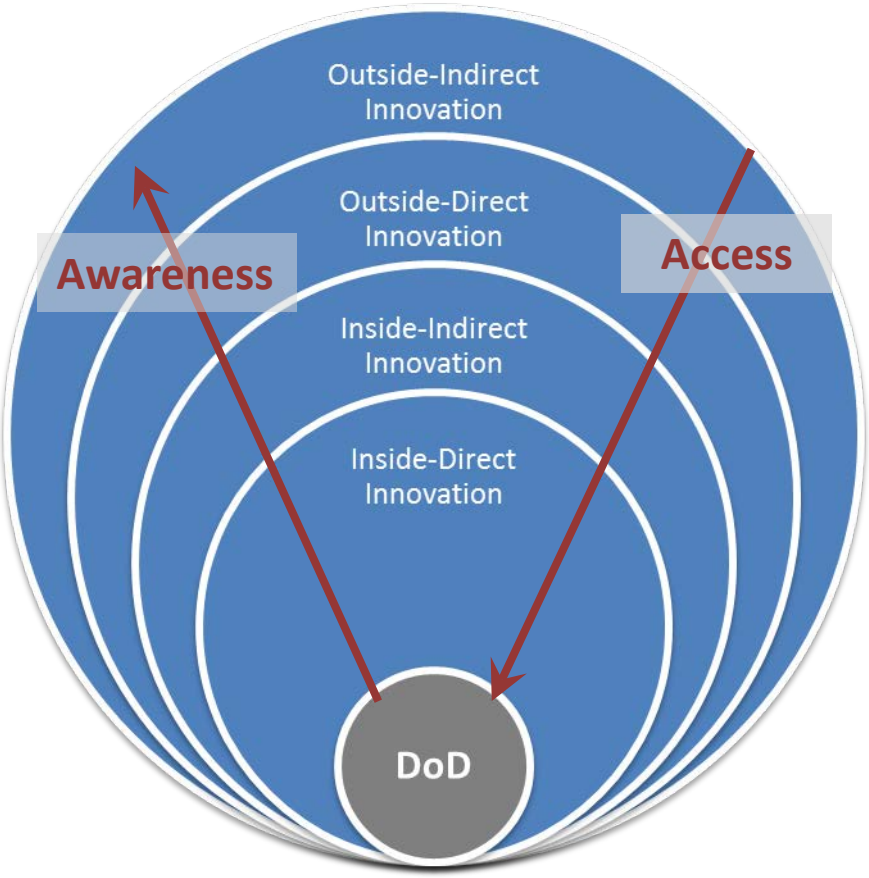
6. *Use Modular Open Systems Architecture to stimulate innovation*. Closely related to #5 above, by setting up systems form the beginning as open and modular will allow for easier upgrade and insertion/replacement of new technologies.

First, there is a gap within the defense community of knowledge of new technology and processes being developed in the global nondefense market, innovation with relevance but no physical connection to any defense activity. In addition, those bridging that gap are often on the margins and doing so in relative isolation without any structures to either “push” or “pull” that information between the communities of other gap-fillers. Whether these individuals and organizations are seeking targeted solutions to individual problems or are looking for places to input new technologies to shape

requirements, they are hamstrung by their isolation. There is a lack of awareness of who else is pursuing similar efforts or who shares the same needs. We call this set of issues the "Awareness" challenges.

Second, there are structural and institutional barriers to accessing and leveraging this outside innovation once it has been identified. From requirements generation to acquisitions and funding, many *processes* in DoD serve to raise barriers instead of enabling practitioners. These barriers run the gamut from internal processes and procedures, to cultural barriers, budgetary roadblocks, legislative requirements, and statutory and regulatory hurdles.

**Figure 12: Enabling DoD Leveraging of Outside Innovation**




What does this search for outside innovation activity look like? It is largely user-driven. It aims at meeting identified needs or requirements, but it also aims at identifying opportunities under which emerging technology or process innovation can shape requirements, not simply respond to them. This innovation is not just focused on capability and technological superiority, but also on cost and efficiency. It's largely happening in the field, not in the Pentagon. It's largely independent of the budget, especially in the sense that funding needs for outside innovation often cannot be identified two years in advance and included in DoD budgets. It's largely underfunded, with user-identified solutions depending on finding support from among previously appropriated funds that have not yet been expended.

## Awareness

Despite the many clear statements from DoD officials reflecting recognition of the changing nature of the global innovation environment and its impact on the Department, DoD as an institution remains staunchly focused on the inside innovation for which it has already paid. The first step to leveraging outside innovation is greater awareness of the universe of innovation by increasing the points of connectivity between the Department and the outside innovators. As described earlier, the globalization and privatization of R&D have resulted in immense diffusion of both science and technology and development activities. Once centered on government-owned labs and government-funded research centers in academia, in a small number of countries, global R&D is proliferating and diffusing, making maintaining awareness of the leading edges of S&T as well as technological advances in products and software increasingly challenging. Awareness challenges for DoD come in four interconnected areas.

First is awareness of the issue set. DoD must continue to reinforce throughout the chain of command in both the services and the Office of the Secretary of Defense (OSD) the value that outside innovation can provide. There is no doubt that recognition in DoD leadership of the challenges presented by global commercial innovation is at an all-time high. Top-level strategy documents of all types, ranging from the 2014 Quadrennial Defense Review to individual technology roadmaps, address the growing impact of commercial technology on DoD. A growing number of conferences (both government-initiated and externally driven) are raising awareness of these challenges. Along with this guidance there has been a proliferation of organizations and activities seeking to fill this gap between the Department and these outside innovators. However, that does not mean there is deep understanding of the issues involved throughout the DoD organization or that it is penetrating the culture in the bureaucracy.

