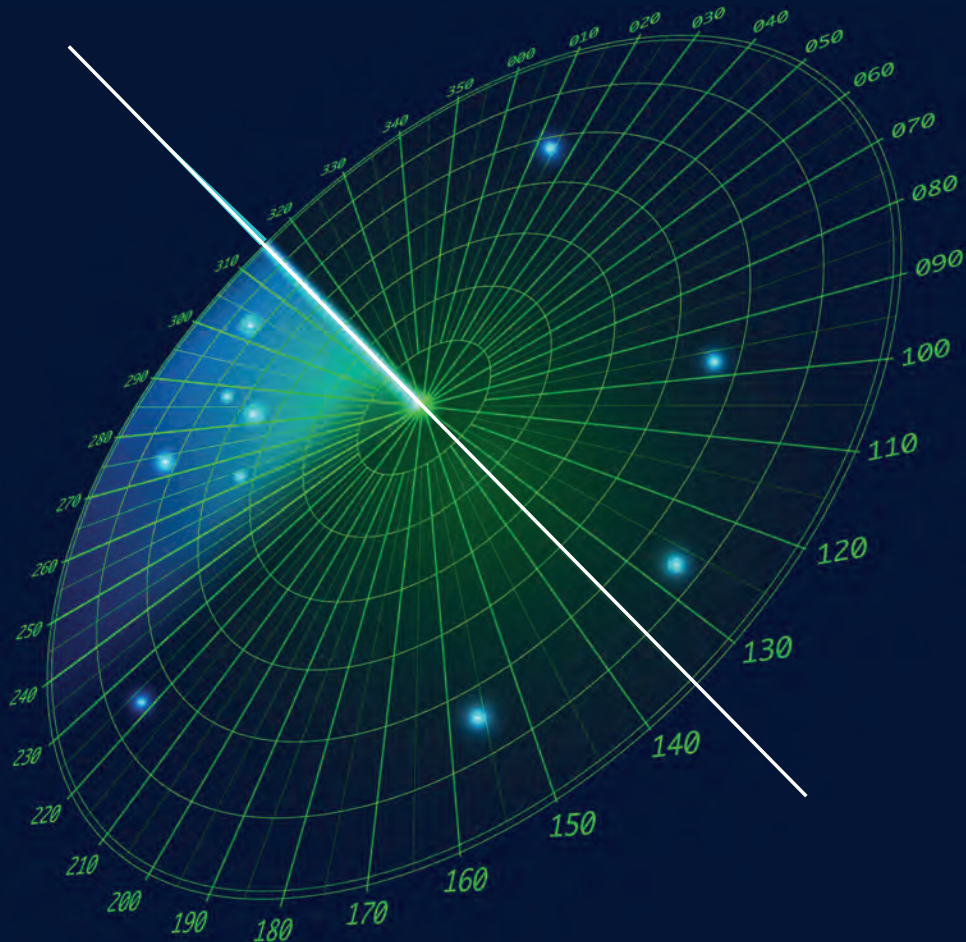


Against the Odds

Driving Defense Innovation in a Change-Resistant Ecosystem



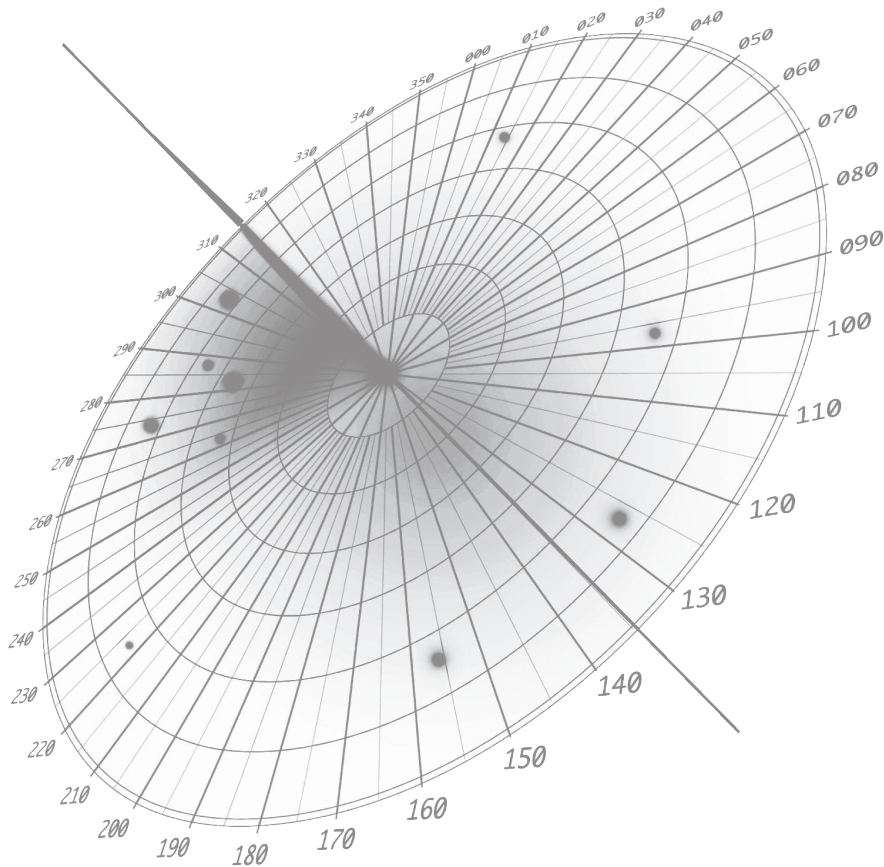
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Special Foreword by the Honorable David Oliver, Jr.

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Special Foreword

Over the decades, there have been few complaints about the manner in which the Army, Navy, Air Force and Marine Corps Service Chiefs prepare America's forces for war fighting. These Generals and Admirals have generally been deemed to wisely use the funds Congress provides to recruit, train and equip their services, with only minor assists from the civilian principals appointed over them and the interested members of Congress. It is particularly noteworthy that the Chiefs have done so without major scandal. As might be expected, they needed the occasional nudge in adapting to revolutions in warfare, as was seen when Congress stepped forward in the sixties and seventies and pushed nuclear submarines, and Bill Perry later forced initiation of development of unmanned vehicles. But, on the whole, it is hard to find critics of the Chiefs when they act in their war-fighting hats.

On the other hand, the Chiefs and the Defense Department are often criticized for not getting the same full value for money with respect to the acquisition of combat systems and capabilities (such as airplanes, ships and vehicles) as well as services. There is a tantalizing history that proves exceptional management can deliver breakthrough technology on time and on budget. This includes such diverse achievements as that achieved by Admiral Raborn with the Polaris Program, as well as the Sidewinder missile Bill McLean delivered from his garage in China Lake.

But the norm on defense acquisition programs tends to be technical underperformance, fiscal overruns and delays. The same charge is often laid against other U.S. government departments, but since Defense spends three-quarters of the tax dollars not linked to "sticky" requirements like interest on the national debt, public attention inevitably bounds back to the Pentagon.

This dichotomy between the success in war fighting and the rocky road in defense acquisition has been a frustration for decades. Many fixes have been attempted, even some that, in retrospect, defied every good rule of management. For example, the Goldwater-Nichols legislation of 1986 effectively permitted taking responsibility for the management of acquisition away from the Service Chiefs, while still leaving the Chiefs tasked with the job of recruiting, training and filling the people in the procurement ranks. Since all functions in a Service are competing for the same talent, over time, the procurement ranks suffered disproportionately to the war-fighting grades with the expected negative results in acquisition.

It is also no secret that, over the last several decades, there have been literally dozens of announced procurement reforms but no grand improvements. All of these remedies seem to follow a similar desultory trend. A good idea is proposed with enthusiasm, greeted with alacrity, organized with enthusiasm, but then is resisted by the first Uniformed Service which might have to change the slightest bit its operational paradigm. Thereafter, everyone collapses in obeisance.

As someone who had the honor of participating in the management of the defense acquisition system for a number of years, I cannot emphasize enough the challenge of taking on a change resistant system with engrained processes and parochialisms. These systemic impediments limit our ability to provide innovative and affordable solutions to our war fighters.

To get the procurement reform America deserves, the will to make progress needs to persevere over time. This is the clear responsibility of the Secretary of Defense. With the support of the Secretary of Defense, it is possible to introduce real innovation into the system.

I well remember the key roles Generals Jim Jones and Speedy Martin played under Secretary William Cohen in introducing Global Hawk into the Air Force budget following the Predator success during the Bosnia conflict, a change that has truly altered air power. Traditionalist elements of the Air Force leadership, wedded to the manned aircraft paradigm, opposed this shift in the late 1990s and resisted funding unmanned aerial vehicles notwithstanding this demonstration of their potential battlefield merits. It was only through the leadership of the Secretary and others at Defense, as well as private firms who gambled and invested in this new and largely unproven innovative capability at a time when it was uncertain if Defense would support it, that this entrenched resistance to change was overcome and UAVs transitioned from ideas and prototypes into today's effective war fighting capability.

Today, these types of achievements are not easy to make happen. They require an understanding of the global security and business dynamics, the Congressional environment and the ongoing technological revolutions. Such an accomplishment also requires a real appreciation of the trillion-dollar defense industry as well as Service needs and cultural differences as well as a sustained commitment of leadership resources. A difficult task, but this is the most important challenge we must solve before our next peer competitor takes form.

The new Administration, with its early focus on affordability in defense procurement, has a chance to shake things up—make change—and make progress on the elusive goal of providing innovative and affordable weaponry to our war fighters across the range of contingencies—from near peer competitor competition to counter insurgency. *To put it bluntly, we need to find a way to make it less Herculean for innovative change to flourish in our armed forces.*

Jeff Bialos, along with co-contributors Christine Fisher and Stuart Koehl, provide a strong range of recommendations that the Trump Administration should seriously consider as it looks to address the acquisition challenge in an across-the-board manner. There is little doubt that, as they suggest, we need a balanced approach across a range of contingencies we face, and we need a comprehensive approach. We need not only to develop “offsets” that can help to deter against potential high end threats but also to make sure that we do not short-change the development of the tools our war fighters need to address the range of low intensity conflicts that are likely in the years to come, if past is prologue.

Further, better use of tools like Other Transaction Authority and private equity financing is important and probably needs to be forced on a reluctant system. Also, I wholeheartedly agree that it is time to seriously review the ability of our large system of DoD laboratories to meet the

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demands of a fast paced threat environment and the rapid diffusion of technology to our potential adversaries.

Equally important, however, are the insights they have offered into what the challenges are in our existing system and in particular the fundamental resistance to change that has to be overcome—that is, how to better access vibrant sources of technology, improve our speed of acquisition, and better transition our many ideas to the war fighter.

In a sense, these observations may be more important than the specific plan they offer. As Mike Tyson is famous for saying, “Everyone has a plan until they get hit in the face,” and each day in Washington brings at least body blows. But what Jeff and his colleagues have done is to aptly sketch and describe the levers that the senior manager who sets out to make fundamental change has at his disposal. He also gives a sense as to how a senior manager might integrate them to achieve better results. With the framework Jeff herein presents, a plan can be developed to meet the dynamic circumstances of the moment.

If you would seek to help solve one of our most vexing Defense problems, I highly recommend reading *Against the Odds: Driving Defense Innovation in a Change-Resistant Ecosystem*.

*The Honorable David (“Dave”) Oliver, Jr.
Rear Admiral (Ret.)
Trinidad, California*

Top Level Recommendations for the Really Busy Executive

The Problem Set. Nobody knows the source of the next major innovation with significant defense applications. There is a wide range of possibilities, traditional and non-traditional, in an era where commercial research and development (R&D) is outpacing government R&D and innovation is increasingly globalized. The question is whether the Department of Defense (DoD or the Department) can expeditiously seize these types of opportunities as they arise:

- The “next SpaceX” introduces a new system, primarily commercially developed, that has significant defense applications, and seeks to sell it to a U.S. armed service that is wholly dependent on, and wedded to, an existing system embedded in its concept of operations;
- A large U.S. IT firm develops a particular area of artificial intelligence, and DoD seeks to work with the company’s scientists and engineers on a related defense application;
- A scientist at a small laboratory in the UK develops a new electro-optic sensor a generation ahead of existing technology, but needs mezzanine funding to proceed;
- A U.S. small business develops to mid-level maturity a new high-powered solid state microwave device far better than anything available, but needs more funding to complete development; the DoD customer community responds with indifference or resistance.
- An experienced scientist in a DoD laboratory, working with exotic materials with few commercial applications, invents a new type of armor better than other solutions; it is only at the conceptual level and needs to be prototyped and tested.

The Solutions: Forcing Culture Change in a Risk Averse System. DoD leadership must ensure sustained U.S. military superiority, in a dynamic and uncertain world with multiple threats, by developing and fielding innovative nuclear, conventional and irregular warfighting capabilities. Accessing, developing, and handing off to the warfighter the best ideas from all sources, as rapidly and affordably as possible, is the key to making that happen.

Unfortunately, the current DoD ecosystem makes the types of engagements highlighted above very challenging. Wedded to its existing, and successful, operational paradigms and capabilities, the Department’s culture is inherently change-resistant to the introduction of new and innovative capabilities. DoD employs antiquated, cumbersome and slow R&D and procurement processes, and has demonstrated, time and again, an unwillingness to employ legally available non-traditional contracting and business alternatives—despite numerous calls for change by DoD leadership, Congress, business, and think tanks. While DoD’s recent focus on innovation has unleashed some additional impetus toward change, it is limited in scale and scope; the overall DoD enterprise is still slow to move.

It was an unnatural act for DoD to do business with SpaceX. Indeed, DoD only changed its launch business, after years of resistance, due to strong budgetary and congressional pressure, the firm’s perseverance, and ultimately private litigation. And, it was only the foresight of

another U.S. agency, NASA, that utilized alternative contracting methodologies to successfully develop commercial space solutions, that paved the way for a similar approach at DoD.

DoD's culture must be changed, using forcing functions as necessary, to make engagement with the next SpaceX and other sources of innovation natural rather than unnatural acts. The "new" DoD should seek out, rather than resist, new solutions.

To do this, DoD needs to adopt system-wide measures to: infuse acceptance of risk taking into an inherently risk averse culture; access all key sources of innovation (not just the latest fad); embrace, new, more agile processes and streamline existing processes; rely, wherever possible, on alternatives to traditional DoD contracting; and more rapidly transition new ideas to the war fighter.

Cultivating and nourishing innovative concepts already in the DoD ecosystem and transitioning them to the war fighter innovative concepts is as much the challenge than identifying novel ideas at the front end of the system.

Clearly, small pilot programs like the new Defense Innovation Unit Experimental (DIUx), standing alone, while useful, are not going to change the direction of, or address the systemic challenges facing, the large DoD R&D and procurement system. Put another way, a small row boat (DIUx) is not likely to reorient and change the direction of a large aircraft carrier (our perennial \$70 billion R&D budget).

While there is no silver bullet, the Department should take the following steps, among others set forth in detail below, to force, culture change in the existing DoD ecosystem:

- **Adopt an R&D Investment Strategy Balanced Between Irregular Warfare, High Intensity Conventional Warfare and Nuclear Deterrence**, and increase DoD funding by 10% to support these pressing needs. Since it is difficult to predict which technologies will pay off, DoD should maintain a diversified portfolio, with no single technology (e.g., autonomy, artificial intelligence) dominating our spending. *Speculative theories like the "Third Offset" should not serve as the basis to create an imbalanced portfolio weighted too heavily in one direction. In particular, given the likelihood that we will face a range of irregular and other low intensity contingencies in the years ahead, we should not further diminish our eroding capabilities and investments in this type of warfare.*
- **Make a Strong and Sustained Commitment to Commercial, Streamlined and Speedier Buying** (FAR Part 12, Other Transaction Authority, and other novel processes) to make it easier for the next SpaceX to do business with DoD. Commercial buying should be the default rule for new R&D and production programs in select areas, with top management approval required for exceptions. A new DoD center of excellence for commercial buying should be created to lead the way. DoD also should make leaner its acquisition processes and practices and engage with Congress where the rollback of legislation is needed; "it's too hard" should not be an excuse to avoid this long overdue action.

- **Expand and Reform DoD Modalities for Accessing Commercial Technology:** Broaden the Small Business Innovative Research Program; expand the role of venture capital in defense markets (through \$500,000-\$1 million for one or more In-Q-Tel-like funds focused on DoD problems); and fund Centers of Excellence in targeted private firms and universities to improve access to leading private sector scientists and engineers.
- **Cultivate a More Entrepreneurial DoD Culture:** Integrate the DIUx into the defense R&D ecosystem in order to generate broader systemic change; create a Prototype Fund (\$750,000-\$1 billion per annum) to serve as an onramp for commercial technologies and firms; establish a DoD-wide Technology Transition Review Board to focus decisions on whether to graduate technologies to the war fighter; require consideration of technology insertion at major milestones on acquisition programs; and require, with few exceptions, the use of open architecture on new defense systems.
- **Develop Incentives and Evaluation Metrics** to enhance the critical role of prime contractors in accessing and transitioning commercial technology.
- **Adopt a DoD Policy to Better Access and Fund, Foreign Technology** and ideas through both traditional “top down” government-to-government approaches and “bottom up” industrial cooperation. The current level of spending on foreign sources of innovation is too low, and export controls and other regulations unnecessarily limit collaboration.
- **Conduct a BRAC Exercise to Fully Evaluate DoD National Laboratories and Federally Funded Research and Development Centers,** and in the interim, cut DoD lab spending on in-house scientists and engineers by 5%. Duplication of private sector capabilities, recruitment and retention challenges facing an aging workforce, and aging infrastructure, among other issues, makes some lab downsizing inevitable; we need to begin the process of shifting resources to alternative private sector uses.
- **Incentivize Enhanced Defense Industry IR&D Activity,** including both increased industry spending and a greater focus on the force of the future (i.e., in the range of a third of all IR&D).

Key Findings and Recommendations—Still a Short Read

Generating the innovation to sustain the United States' technology-based military superiority will, of necessity, be a core element of defense strategy for the Trump Administration. This paper identifies the challenges faced by the DoD's large, multi-faceted research and development ecosystem in meeting that national security goal, and proposes a holistic and balanced strategy for addressing them.

Fundamentally, the outgoing Obama Administration concluded that the U.S. military dominance against our near-peer adversaries is eroding in a globalized environment where commercial innovation is not only being rapidly generated through agile and fast-paced processes but is being rapidly disseminated globally and therefore available to potential adversaries.

In contrast, the DoD faces the challenge of building a future force that is second to none while using internal processes that generally are overly cumbersome, somewhat antiquated and slower—processes which constrain its ability to access all available innovation, commercial and otherwise, and to rapidly transition that technology to the war fighter in order to produce robust effects on the battlefield.

Notwithstanding years of studies that have highlighted well known institutional obstacles to change in both our defense R&D ecosystem and the Department more broadly, these challenges still largely remain. Numerous DoD initiatives to address these issues and incentivize change unfortunately have not moved the needle.

It therefore is time to shake up and reshape our overall defense innovation infrastructure, using forcing functions where appropriate, in order to improve our chances of producing more robust and timely military effects for our war fighters against the broad range of threats we face.

Summary of Key Findings

In adopting a holistic and balanced innovation strategy for the new Administration, it is important to understand: whether and to what extent our vast defense R&D enterprise has underperformed to the detriment of our national security; the reasons for its underperformance; and whether the Obama Administration's Defense Innovation Initiative (DII) offers meaningful solutions.

Applying a number of relevant metrics, we found as follows:

- ***Metric 1: Has the United States Sustained a Robust Spending Stream for Defense R&D?***
The challenges faced by the defense innovation ecosystem are not, on the whole, the result of inadequate funding. Through war, recession, and even sequestration, the United States

has maintained a robust spending stream on defense R&D generally, and early stage science and technology (S&T) in particular.

- ***Metric 2: Has the United States Invested in Defense R&D Pursuant to Reasonable and Strategy-Driven Priorities?*** The DoD does not appear to have an overall defense R&D investment strategy, let alone spending aligned with that strategy. In practice, it is difficult to discern the priorities of our large defense investment portfolio, given the broad distribution of funding among numerous DoD components, projects and participants, the lack of transparency of the complex defense budget, and some degree of decentralized decision-making (which affords components the freedom to innovate). Investments tend to lurch in accordance with changing security needs as well as the changing priorities of senior DoD leadership. During the post-9/11 era, our spending “tilted” toward investments in irregular warfare and incremental improvements to our existing force for use in ongoing operations. Subsequently, and long before DII, as our operations in Iraq and Afghanistan wound down, the United States gradually increased investments in high intensity warfare and gradually decreased our investments in irregular warfare—allowing our capability for the types of low intensity conflicts we are likely to face to gradually erode over recent years.
- ***Metric 3: Has the United States Sufficiently Accessed, and Incentivized the Participation of the “Best and the Brightest” Sources of Innovation in Our Defense Enterprise?***
 - a. **Access to the Commercial Sector: An Overstated Challenge.** The recent narrative of a significant disconnect (“walls”) between DoD and the commercial sector has been considerably overstated. The degree of engagement is broad and deep and permeates numerous levels of the defense enterprise. Today commercial technology is a central and critical enabler of U.S. warfighting capabilities, and is integrated into, and often serves as the backbone of, numerous DoD platforms and capabilities. But access to commercial innovation is uneven across business sectors and limited at the front end (in the laboratories). And, the sheer speed and scope of commercial innovation, driven by 21st century business practices, may hinder DoD’s ability to keep pace with our adversaries.
 - b. **Foreign R&D: A Limited Track Record.** While R&D is increasingly globalized, DoD’s access to this vital source of innovation is nevertheless limited by a system that tends to create barriers, formal and informal, to foreign participation. Each major U.S. armed service laboratory has multiple foreign offices to seek out potentially promising ideas for research and evaluation, but this internal DoD capability is significantly underutilized in practice. In total, a small percentage of DoD R&D is spent on sourcing foreign ideas and concepts, especially in the formative stage. To ensure that the United States is able to draw upon the best ideas for new military capabilities and avoid technological surprise from abroad, expanding our access to globalized R&D is no longer a luxury but a necessity.
 - c. **Defense Labs: The Need for Realignment.** Our national defense laboratories face a number of key questions: 1) should DoD labs continue to work in technology areas where private sector firms today have robust capabilities and DoD’s capabilities are not aligned with customer needs; 2) how to address the limitations on DoD’s ability to attract and retain top level scientists and engineers, and how to cope with an aging lab work force; and 3) whether additional investment is warranted to modernize and sustain

the advanced age of a considerable portion of DoD's laboratory infrastructure. Given that a core mission of the defense labs is to perform in areas where the private sector is not engaged in solving challenging problems, the threshold question is not whether steps should be taken at existing labs to ameliorate these challenges, but whether some reallocation of resources away from our laboratories would be appropriate. Therefore, a full examination of our national defense laboratories is warranted to assess whether we are getting a sufficient return on our investment, focused on, among other things, on whether some of these capabilities replicate private sector capabilities and should be downsized, streamlined, or privatized. Available evidence suggests some realignment of the scope and size of the defense labs is warranted.

- d. **The Defense Industry: The Focus on Level and Time Horizon of R&D Investments.** Simply put, the United States is not getting a sufficient national return on our investment in the traditional defense and aerospace private sector and its many talented scientists and engineers. After a sustained period of decline, defense firms' independent R&D (IR&D) spending remains below historic levels and relevant industrial norms—although it has recently increased in apparent response to DoD encouragement. Moreover, this spending has been too focused on short term incremental improvements to the force, rather than long term innovation for the “force after next.” Shareholder pressure for the return of capital and short-term financial returns, and individual customer pressures to improve current forces, have contributed to this situation.
- ***Metric 4: DoD's Policies, Processes and Practices Reflect a Risk Averse Culture That is Slow to Embrace Innovative Change.*** The challenge is as much about the limited receptivity of DoD components to new, and in particular, disruptive technologies as it is about impediments to access for non-traditional sources of innovation. In effect, two phenomena from the business and government worlds are in play: the conservatism innate in large, successful organizations, and the reluctance of leading incumbents in economic markets to shift from the paradigm that has made them successful. While many focus on the issues inherent in DoD's complex acquisition system (and they do exist), the cultural resistance to change is a reflection that the U.S. Armed Forces are organized around longstanding operating paradigms and military capabilities that have proven successful; these excellent fighting forces tend to resist disruptive change that threatens existing paradigms in favor of incremental improvements in existing capabilities. DoD's reluctance to embrace change is also reflected in:
 - a. A longstanding reluctance to aggressively utilize the flexible authorities, tools and processes available to it to bring new technologies and non-incumbent suppliers into the defense ecosystem, including its commercial contracting procedures, Other Transaction Authority (OTAs) and open architecture policies and procedures. Budget constraints and detailed congressional oversight (some might say micro-management) contribute to DoD's unwillingness to deviate from traditional Federal Acquisition Regulation (FAR)-based contracting and take the risks inherent in adopting alternative methodologies. These are the attitudes and inflexibilities, perhaps reflecting innate resistance to change, that have made it difficult for innovative commercial firms—like SpaceX to business with the Department.

- b. The well documented difficulty in graduating new technologies from the laboratory to the war fighter. While more developmental prototyping and experimentation could help address this dilemma and graduate more new ideas from S&T to production, there has been insufficient funding to meaningfully execute this agenda.
 - c. DoD's sustained lack of interest in utilizing venture capital or other similar models for engaging with high tech startups and the new technology that they can offer.
- **Metric 5: Outputs of Innovation.** Over a sustained period, the DoD R&D ecosystem has produced significant, if not often *breakthrough*, innovation in many technology areas. This may not be dramatic “game-changing” innovation, but it is more typical of the pace of military innovation, adding incrementally to capabilities and creating opportunities for “horizontal innovation” at the tactical and operational level (where real, and more lasting “offsets” are likely).

Summary of Recommendations

How to Drive Change—What Model Makes Sense

The overarching question is how to drive change in an inherently change-resistant culture.

Adopt a Wholesale New System. One option is to abandon the existing acquisition system, and/or create an entirely new and “better” system for the acquisition of some types of commercially oriented capabilities, based on more speedy and agile commercial processes. The dilemma is the difficulty in determining what a new, more effective system would look like. History teaches that shaping a new system to address all relevant equities would be difficult; starting fresh also would throw out the lessons learned over recent years, some of which have begun to bear fruit in the form of lower cost growth on major programs.

A Hybrid Model of Systemic Change—Shake Things Up But Don't Start Anew. Multiple Administrations have adopted persuasion-oriented reform efforts designed to encourage or incentivize change—policy memoranda, carrots and sticks, development of tools for acquisition executives, and the like. Unfortunately, they have been ineffective in bringing change to an overly rigid and reluctant acquisition system.

Accordingly, the new Administration should adopt a different approach: generating forced culture change in the existing system through a series of default mechanisms, or forcing functions, designed to: create varied, non-traditional onramps for commercial technology; adopt more agile and time-sensitive commercial processes to the fullest extent possible; and more broadly and rapidly incorporate innovative concepts into fielded solutions. Among other things, this approach would require the expanded use of flexible, alternative acquisition approaches, subject to limited exceptions to be reviewed, through escalation measures, by senior acquisition executives.

Over time, gaining more experience with these novel approaches will allow us to assess what works and does not. In the long term, these early actions may result in a new system, at least for commercially oriented capabilities—but one built on experience rather than out of whole cloth today.

Core Principles and Realities

Within this overall framework, the R&D ecosystem should be reshaped in accordance with the following principles:

- **A Sustained Leadership Commitment to Change.** DoD leadership should infuse more risk-taking into the R&D ecosystem and change the culture to one that embraces new, more agile processes, new technology paradigms, and new operational constructs.
- **Address Systemic Challenges with Systemic Rather Than Piecemeal Solutions.** The focus should be on challenges that permeate the system: accessing all potential sources of future innovation; streamlining the transition of innovation from the lab to the war fighter; and incorporating more agile, speedier practices into the DoD ecosystem. Since the challenges are system-wide, the solutions should be as well. *We need to reorient the direction of our roughly \$72 billion defense R&D enterprise—the equivalent of turning an aircraft carrier.*

While DII has unleashed and catalyzed some change, it has not sought to, nor in practice addressed, the challenges facing the overall enterprise. DII's small scale experiments like the recently established Defense Innovation Unit Experimental (DIUx), however useful, will not solve or address the underlying institutional issues identified herein. In laymen's terms, you can't move a carrier with a rowboat.

- **Since We Do Not Know Where the Next Technological Breakthrough Will Come From—The Vibrant Commercial Sector, DoD Labs or Elsewhere—the Strategy Should Cover All Possible Bases and Make Bets on All Relevant Sources of Innovation.** The very ubiquity of commercial innovation may limit the private sector's ability to create game-changing military offsets or overmatches. It is just as plausible that exotic defense-unique solutions or applications of commercial technology will come from our labs or traditional defense firms.
- **There Are No Silver Bullet Solutions.** Different approaches will be needed for facilitating innovation and the insertion of commercial technology in large defense systems and platforms, subsystems, and components. Similarly, different approaches are needed at different points in the acquisition system, with more risk taking easier in early stage R&D and more difficulty in later phases where there is a necessary focus on affordability and schedule).
- **DoD Cannot Entirely Become Like Google.** While we need to speed up and streamline DoD's internal acquisition processes, borrowing from commercial models wherever we can, there nevertheless are inherent limitations to the commercialization of defense demand. The unique aspects of national security missions and requirements and fundamental differences in business models ultimately limit the ability of DoD to act entirely like a Silicon Valley startup. Even startups must mature and transition from being purely innovative to having stable, revenue-generating product lines.