The resistance to this new reality comes in many forms, predominantly arising from cultural factors. There are still many who, behind closed doors, firmly believe that the global commercial market has little to offer the Department in the way of innovation, except possibly for cost savings on mature technologies. Whether in the acquisition or operational domains, this mindset persists in some corners of the Department. But, it is eroding. As soldiers return from Afghanistan with stories of smartphones that out-perform whole groups of military tools, the hold that this perspective has on the bureaucracy breaks down. Beyond these stalwart antagonists, there are other psychological and cultural barriers that are particularly insidious, as they persist even among those who purport to champion outside innovation.

There are many others who accept the premise of outside innovation but have not internalized its real relevance. This cultural barrier became clear as a pattern emerged in many interviews with DoD, interviews with individuals that were already broadly self-selected by their professional interest in the issue of outside innovation by virtue of agreeing to the interview and/or being recommended to the study team. A common back-and-forth would begin with the interviewee asserting the value of outside innovation and the growing importance of the global commercial market. Then, when pressed for an example or personal experience, the subject would immediately revert to examples from the service labs, UARCs, or other inside innovation centers. The prevalence of this kind of conversation suggests that there is still a long way to go to pushing the idea of outside innovation through the cultural norms and established ways of thinking in the Department.

The second stage, to steal from the ubiquitous Rumsfeld-ism, is to improve awareness of the "known unknowns." There is a universe of technologies, some of which originated in DoD, where DoD is a player, but the commercial market is taking a lead in pushing the boundaries of the science or product. Advances in technologies like robotics, automation, materials sciences, nanotechnology, and machine learning have clear military applications. While DoD is involved in these sectors, it does not necessarily have entrenched methods for following technology in global commercial markets or maintaining connectivity with those at the forefront of the commercial technology. Whether in hardware, software, or business process, innovations occurring in the private sector without any internal DoD stakeholders, without DoD awareness, will have less of a chance to penetrate the membrane of DoD.

For years, DoD retained item managers whose primary purpose was to act as a repository of knowledge on particular components, subcomponents, and parts. With the restructuring and downsizing of the department in the 1990s and the move away from MilSpec products, these item manager positions were eliminated, and that job was implicitly outsourced to the original equipment manufacturers (OEMs) responsible for actually building the products that the Department needed. As the structure of the defense industry changed over the 1980s and 1990s, these OEMs became increasingly divorced from the commercial markets as they shifted into more defense-specialized firms, decreasing their ability to capably fill this role. More recently, the levels of R&D occurring in these firms have declined. Since 2000, R&D expenses for the group of defense industrial base firms that CSIS tracks as part of the CSIS Defense Index fell from over 5 percent of sales to less than 3 percent. And, if 2013 is any sign, budget cuts will continue to cut into this spending, as the industry underwent a 20 percent cut in R&D spending in response to sequestration in just that one year, cutting back to 2004 levels in nominal terms. While this is not to say that OEMs are not attached to the commercial market, or that DoD is asleep at the wheel, there may be a gap in propagating knowledge about the state of industry and technology in some commercialized sectors.

This stage of awareness is critical for delivering "blue team" (i.e., U.S. and partner) solutions, but also necessary for "red team" analysis. Institutionalized understanding of the state of the art in various military-relevant but commercially driven technologies is critical for requirements development, systems integration, testing, etc. Just as important is understanding the global commercial market and public S&T feeding into competitor states. As military and commercial technologies converge, technology costs drop, and barriers to using technology fall, adversary states and non-state actors will find novel uses for commercially available technologies. Competitive technology analysis will increasingly need to take into account available commercial technology and publicly available S&T. As George H. Heilmeier, the former Director of DARPA, explained,[41]

> ***The real difference between the surpriser and the surprised is usually not the unique ownership of a piece of new technology. The key difference is in the recognition or awareness of the impact of that technology and decisiveness in exploiting it.***

[41] George Heilmeier, "Guarding against Technological Surprise," *Air University Review*, September-October 1976, http://www.airpower.maxwell.af.mil/airchronicles/aureview/1976/sep-oct/heilmeier.html.

Third is to get at the "unknown unknowns"—the technologies occurring beyond the horizon of what DoD is aware. These may be in nascent technology fields or fields that have not yet seen crossover with defense-relevant technology. DoD does not have a comprehensive horizon-scanning and hedging strategy for monitoring potentially relevant trends in outside innovation and for taking advantage of innovation emerging from nontraditional and global sources.[42] While there are individuals and smaller organizations that may be doing some of this work, there is not currently a comprehensive perspective being provided.

Fourth is spreading the "known knowns." There are pockets of interactivity with global commercial innovation sprinkled throughout the national security enterprise, as well as areas of distinct expertise, but DoD lacks adequate processes for disseminating the knowledge that it already has in niche areas. The nature of information technology enables collaboration and coordination among stakeholders from throughout the enterprise at all levels, but there are few processes that encourage the breaking of the stovepipes that dominate the DoD structure and hierarchy. As systems-of-systems approaches for technology development and acquisition grow, better cross-domain coordination and information sharing will be critical.

The CSIS study found considerable activity looking to bridge this knowledge gap and harness outside innovation, but many of these activities tend to be disparate, relatively small, and not highly visible. We also found that most of these people were operating within the narrow confines of their own organizations, with little awareness of similar activities elsewhere (sometimes on the same problems) and with little structure or support. The ASD(R&E) communities of interest framework is doing some of this, bringing together stakeholders in particular technology areas from across the enterprise. Nonetheless, much of the value in collaboration is cross-domain as well as cross-organizational. The Reliance 21 framework in ASD(R&E) is also doing some work in trying to connect across communities. Additionally, the S&T communities, including COCOM S&T offices and global research offices of the services, particularly those less burdened by classification concerns and involved in the more basic research world, have a key role to play here.

### *Recommendations for Improving Outside Innovation Awareness*

1. *OSD should create and share across DoD a better knowledge base of emerging commercial technologies and processes*, whether found at home or globally. While many parts of DoD are highly conversant with the latest advances in technology, this awareness is not universally shared by critical elements of the acquisition, resource, and requirements communities. In order to avoid technology surprise and stay on the positive side of disruption, DoD must maintain persistent, organized connection to the global innovation market, as well as ensure the dissemination of innovation and information across the national security enterprise. No such fully formed knowledge base exists in DoD today, although there are pockets of identification and sharing. To date, much of the activity for increasing outreach has in fact been focused on increasing transparency in the needs of DoD (increasing public understanding of what DoD is trying to buy), therefore increasing the efficacy of the "pulling" process.

[42] Defense Science Board, *Technology and Innovation Enablers for Superiority in 2030*.

This is a critical component of an outside innovation strategy, but does not necessarily improve DoD awareness of what others are doing.

The knowledge base and accompanying policies should aim at leveraging the benefits provided by different communities of knowledge. One of the key challenges for a knowledge base system will be to leverage the benefits for diverse communities with differing needs and strengths. To be optimally effective, this knowledge base will need to both harness the insights of the warfighter communities, as well as leverage the centralized implementation capabilities of the military services and OSD to institutionalize the benefits of innovation. The need of some systems for long-term sustainment and funding requires that the knowledge base be maintained and kept up to date over the longer term.

The nascent Technology Domain Awareness (TDA) initiative may indeed facilitate this function and bears watching. TDA seeks to both facilitate DoD access to commercial markets and track innovation across the acquisition lifecycle through "reducing the interaction latency between defense technology stakeholders," and "capturing and synthesizing transactional and technical information."[43] TDA faces challenges in gaining user and producer buy-in through effective incentive systems, reaching critical mass in operating system adoption, and effectively mapping communities and technologies for ease of use. This initiative is just in pilot stage, with early projects underway, but is a promising start toward a knowledge and information system for both sharing and analysis that will create a "user-defined operational picture" that would both facilitate and incentivize greater interaction between government and the commercial market and support decisionmaking.[44]

*2. DoD should more extensively utilize efforts to promote operational innovation and support the use of small "demonstration" projects and operational experimentation to identify and incorporate outside innovation in the field.* Field-level testing and experimentation is a crucial component for validating the operational effectiveness of outside innovations. Demonstration projects offer inexpensive means to test and mature militarily applicable technologies. The knowledge base would facilitate the discovery of relevant technology to map to operational innovation gaps and identify possible areas where demonstration and testing would add value. The Emerging Capability and Prototyping Office has had success performing this function but better inclusion of warfighters at the front end and an expanded portfolio would develop this capability to validate the potential of innovative technologies further. The knowledge base should not just identify opportunities for such experimentation, but also provide a feedback loop to report results and help the system retain lessons learned. Most importantly, these initiatives need more room to scale up, both in terms of doing more, and providing more outlets for them to grow from demonstration into programs. Expanding the quantity is key to enshrining the acceptance of failure that is so critical to effective use of innovation.

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[43] For a full description of the Technology Domain Awareness initiative, see Adam Jay Harrison, Jawad Rachami, and Christopher Zember, "Technology Domain Awareness: Building the Defense Innovation Base," *Georgetown Security Studies Review* 3, issue 1 (January 2015), http://georgetownsecuritystudiesreview.org/wp-content/uploads/2015/02/GSSR-Vol.-3-Iss.-1.pdf.

[44] National Defense Industrial Association, *Pathway to Transformation: NDIA Acquisition Reform Recommendations* (Washington, DC: National Defense Industrial Association, 2014), 62–63.

Additionally, *DoD policy should encourage and support more Warfighter-Innovator collaboration* by using "technology matchmaking" to connect DoD offices with the requirements generators and the identified and potential sources of outside innovation. This iterative feedback between acquisition and requirements has been successfully demonstrated in the rapid acquisition processes, but has not yet pervaded the regular acquisition process. Some steps have been made in this direction, including having AT&L attend the Joint Requirements Oversight Council (JROC), but this kind of coordination needs to occur on a regular, ongoing basis at lower levels.

DoD policy should also encourage the *use of field-testing for quicker evaluations of outside innovations*. Efforts such as NAVAIR's Technical Experimentation Center should be supported and expanded. DoD policy should mandate that warfighters use exercises and war games to improve the evaluation and incorporation of new concepts for combat operations. It's a waste of time and money *not* to use exercises for these additional purposes.