Requiem for the Third Offset

In shaping its new strategy, the Trump Administration should seriously consider leaving aside the Third Offset paradigm. While it has been a constructive tool for focusing on the need

to innovate and maintain our military edge, as a true construct of a technology-based military strategy for the future, it is at best a speculative theory—one group of investments among many, centered on autonomy and artificial intelligence, that may or may not pay off. We should not allow this theory, to create an imbalance in our diversified R&D investment portfolio and short-change a focus on the types of irregular warfare we are more likely to encounter in the foreseeable future.

Indeed, the very premise of the Third Offset—that the spread of advanced technology is eroding U.S. military superiority—makes it dubious that a set of ubiquitous, commercial-based technologies (like autonomy) could provide a sustained qualitative advantage over our potential adversaries. Moreover, the implications of the Third Offset for defense priorities is problematic. *Simply put, now is not the time to further shift investment away from the types of irregular and other low-intensity forms of warfare we are likely to fight in the foreseeable future.*

Actionable Recommendations

- **Adopt a Strategy-Driven DoD R&D Investment Portfolio Balanced Between Irregular Warfare, High Intensity Conventional Warfare and Nuclear Deterrence**
 - Develop a strategy for force development, derived from an overall national security strategy, which can be utilized as a roadmap for R&D development.
 - Increase DoD's Research, Development, Test and Evaluation (RDT&E) funding by roughly 10% to support a balanced R&D portfolio across the broad range of pressing needs and ensure that, as in the past, the lack of funding does not hamper our ability to maintain our military superiority.
 - Conduct a top down review of gradually declining U.S. irregular and other low-intensity war fighting capabilities to ensure we have the right doctrine, organization, training, equipment, and investments for these types of engagements—which, if past is prologue, are likely to be a major feature of the landscape in the years ahead.
- **Assess and Realign the DoD S&T Portfolio with a Balanced Investment Strategy**
 - Conduct a top-down effort to fully understand the existing R&D investment portfolio
 - Adopt a corporate model of investment decisions made by a top level committee
 - Maintain a diversified portfolio with potential payoffs, and do not allow any single technology area (e.g., autonomy, artificial intelligence) to dominate our spending unless there is demonstrable evidence, not just theory, that this focus is warranted.
- **Make a Strong and Sustained Commitment to Commercial Buying Processes—to Make It Easier for the Next SpaceX to Do Business With DoD**
 - Recommit to FAR Part 12 commercial item buying, and streamline its practices and processes; traditional standards, such as certified pricing or cost data (or its equivalent), should not be required for commercial buying.

- Establish a rebuttal presumption of commercial buying (i.e., the use of OTAs, commercial item authority or streamlined FAR-based buying) in R&D and production programs in designated product areas, which can only be overcome for compelling reasons; exceptions are subject to approval by a senior DoD acquisition executive.
- Establish a DoD-wide commercial center of excellence and develop best practices and processes in the use of OTAs, Commercial Item Buying and Other Non-Traditional Contracting Approaches.
- Require that DoD components take into account the need for competition and participation by non-traditional suppliers in shaping long-term acquisition strategies.
- Consistent with the President's new regulatory reform initiatives, DoD should, within the next three months, take steps to make leaner its acquisition-related processes and practices, including the streamlining of requirements for major acquisition systems and audit functions to test compliance with DoD's cost accounting standards and other DoD contractual standards.
- **Expand and Reform DoD Modalities for Accessing Commercial Technology**
 - Broaden DoD's Small Business Innovative Research Program (SBIRs) size standards and expand the level of funding for single grants to facilitate the full development of ideas capable of being transitioned to the war fighter.
 - Reform the DoD requirements process to facilitate the use of commercial technology.
 - Expand the role of venture capital in defense markets, providing \$500 million-\$1 billion for one or more funds that would, in coordination with DoD, make equity investments, loans and the like. The fund(s) would consider successful SBIRs participants for funding to aid the transition of their concepts to the war fighter.
 - Create funded centers of excellence in targeted firms and universities to ensure DoD access to leading private sector scientists and engineers.
- **Adopt a Series of Measures to Cultivate a More a Risk-Taking, Entrepreneurial DoD Culture and Better Facilitate Transition of Technology to the War Fighter**
 - Integrate the DIUx into the defense R&D ecosystem, de-conflict its mission with other DoD R&D units, scale up its activities and expand its funding to \$250 million in order to better leverage its resources and incentivize collaboration with other DoD R&D units and customers.
 - Create a Prototyping Fund with funding in the range of \$750 million-\$1 billion per annum, and set aside a significant portion of the Fund, to be managed by DIUx, as an onramp for commercial technologies and firms, using competition as appropriate.
 - Establish a senior, DoD-Wide, Technology Transition Review Board to ensure focused decisions on whether to graduate technologies to the war fighter—to help *force* the next SpaceX type offering through a reluctant system.
 - Require focused consideration of technology insertion at all major milestones on ongoing acquisition programs.

- Require that new defense systems be designed and implemented with open architecture absent a finding that it is contrary to the public interest, which finding is subject an override by the relevant DoD senior acquisition executive.
- **Develop Incentives and Evaluation Metrics to Enhance the Critical Role of Prime Contractors in Accessing and Transitioning Commercial Technology**
 - Require prime contractors to submit Commercial Technology Plans in response to Requests for Proposal (RFPs)—just as they prepare small business plans.
 - Require primes to adopt a presumption in favor of commercial buying (OTAs, commercial item authority or similar approaches) in areas where commercial capability is better value, with exceptions subject to review and approval by DoD.
 - Add new evaluation metrics in RFPs on commercial technology gathering and the use of open architecture, and require that primes provide relevant past performance data.
- **Adopt a DoD policy to better access and fund promising foreign talent and ideas through both traditional “top down” government to government approaches and “bottom up” industrial cooperation between U.S. and foreign parties**
 - Increase funding for (Science and Technology (S&T) international engagement by \$250 million so that DoD can get a sufficient return on its sizable S&T international infrastructure.
 - Create a DARPA Early Stage Foreign Innovation Window to access foreign innovation not mature enough for the Foreign and Comparative Test Program.
 - Expand funding for the existing Coalition Warfare Program to \$500 million and add a focus on prototyping in order to strengthen our efforts to work with allies on advanced coalition capabilities and leverage the contributions of foreign partners.
 - Create a program to have foreign scientists and entrepreneurs in residence for 1-3 year periods at U.S. universities, private sector firms, DoD laboratories and other appropriate venues to pursue work on a collaborative basis with U.S. counterparts.
 - Make a concerted effort to draw on Japanese commercial technologies through using all the commercial buying tools and authorities available to DoD (while addressing U.S. concerns over Japanese technology security in a practical fashion).
 - Undertake technology transfer reform to support this agenda, including streamlined export licensing, broader release policies vis-à-vis close allies, and the elimination and consolidation of various DoD committees that oversee technology transfer.
- **Conduct a BRAC-Type Exercise to Evaluate DoD’s National Laboratories and Federally Funded Research and Development Companies (FFRDCs)**
 - Consider downsizing, streamlining, and privatization in order to address duplication with private sector capabilities and workforce issues (recruitment and retention challenges as well as reliance on an aging workforce).

- Immediately cut laboratory S&T spending on scientists and engineers by 5% to make a down payment on inevitable downsizing and accelerate the process of shifting resources to alternative S&T activities in the private sector.
- **Incentivize Enhanced Defense Industry S&T Activity**
 - Encourage greater defense industry spending on IR&D in order to bring industry levels in line with historic and comparable industrial norms.
 - Create a rebuttable presumption that defense firms will spend at least 1/3 of their IR&D spending on the longer development of the force of the future rather than short-term incremental development or customer directed development.
 - DoD should provide top-level guidance to industry on key areas for investment that can override short-term customer pressures that often shape IR&D spending.

Framing the Innovation Challenge

Over recent years, the defense innovation challenge has become more urgent as the senior U.S. defense leadership, civilian and military, has signaled that the longstanding U.S. technological military superiority or “offset” over our adversaries—a central tenet of U.S. national strategy since World War II—is now at risk.¹

While the formulations have varied somewhat—from our margin of technological superiority is “eroding” to is “at near term risk, or, as Deputy Secretary of Defense Robert Work recently put it, is “slowly eroding”—the underlying message of U.S. defense leaders is the same. Specifically, U.S. defense leaders have argued that the long-standing U.S. dominance in precision weapons, based on advanced microelectronics and information technology, is receding as these and other advanced technologies, many from the commercial sector, proliferate and becoming available to our potential adversaries.²

In response, the Obama Administration adopted the DII, the principle objective of which was development of a new “Third Offset” to sustain our overmatch against high end adversaries into the foreseeable future. As it has evolved, DII has included several distinct lines of effort:

- New and innovative leadership approaches and efficient business practices
- Reinvigorated war gaming to test alternative ways to achieve strategic objectives
- New operational and organizational concepts
- Efforts to better access innovation from our thriving commercial sector

¹ While beyond the scope of this essay, one can debate whether there has been a general erosion of U.S. military superiority although there may be some select areas where the U.S. margin of superiority has decreased. In core areas—such as combat aircraft and unmanned aerial vehicles, naval combatants and weapon systems, ground combat systems, and major intelligence, reconnaissance and reconnaissance (ISR) systems—the United States remains second to none in technical capabilities, sheer numbers, and the ability to effectively integrate these capabilities into our forces. Accordingly, in any direct, broad scope, conventional confrontation, it is difficult to believe that our unique and large combination of lethal, networked systems and platforms—with a panoply of strike and defensive systems—would not be dominant. Moreover, U.S. economic power should not be dismissed from the equation. Building a large, robust conventional warfare capability is prohibitively expensive, which is why so few countries even try. For a full discussion of this issue, see Jeffrey P. Bialos and Stuart L. Koehl, “What America’s Big New Defense Plan Gets Wrong, *The National Interest* (June 2, 1016). Available at: <http://nationalinterest.org/feature/what-americas-big-new-defense-plan-gets-wrong-16421>.

² Deputy Secretary of Defense Robert Work, Speech, National Defense University Convocation (Washington, D.C. Aug. 05, 2014) (In the years since the dominant U.S. military performance in Iraqi Operation Desert Shield, other nations have studied U.S. technological superiority and “set about devising ways to compete. Today, many of these earlier innovations ... have proliferated widely” and have become available to our adversaries. Thus, “our forces face the very real possibility of arriving in a future combat theater and finding themselves facing an arsenal of advanced, disruptive technologies that could turn our previous technological advantage on its head—where our armed forces no longer have uncontested theater access or unfettered operational freedom of maneuver.”). Available at: <http://archive.defense.gov/Speeches/Speech.aspx?SpeechID=1873>

The elements of the DII also reflected the senior DoD leadership's view that developing technology alone is not the answer, but that we must "be able to incorporate those technologies into new operational and organizational constructs."³ DoD also has rightly focused on the need to engage more in prototyping in order to generate new demonstration capabilities and test them and work with them to ascertain how, if at all, they fit in new operational or organizational constructs.

A. Begging the Fundamental Question: Has the DoD R&D Enterprise Underperformed?

While focusing their attention on the diagnosis—the perceived erosion of our longstanding military dominance, senior Defense Department officials have largely begged a fundamental underlying question: why has our vast Defense Department research and development "enterprise" (or ecosystem) failed to produce, over a sustained period, the breakthrough technologies that will maintain our qualitative edge for the future? Thus, the focus of this essay is on whether and why the DoD innovation ecosystem has failed us.

The DoD research and development enterprise is complex and variegated—one can think of it as a multi-tiered cake with different flavors, textures, and fillings, and varying degrees of connections between the layers. As shown on Figure 1, it includes among its elements:

- The numerous DoD-owned and operated laboratories and the Defense Advanced Projects Research Agency (DARPA)—together, considered the front end of our innovation enterprise
- R&D components throughout the Department (commands, program offices, and the like spread across services and other DoD units)
- Federal Funded Research and Development centers (FFRDCs)
- Private and public universities that participate in DoD R&D, typically through grants and participation in numerous DoD-sponsored public-private consortia
- The vibrant private sector, including not only the traditional defense and aerospace sector but the broader commercial sector and small businesses

Curiously, in its many statements on DII, DoD leadership has barely mentioned our multi-faceted defense R&D enterprise, with its hundreds of thousands of scientists and engineers and annual budget in excess of \$72 billion, let alone given any assessment of the underlying problems, if any, hindering its performance.

³ Charles Hagel, Secretary of Defense, "Memorandum: The Defense Innovation Initiative," Office of the Secretary of Defense (Washington, DC), November 15, 2014. Available at <http://archive.defense.gov/pubs/OSD013411-14.pdf>.

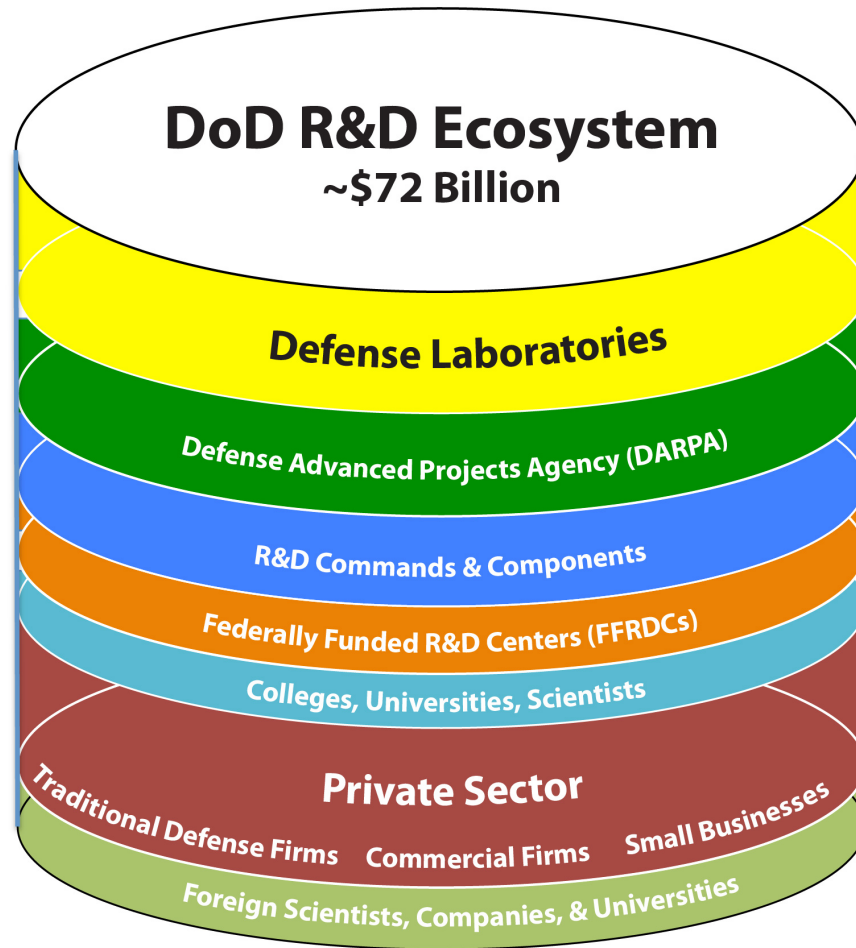


Figure 1. DoD Research and Development Enterprise

The only real focus on the existing R&D ecosystem has been the perceived disconnect between our defense establishment and our commercial high tech centers. As then-Secretary of Defense Ashton Carter stated on numerous occasions, there are “walls” between DoD and our “commercial and scientific” sector that “we need to drill holes in....”⁴ To be sure, commercial firms have long complained about arcane DoD acquisition rules and policies that they believe inhibit their ability to do business with the Department. In effect, this and other statements reflect the view that the DoD R&D enterprise have failed to sufficiently attract the best available ideas and talent from the commercial and technology sector.

The Obama Administration’s proposed solutions were largely “outside the box” new offices and pilot programs, primarily kept separate and distinct from the existing RDT&E

⁴ Secretary of Defense Ashton Carter, “Rewiring the Pentagon: Charting a New Path on Innovation and Cybersecurity” (“Rewiring the Pentagon Speech”), The Drell Lecture, Stanford University (Palo Alto, Ca. April 23, 2015). Available at: <https://www.defense.gov/News/Speeches/Speech-View/Article/606666/drell-lecture-rewiring-the-pentagon-charting-a-new-path-on-innovation-and-cyber>.

system. Chief among the Obama experiments is the recently created DIUx. With offices in Silicon Valley, Boston and San Antonio, DIUx is intended to forge relationships between DoD and non-traditional sources of defense innovation. An independent DoD unit reporting directly to the Secretary of Defense, DIUx stands separate from the rest of the defense R&D system. As a pilot program, DIUx is designed to explore innovative acquisition approaches and offer them as tools and examples for the ecosystem at large to adopt as appropriate.

In effect, through their silence and “outside the system” approaches, DoD’s leadership have signaled their concerns over the effectiveness of the existing R&D enterprise—causing consternation among its leadership, and scientists and engineers throughout government, nonprofits, and industry.⁵ By implication, the current DoD R&D ecosystem is innovation challenged. Significantly, however, no broad, systemic efforts have been made to effect structural changes in the system defense R&D ecosystem itself.

Put another way, if our current approximately \$72 billion defense R&D enterprise has problems, why not directly fix them and “drill holes” in walls between DoD’s existing system and our commercial and scientific sector rather than create an entirely new structure outside of the enterprise?

The Analysis: Steps for Shaping a Strategy to Meet the Innovation Challenge

Thus, in setting an innovation strategy for the next Administration, it is important to understand whether and to what extent this vast enterprise is broken and underperforming to the detriment of our national security; and, if so, whether the DII offers meaningful solutions. As discussed herein, there are several important questions that warrant examination:

- What metrics are appropriate to evaluate the success of our defense innovation enterprise, public and private, and is the ability to produce a generational offset the correct measure of success?
- Under applicable metrics of innovation inputs and outputs, is our defense ecosystem’s innovation performance up to par?
- Does the DII constructively address the structural deficiencies in our defense ecosystem, if any?
- What, if anything, can and should be done beyond the DII to reshape and redirect this massive R&D enterprise to produce better and quicker, if not game changing, results for the future?

⁵ See, e.g., Munsil, Leigh, and Ewing, Philip, “Pentagon’s Silicon Valley Push Angers Defense Contractors,” *Politico* (July 17, 2015). Available at: <http://www.politico.com/story/2015/07/pentagon-outreach-to-silicon-valley-stirs-a-fuss-120177>

B. Identifying Sensible Metrics to Assess the Performance of the DoD R&D Enterprise

i. Offsets as Outliers—Not a Useful Metric

Notwithstanding the intensive focus on offsets, it does not make sense to use the ability to produce military game changers as a metric of the effectiveness of our defense R&D ecosystem.

True offsets or game-changers in defense technology are rare events—most innovations are incremental and evolutionary in nature rather than revolutionary. History teaches that true technological revolutions in military affairs are few and far between: the use of the horse, the development of the composite bow, and the introduction of iron weapons, firearms and nuclear weapons. These represent true step discontinuities that changed the face of warfare in profound ways.

Almost all other military innovations have been largely incremental in nature.⁶ Evolutionary innovation usually takes time, during which tactics, equipment and operational concepts change iteratively and gradually. History shows that the degree of innovation, year-over-year, is likely to be small, but cumulative sum of those changes can have an impact depending on how they are assimilated by the military organization into its structure and operations.

Indeed, looking ahead, the notion we can develop an across-the-board, game-changing Third Offset seems unrealistic, due to the broad range of threats we face (making it unlikely that one or several technologies can produce a universal overmatch), and the global proliferation of advanced technologies that DoD believes is reducing our existing military edge.

Throughout history, technological innovation has seldom provided more than a transient tactical or operational advantage. Ironically the very reasons that DoD cites for the apparent erosion of the U.S. overmatch in the first place—notably, the proliferation of advanced technologies—make obtaining and sustaining another broad spectrum overmatch in the future unlikely. Any offsets will likely be fleeting, and given the time needed to bring new technologies from the laboratory to the field, one must constantly be seeking new offsets because the current one would likely be out of date soon after it is deployed.

Directed Offsets as the Antithesis of the Messy Innovative Process. Additionally, the notion that the United States can, in advance, target a developmental area as an “offset” and then proceed to implement it appears contrary to the general nature of the innovative process. It implies that innovation is top down rather than bottom up, which is largely not consistent with

⁶ For a full discussion on military innovation, see Williamson Murray and Allen R Millet, eds., *Military Innovation in the Interwar Period* (“Military Innovation”), Cambridge University Press (Cambridge) 1996 (“In most cases, such innovation is evolutionary, rather than revolutionary in nature. In fact, . . . revolutionary innovations are the exception.”)

the historical record.⁷ In fact, it is hard to know where innovation may even come from. *To suggest that we even can come close to identifying, in advance, with any clarity or reasonable probability, an offset and then go and develop it, is a dubious proposition.*

Indeed, top down efforts to innovate can have adverse implications, as organizational leaders attempt to direct research and development into preconceived concepts that may be operational or strategic dead-ends.⁸

In fact, innovation broadly conceived (including incremental as well as leap ahead developments) is a messy, non-linear process, which percolates from the bottom up more often than it is directed from the top down. It often involves junior officers and scientists who are encouraged to experiment and “think outside the box” and even risk failure. It typically involves much experimentation, trial and error, some degree of serendipity—ultimately risk taking and some failures (i.e., numerous investments that do not pan out).

Innovation also can be driven by necessity and the presence of clear cut threats. It tends to accelerate rapidly in wartime, as military officers need to find solutions to pressing tactical and operational needs—which tends to eliminate barriers between operational and technological communities. The United States observed this during the Iraq insurgency, where small fighting units were finding their own solutions to problems of mines, snipers and Improved Explosive Devices. When peace returns, and the system falls back to its regular acquisition methodologies, innovation tends to slow down.

Thus, in periods of relative peacetime with a range of prospective, theoretical threats, it is more difficult to identify strategic priorities. R&D in these periods thus tends to be somewhat more scattershot.

ii. Relevant Innovation Metrics

Then, what should be the metrics to rely on, in evaluating the effectiveness of our S&T enterprise? While there are varied views on this subject, there is a general consensus that it is important to look at both “inputs” into achieving innovation as well as innovation “outputs”—are we getting a sufficient return on our investment—to assess whether we have been proper stewards of the ecosystem.⁹

In a DoD context, the following metrics appear appropriate and are used herein:

⁷ Military Innovation, *supra* n.7, at 265–299.

⁸ *Id.* at 306–308.

⁹ See generally Background Paper on “R&D and Productivity Growth,” Congressional Budget Office (June 2005). Available at: <https://www.cbo.gov/sites/.../06-17-r-d.pdf>.

Metric 1	Levels of Defense Investment	Have we been investing enough in R&D?
Metric 2	Investment Priorities	Are they reasonable, balanced, consistent with our defense strategy, and being effectively executed?
Metric 3	Access to Sources of Innovation	Is DoD sufficiently accessing, and incentivizing the participation of, the “best and the brightest” in our defense ecosystem and broader technology sectors—the mostly likely and dynamic sources of innovation that can enhance our defense capabilities?
Metric 4	DoD’s Organizational Structures, Processes and Practices	Do they facilitate speedy and robust innovation?
Metric 5	Innovation Outputs	Can the defense ecosystem sustain ongoing, significant innovation across a range of defense sectors to produce meaningful, fielded military capabilities relevant to maintaining our military advantage?

Examining the Defense R&D Ecosystem Writ Large—Not Just the Science and Technology Enterprise. The development of innovative capabilities is a process that occurs throughout the entire defense investment enterprise—from front end laboratories studying basic science to program offices doing advanced system development and prototyping to the insertion of new, innovative capabilities into systems in later stages of development or already in production.

Of course, cutting edge, breakthrough innovation often is produced more in the front end of the system than in late stage development and production, where the central issue is typically managing mature technologies to achieve affordability or add incremental, new capabilities. Thus, the focus of this examination is on the range of R&D capabilities of DoD and the transition of new technologies to meaningful capabilities.

I.

Metric 1: Has the United States Sustained a Robust Spending Stream for Defense R&D?

Through war, recession, and even sequestration, the United States has maintained a robust spending stream on defense research and development generally, and early stage science and technology in particular.¹⁰ While there have been ups and downs, they have been modulated, and, most significantly, the U.S. has not radically cut R&D spending during periods of fiscal constraint.¹¹

A. Total Defense Research and Development

Figure 2 shows that between 1976–2016, overall Defense Department spending on research and development, as reflected in the Department’s (RDT&E) budget, has grown modestly in constant dollars, by a compounded annual growth rate (CAGR) of 2% (versus 1% for the DoD budget as a whole). A post-Vietnam downturn was followed by the Reagan build-up of the 1980s, and a decline during the post-Cold War “peace dividend” of the 1990s gave way to the post-9/11 ramp-up to fight the wars in Iraq and Afghanistan.

¹⁰ In the absence of objective standards for evaluating what levels of R&D spending are appropriate, the analysis herein looks at the levels of various types of R&D spending in historic terms (i.e., asking if we are spending on R&D in a manner consistent with historical norms). A very recent Congressional Research Service report identifies possible standards or benchmarks based on various sources, including a 1998 Defense Science Board Task Force Report. See John F. Sargent Jr., “Department of Defense Research, Development, Test, and Evaluation (RDT&E): Appropriations Structure,” Congressional Research Service (December 13, 2016). Available at: <https://fas.org/sgp/crs/natsec/R44711.pdf> (citing Defense Science Board, Report of the Defense Science Board Task Force on Defense Science and Technology Base for the 21st Century (June 1998)). The benchmarks noted therein include: for RDT&E, 14% of total annual DoD spending (based on similar ratios in other industries like pharmaceuticals); for S&T, somewhere between 2.4% of total DoD funding (similar to the ratio in high tech industries) and 3%, or in the range of 20-24% of RDT&E (based on high tech industries); and for Basic Research, 20% of S&T (basis unknown). One can debate the merits of any of these possible standards. For one thing, using total DoD spending as a baseline is questionable as such spending can change measurably due to cost of operations, munitions replacement and changing force size—factors not directly related to R&D spending. *Id.* at p. 11. In all events, even assuming these metrics are appropriate, DoD’s RDT&E, S&T and Basic Research spending is reasonably consistent with them.

¹¹ The data herein does not include data for classified programs, which is likewise sizable but not publicly available. According to open sources, the National Intelligence Program (NIP) had a budget of more than \$50 billion in FY 2015; if only 5% of this was devoted to S&T, it would amount to more than \$2.5 billion. When Edward Snowden leaked the FY 2013 NIP budget briefing, it showed the CIA (just one of several intelligence agencies) spending 1% of its total budget on Research & Technology, or roughly \$140 million. The National Reconnaissance Office (NRO) spent 4% of its budget on R&T, equivalent to \$400 million. The National Security Agency likewise spent 4% on S&T, for another \$400 million. Since this budget briefing is by no means complete, one can safely say that classified intelligence programs add at least \$1 billion to U.S. national security S&T. DoD classified programs are carried on the books of the RDT&E budget, but are either code-named or simply called “Undisclosed Programs”).

Notably, while the post-9/11 wartime bulge in spending has receded, overall RDT&E spending is still at a relatively high level in historic terms. Notwithstanding sequestration, the reduced levels of defense R&D in 2013–2015 were still higher (in constant dollars) than in *any* other years since 1953, other than the wartime surge of 2003. For 2017, DoD has proposed a modest increase in research and development spending to \$71.4 billion.

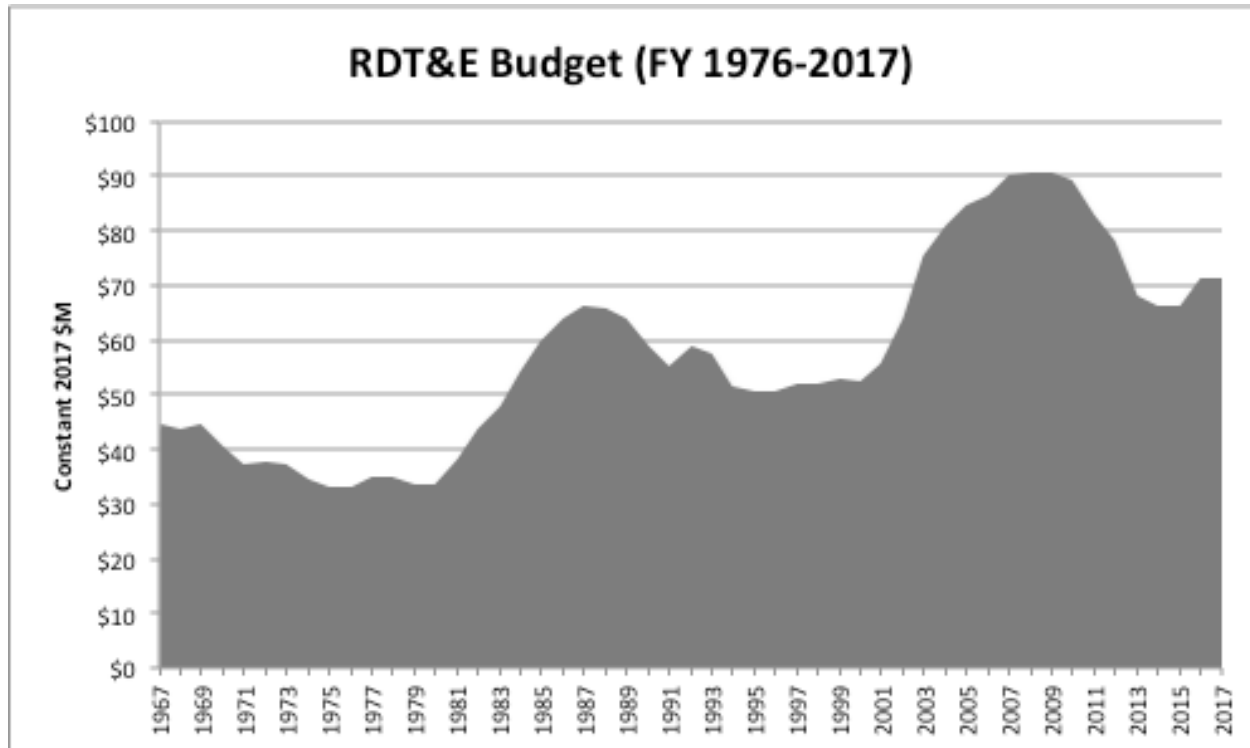


Figure 2. U.S. RDT&E Budget, FY 1976–2017¹²

B. Defense Science and Technology Spending—for the Future Force

Similarly, the United States did not shortchange the portion of its defense RDT&E budget focused on front end science and technology (i.e., generating the innovation needed for the force of the future) in either absolute terms or relative to the funding levels for development of systems to be fielded in the near term (the forces of today and tomorrow).

Specifically, the RDT&E budget is divided into a set of six different “accounts” or “Budget Activities” (BA), with science and technology spending centered on BAs 1-3, which include Basic Research (BA-1), Applied Research (BA-2) and Advanced Technology Development (BA-

¹² Source: President’s Biennial Defense Budget Submission, FY 2017.

3).¹³ BAs 4-6, cover the expenditures needed to taking concepts and developing them into fielded weapons systems, including development of advanced components, systems, and the testing and evaluation needed as part of that process. Specifically, BA-4 covers demonstration and validation and BA-5 covers engineering and manufacturing development, and BA-6 covers sustainment of fielded systems.

In this context, Figure 3 shows that the absolute level of spending on the DoD S&T enterprise (BA-1, 2 and 3) has remained high by historical norms despite a modest downturn during sequestration. Moreover, in percentage terms, S&T spending is well within historic norms; it constitutes 17% of RDT&E today and has been in the range of 15–21% for twenty years (see Figures 3 and 4).

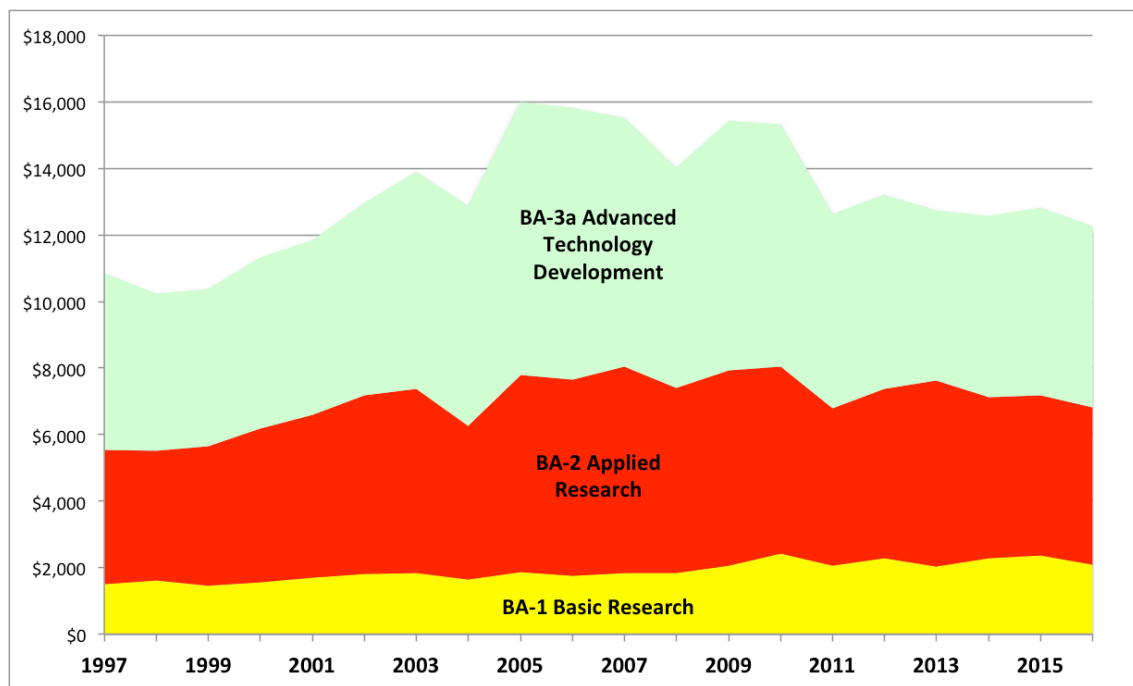


Figure 3. U.S. Basic & Applied Research & Adv. Technology Dev. FY 97-17 (2016 \$M)¹⁴

¹³ For full definition of these appropriation categories, see DoD Financial Regulation, Volume 2 (B), Chapter 5 generally (Research, Development, Test and Evaluation Appropriations). Available at: http://comptroller.defense.gov/Portals/45/documents/fmr/archive/02barch/02b_05old.pdf.

¹⁴ Source: Department of Defense Biennial Budget Submissions.

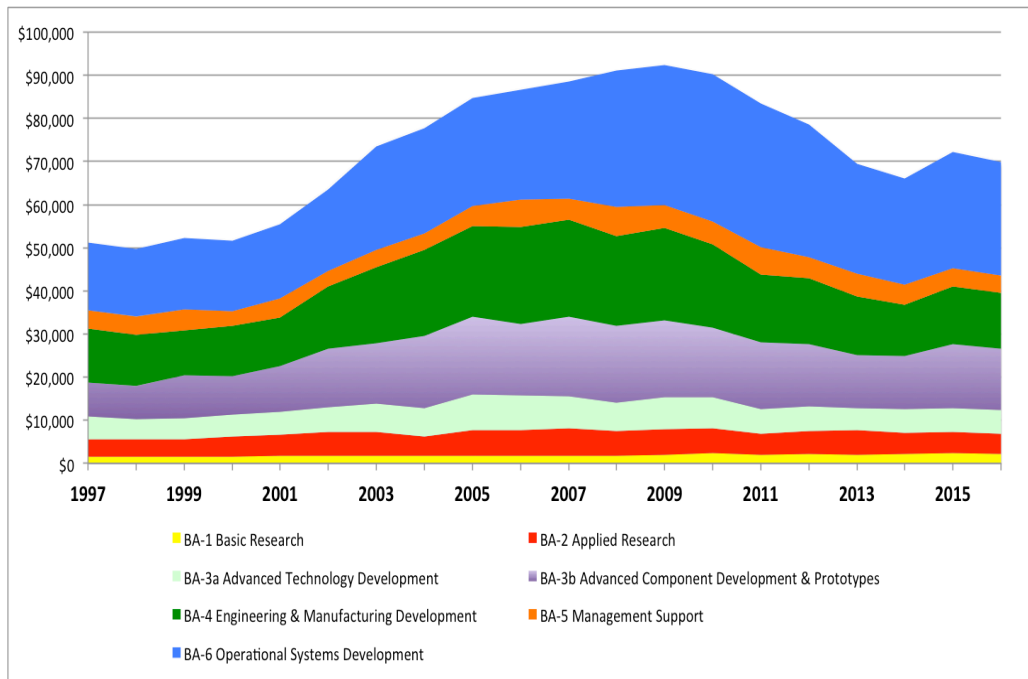


Figure 4. U.S. Defense RDT&E, FY 1997-2016 (Constant 2016 \$M)¹⁵

C. Overall U.S. R&D Spending

Finally, under virtually any meaningful metric, overall U.S. research and development spending generally (including all sources, public and private) continues to be robust and has increased significantly over a sustained period—fueling U.S. innovation, as shown in Figure 5 below. Total U.S. R&D spending as a percent of GDP also has stayed within a range of 2.4–2.8 per cent over most of the last half century, as shown on Figure 6 below.

While U.S. government R&D spending has declined as a percentage of GDP, the enormous overall growth in total U.S. R&D (both federal and private sector) offsets this decrease. Indeed, in real terms, private sector R&D has grown enormously in that period—dwarfing the growth of federal R&D.

¹⁵ Source: Department of Defense Biennial Budget Submissions.

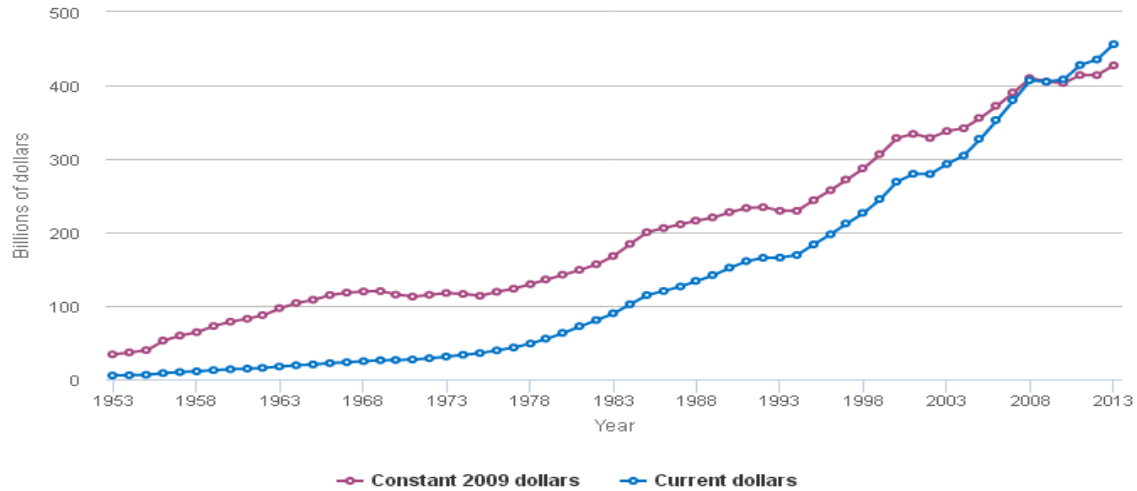


Figure 5 U.S. Total R&D Expenditures 1953-2013¹⁶

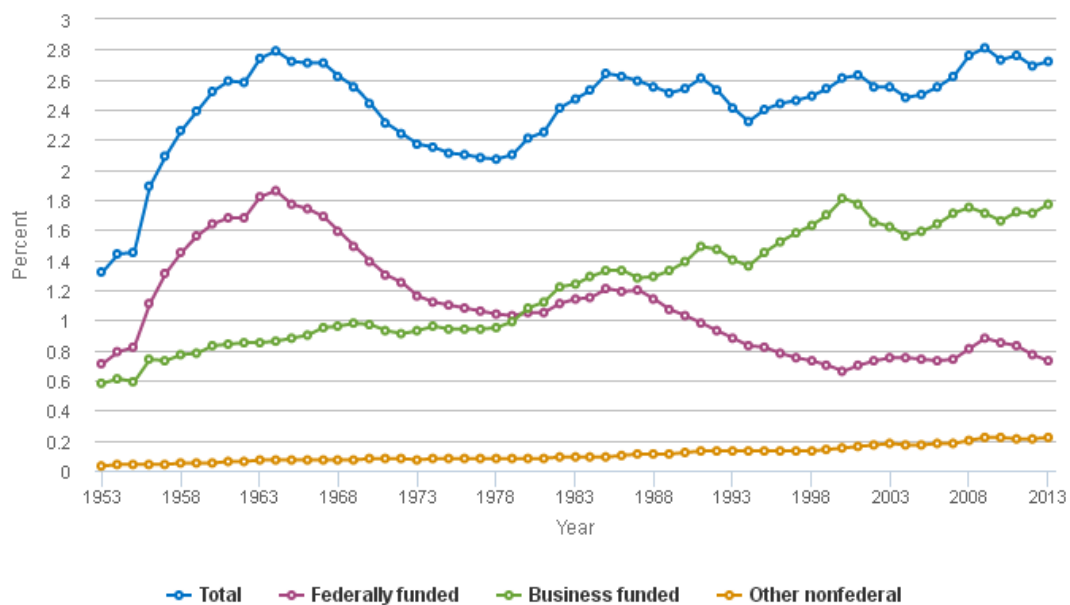


Figure 6 Ratio of U.S. R&D (Total) to GDP, 1953-2013¹⁷

¹⁶ Source: National Science Foundation, Science and Engineering Indicators 2016, Patterns of R&D Resources (annual series). Available at: <https://www.nsf.gov/statistics/2016/nsb20161/#/report/chapter-4/recent-trends-in-u-s-r-d-performance>. Note that data for 2013 included some estimates and may have later been revised.

¹⁷ Source: National Science Foundation, Science and Engineering Indicators 2016, National Patterns of R&D Resources (annual series). Available at: <https://www.nsf.gov/statistics/2016/nsb20161/#/report/chapter-4/recent-trends-in-u-s-r-d-performance>. Note that data for 2013 included some estimates and may have later been revised. The "Federally Funded" data reflects the federal government as a funder of R&D by all performers; the "Business Funded" data have a similar function for the private sector. The "Other" nonfederal category includes R&D

D. The U.S. as a Global Defense R&D Leader

Finally, U.S. defense R&D funding is an order of magnitude (or more) greater than near-peer competitors such as Russia and China as well as our allies and all other nations. Today, as shown on Figure 7, U.S. defense R&D funding, at roughly \$14.3 billion, accounts for almost half of global defense R&D. By way of comparison, the UK spends barely \$2.4 billion on defense R&D; France and Germany about \$2.5 billion; Russia barely \$1.5 billion; and China about \$22 billion.¹⁸ According to the European Defense Agency, the entire European Union spends barely \$8 billion on defense R&D annually.¹⁹

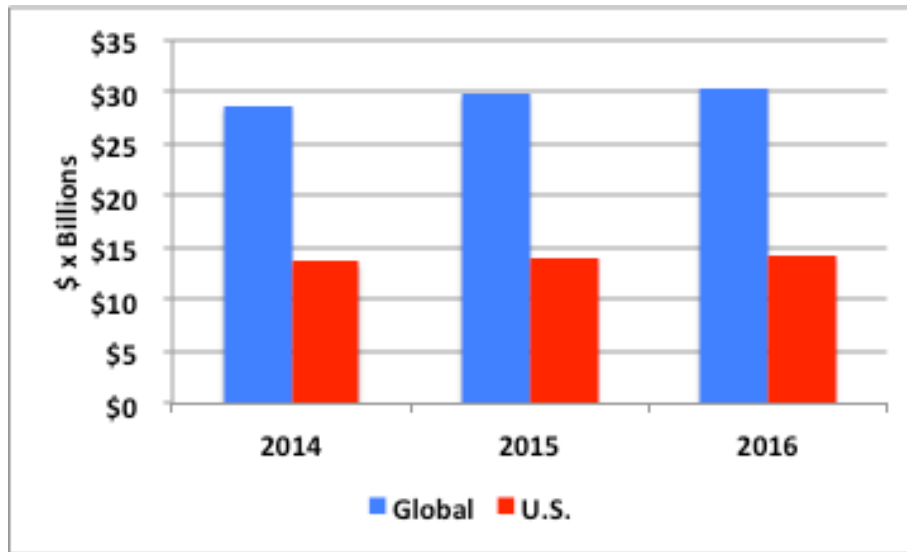


Figure 7. U.S. vs Global Defense R&D, 2014–2016²⁰

* * *

In sum, it is reasonable to conclude that lack of funding has not been a major cause of whatever challenges we face in the defense investment ecosystem. Simply put, the United States has and continues to be the global leader in applying resources needed to incubate defense capabilities in order to enable superior war fighting capabilities.

funded by all other sources—primarily universities and colleagues, nonfederal government, and other nonprofits. The GDP data reflects the Department of Commerce, Bureau of Economic Analysis’s comprehensive revisions of national income and product accounts as of July 2013.

¹⁸ Estimating R&D expenditures across national budgets is difficult due to both currency exchange rates and different methods of accounting. Most countries do not follow U.S. practice, and only include the equivalents of BA 1-3 in their S&T budgets. Global Security cites U.S. documents indicating China typically expends about 15% of its defense budget on R&D, which assumption is reflected here. See: <http://www.globalsecurity.org/military/world/china/budget.htm>

¹⁹ Defense Data 2013, European Defense Agency (Brussels) March 2015. Available at: <https://www.eda.europa.eu/info-hub/press-centre/latest-news/2015/03/31/latest-defence-data-published>.

²⁰ Source: “2016 Global R&D Funding Forecast”, *R&D Magazine (Supplement)*, Winter 2016. Available at https://www.iriweb.org/sites/default/files/2016GlobalR%26DFundingForecast_2.pdf.

Indeed, the U.S. willingness to maintain significant defense R&D spending, even in periods of defense austerity, is one of the main factors contributing to our military edge on the battlefield over the last generation. No doubt, our robust levels of spending in the 1980s and 1990s fueled our ability to develop innovations like unmanned aerial vehicles, intelligence and surveillance solutions, night vision and precision strike weapons—and ultimately, to field the world’s most effective fighting force since the turn of the century.

II.

Metric 2: Are U.S. Defense R&D Investments in Accordance with Reasonable, Strategy Driven Priorities?

It is not clear that the United States has an overall defense R&D investment strategy, let alone spending aligned with that strategy.

A. Viewing R&D as a Diversified Investment Portfolio

In theory, given the broad spectrum of actual and potential threats the United States faces, and the wide range of technologies that could make a difference in various operational concepts and scenarios, DoD should act like a prudent manager of a diversified financial portfolio in the modern investment world.

Thus, the defense R&D portfolio (and the S&T component thereof) should allocate spending between different investments or “bets,” based on: the nature, probability and magnitude of various threats; the time periods involved; capability areas; and technologies (their maturity and effectiveness, and the ability to utilize them in sensible operational concepts). Allocations of this type make sense and mitigate risk, because it is impossible to know in advance which technology “bets” will pay off and result in fielded capabilities. Additionally, the possibility of surprises warrant some investment in areas that may seem of limited interest today.

B. The Challenge of Identifying R&D Priorities Today

While this S&T “investment portfolio” approach sounds sensible in theory, it is in practice difficult to discern the priorities of our large defense investment portfolio today for a number of reasons:

- The sheer size, scope and complexity of the defense R&D (and S&T) enterprise and the many programs and projects it sponsors
- The complexities of the defense budget and the various complex ways that funds are appropriated among numerous different accounts
- The limited transparency of the enterprise and its constituent elements
- By design, the desire to afford some freedom or discretion to DoD components and researchers in make investment choices and determine what projects to pursue ²¹

²¹ DoD “zealously” guards the freedom of DARPA “to choose its own high-risk but high-payoff investments.” As former Under Secretary of Defense Frank Kendall recently noted, “[i]n DoD more broadly, we set strategic goals

At the front end of the system, spending by defense laboratories and other research components, typically on smaller projects, consortia and the like, are particularly opaque and hard to trace. Indeed, DoD itself admits it lacks full insight into the allocations of defense R&D (especially at the S&T level).

Reliance 21: An Effort to Prioritize. In this regard, DoD's Reliance 21 initiative essentially admitted that is difficult for anyone, even its own senior leadership, to understand how funding is being allocated when it created Reliance 21. Under the Reliance 21 umbrella, DoD S&T manages the "Communities of Interest," a set of seventeen technical groups with a top level DoD steering group that are designed to ensure DoD-wide coordination and collaboration between various DoD components in cross-cutting technology focus areas. The seventeen technical areas are set forth in Figure 8 below.

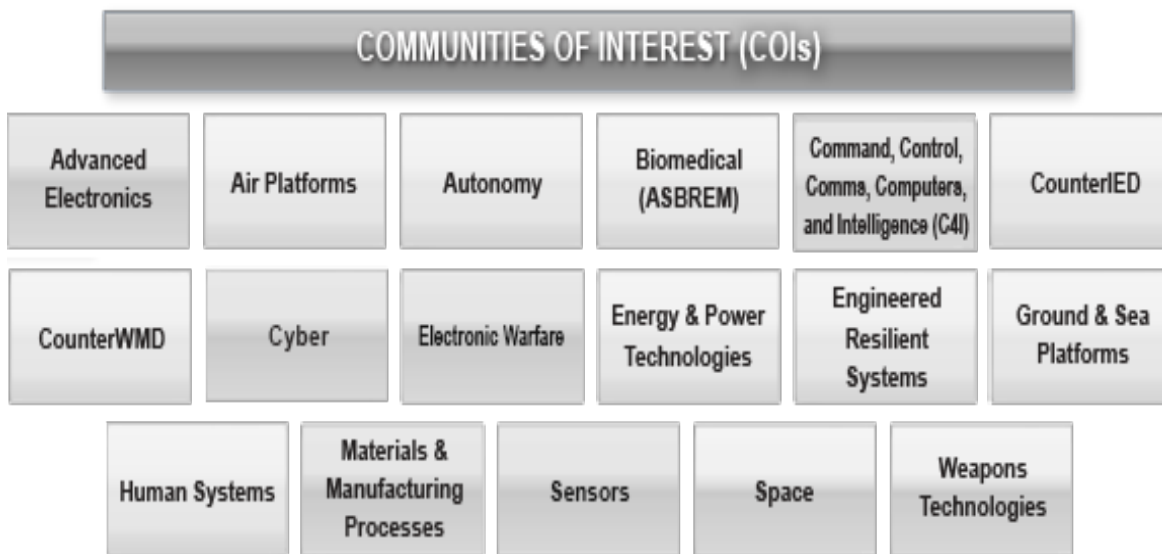


Figure 8. Source: DoD

The main goal of Reliance 21 is to avoid duplication of effort across DoD components and create efficiencies.²² The Communities of Interest (COIs), which prepare technology roadmaps, provide a forum for "coordinating S&T strategies across the Department, sharing new ideas,

for technology investment, require a certain fraction of the Services Science and Technology work to be in these areas and leave those organizations the freedom to choose their own priorities for the balance of their work."

Frank Kendall, Under Secretary of Defense for Acquisition, Technology & Logistics, "Innovation in the Defense Enterprise," Defense Acquisition University, Defense ARJ and Defense AT & L Publications Website. Available at: <http://dau.dodlive.mil/2015/10/14/innovation-in-the-defense-acquisition-enterprise>.

²² Testimony of Alan Shaffer ("Shaffer Testimony"), Principal Deputy Assistant Secretary of Defense for Defense Research and Engineering, before U.S. House of Representatives Committee on Armed Services, Subcommittee on Emerging Threats and Capabilities (March 26, 2016) at 11. Available at: http://www.defenseinnovationmarketplace.mil/resources/Shaffer_writtenstmt_HASC_26Mar015.pdf.

technical directions and technology opportunities, jointly planning programs, measuring technical progress, and reporting on the general state of health for specific technology areas.”²³

C. Investment Patterns: Breadth and Shifts

At a top level, however, what we can observe is several overall system thrusts over time:

A Broad Investment Portfolio. Investments have been made very broadly over a wide range of threats, capabilities and technologies, with some emphases on specific areas that vary by DoD components.

Certainly, in principle, this makes sense—there is some merit to letting 1,000 flowers bloom, so to speak. However, most of these thrusts are not based on a concerted strategy but the cumulative effect of largely decentralized decision-making across the S&T enterprise where coordination has been limited until recently.

While various of the services and other DoD components often have S&T strategy documents, they appear more to be in the nature of compiled lists of ongoing investments than focused sets of investment strategies.

Changing Priorities: A Shift to and Away from Irregular Warfare. We also can discern shifts over time.

Specifically, during the post-9/11 era, the front end S&T enterprise tilted toward investments in irregular warfare and incremental improvements to our existing force for use in ongoing operations. The enormous pressure of the war years—the need to address the threats here and now, such from IEDs in Iraq, and to improve our fielded capabilities in areas like night vision, armor and intelligence, surveillance and reconnaissance—created powerful incentives for virtually all parts of the defense enterprise to help in these areas of tactical and irregular warfare. Some of this focus was in incremental improvements in today’s capabilities—issues of improved ballistics, lower weight, and improved protection—while other focus was on new capabilities for irregular warfare, in which we had underinvested for a generation after Vietnam.²⁴

²³ Department of Defense Research & Engineering Enterprise Website. Available at: <http://www.acq.osd.mil/chieftechnologist/COIs.html>.

²⁴ The trend away from investment in high intensity capabilities actually began shortly earlier, after Operation Desert Storm, with the collapse of the Soviet Union. At the time, there was a focus on reducing force structure and operating costs to cash in the “peace dividend” at a time when it appeared long-term U.S. military leadership was assured. A number of the systems and capabilities developed to defeat Soviet ground forces and “Anti-Access/Area Denial” (A2AD) capabilities were either retired or abandoned as irrelevant legacies of the Cold War. For example, the U.S. Navy’s Outer Air Battle concept, intended to defeat Soviet long-range anti-ship cruise and ballistic missiles, was set aside in favor of more affordable short-range weapons, such as the FA-18 Hornet and AIM-120 AMRAAM. Now, with Russia and China reviving their A2AD capabilities, much of what the United States is doing today is really restoring capabilities we once had but allowed to wither in favor of low-intensity “Military Operations Other Than War.” See, e.g., Norman Friedman, *Fighters Over the Fleet: Naval Air Defense*

The focus on today's wars can be seen in the numerous ad hoc committees and other structures that were put in place quickly to satisfy the needs of combatant commanders in the field (drawing necessarily, out of expediency, on more mature technology rather than ideas still in the laboratory). For example, the U.S. Army stood up the Rapid Equip Force and the Rapid Fielding Initiative to meet pressing operational needs and the Joint Improvised Explosive Device Defeat Organization (JIEDDO, now the Joint Improvised-Threat Defeat Organization, or JIDO), to develop and field new technologies to deal with IEDs and other counter-insurgency threats. Among the capabilities developed were the Mine Resistant-Ambush Protected (MRAP) armored vehicles; radio-frequency jamming devices to neutralize remote controlled IEDs; mine removal robots; sniper detection and location systems; digital translation devices, and soldier equipment to enhance performance in a desert environment.

Inevitably, the sustained focus on fielding a more effective force for today's wars—to be sure, a very legitimate goal—detracted from the enterprise's focus on future game-changers for the force of tomorrow.²⁵ It is hard to trade the needs of soldiers dying in the field today for investments in capabilities against hypothetical long term threats. The intense focus on current conflicts, and the allocation of resources to fight them, created a preference for incremental improvements in the present force at the expense of efforts to ensure dominance for the long term future force.²⁶ It is admittedly difficult to quantify this effect, but it clearly was present.

But, the drawdown of operations Iraq and Afghanistan, combined with Chinese expansion into the South China Sea and Russian revanchism in Eastern Europe, caused DoD to reassess its R&D priorities, and begin shifting away from low intensity conflict and back to high intensity war fighting, in order to preserve our superiority in conventional warfare.

Indeed, years before Secretary Hagel announced DII, there were any number of “thrusts” in our S&T enterprise toward enhancement in high intensity war. These identifiable “force of the future” focus areas included: autonomous vehicles (where we have invested heavily for over a decade); robotics; cyberwarfare (both offensive and defensive); directed energy weapons; hypersonic propulsion; and electronic warfare.

from Biplanes to the Cold War, Naval Institute Press (“Fighters Over the Fleet”) (Annapolis, MD) 2016, pp. 382–393.

²⁵ The same phenomenon was seen during the Vietnam War, when the focus on counterinsurgency (“COIN”) operations in Southeast Asia distracted the United States from the broader Cold War conflict with the Soviet Union, and the development of a new generation of weapon systems intended for high intensity conflict. But the Vietnam War also served as a proxy war between the United States and the USSR, in which both sides learned much about the other's aircraft, missiles, radar and communications, which, in the case of the U.S., led to the development in the 1970s and 80s of the weapons systems we field today. The wars in Iraq and Afghanistan, in contrast, provided no such insights into the capabilities of potential high intensity adversaries.

²⁶ Anyone who regularly attends DoD Planning Briefings to Industry can spot the tell-tale signs in the presentations of the various program offices: the “No new starts” admonishments; an emphasis on “off-the-shelf” solutions and “non-developmental items”; “spiral development” and “lateral technology insertion.” Throughout the Bush and Obama Administrations, the needs of ongoing operations, with a few notable exceptions such as the Joint Strike Fighter, came at the expense of future high intensity capabilities.

Without regard to the merits of these individual initiatives, there is little sense DoD has an overall S&T investment strategy, or how these elements fit within in it.²⁷ Most presentations given by DoD components on S&T are descriptive rather than analytical in nature—setting forth lists of the projects that the unit is doing rather than providing some intellectual framework for it.²⁸ And, while DoD has over recent years stated these and other areas as priorities, it is hard to know how much funding is assigned to each.