3. Beyond knowledge sharing and collaboration, *DoD should expand and connect initiatives at OSD and in the military departments that search for specific technology development from outside innovation*. Those initiatives should actively build on and integrate existing DoD activities that monitor maturing technology, consider potential DoD and non-DoD uses, and anticipate timeframe for maturation/development. Such activities generally are in the DoD labs, FFRDCs/UARCs, etc., but are not well integrated with the needs of warfighters. There needs to be a warfighter input to focus on meeting current and future gaps. Field users and operators should be able to conduct open dialogues with industry providers on potential/anticipated DoD uses (DoD provides potential uses, industry provides feedback). This recommendation builds on and expands existing attempts to conduct such dialogues.

Furthermore, DoD needs to expand the search to identify outside innovations with military value, particularly including innovations that could be used by potential adversaries. While many of the challenges and recommendations documented here focus on awareness for the sake of eventual accessing by DoD, just as important will be the recognition of innovations that may not make sense for DoD but could become part of a cost-imposing strategy that DoD could face. The Office of Technical Intelligence in the DoD Research & Engineering enterprise provides technology watch and horizon scanning in this context, and expanding this capability and continuing to connect it across DoD will be an important enabler to many other activities listed here.

Additionally, new open innovation models, including challenges and technology search and information sharing and partnering platforms should be explored beyond current usage (in places like DARPA) to broader communities, especially users with near-term problems that may be solvable with low-cost solutions.

4. CSIS recommends that DoD use the increased awareness, knowledge sharing, and collaboration from the preceding recommendations as a basis to *guide funded development activities toward potential uses (for example, via IR&D investment or technology development that targets specific capability gaps and creates/highlights market demand)*. Currently, if a company is spending on IRAD on something the field would find helpful, there is no easy way for them to know that. Overall, CSIS found that DoD shares too little with industry, even at the Secret level. In contrast, the CIA through In-Q-Tel provides publicly releasable unclassified material to vendors, and DoD should also be able to get more information to

potential innovators. The challenge ranges from problem statements that DoD is trying to solve, to priority lists from combatant commands to requirements documents from the services. These classification challenges present real-world barriers to reaching out to the global innovation community. The new iteration of Better Buying Power is working to correct this imbalance by strengthening early requirements dialogue between government and industry, and is important to continue pursuing.

## Access

Increasing awareness is an important outreach activity for informing the decisionmaking processes inside of DoD. But, while awareness is an enabling capability, access is ultimately the goal of most of these proposed awareness capabilities. Once better awareness is achieved, the goal must be to break down the many barriers (statutory, regulatory/policy, cultural, methodological) that hinder DoD's ability to access potentially valuable outside innovation. The centers of friction that arose in our investigation inhibiting access to outside innovation can be divided into three categories: requirements, acquisition, and funding.

These three areas are ideally intended to be the wheels that move technology access forward and enable the delivery of capabilities to the warfighter. The layers of regulation and bureaucracy, in practice, often play an inhibiting role as opposed to an enabling one.

### Requirements

Requirements provide the primary demand inputs for technology across the Department and thus are the first place where awareness can generate technology "pull." They are generated in the military services and validated by the joint staff, where the rubber hits the road and the demands of the threat environment are translated into the operational capabilities needed. Yet, the structure and nature of the process often impedes the timely, efficient delivery of these systems to the end-user. The outcomes of CSIS interviews made clear that DoD's requirements process does not take full advantage of refining draft requirements to leverage the technological, timeliness, and/or affordability benefits associated with utilizing available outside innovation.

Requirements written in the vacuum within the walls of the Pentagon often do not adequately consider the state-of-the-art or the state-of-the-market for technologies. While there are certainly areas, particularly in MDAPs, where reaching a certain standard is critical for viable high-end capability, there are many opportunities for better leveraging existing levels of capability from the commercial market by increasing interaction between needs and external technical standards.

A crucial role of outside innovation is shaping requirements, not just responding to them. The study team found that institutionalized walls separating DoD's operational, material, technological, and acquisition communities impede warfighter-developer communication and collaboration on establishing requirements. While ultimately most acquisition is aimed toward delivering capability to the warfighter in the field, there is often little space for warfighter input in generating requirements. One area that the requirements process diverges from warfighter needs is in the time aspect. Warfighter communities operate on much shorter timelines than the requirements and contracting communities. Time-to-market tradeoffs are frequently not adequately considered or communicated in the service-based

requirements process, while the warfighter might be far more interested in a 75 percent solution that arrives in one-tenth of the time. As Admiral Gary Roughead articulated,

> ***I would add "warfighting" to the risk list of technological, integration and manufacturing risks with the focus on operational shortcomings in capability and capacity vis-a-vis likely adversaries. That will inevitably drive the entire acquisition process to address time to deployment as a critical factor. Weapon system development is about competition with likely adversaries. Yet there is minimal ongoing discussion, at a classified level, within the complete acquisition and oversight process as to whether or not we are winning.***[45]

Experimentation and outside innovation are not being optimized to evaluate potential requirements. Demonstration and experimentation provide an enormous opportunity for testing new technologies prior to committing to an acquisition program, particularly for those technologies being purchased off the shelf, or in slightly modified form. User communities are eager to try new things, but have limited ways to access technology for these purposes.