The recent Third Offset strategy effectively doubled down on high intensity conflict, signaling to the Pentagon R&D bureaucracy the need to continue to shift resources in that direction—with a focus on autonomy and artificial intelligence among other areas—after years when DoD already has invested in those areas. Thus, the “pack” is now running in this direction full speed.²⁹

Not surprisingly, this history reflects that numerous specific priorities change over time in response to changes in perceived threats, changes in Administrations, and changes in S&T executives. In effect, there at times is a lurching quality to our investment strategy. New Departmental leaders arrive, and add new initiatives that effectively reallocate investments—without much thought being given to overall investment priorities or how this new focus fits with or duplicates existing work.

* * *

In sum, DoD does not appear to have an overall S&T investment strategy, nor the ability to assess how our existing investments align with that strategy today. At best, we can discern certain current technology thrusts, but not the nature of the resources applied to their development, or how they fit in the broader scheme.

²⁷ See, e.g., “Final Report of the Defense Science Board Task Force on Defense Research Enterprise Assessment” (“2017 DSB Report on Defense Research Enterprise”), at p. 17 (noting need for a national security S&T strategy that will inform investment in critical DoD mission areas and frame investment priorities) (Washington D.C.)(January 2017). Available at: http://www.acq.osd.mil/dsb/reports/Defense_Research_Enterprise_Assessment.pdf.

²⁸ See, e.g., 2017 DSB Report on Defense Research Enterprise, *supra* note 28, at pps. xiii–xiv, 73 (noting the use of “list[s] of critical technologies” rather than an overall set of strategy priorities).

²⁹ The underlying systemic problem is, of course, lack of a coherent strategic vision, one which clearly identifies U.S. strategic objectives, threats, potential adversaries, and available resources, in a manner that allows the armed services to focus clearly on the problems that need to be addressed in order to formulate requirements, develop new operational concepts, than thus provide the S&T community with a set of priorities to guide investment.

III.

Metric 3: Is the U.S. Defense Enterprise Sufficiently Accessing, and Incentivizing the Participation of, the “Best and the Brightest” Sources of Innovation?

Overall, the defense R&D ecosystem, including the smaller S&T enterprise, has invested widely in a wide range of sources of innovation: universities, internal DoD laboratories, federally funded research and development centers, and the private sector. Available data suggests that roughly 66% of U.S. RDT&E funding is widely disbursed to external parties (62% to industry, 3% to colleges and universities, and less than 1% to FFRDCs), with the remaining 34% spent in house at DoD.³⁰

However, there are questions as to whether DoD has sufficient access to vibrant sources of innovation in the commercial sector and globally. In this regard, long term secular trends show that R&D is increasingly being undertaken in the commercial sector and on a global basis—and is being conducted in these sectors in a different manner, using different—faster and more agile—processes and practices than in the DoD ecosystem, with more peer to peer collaboration and fusion of business areas and more willingness to take risk. The reliance on open source technologies, cloud computing and big data is driving change.

Specifically, Figure 5 above shows that private sector research and development spending took off in the 1970s and today far surpasses government research and development spending. The wedge between government and private sector spending thus is not new, and it is today well accepted—virtually a truism—that DoD needs to draw upon the breadth and speed of innovation in the commercial sector.

Recent metrics—the level of R&D spending, number of scientists, and other factors—also highlight the increasing globalization of innovation, with the United States having the largest, but a gradually declining share of global research and development, as other firms countries, notably China, ramp up their investments.³¹ Generally, the U.S. share of global R&D has gradually declined from 34% in 2009 to the 26%–27% range in 2014–2016 (with roughly 73–74% of total R&D spending outside the United States).³² Asia’s share of global R&D investment has continued to grow, especially in China—with a two decade trajectory of growth, and today holds in the range of 40% of global R&D (see Table 1).

³⁰ National Science Foundation, Science and Engineering Indicators 2016, Appendix, Table 4-23. Available at: <https://www.nsf.gov/statistics/2016/nsb20161/#/data>.

³¹ “2016 Global R&D Funding Forecast,” *R&D Magazine* (Supplement, Winter 2016). Available at: <http://www.iriweb.org/sites/default/files/2016GlobalRDFundingForecast.pdf>.

³² Id.

	2014	2015	2016	CAGR
United States	26.9	26.4	26.4	-1%
Rest of North America	2.3	2.2	2.1	-3%
China	19.1	19.8	20.4	2%
Rest of Asia	21.1	21.4	21.3	0%
Russia	3.1	2.9	2.8	-3%
Europe	21.5	21.3	21.0	-1%
Middle East	2.2	2.3	2.3	1%
South America	2.8	2.6	2.6	-2%
Africa	1.0	1.1	1.1	3%
Total	100.0	100.0	100.0	

Table 1. Share of Global R&D Expenditures by Percent, 2014–2016³³

There also are questions, discussed below, whether DoD is sufficiently drawing from traditional sources of innovation in the defense industry and our DoD laboratories.

A. Commercial Innovation: Fewer “Walls” and More Engagement Than Advertised But Still a Need for More Access

A longstanding goal of the Defense Department is to access new and innovative commercial technologies from “non-traditional” private sector companies that can enhance our defense capabilities.

A History of Private-Public Collaboration. There is a long and rich U.S. history of engagement between U.S. private sector and the U.S. military in support of national defense. It dates back as far as the Civil War, and rapidly accelerated during World War II. Military aviation, automotives, shipbuilding, and even the Manhattan project benefited from innovations in the private sector; in return, the private sector benefited from numerous commercial spin offs from military programs. Recent notable successes include the internet and “dual use” technologies (with both defense and commercial applications) such as the Global Positioning System, jet engines and satellites among others.

More recently, as then-Secretary of Defense Carter noted, “iOS’s Siri grew out of not only decades of DARPA-driven research on artificial intelligence and voice recognition, but also a specific DARPA project funded through SRI to help develop a virtual assistant for military personnel. And Google’s self-driving cars grew out of the DARPA Grand Challenge.”³⁴ Spin-offs have been considerable and important.

³³ Id.

³⁴ Rewiring the Pentagon Speech, *supra*, note 5.

However, the enormous growth of commercial R&D, in both real terms and relative to federal R&D, has made it increasingly important for the United States to benefit from technology flow in the other direction—so called “spin-ons.” The idea, now prevalent for several decades, is to leverage off commercial sector investments and draw on emerging commercial sector technologies in meeting our defense needs. Then-Secretary Hegel reiterated this concern in announcing the DII in 2014, stating 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.”³⁵

In fact, this is not a new issue for DoD. Long before DII, the prospect of better harnessing commercial technology for defense needs has been discussed, analyzed and subjected to numerous reports and studies for years, with increasing fervor and focus since the digital information revolution in the 1990s.³⁶ Indeed, there have been numerous DoD initiatives over the years—some systemic and some focused—designed to take advantage of emerging commercial technology, in wide-ranging areas from information technology to microelectronics and sensors, to biotech. And, for decades DoD has had a policy priority to require acquisition organizations to seek commercial solutions to DoD requirements.³⁷

***The Perceived Disconnect.** Notwithstanding these efforts, there is a perception that the Defense Department’s ecosystem continues to be disengaged on a sustained basis from our thriving commercial technology sector. As then-Secretary of Defense Carter recently observed that “we need to drill holes in the wall that I think exist [sic] and has built up over the years between the Department of Defense and the commercial and scientific sector.”*³⁸

The concern has been fueled in part by the fact that commercial and high tech firms over the years have evinced a desire not to do business with DoD due to the low rates of return and barriers to entry, with a focus on legal/regulatory requirements inherent in contracts executed to government procurement laws and regulations embodied in the Federal Acquisition Regulation (FAR).

³⁵ Secretary of Defense Chuck Hagel, Speech, Reagan National Defense Forum Keynote, Ronald Reagan Presidential Library (Nov. 15, 2014). Available at: <http://www.defense.gov/News/Speeches/Speech-View/Article/606635>.

³⁶ The three decades of studies on the challenges, insufficiencies and gaps in using commercial solutions for defense are too numerous to list here. For recent examples, see, e.g., Defense Business Board Report FY14-02, “Innovation: Attracting and Retaining the Best of the Private Sector” (“DBB Innovation Report”), at p. 53 (available at [http://dbb.defense.gov/Portals/35/Documents/Reports/2014/DBB-FY14-02-Innovation%20report%20\(final\).pdf](http://dbb.defense.gov/Portals/35/Documents/Reports/2014/DBB-FY14-02-Innovation%20report%20(final).pdf)), and Defense Science Board Report, “Buying Commercial: Gaining the Cost/Schedule Benefits for Defense Systems” (February 2009)(available at <http://www.acq.osd.mil/dsb/reports/ADA494760.pdf>).

³⁷ For a history of the focus on this issue over the years, see Gansler, Jacques and William Lucyshyn, *Commercial-Off-the-Shelf (COTS): Doing it Right*, University of Maryland School of Public Policy, Center for Public Policy and Private Enterprise, UMD-AM-08-129, September 2008 (“... there are examples of Commercial-Off-the-Shelf (COTS) being used as far back as the 1970s, [but] the advent of the information age ... and the growing DoD emphasis on information systems heralded a shift in acquisition policy... [the 1994 policy memo] by the then-Secretary of Defense, William Perry... called for the military to increase the purchase of commercial items and systems... [and] increase use of commercial practices and specifications.”). Available at <http://www.dtic.mil/dtic/tr/fulltext/u2/a494143.pdf>

³⁸ Rewiring the Pentagon Speech, *supra*, note 5.

In particular, tech firms long have been concerned over the protection of their intellectual property rights; under the Federal Acquisition Regulation (FAR), the government customer can receive some degree of intellectual property rights in inventions resulting from DoD-funded R&D. They also are concerned over the application of arcane government cost accounting rules required by federal law and regulation (and audits against those rules by DoD agencies) as well as the numerous other requirements and obligations set forth in the FAR—from requirements for small business participation to Buy America rules.³⁹ To be sure, these market access issues are legitimate ones for all firms—these arcane rules do create limitations on entry into defense markets.

**The Commercial-Defense Disconnect is Overstated;
Commercial Technology is a Critical Enabler of Today's U.S. Military**

Simply put, however, the recent narrative of a significant disconnect between DoD and the commercial sector has been overstated to a considerable degree. DoD's R&D ecosystem is more connected to, and able to access, the commercial sector than the DII would suggest. At every level, the U.S. defense enterprise significantly draws upon our commercial sector—from components to major systems. Thus, there are far fewer "walls" between the defense and commercial arenas in which we need to poke holes.

The degree of engagement is broad and deep and permeates numerous levels of the defense enterprise:

- **DoD's Embrace of the Information Revolution.** Over the last three decades, DoD has embraced the commercial information technology revolution across its doctrine, concepts, structures and systems, including the focus on network-centric warfare and sensor-to-shooter links. From Vision 2010 and beyond, DoD has recognized the need to, and in fact has, integrated digital technologies into its command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) capabilities. Indeed, it was the DoD embrace of the information revolution that led it to incorporate certain technology applications such as increasingly miniaturized sensors and ultra-high speed processing in small packages for precision electronics and space
- **The Role of Primes as Hunter/Gatherers of Commercial Technology.** Under 1990s acquisition reforms, prime level firms have been delegated system authority on major platforms and, therefore, it is their role, more than that of DoD, to hunt and gather for commercial technologies to provide "best value" solutions to DoD customers. In fact, primes have long spent resources to reach out to commercial firms, small and large, including Silicon Valley, and collaborated with them for the benefit of the war fighter. Primes have engaged with innovative high tech firms in numerous ways, ranging from outright acquisitions of key businesses and cutting edge technologies, to joint ventures, to licensing and teaming arrangements, to subcontracting. More recently, in response to DoD's focus on these issues, defense primes are engaging in various types of additional

³⁹ See L. Elaine Halchin, "Other Transaction (OT) Authority," Briefing to Congress, CRS 4-5 (Nov. 25, 2008). Available at: <http://www.sosseconsortium.com/pdf/CRSReportforCongress.pdf>.

outreach to small commercial firms through events like industry “speed dating” and crowd funding.⁴⁰ However, an open issue for inquiry is whether primes are doing an effective job as hunter/gathers. Unfortunately, there are no readily available metrics to evaluate this issue. And, it should be recognized the primes do face some countervailing incentives, such as a desire to use internal subsystem capabilities and to use more mature technologies to avoid program risk.

- **Dual Use Subsystem Firms.** DoD also procures, directly and through primes, from a number of leading dual use firms that have technologies with both commercial and defense applications—from engines to electronics to biotech to robotic vehicles.
- **Defense R&D Ties to the Commercial Sector.** The Defense Advanced Research Projects Agency (DARPA), DoD laboratories, and Defense R&D commands have long records of connection to commercial and dual use firms across the country, including Silicon Valley and elsewhere. DARPA in particular has utilized numerous innovative means, including prizes, engagement with consortia and the like, to collaborate with the commercial sector. The same is true of various R&D commands. Witness for example the Tank Automotive Command’s long engagement with the auto industry, or Air Force Systems Command’s engagements with both the airlines industry and aero-engine companies.
- **Small Business.** It is well accepted that small business is a major source of innovation. One study after another observes that small businesses, without the bureaucracy and established product incumbency of larger firms, are more willing to take more risk and are more entrepreneurial and inventive in nature, as reflected in numbers of patents issued and other measures.⁴¹ Available information indicates that DoD is able to access the creativity of these smaller, more commercially oriented firms through small business programs and technology transition programs, the participation of small firms (primarily as subcontractors) in large defense programs, and the business relationships between these small firms and larger defense firms (whether through acquisitions, joint ventures, licensing or other agreements). In particular, under the SBIR and related programs, DoD has, for more than a decade, expended considerable funds, in the range of \$700 million or more per annum on grants to roughly 700 hundred small businesses per year, located all over the country, in a wide range of science and technology areas. The recipient firms range from defense oriented companies to others that are either dual use or commercial in orientation. While there is anecdotal evidence that some of the technologies developed under the SBIR has transitioned into fielded capabilities, the breadth and scope of transition is difficult to

⁴⁰ See, e.g., Erwin, Sandra I., “Defense Companies Courting Startups: Fad or Lasting Trend?,” National Defense (December 2016). Available at: <http://www.nationaldefensemagazine.org/archive/2016/december/Pages/DefenseCompaniesCourtingStartupsFadOrLastingTrend.aspx>.

⁴¹ The Small Business Administration (SBA) reports that “[o]f high patenting firms (15 or more patents in 4 years), small businesses produced 16 times more patents per employee than large patenting firms.” See also A. Breitzman, PhD and Diana Hicks, PhD for SBA, *An Analysis of Small Business Patents by Industry and Firm Size*, Executive Summary, p. v (2008) (finding “small firms are much more likely to develop emerging technologies than are large firms [in many defined emerging technology areas] ... although small firms account for only 8 percent of patents granted, they account for 24 percent of the patents in the top 100 emerging [technology] clusters.”) Available at: <http://www.imamidejo.si/resources/files/doc/analiza%20patentov%20v%20msp%20usa.pdf>.

determine.⁴² Moreover, small businesses fully participate in larger defense programs—in good measure because primes are typically required under the FAR to include small businesses as subcontractors. Indeed, available data shows that firms that qualify as small business under federal rules receive significant awards as either prime or subcontractors, totaling roughly \$54 billion (prime contracts) and \$44 billion in subcontracts in 2014.⁴³ Certainly, a sizable number of these small firms are commercial or dual use in nature.

- **IT and Big Data Firms.** A range of service-oriented IT firms provide “Big Data” analytics, enterprise IT, cyber security and other services, to DoD and other government agencies, including on weapons systems. Large companies like Accenture, CACI, SAIC, Computer Sciences Corp. and Leidos, as well as smaller businesses such as Palantir, Computech, and a host of “boutique” companies, are a unique genre that certainly are more commercial in nature and, in any event, draw their technology from the commercial sector.
- **Commercial Components and Other Commercial Items.** Finally, at the component and even subsystem level, many commercial technologies are incorporated into U.S. defense systems, from semiconductors to digital technology to various other commercial parts and components. Since the 1990s, recognizing that development cycles in the commercial sector were several orders of magnitude faster than in the defense sector, especially in cutting edge areas such as electronics and information technology, the U.S. military began seeking ways to more effectively and rapidly incorporate “Commercial Off-the-Shelf” (COTS) hardware (and software) into platforms and weapons systems. Not only are COTS components and subsystems typically cheaper than equivalents developed specifically for the military, but they are more technologically advanced. Thus, as discussed below in section IV(C), for several decades, it has been an integral element of U.S. defense acquisition policy to rely on COTS products whenever possible. While DoD has not sufficiently utilized its authority to purchase commercial products and technologies (especially at the subsystem and system levels and in R&D programs), it has benefited from these products to a considerable degree at the component level.

In short, commercial technology is a central and critical enabler of warfighting capabilities, with considerable commercial technology integrated into, and often serving as the backbone of, numerous DoD platforms and capabilities. The reliance on commercial technology for our capabilities ranges across the gamut of business domains, including advanced avionics, advanced manufacturing technologies (e.g., additive manufacturing and 3D printing), high speed communications, commercial software and information technology, electro optics, miniaturization, propulsion systems, robotics, sensors of all types, nanotechnology,

⁴² The U.S. General Accounting Office (GAO) has conducted several studies of how well DoD tracks and quantifies SBIR success stories, but finds most of the data to be anecdotal at best. See *GAO-14-96, Small Business Innovative Research: DoD’s Program Supports Weapon Systems, but Lacks Comprehensive Data on Technology Transition Outcomes*, Government Accountability Office (Washington, DC) (December 2013) (available at: www.gao.gov/assets/660/659874.pdf); and *Small Business Innovative Research: DoD’s Program Has Developed Some Technologies That Support Military Users, but Lacks Comprehensive Data of Transitional Outcomes*, Government Accountability Office (Washington, DC) July 2014) (available at: www.gao.gov/assets/670/664971.pdf).

⁴³ SBA “small” standards for participation in federal contracts and set asides are different than the SBIR standards and, depending on the particular industrial sector, can be based on the number of employees or revenue of affiliated firms. In contrast, SBA’s SBIR/STTR standards use 500 employees by affiliated firms as the basis for determining eligibility.

semiconductors and other components. And, in some domains like space, commercial technology is at the core of our systems (both satellites and payloads).

* * *

But Access to Commercial Innovation is Lumpy and Limited at the Front End. Nevertheless, the degree of commercial-defense integration is lumpy, with domain areas in which DoD's access to the commercial sector is more limited than in others. The core challenges are a) the ability of DoD to attract the best minds in the private sector to work on its problems, and b) its limited insight into what is occurring in the front end of R&D in the commercial sector.

These access issues are partly the result of well-known institutional impediments, as well as differences in business models. The use of relatively rigid contracting methods under the Federal Acquisition Regulation (FAR) clearly have chilled participation by some commercial firms in the defense ecosystem. Thus, commercial firms that routinely make large-scale investments in order to generate short-duration, high volume production runs of low cost/high margin products have to consider whether it is worth the return on investment to participate in defense markets with long duration, low-volume production runs of low margin products, combined with difficult-to-master rules of the road which effectively serve as barriers to entry.

The Pace and Scope of Commercial Innovation, Driven by 21st Century Business Practices, Can Hinder DoD's Ability to Keep Pace with Our Adversaries. Moreover, rapid-fire commercial practices that drive innovation in the private sector, and the ability of our adversaries to benefit from these practices, may make it difficult for DoD to keep pace due to DoD's bureaucratic, antiquated processes. In contrast, our adversaries, not so burdened, can better exploit the rapid pace of private sector innovation.

While DoD in recent years has successfully found solutions to new challenges such as IEDs using ad hoc procurement mechanisms, new challenges are constantly emerging. Moreover, our solutions were in some cases the result of ad hoc "band aid" processes forced into the Department's structure out of sheer necessity and given elevated priority just to be certain they delivered as needed.

Today and in the future, new challenges that demand extraordinary responses can be expected to emerge from many sources, all the time, and without warning. Can DoD afford to "band aid" ad lib every such scenario?

B. Foreign Innovation: A Record of Limited Access

DoD's access to globalized R&D, a growing source of future innovation, is at best limited because our system has tended to create barriers, formal and informal, to foreign participation.

While the United States has in the past borrowed some of the best ideas for its defense from abroad, in practice, foreign participation in the U.S. defense procurement market has been limited and participation in U.S. R&D programs even more restricted. Moreover, our

international cooperative programs also have been relatively limited, with most work confined by small, science-oriented projects, due to the well-known challenges of bilateral and multilateral efforts (different requirements and budget cycles, issues of work share, and the like).

The Nunn Coalition Warfare Program: Underfunded and Underutilized. While the United States has made coalition warfare a key element of national security strategy and has fought in coalitions for decades, our willingness to commit resources to the development of coalition capabilities has been very limited. The primary program focused on these issues is the Coalition Warfare Program (CWP), designed to address challenges the United States and its foreign partners face in conducting coalition operations.⁴⁴ The *only* DoD program dedicated to initiating cooperative RDT&E projects with allied and partner nations, the CWP management plan recognizes capability gaps in a range of areas such as ISR, cyber security, autonomy, and combating weapons of mass destruction.⁴⁵ CWP provides seed funding to DoD organizations to conduct cooperative research, development, test, and evaluation (RDT&E) projects with foreign government partners.

However, funding for this program has been scaled back over the years and is now very limited in nature. In recent years, CWP's annual budget is in the range of \$10 million annually, an almost insignificant amount.⁴⁶ Moreover, specific projects under CWP, selected on a case-by-case basis by the International Programs office in the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, are capped at \$1 million a year, and \$3 million over three years. While the program has been good at leveraging U.S. resources (with roughly a 1:4 ratio in U.S. to foreign funding), its low overall investment level renders it of very limited value.

Limited S&T Engagement Abroad. Our S&T community similarly has limited focus on international innovation. There is a long history of U.S. bilateral and multi-lateral cooperation and exchanges on science and technology in numerous international fora, including the NATO Council of National Armaments Directors (CNAD) and Five-Power meetings of Armaments Directors from the United States, the UK, France, Germany, and Italy as well as various bilateral fora.⁴⁷ However, despite many government-to-government discussions, the signing of numerous bilateral and multilateral Memoranda of Understanding (MOUs), and some small-scale projects, few have evolved into full scale R&D programs and the results have been relatively insignificant.

DARPA's Limited Foreign Connections. DARPA, a core funder of early stage innovation, lacks both international offices and substantial outreach functions to engage with

⁴⁴ For an overview of CWP, see <http://www.acq.osd.mil/ic/cwp.html>.

⁴⁵ See Coalition Warfare Program Management Plan, Office of Director for International Cooperation, Under Secretary of Defense for AT & L. Available at: <http://www.acq.osd.mil/ic/Links/.../FY17%20CWP%20Management%20Plan.pdf>

⁴⁶ See Department of Defense Budget, Exhibit R-1, PE 060323D8Z (Coalition Warfare).

⁴⁷ For a full review of various fora for international armaments cooperation, see International Armaments Cooperation Handbook, Office of Director for International Cooperation, Office of Under Secretary of Defense for Acquisition, Technology & Logistics. Available at: <http://www.acq.osd.mil/ic/handbook.pdf>.

foreign innovators.⁴⁸ In general, only a small percentage of the DARPA's funding is disbursed for international activities, whether foreign firms, universities or otherwise. Some of DARPA's solicitations are open to foreign participation⁴⁹ and some foreign parties have participated in DARPA challenges (essentially contests to demonstrate new capabilities). DARPA also will occasionally fund ideas presented by foreign firms or persons. In practice, however, security regulations and export controls make foreign participation difficult.

The DoD Labs: A Sizable but Underutilized International R&D Infrastructure. The main or so-called "corporate" U.S. armed service laboratories—the Air Force Research Laboratory (AFRL), the Army Research Laboratory (ARL), and the Naval Research Laboratory (NRL)—all have foreign offices, manned by scientists, engineers, and technologists, that are tasked to stay abreast of foreign scientific research and technology development and seek out potentially promising ideas for research and evaluation that can benefit the development of U.S. capabilities.⁵⁰ These foreign offices provide:

- 1) a small number of direct small grants to foreign scientists, universities and companies to prepare research papers on promising new ideas (typically in the range of \$100,000–\$300,000);
- 2) funds for joint S&T projects with foreign governments, often developmental prototypes for experiments (where the U.S. and foreign governments both make contributions to a project, thereby allowing the United States to leverage its resources); and
- 3) workshops, conferences, seminars and other exchanges as well as programs that allow foreign scientists to visit the United States to socialize new S&T ideas or findings

Unfortunately, this capability is significantly underutilized—with limited funding spent on nurturing foreign inventiveness for the benefit of the war fighter. Overall, we estimated that the total direct S&T funding provided to foreign universities and companies (whether through direct grants, CRADAs, contracts or otherwise) is on an order of magnitude of roughly \$75–\$100 million per annum; most of this funding is in fact disbursed in very small amounts to universities and scientists rather than firms. Also, the total U.S. funding disbursed for joint S&T projects is in the range of \$300–\$500 million per annum (dispersed over numerous relatively

⁴⁸ DARPA only has an international support function in its Mission Support office, which serves largely as a liaison office for dealing with foreign governmental entities.

⁴⁹ The typical DARPA broad area announcement states that "Non-U.S. organizations and/or individuals may participate to the extent that such participants comply with any necessary nondisclosure agreements, security regulations, export control laws, and other governing statutes applicable under the circumstances."

⁵⁰ The U.S. Office of Naval Research's "ONR Global" function is among the most developed of these capabilities. It has a long history, and a physical presence abroad through offices on five continents (manned by 50 scientists, technologists and engineers). Currently, it has offices in Singapore, Tokyo, Santiago, Prague, and most recently, São Paulo. See generally <http://www.onr.navy.mil/en/Science-Technology/ONR-Global/About-ONR-Global.aspx> The U.S. Air Force Research Laboratory also has offices in London, Tokyo and Santiago, where they are jointly housed with ONR. Similarly, the U.S. Army Research, Development and Engineering Command stations scientists and engineers around the globe in various locations (typically called international technology centers) to explore international collaboration opportunities in scientific research and technology development that can be beneficial to capability development for the U.S. Army.

small projects).⁵¹ These are relatively small amounts in the overall context of S&T funding. Simply put, we are getting an insufficient return on our global R&D infrastructure.

Foreign Comparative Testing: A Lonely Bright Spot for Mature Technologies. One of the few exceptions to this picture of limited U.S. engagement with foreign sources of innovation is the Foreign Comparative Testing (FCT) Program, which explicitly focuses on adapting *mature, non-developmental* foreign solutions to U.S. needs. The stated mission of the FCT Program is “to test items and technologies of our foreign allies and friends that have a high Technology Readiness Level (TRL) in order to satisfy valid defense requirements more quickly and economically.”⁵² The concept of the program is to fund the testing and evaluation of equipment either ready for, or already in production, that may meet war fighter needs.

While useful, there is no counterpart program for front end innovation: foreign inventors, scientists and small firms whose original work is in process and requires funding for development. Foreign firms are not eligible for the SBIRS and other programs discussed above.

The factors that have constrained DoD’s ability to access foreign talent include:

- The lack of an overarching policy framework for accessing foreign innovation, with no clear policies or guidance, which results in inconsistent approaches across DoD units and overly restrictive approaches in some areas
- National disclosure and technology transfer rules and underlying release policies, which limit our ability to exchanging sensitive information—requirements, military strategy, and technical data—with foreign scientists and engineers and have resulted in restrictions on foreign participation in U.S. programs
- Protectionist impulses by parts of the DoD community—a “not invented here” syndrome and a longstanding, understandable desire to spend R& D resources at home
- an institutional preference to work with longstanding, indeed favored, U.S. partners

In informal discussions, the relevant DoD units all observed that the United States could potentially get more value from increased engagement with and the provision of funding to foreign firms and other innovators.

The Policy Choice. In sum, it is clear that the percentage of DoD’s R&D funding for foreign innovation is a very small percentage of our overall defense R&D spending.

⁵¹ The total S & T funding for foreign projects is not publicly available. The estimate above is extrapolated from data we do know. Specifically, we understand from off-the-record interviews with officials that: AFRL spends approximately \$30 million per annum on direct funding of universities and firms, and approximately \$100 million per annum for joint S & T projects; and NRL spends approximately \$8 million per annum on direct funding of universities and firms, and approximately \$80 million on joint S & T projects (with foreign governments providing roughly \$100 million in matching funds on such projects).

⁵² See Office of Secretary of Defense Comparative Technology Office Website (available at: <https://cto.acqcenter.com/osd/portal.nsf/Start?ReadForm>).

The dilemma is that, with the growth of foreign innovation in science and technology (as reflected in the rise in foreign patents and people with advanced science and technical degrees), lack of access to these developments have potentially significant national security risks. First, the prospect of less accessible foreign innovation creates short to medium risks of technological surprise as foreign adversaries incorporate into their forces new technologies with which we are not familiar. Second, in the longer term, lack of access to growing foreign innovation may, in the long term, leave the United States at a disadvantage in the global competition for advanced military capabilities.⁵³

Ultimately, however, the question of whether to broaden U.S. access to global innovation is philosophical in nature—at what point along a continuum of engagement do we balance our desire for access to these new ideas for the warfighter and the avoidance of surprise from foreign innovation against the natural impulse to spend most of our taxpayer-financed R&D dollars at home. While there is no single “right” answer to this question, the range of security threats we face today suggest that it would be prudent to deepen our engagement abroad to obtain access to new ideas and also better understand ongoing developments from a defensive posture.