### *Recommendations for Ameliorating Requirements Challenges*

1. The first recommendation is that DoD should *develop forcing functions within the warfighter and acquisition communities that identify capability gaps, match available and emerging technologies and concepts with those gaps, and rapidly pull those technologies and concepts into operational use*. The study team found some areas within DoD that are doing this. The Joint Capabilities Technology Demonstrations and Emerging Capabilities Technology Development programs inside of the Emerging Capability & Prototyping Organization in OSD are aimed at this recommendation. The challenge is to ensure that there is a search for common gaps by arraying integrated priority lists and other gap descriptions, thinking both strategically (for example, using the National Intelligence Council's global trends) and tactically (through combatant-command-reported challenges). Additionally, the study team found that there was insufficient work to connect these gaps to any knowledge base of innovation solution options to address those gaps (whether from inside or outside innovation).

2. DoD policy and practice should *create and foster requirements flexibility that allows consideration of potential solutions that don't fit existing programs or requirements*. Often ideas and technologies present themselves to warfighter communities, as well as to the in-house innovators, but are unable to gain a foothold as they do not fit existing requirements, as requirements may in fact lag technological advancement. A typical response may be, "That's interesting but I don't have a requirement for it," and without a requirement, there is also no money for it. Key to responding to this challenge will be developing forcing functions for evaluating emerging requirements and institutionalizing decisionmaking on these challenges.

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[45] Gary Roughead, "Views from Admiral Gary Roughead, USN (Ret.)," in *Defense Acquisition Reform: Where Do We Go from Here?: A Compendium of Views by Leading Experts*, Staff Report to the Permanent Subcommittee on Investigations, U.S. Senate, October 2, 2014, http://www.hsgac.senate.gov/download/report_-defense-acquisition-reform-where-do-we-go-from-here--a-compendium-of-views-by-leading-experts-october-2-2014.

DoD should *build early and continuous warfighter input into the technology identification and validation process at their level by emphasizing technology insertion in exercises*. The study team found numerous opportunities for using exercises for experimentation but found little organized effort to use those opportunities. Once a technology demonstration occurs, creating a decision pathway for that technology is critical.

3. DoD needs to improve its ability to *specify the necessary architectures and identify desired outcomes, particularly by focusing on expanding modularity and use of open systems architecture*. Part of the value of open systems is the need to provide warfighter flexibility in approaches to meet those specified outcomes. The key aspect of open systems is the standards-setting process, which inherently necessitates the opening of a dialogue with industry over these standards. By interfacing with industry, the requirements generators and users can get a clearer understanding of the state-of-the-market and the art of the possible. Additionally, through the standards-setting process, involvement with DoD is encouraged, as those who do not play in the standards-setting discussion and process are implicitly penalized by not ensuring that standards do not eliminate their own offerings. Both BBP 3.0 and the 2015 National Defense Authorization Act address this objective of open systems and modularity, but implementation and execution are yet to be determined.

4. DoD policy should, as part of identifying options to address capability gaps, support *consideration of disposability (i.e., planned obsolescence), not updating, as a viable acquisition strategy* where circumstances warrant such an approach. A substantial element of innovative success in global commercial markets comes from recognizing that cycle times of innovation may make it more cost effective to build in disposable, planned obsolescence. This planned obsolescence can also remove some of the burden of sustainment funding and planning for those innovative capabilities acquired outside of the traditional acquisition process. Where innovative capabilities are acquired as subsystems need to be maintained over a longer term and DoD does not have the intellectual property and/or the human capital for such maintenance, performance-based logistics may offer an affordable way to sustain innovative capabilities.

## Acquisition

DoD's existing processes for accessing and managing outside innovation are challenging and not widely appreciated. There are a series of authorities that already exist, but which are not necessarily well understood throughout the acquisition workforce. Acquisition culture and processes can be rigid and risk-averse, and can make it harder for DoD entities to consider outside innovation in technology and processes. The acquisition communities face a difficult balance between rapidly delivering cutting-edge technology and ensuring documented stewardship of taxpayer dollars. These mandates are often in competition in the acquisition system. Taking the time to ensure fair prices for parts and components throughout a supply chain takes time. Buying rapidly from the commercial market can require judgment calls and may not allow for full accounting of every part. Therefore one of the significant barriers is that, at times, the most significant incentive that an acquisition office has is to not get audited, not be the subject of an inspector-general report, and not have their boss get hauled before Congress. This risk aversion is a natural outcome of the incentives in place in the bureaucracy and is not easy to overcome.

This is not to say that acquisition of commercial and nontraditional innovation doesn't happen, but that it often happens on the "edges" of formal DoD acquisition processes. The intelligence community and Special Operations Command offer the most significant examples, as they operate with their own acquisition authorities outside of the services, and have a much smaller, targeted set of requirements, and fewer bureaucratic layers and processes to impede acquisition, but this is not easily scaled.

In finding solutions to these challenges it is important to recognize that balancing the opposing imperatives of creativity (which is aided by decentralization) and implementation (which is aided by centralization) is very difficult. There are indications that experimentation is more effective when it is decentralized. If true, institutionalizing innovation could inhibit rather than foster the process. The reality is that innovation will never be maximized by institutionalizing it. It is widely recognized that most innovation happens at the seams between organizations and disciplines and at the margins of organizations. Nonetheless, to utilize this innovation most efficiently and effectively, there need to be established avenues for sharing the information gained, both positive and negative, as well as for then integrating that innovation into the larger system. It was widely recognized in interviews that most innovation-focused organizations in DoD fell into two bins. The first type is those organizations that had top cover through high-level buy-in to their specific mission and processes. More damning to the efficacy of the Pentagon innovation enterprise is the second type—insiders that have carved out niches for themselves as conduits for bringing outside innovation into the department, but show little interest in publicizing and highlighting their work for fear of being squashed by the bureaucracy.