C. DoD Laboratories: The Need for a Disciplined Evaluation and Possible Realignments

A key component of the overall DoD S&T Enterprise is the large array of DoD-owned defense laboratories. Numbering approximately 78 in total,⁵⁴ they have a total annual appropriation of roughly \$30 billion.⁵⁵ Covering a wide range of disciplines, these laboratories are located in some 22 states,⁵⁶ and employ 39,000 or more⁵⁷ of the Department’s roughly 106,000 scientists and engineers.⁵⁸ Approximately one-third of the labs’ \$30 billion annual appropriation probably comes from S&T accounts with the rest distributed between other RDT&E budget accounts as well as Operations & Maintenance. While a significant amount of

⁵³ For a useful but somewhat dated discussion of these issues with respect to basic research, see “*Report of the Defense Science Board Task Force on Basic Research*” (“2012 DSB Basic Research Report”), Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (Washington, DC), January 2012, at pp. 56–67. Available at: <http://www.acq.osd.mil/dsb/reports/BasicResearch.pdf>. This report made a number of suggestions for expansion of DoD’s engagement with foreign innovators that do not appear to have been realized.

⁵⁴ See Defense Laboratory Enterprise: Laboratory Listing (accessed in February, 2016). Available at: <http://www.acq.osd.mil/rd/laboratories/labs/list.html>. The Air Force has 15 laboratories, the Army 36, the Navy 26, and DoD 1.

⁵⁵ Under Secretary of Defense Acquisition, Technology and Logistics Frank Kendall, “Better Buying Power 3.0 White Paper,” at p.5 (Sept. 19 2014). Available at: [http://bbp.dau.mil/docs/2_Better_Buying_Power_3_0_\(19_September_2014\).pdf](http://bbp.dau.mil/docs/2_Better_Buying_Power_3_0_(19_September_2014).pdf).

⁵⁶ Defense Science Board Interim Task Group Update, “Guiding Principles to Optimize DoD’s Science and Technology Investments,” at p. 6 (Oct. 23, 2014). Available at: http://dbb.defense.gov/Portals/35/Documents/Meetings/2014/2014-10/RD%20Task%20Group%20Interim%20Brief_21Oct2014_Final.pdf

⁵⁷ See, e.g., 2017 DSB Report on Defense Research Enterprise, *supra* note 28, at p. 12.

⁵⁸ See Shaffer Testimony, *supra*, note 23, at 6 (citing data from the Defense Manpower Data Center). Below these top level figures, there is a lack of transparency associated with the labs; it is difficult to derive from open sources detailed information about funding levels, numbers of scientists and other employees and use of funds cross the full range of these labs.

these funds are spent on lab personnel, a considerable portion is actually further dispensed by the labs to universities and the private sector.

The DoD labs are varied in nature. As DoD has acknowledged, “each Service has a fundamentally different operating model for their laboratories. . . .” with different approaches to budgeting.⁵⁹ There are the so-called “corporate” labs—AFRL, ARL and NRL, which are broadly based and cover a wide range of capability and technology areas. There also are numerous more mission-focused centers and specific laboratories. The labs also have significant test facilities used by private companies working on defense programs as well as for lab projects.

The central question is whether the United States is getting a sufficient return on this investment in government laboratories today and for the future relative to other alternative R&D investments (e.g., in the private sector). As noted at the outset, are these laboratories providing sufficient innovation, including game changers, to warrant the investment, or should we consider allocating some of these funds to other S&T activities?

It is clear that DoD’s laboratories have in the past generated significant innovation. Recent Defense Science Board studies highlight the technical value of the laboratories’ heritage contributions to national defense.⁶⁰ However, these reports notably do not offer many *recent* examples of “game changing” contributions. Thus, whether and to what degree the laboratories have produced path-breaking technology should be evaluated.

In evaluating the relative contributions of the DoD labs, three issues stand out: 1) are the DoD labs performing tasks that could not be reasonably performed by the private sector; 2) the ability of DoD to attract and retain top level scientists and engineers to perform these tasks; and 3) the relative state of DoD’s laboratory infrastructure and whether additional investment is warranted to enhance the capability or efficiency of the labs.

The Nature of the Labs’ Efforts. It is well established that a central mission of the DoD labs is to “[f]ocus on and anticipate warfighter needs in the future and work on problems that will not be solved by the technology community outside the defense enterprise.”⁶¹ Thus, a key question is whether all of the various DoD labs today truly are needed to perform these functions, i.e., to what extent are they undertaking tasks that could capably be handled in the private sector today? In some technology areas, for example, where the labs have been active for many years, they may well be focused on science areas that at one time were not being explored in the commercial sector (and could potentially generate game changing innovation), but which today are mature, being developed commercially and/or subject primarily to incremental innovation that is being achieved in the private sector and universities.

⁵⁹ Memorandum from Under Secretary of Defense for Acquisition, Technology, and Logistics Frank Kendall to Secretaries of the Military Departments and Other Officials, “Implementation Directive for Better Buying Power 3.0 – Achieving Dominant Capabilities Through Technical Excellence and Innovation” (“BBP Implementation Directive”) (April 9, 2015), at p. 10. Available at: [http://www.acq.osd.mil/fo/docs/betterBuyingPower3.0\(9Apr15\).pdf](http://www.acq.osd.mil/fo/docs/betterBuyingPower3.0(9Apr15).pdf).

⁶⁰ See, generally, 2012 DSB Basic Research Report, *supra*, note 53 and 2017 DSB Report on Defense Research Enterprise, *supra* note 28.

⁶¹ 2017 DSB Report on Defense Research Enterprise, *supra* note 28, at p. 15.

There is little doubt that there may be some overlap today between the labs and private sector capabilities. Moreover, there are questions of alignment of the labs' historic activities with current and future needs. A recent Defense Science Board study noted that the labs "historical portfolios" can "create blind spots and gaps" and in certain areas like software development are "not as current" as they should be."⁶² The Board also notes that DoD's labs have not built sufficient links to key private sector commercial innovation hubs and have not sufficiently practiced "open innovation" techniques utilized in the private sector—which would enable the labs to better anticipate and address emerging DoD needs.

Despite the recognition that the labs have some limitations in meeting DoD needs, there nevertheless have been no comprehensive studies of the relative merits of these facilities for years. Moreover, what studies have been conducted have not focused on the critical question of whether some of the DoD facilities should be privatized, streamlined, or downsized (i.e., with the funds reallocated to alternative R&D or other uses).⁶³ Rather, DoD's own studies focus instead on how to improve their performance of existing DoD labs rather than address the underlying question of whether their retention is warranted.

Undoubtedly DoD should maintain a core set of some laboratory capabilities in order to understand and evaluate technologies in key areas of the DoD mission, monitor global and domestic innovation and developments, and perform research and development in exotic areas not otherwise being undertaken in the private sector (or that might require facilities or equipment only available in DoD laboratories). But the sheer size and scope of the DoD lab enterprise and the focus of some on historic mission areas warrants serious examination. Indeed, if there are areas where the lab functions are not aligned with DoD's needs today, as the Defense Science Board has found, the threshold question should not be how to better align them. Rather, the better question is whether these functions are appropriate at all for DoD to maintain.

Retention and Recruitment. Second, a central challenge is the ability of DoD laboratories to attract and retain the most talented scientists and engineers. With respect to recruitment, the availability of attractive private sector alternatives and constraints on DoD's ability to make timely and competitive offers at comparable salaries poses challenges. As the Defense Science Board recently observed, "the Labs ... face significant challenges in bringing in fresh blood across all experience levels: entry, mid-career, and senior. Additionally, it is difficult for the Labs to attract specialized, high-demand skills, such as data science and analytics."⁶⁴ Obama Administration initiatives only addressed these issues to a limited extent, with short term positions made available for private sector scientists. With respect to employee retention, available data show that the number of scientists and engineers in DoD generally has declined in

⁶² 2017 DSB Report on Defense Research Enterprise, *supra* note 28, at p. 14.

⁶³ The 2012 DSB Report on Basic Research and 2017 DSB Report on Defense Research Enterprise both appear to conclude, with little supporting analysis or evidence, that these labs should be retained; they rely on such criteria as whether the customer is satisfied and its needs are met. While useful, these criteria do not address the more fundamental question of whether this vast array of government facilities is in fact needed today.

⁶⁴ 2017 DSB Report on Defense Research Enterprise, *supra* note 28, at p. 24.

recent years and its work force is aging, with more than half expected to be retirement eligible within the next ten years.⁶⁵ Thus, as in other sectors with aging work forces, there may be some degree of inertia and limited productivity in government laboratories—which in turn raises questions about the ongoing contributions of an aging work force.

Thus, given these challenges, one has to question whether and to what degree to adopt limited measures that will only ameliorate, but not “fix,” recruitment and retention issues in lieu of instead relying on private sector scientists and technologists.

Why Expand Government Labs to Attract Top Talent—The ARL Plan? In this regard, whether to expand DoD laboratories also should be viewed through a litmus test of whether we can achieve the same or better results through alternative private sector arrangements. For example, the Army Research Laboratory (ARL) is expanding to the West Coast to attract scientists and engineers there; its other facilities are all on the East Coast.⁶⁶ The new “ARL West” facility in Los Angeles, California is to be located at the University of Southern California’s Institute for Creative Technologies (ICT) and will employ up to 70 scientists and engineers.

The key question is why this new capability should be hired in house by ARL rather than the alternative of establishing a private center of excellence at ICT and/or some other universities and businesses. Put another way, will the ARL expansion really attract the best West Coast scientists and engineers, or are we more apt to do that if DoD instead reaches out to universities and firms for this talent on some type of outsourced basis?

Lab Infrastructure. Finally, there are issues of aging infrastructure at DoD labs. The average ages are 50 years for Army labs, 45 years for ARFL facilities, and 46 years for Navy labs. Lab directors have indicated that “they are unable to maintain their facilities and infrastructure to a reasonable standard.”⁶⁷ There are potential costs associated with modernizing and sustaining these facilities. Again, the threshold question should not be how to improve the infrastructure but whether it is all warranted going forward. There may be a range of physical facilities with testing and other capabilities that can be privatized or downsized.

In sum, it is important to take, a focused look at realigning these facilities with our overall strategy, putting in place metrics to ensure that they are producing meaningful results, and re-allocating resources to other uses as appropriate. Accordingly, a full examination is needed to assess whether some of these capabilities replicate private sector capabilities and should be downsized, streamlined, or privatized. Issues of customer satisfaction (the alignment of lab capabilities with mission needs), recruitment and retention (i.e., whether to improve the pool of

⁶⁵ Shaffer Testimony, *supra* note 23, at 6-7.

⁶⁶ See J. Conant, “ARL increases presence on West Coast,” Army Research Laboratory (available at <http://www.arl.army.mil/www/default.cfm?article=2689>); O. Belman, “Army Research Laboratory selects USC institute as base for breakthroughs in science and technology” (available at: <http://news.usc.edu/88251/army-research-laboratory-selects-usc-institute-as-base-for-breakthroughs-in-science-and-technology/>).

⁶⁷ 2017 DSB Report on Defense Research Enterprise, at p. 28.

DoD scientists and engineers), and infrastructure modernization all should be viewed in that context.

FFRDCs. Another source of potential innovation are federally funded research and development centers (FFRDCs) sponsored by DoD, the list of which is set forth on Table 2. FFRDCs were established to provide the Department with unique capabilities in areas where the government cannot attract and retain personnel in sufficient depth and numbers. They operate in the public interest, free from organizational conflicts, and maintain long-term capability in core competencies in domains of value to the Department.

Of the ten DoD FFRDCs listed on Table 2, three of them are engaged largely in R&D work while the others primarily have other technical and analytical functions and provide services to DoD customers. The total DoD outlay for these FFRDCs has been in the range of \$2 billion over recent years, a high percentage of which was for compensation costs per each employee (i.e., “full time equivalent” or FTE).⁶⁸ The FFRDCs constitute a small percentage of DoD’s total annual outlay (in the range of 0.4%) and have been examined every five years, in accordance with FAR requirements, and have been found to be justified.⁶⁹ The FFRDCs are not centrally managed by DoD but by specific DoD sponsors.

Overall, there is broad agreement that FFRDCs provide high quality R&D and technical support that meets the needs of DoD. Analyses performed by these entities can also be performed without the conflicts of interests often found in industry. While five year reviews of FFRDCs are mandated by law, they do not necessarily look at strategic issues related to these entities.

As with the laboratories, it may be that a number of these services could also be capably provided by industry, although more conflicts and access to competitively sensitive information might arise. Also, industrial firms may not have the same deep institutional memory, historical knowledge and experience.

⁶⁸ See “Federally Funded Research Centers: Agency Reviews of Employee Compensation and Center Performance,” GAO-14-593 (August 2014), at p. 43. Available at: <http://www.gao.gov/products/GAO-14-593>.

⁶⁹ Id. at 15. According to GAO, DoD has complied with the FAR requirement to conduct comprehensive reviews, which required it to examine: 1) the special technical needs and mission requirements performed by the FFRDC; a consideration of alternative sources; an assessment of the efficiency and effectiveness of the FFRDC in meeting the sponsor’s needs; 4) an assessment of the adequacy of FFRDC management in ensuring cost-effective operations; and 5) a determination that the sponsoring agreement or contracts complies with other FAR requirements concerning FFRDCs. DoD found that all DoD sponsored FFRDCs met the sponsor’s needs and in all cases recommended continuance of the FFRDCs although it did require changes in the mission and core statement of the Software Engineering Institute to meet evolving DoD needs. Id. at 25-26.

	Budget (\$M) ⁷⁰	FTE ⁷¹	Compensation Per FTE ⁷²
<i>Study and Analysis Centers</i>			
Center for Naval Analysis	\$80.28	343	59%
Institute for Defense Analysis (IDA)	\$145.2	554	57%
Rand Arroyo Center	\$33.91	102	44%
Rand National Defense Research Institute	\$62.07	132	33%
Rand Project Air Force	\$39.35	134	45%
<i>System Engineering and Integration Centers</i>			
Aerospace Corporation	\$838.70	3,717	79%
Mitre Corp. National Security Engineering Center	\$885.38	3,474	58%
<i>Research and Development Laboratories</i>			
IDA Center for Communications and Computing	\$63.19	283	59%
MIT Lincoln Laboratory	\$830.07	3,214	43%
Software Engineering Institute, Carnegie Mellon Univ.	\$123.21	643	53%

Table 2. DoD-Sponsored FFRDCs

Accordingly, it makes sense to conduct a full review of the value of these entities, whether the private sector can offer these services today and whether the FFRDCs should be privatized, or, alternatively, whether there remain reasons to continue to rely on FFRDCs for these services in the future.

D. The Defense Industry: A Focus on Investment Levels, Time Horizons and Alignment of Commercial and National Security Incentives

The U.S. defense industry, a national asset, holds the leading capabilities in defense-related technologies in the United States, if not the world. DoD has historically drawn on our defense firms to perform the lion's share of its funded research and development on defense programs.

The crucial question is to what extent the many talented scientists and engineers in our defense industry are doing R&D *beyond* existing DoD-funded programs. Are their talents being

⁷⁰ See "FFRDC Research and Development Survey, FY 2014," National Science Foundation (Washington, D.C.). Available at <http://ncsesdata.nsf.gov/ffrdcrd/2014/>.

⁷¹ Average full time equivalents for 2010-2012. See GAO-14-593, *supra* note 68, at p. 47.

⁷² *Id.* at 47.

sufficiently applied to develop the best futuristic and novel concepts? Are the traditional defense firms appropriately applying their capital and taking the risks to pursue the development and application of new technology that can produce defense products with the highest future warfighting payoff?

The Context: The Unusual Funding Model for Defense Industry Innovation

For firms in commercial markets, R&D is nearly all self-funded. Corporate management, and ultimately, shareholders, must decide whether to put “risk capital” to work as a crucial element of their strategy to develop new products and maintain a competitive edge. If the investment, which can be very large, bears fruit, ultimately it can generate significant new products and a sizable revenue stream—often from large volume production.

In contrast, most of the defense industry, particularly at the higher levels in the value chain (e.g., prime level integrators and major subsystem providers), have two primary sources of R&D funding, both from the government:

- *Contracted R&D*—The largest share of R&D performed by the defense industry is funded by the DOD’s contracted RDT&E programs rather than through putting their own capital at risk. Private firms received approximately \$42 billion in R&D funding from DoD in 2015, about 65% of all DoD R&D funding provided to any source.⁷³ And, this funding is primarily for applied and full development and testing; historically, only a small per cent is for basic research.⁷⁴
- *Independent R&D*—In addition to contractually funded R&D, defense firms often elect to perform their own independent research and development (IR&D) that can be claimed as a cost against USG contracts. Under long-standing rules,⁷⁵ defense firms are allowed to recover some of the costs of their IR&D as part of the general and administrative expenses charged to existing contracts. Firms thus internally choose which technology projects to pursue provided that they are within the broad range of areas of potential interest to the Department. In recent years, the industry has spent approximately \$4 billion annually on IR&D.⁷⁶

Why is the defense industry business model, and approach to R&D, so different? While a number of factors are at work, in large part it flows from the inherent difference in the nature of

⁷³ National Science Foundation, National Center for Science and Engineering Statistics, Federal Funds for Research and Development, FY2013-15. Available at <http://www.nsf.gov/statistics/2015/nsf15324/#chp2>

⁷⁴ National Science Foundation, National Center for Science and Engineering Statistics, Science and Engineering Indicators, 2014, Appendix Table 4-35. Available at <http://www.nsf.gov/statistics/seind14/index.cfm/chapter-4/c4s6.htm#s2> (noting that, in 2011 of example, only \$259 million of the \$46.5 billion in R&D received by industry—or about one-half of 1%—was contracted to firms for basic research).

⁷⁵ FAR 31.205-18. IR&D generally includes (1) basic research, (2) applied research, (3) development, and (4) systems and other concept formulation studies, and does not include R&D performed under grants or contracts from the Government or third parties and does not include technical efforts in the support of bid or proposal activities.

⁷⁶ BBP Implementation Directive, *supra* note 59. Available at: [http://www.acq.osd.mil/fo/docs/betterbuyingpower3.0\(9Apr15\).pdf](http://www.acq.osd.mil/fo/docs/betterbuyingpower3.0(9Apr15).pdf).

the market. Unlike in the commercial private sector, where a large investment might result in large volume sales of a new semiconductor product or iPhone, the production runs for most defense products—especially large platforms—are far shorter. Simply put, there are a set of unique defense applications needed for national security that simply do not lend themselves to the commercial development model. For these types of applications, there is not a sufficient return in many cases for investors to put sizable private capital at risk.⁷⁷

Is the Defense Industry Strategically Investing in Innovation?

Viewed in this context, there are three central issues that warrant consideration:

- Is the defense industry spending a reasonable amount on IR&D on innovation under appropriate benchmarks;
- Is the research and development that industry is pursuing properly focused on long-term U.S. national security challenges; and
- Is the defense industry properly aligned with the Department and the war fighter (i.e., is it appropriately incentivized by U.S. government rules and policies to spend at reasonable levels on such long term challenges).

1. Has the Defense Industry Spent at Reasonable Levels Under Applicable Benchmarks?

Certainly, the DoD expects the defense industry to invest a reasonable amount in innovation, and to develop and retain superior technology capabilities for defense applications to keep the war fighter at the cutting edge.

Relevant Benchmarks. A threshold question is what is reasonable— i.e., what rate of IR&D spending is realistic for defense firms in light of the numerous factors driving R&D needs and the varied markets in which such firms operate. While there are a range of available benchmarks, we believe that the appropriate standards are: 1) the R&D spending rate of industrial firms with comparable capital and technology-intense products; and 2) the defense industry's own historic spending patterns on IR&D.⁷⁸ Like defense firms, aerospace and other

⁷⁷ While not the norm, some defense firms at times choose to use corporate “risk capital” to pursue new technologies or products, e.g., the 1980s Northrop F-20 and the Lockheed C-130J, which was reportedly privately funded at nearly \$1 billion. See Northrop F-20 Tigershark, Wikipedia (available at https://en.wikipedia.org/wiki/Northrop_F-20_Tigershark); and “All the World’s Hercules,” Asia Pacific Defense Reporter, February 13, 2011 (available at <http://www.asiapacificdefencereporter.com/articles/112/all-the-world-s-super-hercules>). Of course, firms that are more dual use in nature—for example, who develop avionics for both defense and non-defense applications—are more likely to fund work for the broader commercial market and utilize the results subsequently in defense markets (working to tailor the products for defense applications, perhaps using IR&D funds in the process).

⁷⁸ Another possible standard is the R&D investment rate prevalent in the commercial high technology sector—under which the defense industry would be found sorely lacking. Available data shows that tech giants like Microsoft, Google and Apple together invested more than five times the amount spent by the five of the largest

industrial firms have sales in market areas with a mix of complex, mature products with long life cycles and support requirements as well as new products, and have partial or limited exposure to defense.

Under appropriate benchmarks, available data show that major defense firms have been chronically underinvesting in future innovation for most of the last decade. Specifically, Table 3 provides the ratio of IR&D to sales for a number of leading U.S. aerospace firms; this ratio is typically in the range of 3.5-5% and 6-7% at high end (e.g., Harris, Rockwell Collins, Teledyne).⁷⁹ Notably, the IR&D rates of leading defense firms were under these ratios for nearly all of the last fifteen years.

Firm/Revenue \$B	2010	2011	2012	2013	2014	2015
Boeing Rev/Def Rev	64.3/30.86	68.74/30.7	81.7/31	86.62/32	90.76/29	96.11/30.4
% Defense	48%	44.7%	38.4%	36.9%	32%	32%
Tot R&D/Total Sales	6%	5.7%	4%	3.5%	3.4%	3.4%
UTC Rev/Def Rev	54,326/11.6	55.7/11	57.7/12.1	62.6/11.9	58/11.6	56.3/6.8
% Defense	21.4%	19.7%	21%	19%	20%	12%
Def Rev Growth	4.5%	-5.2%	10.2%	-1.8%	9.5%	-48%
Corp R&D % Tot. Sales	3.5%	3.5%	4%	4.1%	4.3%	4.1%
Honeywell Rev/Def Rev	33.37/5.4	36.5/5.3	37.7/5.1	39.06/5.1	40.3/4.75	38.6/4.7
% Defense	16%	14.5%	13.5%	12.5%	11.8%	12%
Def Rev Growth	.3	-1.9%	-3.8%	-3.9%	-2%	-1%
Corp R&D % Tot Sales	4.4%	4.9%	4.9%	4.6%	4.7%	4.8%
General Electric Rev/Def Rev	147.3/4.1	147.3/3.7	247.36/4.0	146.05/4	148.9/4	122.36/3.7
% Defense	2.7%	2.8%	2.7%	2.8%	2.7%	3% est.
Def Rev Growth	-2.4%	0%	8.1%	2.5%	0%	-7% est.
Corp R&D % Ind. Sales (w/o GE Capital or NBC)	4.5%	3.6%	4.4%	4.5%	4%	4%
Oshkosh	9.84/7.16	7.58/4.37	8.2/3.95	7.67/3.05	6.8/1.725	6.1/.940
% Defense	72.8%	57.6%	48.3%	39.8%	25.3%	~15
Def Rev Growth	176%	-39%	-9.6%	-22.8%	-43%	-45%
Corp R&D % Tot Sales	~1.2%	2.3%	2.8%	1.5%	2%	2.4%

Table 3. Revenue and IR&D/Sales for Commercial and Aerospace Firms (2010–2015)⁸⁰

defense firms in recent times, and that even several smaller cyber firms spend at a considerably higher pace than defense firms. See Marcus Weisgerber, “Tech Giants Spend Billions More Than Defense Firms on R&D” (“Tech Giants Spend More IR&D”), *Defense News*, May 26, 2014; available at <https://defence.pk/pdf/threads/tech-giants-spend-billions-more-than-defense-firms-on-r-d.316265/>; B. Callan, “Commentary: For Government and Defense Industry, It’s All About Innovation,” *Defense News*, January 4, 2016; available at <http://www.defensenews.com/story/defense/commentary/2015/12/13/commentary-government-and-defense-industry-s-all-innovation/76935770/>. However, this standard seems inappropriate in light of the significant differences in business models between commercial high tech firms and the defense sector discussed above.

⁷⁹ See, J. Anselmo, “Opinion: Defense Contractors Need Looser R&D Purse Strings,” *Aviation Week & Space Technology* (April 23, 2014); available at: <http://aviationweek.com/defense/opinion-defense-contractors-need-looser-rd-purse-strings>.

⁸⁰ The firms set forth in Table 3 were all listed in order in *Top 100 Firms* by Sales to Defense (except for Boeing, which was added manually, and except that AECOM, Bechtel, and Babcock, which rank higher than Oshkosh, were not utilized as the nature of their businesses makes IR&D comparisons less meaningful). The data sources for the Table were: MarketWatch.com, *Defense News Top 100*, and 2010-15 corporate 10K reports. The following should be noted with respect to the data on Table 3: 1) defense sales may include foreign sales; 2) the percentage

In contrast, Table 4 shows defense industry IR&D spending in historic terms over the 2001–2015 period for select defense firms. *The defense sector also has spent below its historic IR&D levels for over a decade—down from the historic range of 3.5 percent of revenue in the 1990s to 2 percent or less in recent years*⁸¹—a clear trend of lower investment by the defense industry relative to sales.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Lockheed Martin																	
Revenue	25.53	25.33	23.99	26.58	31.82	35.52	37.21	39.62	41.86	42.73	43.99	45.67	46.5	47.18	45.36	45.6	40.5
IR&D	1.1	.850	.798	.830	.903	.962	1.042	1.14	1.21	1.22	.724	.639	.585	.616	.697	.751	.834
IR&D/Sales	4.3%	3.4%	3.3%	3.1%	2.8%	2.7%	2.8%	2.9%	2.9%	2.9%	1.6%	1.4%	1.3%	1.3%	1.5%	1.6%	1.8%
Northrop Grumman																	
Revenue	8.99	7.62	13.56	17.21	26.21	29.83	30.72	30.15	32.02	33.89	33.76	34.76	26.41	25.22	24.66	23.97	23.97
IR&D	.197	.216	.342	.406	.434	.504	.538	.574	.537	.576	.610	.603	.543	.520	.507	.569	.712
IR&D/Sales	2.2%	2.8%	2.5%	2.4%	1.7%	1.7%	1.8%	1.9%	1.7%	1.7%	1.8%	1.7%	2.1%	2.1%	2.1%	2.4%	3%

Table 4. Revenue and IR&D/Sales for Select Defense Firms (1999–2015) (\$ Billions)⁸²

Specifically, by way of illustration (see Table 4), the R&D spending of two of the largest U.S. defense firms “declined by nearly a third in percentage terms from 1999 to 2012.”⁸³ From 1999–2012, in the context of increased wartime defense spending, the top five defense firms had more than doubled their revenue, and yet did not increase their IR&D proportionally.⁸⁴ Notably, the IR&D rates stayed low across time—as we moved from a period of wartime boom to constrained spending and ultimately sequestration—with a resulting defense industry focus on taking steps to ensure its own bottom line.

growth in defense revenue is the year to year change; and 3) several firms made divestitures and acquisitions affecting revenue.

⁸¹ R. Whittle, “CEOs Question DoD’s New IRAD Rule” (“CEOs Question New IRAD Rule”), *Breaking Defense* (June 30, 2015). Available at: <http://breakingdefense.com/2015/06/ceos-question-dods-new-irad-rule/>.

⁸² Data Source: Byron Callan, Capital Alpha Partners. Note that the data includes commercial revenue, which dilutes slightly the percentage of IR&D relative to defense sales.

⁸³ CEOs Question New IRAD Rule, *supra* note 81.

⁸⁴ Ralph Turchiano, “U.S. Giants Skimp on Research, Development” (“Giants Skimp on Research”), August 19, 2013 (reflecting analysis of inflation adjusted data by Zachary Fryer-Biggs and Marcus Weisgerber in “As Profits Rose, Investment Lagged Behind,” August 19, 2013). Available at: <https://engineeringevl.com/2013/08/19/us-giants-skimp-on-research-development-defense-industry/>

Firm (Revenue, \$Billions)	2010	2011	2012	2013	2014	2015
Lockheed Martin Rev/Def Rev	45.8/42.8	46.5/43.98	47.18/44.88	43.36/40.49	45.6/40.13	46.1/40.6
% Defense	93.4%	94.6%	95.1%	89.3%	88%	88%
Def Rev Growth	1.8%	2.8%	2.1%	-9.8%	-9.9%	~1%
IR&D % Def Sales (no B&P)	1.5%	1.3%	1.3%	1.5%	1.87%	2%
Boeing Rev/Def Rev	64.31/30.86	68.74/30.7	81.7/31	86.62/32	90.76/29	96.1/30.4
% Defense	48%	44.7%	38.4%	36.9%	32%	32%
Def Rev Growth	-3.4%	-.5%	2.2%	2%	-9.4%	4.8%
IR&D % Def Sales (no B&P)	2.5%	2.6%	2.8%	2.9%	2.99%	2.3%
Raytheon Rev/Def Rev	25.18/23.42	24.79/23.06	24.4/22.7	23.7/22.05	22.8/22.2	23.2/21.6
% Defense	93%	93%	93%	93%	97.4%	93%
Def Rev Growth	1.2%	-1.6%	-1.5%	-2.9%	.8%	-.3%
IR&D % Def Sales (no B&P)	2.5%	2.5%	3%	2%	2.2%	3.2%
General Dynamics Rev/ Def Rev	32.47/26.62	32.68/23.5	31.5/21	31.2/18.8	30.85/18.5	31.47/19.1
% Defense	82%	78.1%	66.7%	60.3%	60.2%	61%
Def Rev Growth	2.8%	-4.2%	-10.5%	-10.4%	-1.5%	3%
IR&D % Def Sales (no B&P)	1.2%	1.5%	1.8%	1.6%	1.9%	2%
Northrop Grumman Rev/Def Rev	28.14/26	26.4/21.4	25.22/21	24.66/19.5	23.98/18.4	23.5/17.6
% Defense	89.7%	81.1%	81.7%	79.1%	76.7%	75%
Def Rev Growth	1.7%	-31.4%	-3.7%	-5.3%	-5.6%	-2%
IR&D % Def Sales (no B&P)	2.2%	2.5%	2.15%	2.6%	3%	4%

Table 5. Revenue and R&D/Sales for Top Defense Firms (2010–2015)⁸⁵

Simply put, defense firms have been foregoing more investment in order to return more cash to their shareholders. In general, shareholders appear to prefer the return of cash, and the certain benefits it brings, to investments in future products, facilities or other uses that have uncertain financial payoffs. To be fair, Table 5 also reflects a significant negative growth trend in defense revenues for these top defense firms on a year to year basis. These firms have simply not been seeing defense revenue growth and thus have entrenched to survive a difficult revenue period, as discussed below.