These same acquisition processes provide significant disincentives, discouraging commercial firms from contracting with DoD and discourage DoD from acquiring commercial products. Whether its intellectual property requirements, becoming subject to ITAR and export controls, or required adherence to cost accounting standards (CAS), traditional DoD acquisition methods have downsides that may outweigh the upsides of the market size. This was less of a problem when DoD dominated the high-technology market, but as former Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy Brett Lambert quipped, "when it comes to acquisition, the department continues to assume it is the dog, not the tail of a market. Increasingly that is the wrong assumption."[46]

### *Recommendations for Facilitating DoD Access to Outside Innovation in Acquisition*

1. DoD needs to *capture/leverage wartime rapid fielding lessons learned, under which DoD has accepted more risk, and accept commercial/civil solutions for operationally essential capabilities*. As named operations diminish, there is concern that efforts to capture the lessons learned from the processes developed to support warfighters are weak and incomplete. Flexible funding has been a key enabler to the rapid acquisition system, and will need to be preserved in order to maintain viability and vitality of the enterprises that have grown up to support this model.

2. DoD, the military departments, and defense agencies need to *adjust acquisition incentives to entice commercial and non-U.S. firms*. There is a significant body of work on the acquisition barriers to nontraditional firms looking to do business with DoD. Among areas needing work are:

[46] Sandra I. Erwin, "Defense Procurement: Congress Continues to Search for Answers," *National Defense,* June 24, 2014, http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?ID=1541.

- Cost accounting standards, financial accounting standards, and Truth in Negotiations Act (TINA) requirements
- Export controls
- Less government focus on modifying internal systems/processes to meet contract process requirements and more on innovation itself
- More clarity, and possibly flexibility, in intellectual property from U.S. firms and subsidiaries
- Aggressive tailoring of milestone system when appropriate
- DoD profit policies

CSIS found examples of acquisition best practices and flexibility in the FAR and DFARS that could support incentive adjustment, but there remains cultural resistance to using it. Better Buying Power 3.0 reflects an understanding of this challenge. In addition, the rewrite of DoD Instruction 5000.02 explicitly recognizes the need to better tailor approaches. The acquisition workforce, in turn, needs to be trained and educated in working within this flexible landscape.

Additionally, the incentives in the acquisition system are optimized for focus on competition and fairness, which in turn disincentivizes technology leadership as the system tends to set up competitions that allow those who are "behind" to catch up to compete. This serves to both slow the process and discourage cutting-edge firms from pursuing DoD work. Ensuring that innovation is a prized quality, both in setting up a competition and in source selection (through best value focus instead of best price), will be critical to enticing cutting-edge firms to do business with DoD.

### Funding

Finally, accessing outside innovation is challenged by funding practices. Tightening budgets make it more difficult for DoD entities to fund innovation, generally, and particularly innovation not directly relevant to major programs. Because funding lies predominantly within the Pentagon, current DoD processes focus too little on the role of the end-user/operator in identifying, developing, and pulling innovation into defense capabilities.

As discussed earlier, and demonstrated by the laundry list of organizations and initiatives in Appendix I, there are many corners across DoD that are tapping into outside innovation in their own ways. But, because they are often separated from acquisition authorities and funding streams, they often expend 10 percent of their effort in finding and selecting innovations worth pursuing further and doing due diligence and 90 percent of their time and effort trying to find funding streams. By using new funding streams to help shift this disparity only slightly, these offices and initiatives could deliver a much higher return on their investment in time and effort on doing the kinds of outreach discussed in the awareness section as so important.

The exigencies of wartime requirements over the past dozen years have driven a greater recognition of the need to be able to rapidly acquire and assimilate new products outside of established programs of record. There is broad concern across the defense community that the lessons learned and acquisition skills developed in this area are in danger of being lost. It is not only skills that are in danger, but the

funding mechanisms. Funding for Overseas Contingency Operations, budgeted separately from the base budget appropriations, has provided a large pool of unprogrammed funding that could be used to respond to urgent needs.

### *Recommendations for Resolving Funding Challenges for Outside Innovation*

1. DoD should *continue to expand mechanisms for warfighters to fund urgent operational capability needs,* including Joint Urgent Operational Needs/Joint Emerging Operational Needs funds (JUONs/JEONs), Joint Capabilities Technology Demonstrations (JCTDs), Emerging Capabilities Technology Development (ECTDs), Rapid Innovation Fund, and others. This will enable *more timely and effective warfighter efforts to speed transitions from innovation to application: concept to prototype, and prototype to capability*. Users and operators can evaluate and apply innovation outside the budget cycle to save time and gain advantages.

The JUONs/JEONs set the standard for this expedited process, which both force consideration and prioritize urgency. JUONs are limited to application to named operations only. The reality is that operational needs will continue to exist, even as the named operations of today conclude. Using the framework set by these processes, one way to facilitate user efforts to speed time to market would be a third category (falling in priority below the first two) of Joint Innovation Operational Needs (JIONs). These JIONs would provide a pathway for time-sensitive, mature innovations to rapidly move from application to capability outside of the PPBE process.