As shown on Table 5, IR&D spending has begun to pick up in the last several years,⁸⁶ no doubt in part in response to DoD's urging that firms sustain and increase levels of IR&D in order to innovative.⁸⁷ While closer to historic norms, this remains on the lower side and is also low relative to IR&D levels of commercial aerospace firms.

⁸⁵ Firms represented on Table 5 are in order from the Defense News Top 100. The data sources for the Table were: MarketWatch.com, *Defense News Top 100*, and 2010-15 corporate 10K reports. For the purpose of an analysis, the defense revenues and IR&D as a percentage of defense revenues were broken out separately. The following also should be noted with respect to the data on Table 5: 1) defense sales may include foreign sales; 2) the percentage growth in defense revenue is the year to year change; and 3) several firms made divestitures and acquisitions affecting revenue.

⁸⁶ Tech Giants Spend More IRAD, *supra* note 78 ("Boeing Defense, L-3 Communications, Lockheed Martin, Northrop Grumman and Raytheon...list collectively spent about \$800 million more on internal R&D in 2013 than they did in 2011, Defense News reported in May 2014). Available at <http://www.defensenews.com/story/defense/archives/2014/05/26/tech-giants-spend-billions-more-than-defense-firms-on-r/78531604/>

⁸⁷ See, e.g., Marcus Weisgerber, "DoD to Industry: Invest in R&D", *Defense News*, August 6, 2013 ("The Pentagon's acquisition chief is calling for defense companies to maintain self-funded research-and-development

While applauding the fact that some defense firms have begun to increase their R&D spending in the last several years, there nevertheless remains considerable room for growth relative to R&D spending rates of other analogous firms. Specifically, the data reported on Table 5 shows that in 2015 the top five defense firms earned approximately \$129.3 billion in defense revenue and spent \$3.352 billion in IR&D—or a cumulative ratio of approximately 2.6%. If that IR&D spend rate was 4%—the low end of spending rate for aerospace and similar firms—the IR&D spending would have been \$5.172 billion cumulatively—or nearly \$1.82 billion more in research and development. Needless to say, this is a noteworthy sum that could potentially contribute significantly to national defense.⁸⁸

2. *Are IR&D Investments Properly Focused on Long Term Security Challenges?*

There also have been questions about the focus of defense and aerospace industry R&D. While it is difficult to quantify, based on discussions in the industry, there has been a sense—in particular over the war years and the years following—that industry has utilized most of the funding for short term operational needs rather than the force of the future. It was focused in large part on incremental improvements to existing capabilities or work intended to bring solutions to the war fighters rapidly—to be sure, a very legitimate goal.

DoD confirmed these concerns in its recent 2015 release of its Better Buying Power 3.0 Policy Memorandum.⁸⁹ As DoD concluded:

Reviews of IRAD spending indicate a high fraction of IRAD is being spent on near-term competitive opportunities and on *de minimis* investments primarily intended to create intellectual property. A problematic form of IRAD... is where promised future IRAD expenditures are used to substantially reduce the bid price on competitive procurements. In these cases, development price proposals are reduced by using a separate source of government funding (allowable IRAD overhead expenses spread across total business) to gain a price advantage in a specific competitive bid. This is not the intended purpose of making IRAD an allowable cost.⁹⁰

Indeed, there is some sense that DoD customers, seeking to leverage their own resources, in numerous instances pressured companies to spend on particular issues—gaps in funded R&D programs or an incremental change to something needed rapidly. Some call this “warranted”

initiatives... As companies try to manage their bottom lines in a time of downturn, there's temptation to cut that [IR&D funding],’ [said USD AT&L] Frank Kendall.”). Available at <http://www.defensenews.com/story/defense/archives/2013/08/06/dod-to-industry-invest-in-r-d/78531122/>

⁸⁸ It should be recognized that the nature of defense firms has changed over the years and most large defense firms today also have considerable service segments as well as core design and manufacturing of defense systems and capabilities. Thus, in evaluating recent IR&D levels and projecting reasonable future levels, it is important to consider that one would expect to see less IR&D in service oriented business and lessen future expectations to some degree on that basis.

⁸⁹ BBP Implementation Directive, *supra* note 59.

⁹⁰ *Id.*

IR&D, which is contrary to the very nature of IR&D—i.e., that it be for “independent research” rather than government-directed research. Additionally, there have been situations, anecdotally, where firms have used IR&D funding for bid and proposal work rather than actual R&D.

In sum, the secular decline in R&D spending by defense firms coupled with the apparent overweight in focus on short term needs means that the top minds at defense firms have spent less time and effort focused on the force of the future. Ironically, the very repository of the greatest knowledge on defense capabilities has not been investing enough on tomorrow’s challenges.

3. Are Incentives Aligned to Promote More and Future-Focused Industry R&D?

A final, and important question is what underlying circumstances have led to these secular IR&D trends and whether and to what extent the incentives of defense firms can be aligned with those of DoD so that the industry performs more IR&D and enhances its focus on future force development (i.e., where returns are unlikely for 5 years or more).

Viewed in context, the key dynamics that have driven IR&D spending have, over time, been the declining level of defense demand, DoD policies focused on affordability, and the need for firms to create shareholder value in a dynamic market. At times, the alignment of market incentives has worked to DoD’s benefit and at other times it has not.

Late 1990s: An Era of Financial Fragility. The downward IR&D trend appears to have its roots in the late 1990s, when the large defense firms, in the post-Cold War era of the 1990s, consolidated and took on significant debt in the process. By late 1999, the defense industry, with exceptions, was viewed as financially fragile, and experienced significant declines in stock market valuation. Thus, the focus on improving corporate health, which DoD encouraged, appears to have contributed to the decline in IR&D expenditures.

The War Years: A Focus on Short-Term Needs. Subsequently, as noted above, during the post-2001 war years, industry and DoD interests were aligned as defense firms sought to invest R&D dollars for highest short term payoffs, and customers sought the utilization of IR&D for shorter term incremental improvements relevant to the ongoing U.S. operations—to produce benefits for the war fighters in theatres of operations. As noted above, with the focus on winning the wars we were fighting, there was less customer interest on long-term capability development. Moreover, the long-term capability the DoD was seeking was too often not made very clear to the industry.

Post-War Sequestration. Thereafter, as the wars wound down, the key drivers of IR&D spending levels have been the declining level of defense demand during sequestration, DoD policies focused on affordability, and the need for firms to create shareholder value in a dynamic market. For a period of time after the wind down of U.S. operations in Iraq and Afghanistan (during the 2008-2013 era), there was a tacit alignment of interests between the DoD, industry and the investment community during this period in effect to support efforts by defense firms to remain financially stable during the post-war budget drawdown.

As the steward of the defense industry—with its multiple roles as financier, regulator and customer—DoD’s funding levels and policies, on a cumulative basis, in effect incentivized defense firms to curtail their R&D spending and focus it on affordability.

Certainly, this environment of lower defense demand, limited programs and lack of clear roadmaps created disincentives for firms to put their capital at risk and invest R&D dollars—in effect, to make bets on future concepts that are uncertain to mature. “Any company with any sense is going to invest in things that have a market,” said Jacques Gansler, former Under Secretary of Defense for Acquisition, Technology and Logistics (USD ATL). “If there’s not a market for it, and you’re trying to cut your costs, it’s a reason why companies are cutting back.”⁹¹ As several analysts observed, “[w]hen no clear future payoff exists, contractors may be deterred from making further investments in R&D.”⁹²

Defense Firms: A Focus on Strong Financial Performance. In response to declining demand, limited opportunities, and DoD’s focus on affordability, most defense firms executed a number of steps to return shareholder value, including reductions in personnel and other costs, increased dividends to shareholders and other financial steps such as stock buybacks.⁹³ Notably, stock buybacks and other mechanisms for returning cash to shareholders became prevalent in the industry.

These steps worked well, with defense firms performing admirably during sequestration. As Forbes noted in 2014, “as so-called budget sequestration kicked in, *Bloomberg’s* index of aerospace and defense stocks on the S&P 500 [has risen] about 94% when including dividends, outpacing the S&P 500’s 69% gain. A tip of the hat to CEOs across the industry....”⁹⁴

Of course, one way defense firms maintained their strong profitability and equity positions was through limiting R&D outlays, which, as discussed above, were flat to down during most of the post-war years, as shown above on Tables 4 and 5. *The juxtaposition was clear; available data shows that as financial performance of the companies remained strong, IR&D lagged.*

The Thrust for Defense Innovation. The alignment of interests began to erode, however, as DoD began to focus more on promoting defense innovation, which culminated in the announcement of the DII in late 2014. From 2014 to today, there has been a steady drumbeat of concern raised by DoD itself, various DoD advisory boards and outside observers

⁹¹ U.S. Giants Skimp on Research, *supra* note 84 (reflecting analysis by Zachary Fryer-Biggs and Marcus Weisgerber).

⁹² Sandra Erwin, “CEOs Not Yet Ready to Take a Gamble,” National Defense, National Defense Industry Association (February 2016) (quoting Bloomberg analysts Robert Levinson and Jesse Holler). Available at: <http://www.nationaldefensemagazine.org/archive/2016/February/Pages/CEOsNotYetReadytoTakeaGamble.aspx>

⁹³ Marjorie Censer, “Sales Drop, But Defense Contractors Cut Costs to Keep Profits High,” (quoting William Loomis), The Washington Post, Oct. 23, 2013. Available at https://www.washingtonpost.com/business/capitalbusiness/sales-drop-but-defense-contractors-cut-costs-to-keep-profits-high/2013/10/23/296c6010-3b66-11e3-b7ba-503fb5822c3e_story.html

⁹⁴ Antoine Gara, “Boeing Buyback Shows Battle Tested Defense Sector Can Afford Growth (quoting John Hagan, head of aerospace, defense and government services at BB&T Capital Markets), Forbes.com, December 16 2014, Available at <http://www.forbes.com/sites/antoinegara/2014/12/16/boeing-buyback-shows-battle-tested-defense-sector-can-afford-growth/#3c96c3044bb4>.

questioning the levels of industry R&D and the decision to favor the return of capital to investors rather than new investment in future technologies.

Concerns were raised by a number of observers that stock buybacks and similar approaches to return equity are not a technique for long term value creation and in fact may be harmful to long term innovation and competitiveness.⁹⁵ As an Aviation Week reporter observed in April 2014, “[w]hy are defense contractors investing so little in their future? That question is moving front and center as a budget squeeze forces the Pentagon to curtail R&D investments that underpin the industry’s product lines.”

Indeed, taken to its natural conclusion, an extended period of returns of equity to shareholders by defense firms, including stock buybacks, ultimately could leave the industry with a withered technology base and limit its ability to generate the innovation needed to be competitive for the long time. At some point, firms could begin to de-equitize and become hollowed out. There has been some anecdotal evidence of this occurring in the defense sector over recent years.

As DoD policy priorities changed and more emphasis was put on innovation, the Department not surprisingly began to focus on the need for more and better focused IR& D spending, i.e., spending focused on game changing technologies. In a 2014 study, the Defense Business Board (DBB) encouraged the DoD to reassess its extreme pressure on limiting profit and for awarding contracts to the lowest price bidders. As profit is a source of funding for R&D, the DBB found that these practices were having a negative unintended side effect: driving down R&D, talent development, salaries and experienced personnel.⁹⁶

While sequestration has exacerbated this chronic underinvestment, it has not caused it; the problem existed before sequestration. Thus, the prospect of higher budgets under the new Administration is not alone sufficient to mitigate this dilemma, and some policy action is warranted.

DoD Actions to Realign IR&D Spending Levels and Long-Term Focus with National Security Needs. The challenge for DoD is how to ensure the alignment of defense industry spending levels on IR&D and investment focus with DoD’s drive for long-term innovation.

For many years, DoD had significant oversight authority with respect to IR&D. However, as part of 1990s-era acquisition reforms, DoD’s authority was pared back in an effort to provide more discretion to defense contractors. In recent years, DoD has sought to once again enhance its insight and oversight. In 2012, the DOD issued regulations requiring major contractors with

⁹⁵ Karen Brettell, David Gaffen and David Rohde, *The Cannibalized Company*, Reuters Special Report (Nov. 16, 2015). Available at <http://www.reuters.com/investigates/special-report/usa-buybacks-cannibalized> Also see Obi Ezekoye, Tim Koller, and Ankit Mittal, “How Share Repurchases Boost Earnings without Improving Returns,” McKinsey and Co. Insights, April 2016. Available at <http://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-share-repurchases-boost-earnings-without-improving-returns>

⁹⁶ Defense Business Board, 2014, *supra* note 37, at p.22.

more than \$11,000,000 in IR&D and Bid & Proposal costs to submit IR&D project data in order to be eligible for reimbursement.⁹⁷ Recognizing the need to encourage industry to focus longer-term in its IR&D projects, DoD's 2015 Better Buying Power 3.0 program called for annual joint Technology Interchange Meetings to "provide industry with more detailed information about future program plans and ... enhanced DoD understanding ... of relevant IRAD."⁹⁸

However, this request for additional DoD insight was criticized by industry executives as too bureaucratic and invasive—lacking significant upside.⁹⁹ DoD issued a clarifying memorandum in August 2015, requiring that proposed new IR&D efforts be communicated to appropriate DoD personnel prior to the initiation of those investments and that the results be shared with appropriate DoD personnel.¹⁰⁰ As the memorandum indicates, "the objective of this engagement is to ensure that both IR&D performers and their potential DoD customers have sufficient awareness of each other's efforts and to provide industry with some feedback on the relevance of proposed and completed IR&D work."¹⁰¹

Notwithstanding their concerns, defense firms do see the need for more DoD guidance on targeted areas of specific investment focus or priorities. Firms would prefer, to the extent possible, to be provided a short list of specific, focused areas rather than long laundry lists of technology areas.

* * *

In sum, our analysis of industry investment patterns indicates that the talents of the scientists and engineers in the traditional defense firms are not sufficiently focused on future national security needs. The question is what mix of policies and practices will incentivize firms owned by shareholders understandably focused on short term financial gain to enhance their investment in future oriented technologies.

⁹⁷ See Defense Federal Acquisition Regulation Supplement (231.205-18) and Defense Acquisition University, Acquisition Encyclopedia (available at <https://dap.dau.mil/acquikipedia/Pages/ArticleDetails.aspx?aid=91c3c93b-968b-492f-af08-c1c34f88a0fe>).

⁹⁸ Department of Defense Press Briefing, "Better Buying Power 3.0 in the Pentagon Briefing Room," April 9, 2015. Available at: <http://www.defense.gov/News/News-Transcripts/Transcript-View/Article/607039/departement-of-defense-press-briefing-on-better-buying-power-30-in-the-pentagon>

⁹⁹ CEOs Question New IRAD Rule, *supra* note 81.

¹⁰⁰ Under Secretary of Defense for Acquisition, Technology and Logistics Frank Kendall, "Enhancing the Effectiveness of Independent Research and Development," White Paper (August 26, 2015). Available at: [http://www.defenseinnovationmarketplace.mil/resources/USD\(ATL\)_IRD_White_Paper.pdf](http://www.defenseinnovationmarketplace.mil/resources/USD(ATL)_IRD_White_Paper.pdf).

¹⁰¹ *Id.*

IV.

Metric 4: DoD's Structure, Policies, Processes and Practices— Do They Facilitate or Hinder Innovative Change?

Running through these access issues is a common theme: the challenge is as much about the limited receptivity of DoD components to new, and in particular, disruptive technologies as it is about impediments to access for non-traditional sources innovation. In short, DoD's own organizational structures, policies, processes and practices inhibit access to non-traditional participants and in the process limit the potential for disruptive innovation.

A. A Cultural Resistance to Disruptive Change

While many point to an overly complex acquisition system as the principal culprit (and it does pose challenges), in fact the inherent problem is DoD-wide—the acquisition challenges reflect the cultural resistance to change in the larger DoD enterprise. This includes not only the S&T ecosystem and acquisition system, but the overall armed services, and their organizational structure, operating doctrine, training, and support functions.

In effect, the challenges at DoD combine two underlying phenomena that exist in the business and government worlds and tend to generate resistance to disruptive innovation: the conservatism innate in large, successful organizations, and the reluctance of leading incumbents in economic markets to alter the paradigm that has made them successful. In the economic world, it is well known that successful incumbents, with their large investment in today's leading products, simply lack the incentive to “break glass” and disrupt the very franchise from which they are profiting today. They also tend to focus on incremental innovation that maintains their franchise—often through listening to existing customers who seek improvements in it. Thus, it is not surprising that disruptive innovation often comes from the non-incumbents such as small or new firms.¹⁰²

The fundamental challenge for the Department is how to straddle two worlds—on the one hand, innovating new technologies, systems, concepts and organizations for the force of tomorrow, while on the other hand maintaining and effectively operating the effective fighting force of today while improving it at the margins. The focus of military leadership on *maintenance* of the force of today tends to dominate and make it hard for the Department to embrace change.

The Armed Services are Wedded to Their Operational Paradigms. The U.S. armed services, like other established large institutions with established operating paradigms, reflect this type of resistance to change. The services often are institutionally wedded to a longstanding operational paradigm that is built around core capabilities (like the manned fighter jet) and the

¹⁰²For a full discussion of these issues, see generally C. Christensen, *The Innovator's Dilemma* (1997).

associated doctrine and standard operating procedures, requirements, training, well as support organizations and infrastructure.

Thus, while the armed services welcome incremental innovation to enhance their core capabilities, disruptive innovation would require a radical change in their entire way of operating that can be difficult for them to embrace. Witness, for example, resistance in the Air Force, built around manned fighter jets, in shifting toward the use of unmanned aerial vehicles. For years, the core funding for UAVs had to be added to the Air Force budget by DoD. Ultimately, only the identifiable, urgent need for unmanned platforms in the post-9/11 era caused broader acceptance of this change platform within the Air Force.

The Acquisition System Reinforces Their Aversion to Change. The acquisition system, especially in the late stages, reinforces this risk-aversion and makes it more difficult to inject innovative commercial technology into existing capabilities and programs in order to ensure affordability and on time delivery.¹⁰³ Some of this reluctance is well founded; it reflects the need for new approaches to be technologically mature as well as fully tested, validated and operationally sound. And, some of the resistance is typical of any large institution's resistance to new paradigms. Indeed, innovation can be viewed at times as a threat to existing programs and its incumbents and on that basis can be resisted by acquisition executives and incumbent contractors.

Moreover, congressional oversight has resulted in numerous processes and reports at every stage of the acquisition process, many well intended, that has added time and cost to the process. From milestones on major programs to auditing of firms under the FAR-based cost accounting system, the degree of complex processes and reports have added to the problem. Fundamentally, for every congressional thrust toward alternative and more flexible approaches to FAR-based contracting, the desire to protect the taxpayer and resulting new legal requirements have neutralized these efforts and empowered a generation of Inspector General investigations to ensure compliance with these obligations.

DoD's Failure to Utilize Flexible Authorities, Tools and Processes Reflects Its Innate Conservatism. DoD's resistance to change is reflected in its documented reluctance over many years to utilize the flexible authorities, tools and processes available to it to bring new technologies and non-incumbent suppliers into the defense ecosystem, including its commercial contracting procedures under Federal Acquisition Regulation (FAR) Part 12 and Other Transaction Authority (OTA).

Despite numerous studies calling on DoD to utilize these available alternative approaches to strict FAR-based contracting, DoD has only made limited use of these arrangements—yet another reflection of its cultural reluctance to deviate from standard operating procedures. DoD's reluctance is also driven by other considerations: its lack of experience with these novel mechanisms and its fear of adverse consequences (e.g., scrutiny by Inspector Generals and Congress) for failing to adhere to rigid pricing policies that measure success in terms of low

¹⁰³For a discussion of the adverse impact of the acquisition system on innovation in DoD systems, see 2014 DSB Basic Research Report, *supra* note 53, at pp. xv and 77–86.

prices as well as low profitability. Finally, DoD's recent policy thrusts reflected in DoD's Better Business Practices policies—for affordability, schedule maintenance, producibility and incremental refinements to existing systems (85% solutions)—undoubtedly have limited the receptivity to experimentation and change, especially in the later phases of defense programs.

B. The Limited Use of Other Transaction Authority

DoD generally, and the S&T enterprise in particular, have long had the flexible legal authority to more deeply engage with commercial sector—in the form of Other Transaction Authority.

OTAs were precisely designed to allow DoD to attract, and gain access to, non-traditional suppliers.¹⁰⁴ This flexible authority allows DoD to tailor the transaction to the specific circumstances involved rather than use standard contract terms and conditions typically used in government contracts, and also affords DoD to exempt the agreement from the requirements in the Federal Acquisition Regulations as well as cost accounting standards and negotiate terms on issues like intellectual property and data rights on a project-specific basis. Thus, thorny issues of intellectual property rights can be separately addressed on a project-specific basis. In effect, DoD can write the contract from scratch to suit the situation—on a clean sheet of paper.

Unfortunately, however, this authority has been used very sparingly by the Department, with very few agreements (between 69-88 active agreements over recent years) and a very low percentage of procurement dollars spent through all contracting mechanisms.¹⁰⁵

Commercial Space: A Tale of Two Approaches. By way of comparison, NASA and the Transportation Security Administration, with far smaller budgets and traditional contracts than DoD, made considerable more use of its OTA authority than DoD from 2010-2014. In particular, NASA relied primarily on OTA authority for the commercial space sector, with over \$1 billion in spending in OTAs as of 2014. Among other things, NASA entered into OTAs for the development of concepts, technologies and capabilities to transport commercial crew and cargo to space and to design and develop transportation systems for spacecraft and launch vehicles. This effort—which brought commercial firms such as SpaceX into NASA's space program—highlights how OTA authority can be effectively utilized for the infusion of commercial technology into government programs.

In contrast, the Air Force for years resisted the entry of non-incumbent SpaceX into its launch operations under a more commercial acquisition model. Only the challenging economics of space launch, with costs significantly rising after the termination of the Space Shuttle (which shared facilities and overhead expenses with the traditional DoD launch vehicles), caused the Air Force to re-evaluate its position and open the competition for future launches. Only more

¹⁰⁴ See L. Elaine Halchin, "Other Transaction (OT) Authority," Briefing to Congress, CRS 4-5 (Nov. 25, 2008). Available at: <http://www.sossecconsortium.com/pdf/CRSReportforCongress.pdf>.

¹⁰⁵ GAO Report 16-209, "Use of 'Other Transaction Agreements Limited and Mostly for Research and Development Activities' (Jan. 2016). Available at: <http://www.gao.gov/assets/680/674534.pdf>.

recently, and after increased congressional focus, have we seen deeper relationships emerging between the Air Force and NASA with respect to commercial space launch and satellite companies. But this change has come slowly and grudgingly, with SpaceX resorting to the courts to seek broader market access to DoD bidding opportunities.¹⁰⁶

Why has DoD used its OTA authority sparingly? First, some of the limitations on OTA authority (i.e., the need for partial private sector funding and, until recently, the absence of production authority) may have limited DoD components' interest in its use. Second, a mix of bureaucratic inertia and risk aversion appear to come into play. In this regard, officials from one DoD agency reported to GAO that because they rarely used OTAs and had little experience with them, developing the agreements took longer.¹⁰⁷

Moreover, DoD components have had an innate fear that the use of this authority, precisely because it is flexible, will generate unwanted controversy and result in investigations by Inspector Generals and Congress. The Army's experience on the Future Combat Systems program is a case in point (with Congress requiring the program changed from an OTA to a traditional FAR contract).

Thus, the limited use of OTA authority is to some extent a self-fulfilling prophecy. Procurement officials familiar with traditional FAR-based contracts are reluctant to utilize the flexible OTA approach—which may involve more work and time to establish. Additionally, and somewhat paradoxically, there is additional risk involved using the OTA model precisely because there is inherently less accountability and transparency, i.e., with these arrangements exempt from FAR requirements and cost accounting standards.¹⁰⁸ There are questions of how to monitor contractor performance against OTA standards and what type of auditing, if any, should be done.

In other words, the very virtue of OTAs—the potential exemption from FAR rules—create issues of oversight and accountability that raises issues for public officials charged with ensuring that taxpayer dollars are well spent. Thus, given these circumstances, procurement officials who are required by law to certify that an OTA is necessary before using the authority are likely to be more risk averse in its use. There also may be resistance to the use of OTA authority by DoD entities interested in keeping funds in house to support their own staff operations.

Thus, a combination of factors—among others, risk aversion, bureaucratic inertia, and limitations on the OTA authority itself—have likely conspired to cause the underuse of a tool precisely designed to attract commercial suppliers whose technology we seek.

¹⁰⁶While the lawsuit was settled out of court with the terms sealed, there are indications that it has played a role in SpaceX's recent participation in the Air Force marketplace. See, e.g., Nussbaum, Matthew, "How Elon Musk exposed billions in questionable Pentagon pending," Politico (May 15, 2016). Available at: <http://www.politico.com/story/2016/05/elon-musk-rocket-defense-223161>.

¹⁰⁷Id. at 26.

¹⁰⁸GAO Report 16-209, *supra* note 83, at p. 5.

C. Commercial Buying: A Similar Record of Under-Utilization

As discussed above, it has been a longstanding element of U.S. defense acquisition policy for over two decades to rely on readily available, cost effective commercial products and solutions where they meet DoD needs. The purpose of FAR Part 12 is to offer streamlined acquisition procedures that eliminate red tape and allow the war fighter to get the benefit of commercial investments already made in innovative solutions, rather than to have to develop a defense unique capability.

Nevertheless, despite the two decades plus existence of the commercial exception and the benefits its use can generate, numerous studies over the years found that DoD has seriously underutilized the FAR Part 12 contracting model for innovative commercial solutions to defense challenges.¹⁰⁹ In some respects, DoD's limited use is intentional as it has sought to limit the scope of this authority to a more limited range of commercial sales.

There are multiple reasons for this under-use and aversion to its use. First, there are some inherent limitations on commercial buying authority that limit its efficacy for large complex systems. In this regard, there have been questions as to whether a product is commercial—especially products not directly marketed in the commercial sector, but that nevertheless fall under the commercial rules because they are of “a type” commercial or derivative of commercial products. Contract officers trained to seek the best possible prices, have struggled with this determination and have, in effect, put in place additional processes that appear to be inconsistent with the commercial buying approach.

Second, the limitations on commercial buying authority under FAR Part 11 make it hard to square with the types of unique requirements needed for complex, novel capabilities (.e.g., environmental, quality assurance, acceptance, and other testing typically undertaken during development.).

Further, and somewhat ironically, the DoD acquisition executives' lack of experience in the commercial sector limited their ability to use this tool. They often lack the detailed knowledge of the unique challenges inherent in commercial business models and standards and evaluating their implications for life cycle costs and other program parameters. As one study observed, “[m]ost of the personnel and organizations have years of experience developing requirements-driven, specification-constrained, custom-designed and -built components and systems. Now, they are asked to incorporate constantly evolving, market-driven commercial

¹⁰⁹Defense Business Board, 2014, *supra* note 37, and Defense Business Board, Optimizing DoD's Science and Technology Investments, January 2015. Available at http://dbb.defense.gov/Portals/35/Documents/Meetings/2015/2015-01/RD%20Task%20Group%20Final%20Brief_6Feb2015.pdf. While, DoD certainly has procured large dollar amounts of goods and services under its commercial item authority—for example, approximately \$56 billion in goods and services out of a total of \$308 billion in total procurement spending in 2013 (roughly 18% of all procurements)(see Federal Procurement Data System); available at <https://www.fpds.gov>), the reality is that the “vast majority of items purchased under FAR Part 15 are commodity or common supply items such as fuel, food, medication, management support services, mail delivery services, and household items” rather than defense platforms, subsystems or capabilities. *Id.* at p. 53.

systems. In many cases, this fundamentally changes the work these personnel do and how they do it.”¹¹⁰

Thus, not surprisingly, there has been something of a cultural resistance in DoD components to the use of FAR Part 12. Hence, it will require restructuring of internal processes, additional specialized training of acquisition officials largely schooled in FAR Part 15 on commercial practices and processes, and significant time to adjust DoD to commercial business models.¹¹¹

Some Recent Pushback Against Commercial Buying—Is It Justified? In the last few years, some observers have criticized DoD’s use, and in the views of some, overuse, of its commercial buying authority. The underlying thrust of most of these concerns is that because the products were not truly being offered for sale commercially (e.g., but were “of a type” commercial or derivative of commercial products), DoD was not necessarily procuring them at established and reasonable commercial prices.

To address this situation, DOD’s acquisition leadership has in recent years pushed back against the use of commercial authority in these situations. After Congress refused to amend the law to eliminate this range of sales, DoD recently proposed changes to the commercial item requirements (as amendments to the Defense Supplement to the FAR)¹¹² which are to similar effect. The proposed rule imposes additional burdens on parties to provide cost or pricing data required by the contracting officer, certified or uncertified. These types of changes, if implemented, undoubtedly will chill further the use of the commercial item exception.

In contrast, industry—notably defense prime contractors attempting to incorporate commercial solutions—has repeatedly raised concerns about DoD’s commercial item policies and practices, asserting that defending commerciality has become “unnecessarily burdensome, that DoD has sought too much detailed insight into costs of commercial products (and sought that the data be certified in some situations), and that DoD asserts “excessive control of commercial suppliers’ processes.”¹¹³

Balancing DoD’s Policy Preferences. The key question, therefore, is what DoD’s policy preference is in these circumstances—which goal will shape its willingness to broaden its use of the commercial item exception?

¹¹⁰Gansler, Jacques S. and Lucyshyn, William, “Commercial-Off-The-Shelf (COTS): Doing It Right,” at p. 57, University of Maryland School of Public Policy, Center for Public Policy And Private Enterprise (March 2008). Available at: <http://www.dtic.mil/dtic/tr/fulltext/u2/a494143.pdf>.

¹¹¹See Defense Science Board, *Buying Commercial: Gaining the Cost/Schedule Benefits* (February 2009). Available at <http://www.acq.osd.mil/dsb/reports/ADA494760.pdf>

¹¹²“Defense Federal Acquisition Regulation Supplement: Evaluating Price Reasonableness for Commercial Items” (DFARS Case 2013–D034), 80 Fed. Reg. 2518 (2015) (pending). Available at: <https://www.gpo.gov/fdsys/pkg/FR-2015-08-03/pdf/2015-18938.pdf>.

¹¹³Price Waterhouse Cooper, *Defending Commerciality*, 2013. Available at <https://www.pwc.com/us/en/forensic-services/assets/defending-commerciality.pdf>.

On the one hand, a desire for more access to innovative commercial capabilities would lead to a more expansive use of the commercial item policy and limitations on the ability of contracting officers to impose the types of requirements the commercial item exception was designed to avoid. Concerns over pricing could be addressed, to the extent possible, through using the authority on a competitive rather than sole source basis.

On the other hand, the desire for lowest possible pricing for DoD customers, a policy goal that is deeply engrained in DoD's acquisition system and reflected in the attitudes of Congress, the GAO and the Inspector General, has led to the types of micromanagement reported. These institutions have driven oversight over industry, including auditing, that defense firms argue is overbearing and overly costly. When in doubt, the DoD acquisition community tends to fall back on its traditional, hands on approach to pricing to the extent it can—seeking underlying pricing and cost data—in an effort to ensure lowest possible pricing is as low as possible.

It is important to achieve some balance in this area, affording DoD the ability to seek innovative commercial capabilities without being hamstrung by overzealous acquisition rules, processes and practices. It also is important for Congress and other oversight bodies to understand that shaping acquisition strategy is a multi-faceted endeavor and that some leeway and flexibility is warranted.

In sum, commercial item policy is a useful, underutilized tool to bring commercial capabilities into the DoD ecosystem but one that has certain inherent limitations, requires more training of DoD acquisition executives, and more creativity and flexibility as well as approaches to ensure competitive pricing. The challenge is that risk averse DoD acquisition executives schooled in the traditional approach, with its focus on pricing, tend to default to limiting the use of this approach rather than seeking flexible and creative solutions. And when they do step toward more streamlined and flexible approaches, they have incurred criticism from Congress or the GAO for not conforming to expected norms. To put it bluntly, it is easier to say no than to have to be creative to get to yes.

D. The Systemic Challenge—Transitioning New Technology to the War Fighter

The limited receptivity of DoD components to new and disruptive technologies is also reflected in one of the well documented problems with respect to the operation of the DoD R&D ecosystem: the difficulty in, and lengthy time required to, graduate new technologies from the laboratory to the war fighter. The so-called “valley of death” reflects the fact that numerous innovations are never translated into products that are integrated into the force for one reason or another.

Study after study has confirmed this challenge.¹¹⁴ The technology can be stymied at any point in the process—from early R&D through procurement. Some technologies do not

¹¹⁴See, e.g., GAO Report 06-883, “Best Practices; Stronger Practices Needed to Improve DoD Technology Transition” (Sept. 2006) (available at <http://www.gao.gov/assets/260/251502.pdf>) and GAO Report 14-748T, “Small Business Innovation Research: DOD's Program Has Developed Some Technologies that Support Military

advance beyond the science laboratory, others do not make the cut after the prototype stage, and yet others that are more mature are not selected for insertion into programs in development or production (including legacy programs subject to technology refreshes).

These transition decisions are challenging ones. There often are legitimate reasons why it does not make sense to transition certain technologies to our fighting force; there are trade-offs between technical performance, costs and schedule to consider on programs that may not warrant using a particular new technology. In some cases, for example, the incremental change in capability does not warrant the investment needed to incorporate it in a system.

However, in other cases, more parochial institutional considerations also can drive the decision (e.g., when introduction of a new technology would perturb or undermine the rationale for a major program on the verge of production). With most major programs requiring more than twenty years from inception to production, many reputations and careers become deeply invested in their success, and some executives may see anything that threatens “their” program—even if it is a superior system—as a threat to themselves and their institution. Hence, the armed services at times forego lateral technology insertion into existing platforms and weapon systems when, in so doing, it would diminish the gap between currently a currently fielded system and its replacement—calling into question whether the new system is worth its additional cost. This is a classic case of making “better” the enemy of “good.”

Prototyping as a Means of Transition. It is widely recognized that more developmental prototyping and experimentation could help address this dilemma and “graduate” more new ideas from S&T to production.¹¹⁵ There is a long, rich history of using prototyping to develop, test and experiment with new capabilities, including the integration of tanks into mechanized combat forces and the Bell X-1 prototype that Chuck Yeager used to break the sound barrier.¹¹⁶

As a general rule, whenever technology is in flux and developing very rapidly, it is more prudent to invest in small batches of experimental platforms (whether ships, aircraft, combat vehicles or missiles) in order to test and evaluate as many different technical approaches as possible. This was, in fact, the case between the World Wars of the 20th century, when technology was advancing rapidly in aeronautics, automotive vehicles, radiotelephony and electronics, ship propulsion, and many other areas. With resources extremely limited, the United States and other countries chose to avoid investing prematurely in one specific

Users, but Lacks Comprehensive Data on Transition Outcomes” (July 23, 2014) (available at <http://www.gao.gov/products/GAO-14-748T>), and GAO Report 16-5, “DARPA: Key Factors Drive Transition of Technologies, but Better Training and Data Dissemination Can Increase Success” (Nov. 2015) (available at <http://www.gao.gov/assets/680/673746.pdf>).

¹¹⁵Most prototyping is done under DoD Budget account BA-4, which focuses on prototypes and demonstrations to transition ideas to a more mature technology capable of being used in weapons systems. Some prototyping activity is also done under BA (3), which includes demonstrations of components and subsystems or system models through form, fit and function prototypes or scaled models.

¹¹⁶E. Williams and A. Shaffer, “The Defense Innovation Initiative: The importance of Capability Prototyping,” *Joint Force Quarterly*, v. 77 (April 1, 2015). Available at: <http://ndupress.ndu.edu/Media/News/NewsArticleView/tabid/7849/Article/581867/jfq-77-the-defense-innovation-initiative-the-importance-of-capability-prototypi.aspx>.

approach, lest it prove to be a dead end, or overtaken by a competing technology.¹¹⁷ The United States followed a similar approach in the 1950s, particularly with regard to combat aircraft and naval forces, due to the rapid pace of technological advance.¹¹⁸

For some years, more prototyping have been favored at the policy level for a number of reasons, including: the reduction of risk at key program milestone points; the maturation of cutting edge technologies before DoD invests in expensive EMD program; the enhancement of competition and the affordability it may bring; and the maintenance of industrial base capabilities in certain business areas.¹¹⁹

More recently, however, there has been a steady, growing drumbeat, reflected in numerous studies and the constant refrain of senior DoD executives, in favor of more prototyping and demonstration capabilities in order to experiment in both development and operational use, and take more risks as we seek to regain U.S. technological superiority.¹²⁰ The BBP 3.0 Initiative extolls the benefits of and advocates for the expanded use of prototyping and experimentation.¹²¹

¹¹⁷ See Military Innovation, *supra* note 7, n. 7.

¹¹⁸ *Fighters Over the Fleet*, *supra* note 26, at pp.166-235

¹¹⁹ Under DoD Instruction 5000.02 (Jan. 7, 2015), section 5.d.4.b.2, at p. 19, prototyping (competitive, if feasible) is required, unless waived, for major defense acquisition programs prior to a Milestone B determination (i.e., before moving from the Technology Maturation and Risk Reduction phase to the Engineering and Manufacturing Development phase of the program. For background on prototyping and its benefits, costs and risks, see generally Col. R. Hencke, "Prototyping: Increasing the Pace of Innovation ("Hencke on Prototyping"), A T & L Magazine (July-August 2014); available at: <http://dau.dodlive.mil/2014/10/08/prototyping-increasing-the-pace-of-innovation/>; and J. Drezner and M. Huang, "On Prototyping: Lessons from RAND Research," The Rand National Defense Research Institute (2009); available at http://www.rand.org/pubs/occasional_papers/OP267.html (summarizing experiences on different programs, and noting that prototyping can be beneficial particularly in the development phase but also has associated costs.)

¹²⁰ Shaffer Testimony, *supra* note 23, at p. 12 ("In the Fiscal Year 2016 budget request, we have aligned at least \$4.5 billion as "innovation technology" efforts, which includes prototypes and demonstration capabilities. One of the key pillars of regaining U.S. technological superiority is to take more risk in the systems the Department develops. One way to do this is through the enhanced use of prototyping and demonstrations across the Department. These may be called prototypes, demonstrations, Future Naval Capabilities, Army Technology Demonstrations, or other names; at the end of the day, we expect expanded use of these efforts to develop new capability and retire risk; and to allow use/testing by the operational force, and could lead to a big capability advantage."); Briefing to Assistant Secretary of the Navy for Research, Development and Acquisition Sean Stackley by 2011 Naval Research Advisory Committee, "BA-4 Account Advanced Component Development and Prototypes," (Oct. 2011) (noting insufficient Navy emphasis on technology push and a culture intolerant of failure and unwilling to take risk, and the resulting need to have better management of BA-4 account, including competitive prototyping and other approaches, to mature promising technologies and maintain Navy's supremacy); and Edie Williams and Alan Shaffer, "The Defense Innovation Initiative: The Importance of Capability Prototyping," Joint Forces Quarterly 77 (2d Quarter 2015), generally. Available at: http://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-77/jfq-77_34-43_Williams-Shaffer.pdf.

¹²¹ BBP Implementation Directive, *supra* note 59, at p. 12-13 (As then-Under Secretary of Defense Kendall observed, "[p]rototypes are preliminary versions of a system or major sub-system assembled to resolve some area of risk and/or to explore operational potential. In this context, prototyping occurs prior to making a substantial commitment of resources for engineering and manufacturing and development or production and does not require programming or budgeting for follow-on activities. Importantly, during tight budgets these projects are low cost compared to full scale development and production.")

As modest steps in this direction, the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics also has broadened the mission of the Office of Rapid Fielding in the Assistant Secretary of Defense for Research and Engineering, which has been renamed Emerging Capability and Prototyping (ECP). Its focus has shifted beyond developing prototypes to meet the immediate needs of warfighters to include developmental prototypes that allow the exploration of the operational and technical value of less mature systems.¹²² The ECP Office has also developed a series of project focus areas, which include asymmetric force application, space capability resilience, and electro-magnetic spectrum agility.¹²³

Various of the armed services have similar capabilities. For example, under the auspices of DII, the Navy's Office of Rapid Prototyping, Experimentation & Demonstration has recently launched a Marine Corps project to field-test more than 50 new technologies and move them more quickly to the war fighter.¹²⁴

Yet, despite the consensus in favor of more prototyping and clear calls for action, there have been relatively limited resources available for prototyping and limited use of this approach in practice in light of competing demands.¹²⁵ And, as shown on Figure 4, the funding for advanced prototyping (BA-4) has declined over time although there is some increase in the last two years.

Other Approaches. DoD has also considered and adopted other approaches over the years to address transition issues. There have been numerous programs managed by DoD AT&L and the armed services, which vary in size, mission, approach, funding, and technology maturity expectations. However, as GAO observed, "all are consistent in providing opportunities to transition technologies from the S&T community to a military user, such as an acquisition program or the warfighter in the field."¹²⁶ Numerous of these programs are focused on rapid response to address needs in ongoing operations and therefore focus on more mature technologies that can be quickly fielded. Others focus on the small business community (building on efforts begun under the SBIR program).¹²⁷ Most of these projects also are RFP-based, and leave it to the firms involved to seek to participate.

¹²²Hencke on Prototyping, *supra* n. 97, at 13-14.

¹²³E. Wyatt, Deputy Assistant Secretary of Defense, Rapid Fielding, Briefing, "Emerging Capability & Prototyping" (Sept. 15, 2015). Available at: <http://www.acq.osd.mil/ecp/>

¹²⁴Sydney J. Freeberg Jr., "Marines Rush 50 Technologies To Field Test In 9 Months," *Breaking Defense* (March 23, 2017). Available at: <http://breakingdefense.com/2017/03/marines-rush-50-technologies-to-field-test-in-6-months/>.

¹²⁵Under Secretary of Defense Acquisition, Technology and Logistics Frank Kendall, "Better Buying Power 3.0 White Paper," at p. 6 (Sept. 19 2014). Available at: [http://bbp.dau.mil/docs/2_Better_Buying_Power_3_0_\(19_September_2014\).pdf](http://bbp.dau.mil/docs/2_Better_Buying_Power_3_0_(19_September_2014).pdf).

¹²⁶See GAO 13-286, "Defense Technology Development: Technology Transition Programs Support Military Users, but Opportunities Exist to Improve Measurement of Outcomes," at p. 5 (Washington, D.C.: Mar. 7, 2013) (available at: <http://www.gao.gov/assets/660/652852.pdf>). See also GAO 06-883, *supra* note 92.

¹²⁷For example, the 2011 Defense Authorization Act mandated DoD's establishment of the Rapid Innovation Program (now Fund) to facilitate the insertion of innovative technologies into defense acquisition programs. From 2011- 2016, DoD invested over \$1.4 billion in awards made under the fund. Through 2016, DoD has awarded 450 contracts, 89% of which went to small business (for which DoD has a stated preference), and 59% of the awards went to current or prior participants in SBIR programs. The awards can be no greater than \$3 million,

Some of these programs have successfully transitioned technologies to the war fighter. In some instances, GAO reports that the programs have “disciplined project selection and management processes in place” and to varying degrees appropriately emphasize “the need for early and sustained commitments from senior military leadership, S&T developers, and military users in order to ensure projects are needed, have a sound basis, and risks are reduced.” But the absence of metrics makes it difficult to assess whether the technologies actually resulted in benefits to the war fighter—which is needed to assess effectiveness of these various approaches.

In sum, there is some sense that there are now more options for successful technology transition than in the past, especially for small businesses and firms with relatively mature technologies. But these programs have limitations, and transition remains an issue for less mature projects and firms that are no longer small. Moreover, there is a continued refrain that transition is a significant challenge, with reluctant customers generating countervailing pressure.

E. DoD’s Gradual Shift from Proprietary Systems to Open Architecture

The long-term challenges of shifting DoD systems to open architectures that facilitate the introduction of new and innovative capabilities reflects a similar pattern. While progress has been made, it has been gradual in nature—in part slowed by institutional resistance in the defense ecosystem.

The benefits of introducing open architecture and modularity into complex systems, with the ability to change elements out in a “plug and play manner,” are well known. The commercial sector, with its focus on rapid product introduction and collaboration across platforms, has increasingly adopted this approach in recent years—creating products around industry-wide interfaces and modular designs for “plug and play” features. While there have been times and industries when commercial products were highly proprietary, a number of factors, including the pace of innovation, the digitalization of the economy, and the need for technical collaboration, have driven the commercial world in the direction of open architecture.

i. Closed, Proprietary Systems are Innovation Barriers

Historically, DoD largely procured closed, custom-designed proprietary systems from its contractors—often with unique architectures and componentry tailored to that system. The result is a sizable number of current DOD platforms and weapon systems that are “hard wired” with unique subsystems—particularly computers and other electronics—that are unique to that system, and therefore difficult to maintain, replace or upgrade.¹²⁸ Since many weapon systems

and in practice awards have averaged roughly \$2.1 million. See Dan Cundiff and Alice Williams, “Rapid Innovation Fund (RIF) Program Overview,” Offices of OSD Research & Engineering and Small Business Programs (August 2016). Available at: [http://www.defenseinnovationmarketplace.mil/resources/RIF_Overview\(Aug2016\).pdf](http://www.defenseinnovationmarketplace.mil/resources/RIF_Overview(Aug2016).pdf). See also GAO Report 15-42, “DoD Rapid Innovation Program: Some Technologies Have Transitioned to Military Users, but Steps Can Be Taken to Improve Program Metrics and Outcomes” (May 2015).

¹²⁸See generally, DBB Innovation Report, *supra* note 37.

have life cycles measured in decades, it is challenging and costly to migrate new software and other enhanced capabilities—especially from non-incumbent suppliers—onto these systems.

The proprietary nature of many existing systems acts as a barrier to entry for new suppliers and innovative new capabilities. The historic thrust for proprietary systems was driven by a combination of circumstances, including: the limitations of the existing computer software/architecture technologies and related interfaces well into the 1980s; a conservative, security conscious DoD customer community, that generated some resistance to open architecture; a series of acquisition reforms that devolved substantial authority over decisions on platform architecture to prime contractors; and DoD's historic reliance on a small number of well-established and entrenched prime contractors for its major systems. In this regard, vertically integrated prime contractors with significant internal subsystem capabilities may face powerful incentives to maintain closed architectures to preserve their platform positions over its entire lifecycle.

ii. DoD's Shift to Open Systems Architectures Facilitate Innovation, but Is Not Fully Implemented

DoD Adopted an Open Systems Architecture Policy Over Twenty Years Ago. Recognizing the concerns over closed systems, DOD formally adopted an open architecture policy in 1994 and has reiterated it many times. Today consideration of open systems architecture is required by the DOD Directive 5000.1, and this direction was reaffirmed in DoD's Better Buying Power 3.0.¹²⁹ The Deputy Assistant Secretary of Defense for Systems Engineering, who is the steward of the policy, defines open architecture as a “business and technical strategy for developing a new system or modernizing an existing one” that allows it to “design for affordable change, employ evolutionary acquisition and spiral development.”¹³⁰ To vigorously promote its use, DOD created a Guidebook for program managers' use in implementing open architecture in systems engineering, in contracts, and in buying essential data rights for key elements.¹³¹ DoD also issued directions to perform cost/benefit analyses, and established a Senior leadership oversight committee.

The Implementation of Open Architecture Has Faced Challenges. Over time, DoD and the defense industry have increasingly implemented open system architecture on major new programs and modification programs.¹³² Despite this progress, study after study by GAO and

¹²⁹Better Buying Power 3.0, available at <http://www.acq.osd.mil/fo/docs/betterBuyingPower3.0%289Apr15%29.pdf>.

¹³⁰See http://www.acq.osd.mil/se/initiatives/init_osa.html. (“Open systems employ modular design, use widely supported and consensus-based standards for their key interfaces, and have been subjected to successful validation and verification tests to ensure the openness of their key interfaces.”)

¹³¹USD(AT&L) Memo (May 2013), Employment of Open Systems Architecture Contract Guidebook for Program Managers, Version 1.1. Available at <https://acc.dau.mil/osaguidebook>

¹³²GAO-13-652, DOD Efforts to Adopt Open Systems for Its Unmanned Aircraft Systems Have Progressed Slowly (2013); GAO-14-395, Early Attention in the Acquisition Process Needed to Enhance Competition (2014), and GAO-14-617R, Review of Private Industry and DoD Open System (2014). All available at <http://www.gao.gov/docsearch/repandtest.html>

various DoD advisory boards continue to observe that open architecture is not yet nearly as widely used by the DOD as it should be, and recommend that DOD “require OSA.”¹³³

In practice, the implementation of open architecture has been slowed by a number of systemic challenges (as well as some continued degree of institutional resistance by DoD components and prime contractors). Factors that limit the adoption of open architecture include, among others:

- 1) the large installed base of proprietary systems, for which cost/benefit analysis may not support the shift to open architecture;
- 2) the high complexity, added cost and time associated with the larger number of interfaces needed to ensure rapid, high quality communications and greater interoperability between defense systems;¹³⁴
- 3) the development of a work force conversant in these architectures;
- 4) the need to understand and acquire the full IP/data rights of specific design elements, such as interfaces, critical for open architectures; and
- 5) the need to have proper oversight of the implementation of open architecture (as integrators can create a framework that appears open and modular but is difficult to integrate with external software or other capabilities in practice).

Thinking of the effort it sometimes can take to install application software from Microsoft on an Apple platform gives one a sense of the complexity surrounding this issue. In the absence of effective program oversight and management, architectures purportedly open may in fact be less than fully open.

In sum, the challenge is how to meaningfully advance open architecture in a culture where the established policy supports its use but the practice is not fully implemented.

F. DoD’s Limited Interest in Venture Capital and Other Alternative Models for Accessing Innovation

Finally, DoD’s innate conservatism is reflected its sustained lack of interest in utilizing venture capital or other alternative models for engaging with high tech startups and the new technology that they can offer. Given the well-known role of venture capital as a facilitator of high tech success, DoD’s lack of receptivity is frankly mystifying.

The In-Q-Tel Precedent. Since 1999, In-Q-Tel, an independent, not-for-profit organization, has operated to meet the technology needs of the U.S. Intelligence Community

¹³³DBB Innovation Report, *supra* note 37; GAO-13-651, *supra* note 109; and GAO-14-395, *supra* note 109; and GAO-14-617R, *supra* note 109.

¹³⁴Amaani Lyle, Pentagon Official Outlines Advantages of Open Architecture,” American Forces Press Service (Nov. 12, 2013) (Assistant Secretary Katrina MacFarland “acknowledged the complexities of interoperability, specifically the need for swift, quality communication among multiple weapons systems. That architecture is ... meaningful, but it’s hard.”). Available at: <http://www.militaryavenue.com/Articles/Pentagon+Official+Outlines+Advantages+of+Open+Architecture+-43867.aspx>.

(IC) for emerging commercial innovation. With ongoing funding from the Central Intelligence Agency, In-Q-Tel has invested in over 200 venture-backed startups developing technologies that provide *ready-soon* innovation (within 36 months) vital to the intelligence mission. More than 70 percent of their portfolio companies have never before done business with the government.

In-Q-Tel invests in these emerging firms and typically other private investors also co-invest as well—multiplying and leveraging the impact of In-Q-Tel’s funding. While a private entity, In-Q-Tel collaborates closely with the CIA to ensure its investments meet intelligence community needs and to assist in transitioning the technology developed to the IC.

In a recent limited bow toward this approach, DoD, as part of the DII, invested a small amount of funds in In-Q-Tel as a pilot program.¹³⁵ Of course, with In-Q-Tel focused on IC needs (i.e., a different mission set), its utility for defense needs would necessarily be limited.

Army Venture Capital Fund: OnPoint. DoD’s one foray into this area has been limited in nature and, absent DoD support, has not proved very successful. Specifically, a 2002 appropriations statute directed the Army to establish and provide initial funding (\$25 million) to a non-profit venture capital fund.

Pursuant to the statutory mandate, the Army established OnPoint Technologies, which was designed to serve as a bridge between the Army and the high tech community.¹³⁶ OnPoint has been a strategic investor in a variety of technologies of interest to the warfighter. While its initial core investment focus area was mobile power and energy enabling technologies, it now has a broadened mandate that focuses on such areas as autonomy, cyber, health information systems, and advanced materials.

In truth, the Army was not supportive of this alternative mechanism for encouraging innovation from the outset. Thus, the Army only provided OnPoint with very modest funding in total—in the range of \$66 million in total—which limited its efficacy. While the Army has the flexibility to continue to provide funding to OnPoint (as the CIA has done with In-Q-Tel), the Army has elected not to do so. OnPoint’s performance also suffered due to some investments in failed solar ventures.

In sum, DoD has the flexibility to use its legal authority, including OTAs, to establish a venture capital fund as an alternative means of connecting with small start ups and seeking out new technology. DoD’s failure to exhibit any meaningful interest in this type of alternative approach reflects on its innate lack of receptivity to adding this type of change agent to the DoD R&D ecosystem.

¹³⁵ Amber Corrin, “Pentagon chief looks to Silicon Valley for cyber skills,” Detroit Free Press (April 23, 2015). Available at: <http://www.freep.com/story/military-tech/cyber/2015/04/23/secdef-pushes-to-bridge-gaps-with-silicon-valley-cyber-vulnerabilities/26258515/>

¹³⁶ OnPoint Technologies was created pursuant to an Army Broad Agency Announcement as a result of Section 8150 of the Department of Defense and Emergency Supplemental Appropriations for Recovery From and Response to Terrorist Attacks on the United States Act, Public Law 107- 117 (2002), which set aside funding for a Venture Capital Initiative. For additional information on OnPoint, see its website at <http://onpoint.us/>.

V.

Metric 5: Evaluating Outputs— the Track Record of the DoD R&D Ecosystem

When viewed since the end of the Cold War, the DoD R&D ecosystem has produced significant, if not breakthrough, innovation in many technology areas, which, as noted above, is consistent with the historical reality that most innovation is not revolutionary in nature. Rather, it is a sustained and integrated level of evolutionary change in operating constructs, capabilities, and the like that can produce meaningful war fighting effects.

While the 1980s and 1990s saw significant breakthrough innovations, such as the deployment of GPS, low observables (stealth), night vision, spread spectrum digital communications, and increasingly high speed data processing,¹³⁷ the 21st century thus far has featured evolutionary innovation—the refinement and improvement of existing technologies and integrating them into new systems providing new capabilities.

Much of this refinement has been of the “faster, lighter, cheaper” variety—bringing down the cost of manufacturing a particular technology while reducing its size and the speed at which it operates. Hence, precision guided tactical munitions technology, which two decades ago cost up to \$100,000, today costs just \$10–20,000, and at the same time, is lighter, more accurate and more reliable. Reductions in the size and power requirements for electronic devices have allowed the services to develop robust countermeasures to the threat of GPS jamming of precision munitions, by fitting backup inertial navigation units into guidance packages that once only accommodated a GPS receiver. Similar size-related redundancy has allowed the U.S. to meet its requirements for unexploded ordnance (UXO) rates for cluster munitions, thus preserving a valuable capability that would otherwise have been retired to meet treaty obligations and defense guidance.

Other areas of incremental improvement have included tactical communications, where the military has profited from the wireless revolution in the commercial sector, while doing much innovative research in house on software defined radios.

The last two decades have also seen the combination of existing technologies into new systems and capabilities, most notably in robotics, where the U.S. is rapidly progressing from remotely operated vehicles into the brave new world of autonomous unmanned vehicles—in the air, on land, and in the oceans. Robotic systems are proliferating at both ends of the spectrum, from large, autonomous ships, submersible vehicles and aircraft that can perform persistent

¹³⁷Note, though, that many of these breakthroughs were in fact the result of cumulative evolutionary innovations—numerous small developments coming together over time to create a new capability.

reconnaissance and surveillance in addition to “kinetic” operations, to very small, insect-sized platforms to support the individual soldier or rifle squad in answering the crucial question of what lies over the next hill.

Challenges to our technological advantage by real and potential adversaries, such as the proliferation of unmanned air vehicles and the use of GPS jamming and disruption, have been matched by the rapid development and deployment of more robust GPS technology, as well as the development of non-GPS-based Precision Navigation and Timing (PNT) methods. The use of drones by ISIS in Afghanistan was met by the deployment of high power microwave and GPS jamming systems (some of them hand-held). High power tactical lasers are being deployed on a limited basis for defense against very short range rockets and missiles, mortar rounds, and aircraft.

In sum, this type of rapid development and fielding may not be the kind of dramatic “game changing” innovation that many believe we need, but it is far more typical of the usual pace of military innovation, adding incrementally to capabilities and creating opportunities for “horizontal innovation” at the tactical and operational level (where the real, and more lasting “offsets” are likely to be found).

VI.

The DII in Perspective: Constructive Debate and Pilot Programs but No Solutions to the DoD R& D Ecosystem’s Systemic Challenges

The DII has generated a constructive focus on the need for innovation and a number of its substantive elements undoubtedly may yield future benefits. One central element of DII, for example, is that innovation is not only about technological change (the focus of this essay), but of the need for new organizational and operational constructs to embrace and incorporate changing technologies.