Additionally, the time between submitting a JUON and a decision should be as short as possible. Funds available at decentralized levels of DoD could encourage user experimentation and permit failure without pulling funds.

2. DoD should *expand Better Buying Power goals and encouragement of prototypes to include prototypes for proof of concept, validating requirements, defining requirements, and as a basis for experiments and tests*. Funds spent on experiments and field-level prototypes, outside Programs of Record, can help DoD understand what can be done, help refine requirements, and help design and evaluate user interfaces. Experimentation requires a feedback loop, but that also needs funding support.

3. DoD needs to *create separate funding (at appropriate levels) for warfighter initiatives*. Funding experiments means accepting failures. If the goal is to use innovation to reduce capability gaps, then the negative knowledge obtained from failures is valuable.

4. *Funding cannot wait for the full PPBE cycle, followed by congressional appropriations*. Warfighters in particular need a way to fund innovation without waiting for the PPBE cycle to provide money. DoD needs a limited amount of prearranged set of funds to be available to verify, evaluate, and begin to incorporate outside innovation discoveries.

## Conclusion

There is no doubt that technology innovations in DoD have delivered unmatched national security capability for the United States for the greater part of the last seven decades. However, the circumstances that underpinned U.S. advantages over that time have eroded, and the rise of new systems and a new global innovation environment threaten DoD's way of doing business. Globalization

and privatization have expanded supply and information networks, bringing technology to new players, while also minimizing DoD's role in the global innovation base. The growing commercial role in military-relevant technology and the speed at which that technology is advancing challenges DoD's capacity to keep up with the flood of technologies both for its own adoption and for that of our adversaries.

These realities of the global innovation environment drive to only one conclusion: that while a strong DoD R&D program remains a necessary component to maintaining military technological dominance, this internal program is no longer sufficient for future DoD needs or technology superiority. It remains necessary because there will always be military-unique products that do not draw any commercial investment. Perhaps even more crucially, the federal government makes strategic investments in basic science and technology that lay the foundation for developments critical to both defense and commercial technologies. However, focusing on innovation resulting directly from DoD's R&D program is insufficient today due to the rapid expansion of innovation occurring outside the DoD sphere of influence. In order to harness cutting-edge technology in a world where innovation is increasingly occurring beyond the traditional jurisdiction of government investment, DoD must expand its horizon and look beyond industrial and geographic boundaries and proactively leverage outside innovation.

Ultimately to succeed in leveraging outside innovation, DoD must become a proactive participant in harnessing the power of the market and the "global brain." In order to maximize returns from this proliferating global innovation environment, DoD must organize itself to enhance information flows both in and out, and actively engage a broader segment of the market. The Department must utilize its existing proprietary networks of scientists and suppliers to grow information pathways, and find new ways to tap into the open networks of problem-solvers and technologists that are growing across the networked globe. These organizing principles must center on the development of institutionalizing and enabling processes that will help optimize DoD for increasing its awareness of and access to the fount of global innovation.

The narrative of the Department of Defense to date has centered on minimizing the harm of the features of the global innovation environment. The more revolutionary approach needs to focus not on minimizing damage, but on maximizing opportunity. Today, outreach, interaction, and integration with the global innovation ecosystem is largely happening in spite of the challenges and barriers in the system. The new generation of leaders has begun using the tools of their generation to self-organize around shared experiences, shared needs, and shared frustrations. Groups like the Defense Entrepreneurs Forum and the Center for International Maritime Security (CIMSEC) and outlets like The Bridge provide new ways to collaborate and reach out beyond military stovepipes and traditional organizational structures. These same leaders are blazing paths from the Pentagon out to Silicon Valley, and Boston, and Singapore, looking for new ways to deliver national security in this new era. The Department of Defense needs to continue developing lasting processes and incentives that drive the organization to continuing to become more a part of the solution and less of the problem.

## Appendix I: Examples of Existing Initiatives

In the many interviews and meetings throughout the course of the study, the team encountered examples of existing initiatives for increasing awareness and better accessing outside innovation. These existing initiatives provide a good starting point for identifying both the challenges in trying to access outside innovation, as well as models for how it might be done. This is not intended as either an endorsement or a judgment of the efficacy of any of these initiatives. Additionally, programs addressing commercial technology often experience change over time as they react to the realities of dealing with the commercial market and the requirements of the government; therefore, the descriptions below may not capture changes to these programs since they were introduced to the study team.

Initiatives in the Office of the Secretary of Defense and defense agencies:

- The Rapid Reaction Technology Office develops prototypes and hosts demonstrations for quick-turnaround projects (less than 18 months) responding to emerging needs (http://www.acq.osd.mil/ecp/linesOfOperations.html?id=2).
- The Rapid Innovation Fund is administered by the ASD (R&E) and Office of Small Business Programs to provide a vehicle for small businesses to rapidly insert technologies into acquisition programs (http://www.defenseinnovationmarketplace.mil/RIF.html).
- The NeedipeDIA from the Defense Intelligence Agency conveys capability needs for the agency as well as provides a contracting vehicle for technologies that fill those needs (http://www.dia.mil/Business/Needipedia.aspx).
- DARPA's "Cyber Fast Track" sought to leverage nontraditional performers by engaging in low-cost quick-turnaround projects in the software/cyber domain (http://www.darpa.mil/opencatalog/CFT.html).
- The Joint Capabilities Technology Demonstration (JCTD) effort from AT&L seeks to use operational prototypes of maturing technology with a two- to four-year time horizon to address validated capability gaps more affordably (http://www.acq.osd.mil/ecp/linesOfOperations.html?id=3).
- Related to JCTDs are ECTDs (Emerging Capabilities Technology Development), which instead of contingency-based needs look at emerging capabilities and future threats and ways to use operational prototypes to address them (http://www.acq.osd.mil/ecp/).
- The International Cooperation Coalition Warfare Program in OSD is dedicated to initiating cooperative projects with allies and partners (http://www.acq.osd.mil/ic/cwp.html); and the Foreign Technology Office and its Foreign Comparative Testing initiative finds and assesses globally sourced capabilities that could fit with DoD.
- The Defense Innovation Marketplace (http://www.defenseinnovationmarketplace.mil) is a hub developed for information sharing between DoD and industry to increase productivity of R&D through better knowledge.

- The Technology Domain Awareness initiative from the DoD Information Analysis Centers looks to harness information sharing, collaboration, and connection with innovators across government and throughout industry to support key decisions (http://iac.dtic.mil/tda.html).
- Defense Energy Technology Challenges, organized by TechConnect, uses connections to industry, venture capital groups, and government agencies to identify, vet, and support potential new technology developers in response to government requirements. Also used in COCOM support capacity (http://defenseenergy.com/partner/DETC/).
- The Communities of Interest (COIs) organized by the assistant secretary of defense for research and engineering offer some promise for gathering those with expertise and responsibility in particular domains to address emerging challenges. These groups also may arise as important information-sharing pathways cutting across constituent communities.
- The Small Business Innovation Research program funds feasibility studies, development, and prototyping of innovative ideas from small businesses, which make up a large segment of nontraditional providers to DoD.

Initiatives in the military services:

- In the Navy, the CNO's Rapid Innovation Cell leverages junior leaders to connect emerging technologies with Navy challenges to explore possible revolutionary innovations.
- The Navy Fleet Experimentation (FLEX) Program identifies challenges and tests commercial solutions and government-tested capabilities in operational environments.
- Army Network Innovation Evaluation (http://www.arcic.army.mil/Initiatives/network-integration-evaluation.aspx) permits firms to insert and evaluate innovation in exercises utilizing common standards on a testing network and leverages feedback from experienced users/operators.
- The Army Rapid Equipping Force identifies operational, emerging, and urgent needs and seeks to identify corresponding off-the-shelf solutions (http://www.ref.army.mil/aboutus.html).
- As part of the REF, Army CoCreate is a collaborative platform for developing crowdsourced solutions with government, civilian, industry, and enthusiast input, including designing and building prototypes (http://www.ref.army.mil/news3_cocreate.html).
- Army Research Lab Open Campus Opportunities seek to connect academia and entrepreneurs to work together in cross-disciplinary ways to tackle difficult army challenges (http://www.arl.army.mil/www/default.cfm?page=2357).
- Air Force PlugFest PLUS provides a venue for technologists to bring their technology and software into the Air Force system to plug and play, test and assess, and provide mature tech options for Air Force acquisition.

Initiatives in the combatant commands:

- COCOM J81 Joint Innovation and Experimentation Divisions
- Integrated Priority Lists (IPLs) and Science and Technology Integrated Priority Lists (STIPLs)

Instructive initiatives outside of the Department of Defense

- CIA In-Q-Tel Act as venture capitalist to identify and fund innovative solutions to identified concerns (https://www.iqt.org/). Secretary Carter announced a DoD investment in In-Q-Tel in April 2015 in order to leverage the existing infrastructure and relationships of the In-Q-Tel program to help solve DoD challenges.
- The Department of Homeland Security supports public-private partnerships through the Security Innovation Network (SINET), connecting small emerging technology and cybersecurity firms with national security decisionmakers (http://www.security-innovation.org/).
- The National Security Agency's Provisional Industrial Security Approval (PISA) programs helps bridge the gap between technology firms and the intelligence community by providing for temporary security clearances for firms to facilitate meetings, socialize solutions, and seek potential customers in the intelligence community (https://www.nsa.gov/business/programs/pisa.shtml).
- The Center for Defence Enterprises (CDE) in the United Kingdom is a website intended to provide a vehicle for nontraditional suppliers to alert the UK Ministry of Defence to science and technology of potential interest and begin a dialogue with the potential for future funding (https://www.gov.uk/government/organisations/centre-for-defence-enterprise).
- The Defense Entrepreneurs Forum is a grassroots organization that seeks to bring defense entrepreneurs in the services and the larger defense community together with social and business entrepreneurs to better connect the two communities and collaboration and innovation from the bottom up (http://defenseentrepreneurs.org/).

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From 2005 to 2011, Mr. Hunter served as a professional staff member of the House Armed Services Committee, leading the committee's policy staff and managing a portfolio focused on acquisition policy, the defense industrial base, technology transfers, and export controls. From 1994 to 2005, he served in a variety of staff positions in the House of Representatives, including as appropriations associate for Representative Norman D. Dicks, as military legislative assistant and legislative director for Representative John M. Spratt Jr., and as a staff member for the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China. Mr. Hunter holds an M.A. degree in applied economics from the Johns Hopkins University and a B.A. degree in social studies from Harvard University.

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ISBN 978-1-4422-5896-9

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