Indeed, DII, driven top down by the DoD leadership, has in fact generated some impetus for change in specific elements of the R&D ecosystem, and more focus on issues of transition. There have been a series of ad hoc innovative projects and processes in specific DoD offices, from prototyping to “speed dating” with commercial firms.

On balance, however, DII does not include any significant steps to change the shape or direction of the large, multi-faceted defense R&D ecosystem nor meaningfully address the known institutional impediments to innovation within the system discussed herein. Indeed, if anything, the “out of the system” solutions suggest DoD leadership’s view that addressing the larger system’s problems are too hard and intractable, especially in the last year of an Administration.

A. DIUx: A Limited, Outside the System Experiment

DIUx, DoD’s major initiative to enhance engagement with the commercial sector (make “holes in walls”), is a “bite sized,” out of system pilot project with limited funding—more in the nature of an experiment than a systemic solution.

One can appreciate the philosophy behind the experiment: to establish a separate operation apart from the existing DoD culture and processes that would be more flexible and better shaped for engagement with commercial the world. Then, the idea is to “scale up” the lessons learned and develop new approaches and processes for the larger DoD R&D enterprise.

Fundamentally, however, how can such a small experiment possibly address the underlying systemic issues of the defense R&D ecosystem, or change its culture? When viewed in the context of the \$72 billion defense R&D ecosystem, it is difficult to see how DIUX’s \$60 million in contracts (orders of magnitude less than the total ecosystem) can make a meaningful difference—especially when it is not integrated into the system.

As a matter of scale, it is tantamount to saying that adding a shiny new rowboat to a PT boat can somehow transform an aircraft carrier. Moreover, given the failure of the larger defense ecosystem (the aircraft carrier) to meaningfully adapt non-traditional buying approaches in the past despite ample encouragement and incentives to do so, it is difficult to see why small, bite sizes innovative processes will somehow break through this wall of resistance and take root.

Moreover, DIUx has other challenges: to some extent, it duplicates the activities of DARPA, whose mission is to seek new and innovative technology from a range of sources, make investments across the defense portfolio, and take risks. There also are questions whether DIUx's relatively low level of output justifies the sizable investment in offices and personnel. Finally, its current organizational structure—reporting to the Secretary of Defense—is unsustainable and only serves to limit DIUx's ability to collaborate with the broader R&D ecosystem.

The Recommended Future of DIUx: Re-Integration, Re-Scaling, and De-Confliction. Despite these concerns, DIUx is an experiment worth pursuing. But, to make DIUx a meaningful agent of change—an aperture through which the high tech sector can engage the broader DoD R&D ecosystem—DIUx must be brought back within system, its efforts must be better scaled and funded (which will incentivize more collaboration with other DoD components), and its activities must be clearly differentiated from other key DoD ecosystem entities like DARPA.

B. The Third Offset: A Useful Proxy for Change But Not a Meaningful Operational Construct

The Third Offset construct is a useful proxy of the need to innovate and produce game changers where possible. However, as a true construct of a technology-based military strategy for the future, it is at best a speculative theory—one group of investments among many that may or may not pay off.

Offsets are Rare and Transient. For one thing, true disruptive game changers are rare in warfare and the dominance gained thereby has historically been transient. When they have occurred, they have tended not to be the result of one “big” change, but the application of multiple minor changes, many of which had been in existence for some time. Often, the critical element is not technological at all, but organizational or operational. In other words, the ability to combine technologies in a creative manner that generates new capabilities tends to be more important than simply developing the technologies themselves. Moreover, the notion that DoD or anyone is smart enough to identify in advance, and direct, from the top down, a Third Offset that provides an overmatch across the board seems questionable—on some levels, the ultimate in chutzpah or hubris. This contrived, top down approach appears contrary to the inherently messy and complicated nature of innovation—with its bottom up tendencies, as well as failures and dead ends—and to the history of how we achieved our dominance in the past.

How Can Autonomy, a Technology Becoming Ubiquitous, Become the Basis for an Overmatch? Consistent with these fundamental principles, it is difficult to see any reasoned basis for the assertion that autonomy and artificial intelligence will be the centerpiece or “sauce” for the Third Offset. Certainly, both are worthy of investment. Indeed, long before the emergence of the Third Offset construct, the United States identified both autonomy and hypersonics as areas worth pursuing and has invested S&T resources in both. And there is no doubt that these discrete technology areas are advancing—anyone who test drives a Tesla, with its driverless autopilot feature, can attest to that fact. Critically, however, even if we succeed in sufficiently maturing these technologies to use them on the battlefield—which is fairly likely—who is to say that they will give us an overriding competitive advantage or offset?

How, one wonders, can a set of commercial-based technologies like autonomy, which are rapidly becoming ubiquitous, afford a sustained qualitative advantage over our potential adversaries with access to the same technology? Indeed, this outcome would be at odds with a core part of the rationale for the Third Offset—namely, that the spread of advanced technology is eroding U.S. military superiority. Simply put, if the spread of advanced technology is eroding our existing offset, how can we expect that we can gain a new offset from a rapidly evolving and spreading commercial technology?

The Third Offset’s Questionable Move Away from Irregular Warfare: Is It the Right Signal? Finally, through the Third Offset, DoD has signaled a change in the balance of our S&T spending that warrants serious reconsideration, i.e., that the United States should shift away from a focus on irregular warfare and move more toward a focus on high-end adversaries.

The risk, which should not be discounted, is that this DOD focus on near peer competitors will be taken as a signal by the armed services and other DoD components to overshift the focus too much away from irregular warfare. In recent years, the pendulum had already shifted significantly in the direction of defending against near peer competitors as our operations in Iraq and Afghanistan wound down, low intensity conflict became politically less desirable, and sequestration created significant budgetary pressures.

The Effect of the Pack Mentality. Significantly, there is clear evidence that the U.S. capability for low intensity warfare is beginning to attenuate in all of its dimensions, from organizational structure, to training, to defense investment, to the interagency and civil-military component. In effect, we could have a repeat of the post-Vietnam reversion of the Pentagon away from low intensity forms of warfare we are more likely to fight back to the big wars.

The debate over the future priority of irregular warfare is most significant for the Army, which faces continued questions over its future roles and missions. Even after 9/11, the Air Force and Navy, by the nature of their capabilities, necessarily focused more on high intensity warfare and the deterrence these capabilities generate; their capabilities also offer a range of support to lower intensity missions.

While the Army has been the predominant service focused on low intensity conflict in recent years, there have always been elements that view this as a diversion from its historic mission—its DNA, if you will, which is more along the lines of defending the Fulda Gap.

Notably, as Vice Chairman of the Joint Chiefs General Selva observed with respect to the third offset strategy during the roll out of the Administration’s proposed 2017 defense budget, “[f]or the Army, it supports the ongoing transition back to high-end combat and full-spectrum.”¹³⁸ Thus, they welcome the refocus on great power competition, and would prefer to renew the Army’s focus on developing new, and potentially expensive, future fighting vehicles as part of a “full spectrum” Army—code language for returning to a high intensity focus.

The risk of over-shift should not be discounted. In recent years, the pendulum had already shifted significantly away from irregular warfare as our operations in Iraq and Afghanistan wound down, low intensity conflict became politically less desirable, and sequestration created significant budgetary pressures. There is clear evidence that our capability for low intensity warfare is beginning to attenuate in all of its dimensions, from organizational structure, to training, to defense investment, to the interagency and civil-military component.

To this day, the Army’s organizational embrace of low intensity warfare remains somewhat uncertain—without a true bureaucratic home, clear career paths and the like. The Army closed its Irregular Warfare Fusion Cell in 2014, which was created to assess, integrate, coordinate, and synchronize irregular warfare (IW) activities, initiatives, and capabilities across the U.S. Army and joint services. The Army’s capabilities for large-scale irregular warfare contingencies have certainly been scaled back. And, a review of the Army’s investment accounts indicate a clear focus on high intensity capabilities such as combat and related vehicles.

Moreover, perhaps just as troubling, we have been seeing a related phenomenon arising out of the Third Offset—a new “pack mentality” where nearly every program in the Pentagon now tries to associate itself with the Third Offset to draw off whatever new funding, if any, that exists for this initiative.¹³⁹ Thus, like “transformation” and the “revolution in military affairs” before it, the Third Offset risks becoming a largely empty slogan with no operational meaning.

A Requiem for the Third Offset. Given the issues raised above, the new Administration is best off leaving aside the Third Offset concept. While constructive as a mechanism to bring focus on the issue of innovation, its lack of specific strategic or operational meaning renders it of little use other than as a slogan of change. And, some of its implications—a shift away from irregular warfare and an overemphasis on the centrality of autonomy as a future overmatch—are problematic.

¹³⁸News Transcript, “Department of Defense Press Briefing by Deputy Secretary Work and Gen. Selva on the FY 2017 Defense Department Budget Request in the Pentagon Press Briefing Room,” <http://www.defense.gov/News/News-Transcripts/Transcript-View/Article/653524/departments-of-defense-press-briefing-by-deputy-secretary-work-and-gen-selva-on>.

¹³⁹In any event, other than a slight increase in RDT&E in the 2017 DoD budget request (4%), there also is no indication that significant new funds have been allocated to the Third Offset. While DoD stated that there was \$3.6 billion in Third Offset spending for fiscal 2017 proposed budget and \$18 billion spread over the five year defense planning cycle (the Future Years Defense Program or “FYDP”), DoD has not itemized this spending. See Mehta, Aaron, “Defense Department Budget: \$18b over FYDP for Third Offset,” Defense News (Feb. 9, 2016). Available at: <http://www.defensenews.com/story/defense/policy-budget/budget/2016/02/09/third-offset-fy17-budget-pentagon-budget/80072048/>. By all accounts, these figures simply relabel spending that had been ongoing in any event—and not just for autonomy and artificial intelligence, but a range of “offset related” technologies in other areas. Moreover, only \$35 million in S & T spending was identified as offset-related for 2017, a small figure at best.

VII.

Recommendations: A Bold, Systemic Approach to Enhance the Effectiveness of DoD's R&D Ecosystem

A. How to Drive Change—What Model Makes Sense

The overarching question is how to drive change, and apply these principles, in an inherently change-resistant culture. The challenges have largely existed for a generation and are well known, and ground is well plowed with potential solutions.

Numerous studies over three decades have recommended various incentives and other mechanisms to field more innovative capabilities more rapidly and adopt more commercially oriented practices and processes. While past Administrations have taken a variety of actions, these approaches, ranging from policy memoranda to the development of new tools and experiments, to workforce education, have largely not worked. Simply put, the system tends to resist efforts to encourage change—with little sustained or broad based implementation.

Thus, the question is how to ensure that the past is not prologue.

Adopt a New System. One option is to create an entirely “new” system for the development and acquisition of some types of commercially oriented capabilities that bypasses the traditional system—and perhaps replaces it in the long term. The new system could be designed to allow greater collaboration and use of private sector prototyping and other innovative practices and processes.

The dilemma is that it remains uncertain what a new and more effective system would look like—certain non-commercial elements would still need to be included, including rigorous testing requirements. If history has taught one thing, it is that shaping such a new system that addresses all of the relevant equities would be difficult, to say the least. Undoubtedly, it would take many months to carefully shape and implement, would involve many of the existing issues of the proper balance between congressional and management oversight and procurement flexibility and streamlining. Indeed, efforts to balance these considerations have led to some of the rigidities in the current system in the first place.

Moreover, starting anew would throw out many of the lessons learned over recent years, some of which have begun to bear fruit. There is evidence, for example, that Obama Administration has, for example, made progress in reducing the growth of cost in weapons procurement through its Better Buying Power Initiative.¹⁴⁰

¹⁴⁰ Under Secretary of Defense, Acquisition, Technology, and Logistics, “Performance of the *Defense Acquisition System*,” 2016 *Annual Report*. Washington, DC (Oct. 21, 2016) (Finding that DoD “is making continuing progress in improving acquisition” with regard to cost, schedule, and quality, and that “the 5-year moving average of cost

A Hybrid Model—Shake Things Up But Don’t Start From Scratch. Given these circumstances, we recommend that the Trump Administration adopt a hybrid model of systemic change that “shakes things up” and requires greater use of alternative acquisition approaches under existing law in order to create varied, non-traditional onramps for commercial technology and better incorporates innovative concepts in fielded solutions. It also would involve streamlining existing processes.

As noted above, numerous studies have recommended this and DoD leadership at various points has encouraged more use of these approaches—through memos, incentives, and calls for action. Yet, none of these assuasive approaches have worked.

Thus, at this juncture, the new Administration needs to generate forced culture change. Specifically, it should put in place a series of default mechanisms or forcing functions to move a reluctant system toward faster, streamlined and commercially oriented processes for innovation throughout the acquisition system—from early R&D through procurement. These approaches need to force at least the consideration and use of these flexible, alternative mechanisms, and have “escalation” provisions so that top level executives can help to oversee and drive change.

Notably, this hybrid approach can be phased in without enormous dislocation (especially on newer programs). Over time, gaining more experience with these novel approaches will allow us to see what works and does not. In the long term, these early actions may result in a new system, at least for commercially oriented capabilities—but one built on experience rather than out of whole cloth today. Hence, in the end, this hybrid approach offers potentially the best chance of success.

B. Core Principles and Realities

Within this overall framework to facilitate change, the new Administration should adopt an approach with the following core principles and realities in mind:

1. Recommendations Should Address Fundamental Systemic Challenges. The new Administration should focus on the fundamental institutional challenges we face in structuring a defense ecosystem that meets our war fighting needs—namely, to procure cutting edge, robust, and affordable capabilities in real time. Specifically, these include:

- Accessing, to the extent possible, all potential sources of future innovation, including vibrant technology emerging in the private sector and globally as well as traditional sources from government laboratories and the defense industry;
- Streamlining the transition of innovation, from whatever source derived, from the laboratory to the war fighter; and

growth on our largest and highest-risk programs at a 30-year low”). Available at: <http://www.acq.osd.mil/fo/docs/Performance-of-Defense-Acquisition-System-2016.pdf>.

- Building more agile and speedier practices in the DoD ecosystem that makes it less challenging (and more attractive) to non-traditional players to access.

2. Covering All Bases: Breakthroughs Are Impossible to Predict. The reality is that we do not know where or when path-breaking future innovation will emerge—it can come from any source, whether innovators in Silicon Valley or Route 128 in Boston, or the large array of innovators dispersed functionally and geographically throughout the United States and the world. Innovation tends to percolate from the bottom up more often than directed from the top down. Successfully exploiting innovation, whether in the commercial or the defense sector, depends largely on seeing the potential of inventions or discoveries that spring organically from fertile soil that encourages and enables experimentation and risk taking; it can seldom be forced to conform to preconceived notions of what the future *should* be.

To be sure, the vibrant commercial sector, with its enormous R&D funding stream, innovative development practices and rapid pace of innovation, may provide key enabling technologies for future defense systems. However, funding is not the only driver of innovation, and DoD still spends a considerable amount on R&D by any objective measure. Moreover, the very ubiquity of commercial innovation—its collaborative, trans-national development and rapid dispersion—may limit the private sector’s ability to create game-changing offsets or overmatches. Even with an effective export control system, it may be difficult to staunch the spread of leading dual use technology to potential adversaries.

Thus, it is just as plausible that leading defense technology—whether exotic defense-unique solutions or applications of commercial technology—will come from our laboratories or our traditional defense firms. Simply put, we do not know where the next great innovation will come from and therefore need to ensure our ability to draw off all relevant sources and make investment bets in various directions.

3. Challenges Transcend Organizational Structures. The innovation challenges discussed herein transcend, to a fair extent, different types of organizational structures, including those mandated by recent National Defense Authorization Acts. Thus, the same challenges will remain whether the system is, as it is today, organized under a single Under Secretary of Defense for Acquisition, Technology and Logistics (Under Secretary of Defense for AT&L), or as it will be as of 2018, under a separate Under Secretary of Defense for, on the one hand, Research and Development (Under Secretary of Defense for R&D) or, on the other hand, Acquisition and Sustainment (Under Secretary of Defense for A&S). Similarly, the delegation of more authority over major defense programs from the Defense Department to the armed services does not meaningfully change the nature of these challenges and in some instances may exacerbate them.. For example, having separate R&D and acquisition organizations may make issues of transition more difficult.

4. Solutions Must Be Systemic Rather than Piecemeal. Fundamentally, the challenges are system-wide, not isolated, and therefore the solutions should be as well. In other words, we need to reorient the direction of our \$72 billion defense R&D enterprise—the equivalent of moving or reorienting the direction of an aircraft carrier. To achieve this type of culture change, we therefore need to move beyond adding separate shiny new rowboats (bite-sized

showcase initiatives or pilot programs) and instead should seek to adopt fundamental changes in DoD's culture and approach to innovation needed to ensure a future force that can meet projected threats.

Small scale experiments like DIUx, while useful, will not solve or address the underlying institutional issues identified herein. And we should not be deterred by the reality that fixing the “big system” is hard and messy, could encounter resistance, and may only show results over time that transcends a single Administration. If we don't seek to address the systemic issues, we are at best only playing at the margins and unlikely to improve our ability to generate needed defense innovation.

5. Sustained Leadership Commitment is Needed. To achieve this type of holistic approach, we need a top down organizational commitment to sustained change within the Department—with the Secretary and the USDs (R&D and A&S) in synch and leading the way on the need to reorient the entire ecosystem and incorporate more innovative solutions into our capabilities. A “go along” approach at the top that is risk averse to changing the overall system will simply not produce meaningful results. Similarly, the focus needs to be sustained over an entire Administration or more; a loss of focus will likely doom the effort to failure.

6. There Are No Silver Bullets; Solutions Are Varied. Unfortunately, there are no single silver bullet solutions to these problems, and the solutions vary with the types of systems or capabilities at issues as well as the phase of the acquisition system involved.

Any solutions also have to be shaped with a recognition that there are varying degrees of commercialization that are realistic for different types of defense capabilities—defense platforms, subsystems, software, products and technologies—by virtue of their inherent characteristics. In short, there is no “one size fits all” here.

Defense Platforms/Systems. At the system level, it is unlikely—indeed, unrealistic—to think that commercial firms will or can serve as prime level integrators for many large defense platforms—whether for ground, air, sea or space. To be sure, there are certain dual-use areas such as satellites and space launch (witness SpaceX) where commercial firms can be primes. Where it is possible, DoD should take steps to afford them market access. But in most cases of systems that are exclusively military, non-traditional firms often lack the breadth and depth of integration capability and experience to serve in a prime role (even though they contribute important technologies and expertise). Wholly apart from the complexity of government contracting rules, fielded systems also need to meet rigorous technical standards and undergo strenuous testing—for safety, harsh environmental conditions, ruggedness, redundancy, ballistic performance, and other attributes—that have little commercial equivalent. While there may be some flexibility to streamline some requirements, in the end, some are necessary and appropriate. Of course, there is far more latitude for commercial firms at the prime level with respect to stand-alone systems or new capabilities that need not be integrated into large, existing platforms. New players emerged in the unmanned vehicle market, for example, and one can imagine that in other areas as well.

Software, Electronics and Subsystems on Defense Platforms. Certainly commercial firms can and should play a role in providing the “stuffing,” if you will, for defense platforms. In this

regard, today's defense platforms can be thought of as vessels into which various types of software, electronic systems, and other subsystems are integrated. Indeed, military officials have often referred to some of the new platforms like the F-35 as computers with wings or wheels. Numerous of these elements of "stuffing"—especially software—can and should be upgraded and changed out over time under existing concepts of spiral development, just as we upgrade operating systems on computers and the like. Thus, commercial firms should be afforded latitude to provide these capabilities where they can—and certainly some do today.

Stand-Alone Systems and Products. There is also considerable latitude for commercial firms in stand-alone products to be utilized alone or with defense systems (for example, in areas like directed energy, biotech, cyber technology and the like). In areas where commercial and defense standards and tolerances are fairly similar, this is very realistic.

Also, the insertion of commercial technology requires different approaches at different points in the acquisition system (with more risk taking easier in early stage R&D and more difficulty in later phases where there is a necessary focus on affordability and schedule). In particular, transitioning new technology into existing platforms (horizontal technology insertion) is challenging. More broadly, the challenge is also to encourage more experimentation (deviations from "the book") in military culture as well—by the operational as well as acquisition side of the house.

7. More Innovation Invariably Brings Affordability and Schedule Trade-Offs. Any system to acquire advanced defense capabilities must be structured to achieve the best solution across three variables (the engineer's so-called iron triangle): affordability (lowest price), innovation (technical capability and performance) and schedule.

The reality is that it is difficult, and nearly impossible, for any system or program to simultaneously "maximize" for all of these variables. Thus, trade-offs generally in a program context have to be made to achieve a particular set of outcomes (e.g., typically maximizing on one or two variables and satisficing on the others).

In a broad sense, some reforms adopted to maximize one variable can cause challenges on others. For example, the entire thrust of the Obama Administration's Better Buying Power Initiative focused on enhancing affordability, and perhaps, unwittingly, put practices in place that limited innovation—favoring the 80% solution on programs. If the focus is affordability, you will be less likely to want to spend the dollars to add another 15% capability through inserting new technology into an existing system. And some of the allegedly rigid FAR structures we now complain about may very well help to keep pricing in line. Thus, in making recommendations herein, we need to be eyes open that the proposals below inevitably will have some impact on affordability—at least in cases where we do seek to insert new technology in existing platforms.

8. DoD Cannot Entirely Become Like Google. In shaping future approaches, we need to recognize that there are inherent limitations to the commercialization of defense demand; the unique aspects of national security missions and requirements and different defense business models ultimately limit the ability of DoD to act entirely like Google or a Silicon Valley startup.

Thus, some innovators and technologists inevitably will be frustrated by the inability of DoD to wholesale adapt the “commercial way.” Defense systems ultimately seek to solve defense-unique challenges (e.g., producing specific kinetic effects, operating in a broad range of challenging environments under stress), and must meet certain types of performance standards and undergo rigorous testing that do not apply in the commercial sector. Moreover, there is an inevitable compartmentalization in the security-minded defense world that limits the types of collaborative process found in the commercial sector.

Also, differences in business models are clear. While consumer products such as smart phones are produced in the millions, and are considered outdated within one or two years, defense products tend to be produced in relatively small lots and have a projected service life measured in decades.

Thus, while some sectors in the defense world can look more like Google, others simply cannot due to differences in business models, national security needs, and the like.

C. Actionable Recommendations

1. Adopt a Strategy-Driven R&D Investment Portfolio Balanced Between Irregular Warfare. High Intensity Conventional Warfare and Nuclear Deterrence

The Department should adopt a prudent strategy for force development, derived from our overall national security strategy, that maintains a *balanced* portfolio of investments for the future, with a strong, sustained focus on: a) the low intensity and irregular conflicts that we are more likely to face in the coming years; b) the high intensity conventional warfare against near peer adversaries that we seek to deter but must be prepared to dominate; and c) nuclear modernization, an essential element of deterrence. Having a balance does not imply that each of these investment areas will be funded equally—irregular warfare development activities, for example, are likely to be less expensive than others as they are less platform dependent and more soldier-centric and tactical in nature.

While the United States may not desire to participate in low intensity warfare, a reasonable case can be made that these types of missions are more likely to be the norm than the exception in the coming years (with limited high intensity conflict mixed in, in some cases utilizing hybrid warfare concepts or asymmetric capabilities). Put another way, what is the basis to believe that the threats in the next decade or more will be different in nature than those in the last decade? Thus, in this security environment, the Third Offset’s shift in focus to high end warfare imprudently risks atrophying our irregular warfare capabilities for the future.

This strategy can provide top level guidance for R&D Investment while recognizing the need to allow some degrees of freedom to innovate and flexibility within that strategy. Uncertainty about future threats and which investment will yield meaningful results inevitably means we need to hedge our investments to some degree while avoiding sets of priorities that are really long “laundry lists” of what we are doing rather than more focused sets of core areas for development.

i. Conduct a Top Down Review of Irregular Warfare Capabilities. With this focus in mind, the next Administration should seek to ensure balance in the portfolio by directing a top down, across the board review of our commitment to irregular and low intensity warfare—doctrine, organization, training, equipage, and investment. The review of roles and missions will ensure we have in place the right mix of cross-service capabilities, organization and investments to ensure that we are ready for small and large scale irregular engagements. The Administration should also carefully consider what type of defense planning construct to utilize and to consider a possible mixed threat-capabilities approach to ensure we do not over-shift in one direction or the other.

ii. Increased R&D Funding by Roughly 10% to Support a Balanced R&D Portfolio. While DoD's historic R&D spending, under any metrics, are well within historic norms, DoD nevertheless should increase its level of overall RDT&E funding in the range of 10% in order to ensure the balanced approach being proposed—i.e., to both sustain robust spending streams on irregular warfare while advancing its investments in high intensity conventional war fighting and nuclear modernization. The need for significant innovation in all three areas justifies this increase.

2. Assess and Realign the S&T Portfolio with a Balanced Investment Strategy

The new Administration should assess its S&T investments against this balanced strategy and make adjustments in its investment portfolio accordingly. This involves a top-down effort to fully understand the existing portfolio—to have more insight—because, as discussed above, the complexities of the DoD defense R&D enterprise make difficult efforts to ascertain our allocation of investments, let alone synch it with an overall strategy. Fundamentally, like an investment portfolio manager, DoD must maintain discipline and stick to allocations we have set for the long term.

Of course, there needs to be some freedom of action and independence in the S&T area to encourage innovation. However, our accountability to the taxpayer, the scarcity of funds, and common sense require that we do better and put in place a framework to more fully evaluate and align our portfolio, from a resource standpoint, with our strategy. We should no longer describe a laundry list of investments as a strategy, as we have done in the past.

i. Adopt a Corporate Model of Investment Decisions. One approach to consider is the establishment of a top level investment committee, chaired by the Under Secretary of Defense for AT&L (or R&D under the new legislation), that includes leaders from the armed services and other DoD components and ensures that investments are aligned with strategy. Having a more rigorous, “top down” approach, at least with greater “corporate” insight if not oversight, will help to mitigate the risk that constituent elements of the R&D community will adopt a “herd” mentality and tilt the balance toward the current flavor of the month rather than stay aligned with an overall strategy.

ii. The Need for Portfolio Diversification: Autonomy and Artificial Intelligence as One “Bet” Among Many. The new Administration's team should make sure that the investment portfolio is focused on a range of diversified technologies with potential payoffs

(short, medium and long term), and that no single technology dominates our spending until such time as there is demonstrable evidence that this focus is warranted. Some of these will fail and other will not, and we are simply not prescient enough to be able to discern “winners” and “losers” long in advance. This means that autonomous capabilities and artificial intelligence should be one area of investment, but should not become the central, core focus of spending, at least until such time that there is convincing evidence that it will be so important a game changer. Other so-called offset technologies also should be considered on the merits for investment, but only to the extent that they have demonstrated potential and not because they fit into some future “star wars” construct that may or may not ever be realized.

3. Make a Sustained and Strong Commitment to Commercial Buying Processes

The incoming Secretary of Defense should make a strong, public commitment to commercial buying approaches throughout a product’s lifecycle (development, production and sustainment) and the Under Secretary of Defense for AT&L (or A&S under the new legislation) should direct all DoD acquisition units to utilize commercial item buying, OTAs, or streamlined traditional FAR buying as the default rule, not the exception.

Identify and Execute New R&D and Procurement Projects Using Alternative Authorities. DoD can and should utilize the full range of flexible and non-traditional authorities readily available to attack new defense challenges. Simply put, DoD has ample tools available to “get on with it” and incorporate commercial technology and processes to address new security threats rather than engaging in additional studies, pilot programs or similar initiatives that only serve to kick the can down the road.

The overriding point is that DoD needs to make it easy, not difficult, for the next SpaceX to offer a commercial solution and utilize alternative authorities to break down existing barriers to entry.

More specifically:

i. Recommit to FAR Part 12 Commercial Item Buying, and Streamline Its Practices and Processes. The Under Secretary for AT&L (or A&S starting in 2018) should provide guidance to DoD components and its own Defense Procurement staff that, within 180 days after Inauguration, the determination of commerciality should be streamlined, that certified pricing or cost data (or its equivalent) should not be required for commercial buying, and that DoD should not establish any measures that seek to impose traditional standards on commercial contracts.¹⁴¹ Consistent with this approach, DoD should withdraw its proposed DFAR amendments that would impose additional burdens on contractors and effectively limit the scope of the commercial item exemption.

¹⁴¹The 2017 National Defense Authorization Act, section 872, includes provisions that also are designed to limit the use of defense unique requirements and standards in commercial contracts.

ii. Establish a Presumption in Favor of Commercial Buying in Certain R&D and Production Product Areas, and Require Compelling Reasons to Overcome the Presumption. To overcome the historic reluctance of DoD components to utilize OTAs and commercial item authority, the Under Secretary for AT&L (or R&D and A&S starting in 2018) should establish, initially by policy memorandum and later by regulation, a *presumption* in favor of using one or more non-traditional commercial buying approaches (whether OTAs, Commercial Item authority or streamlined FAR-based buying) in any new research and development project or production contract over certain dollar thresholds in certain program areas.

The “presumption” on a particular program should only be being overridden where the senior acquisition executive in a DoD component (e.g., a service Assistant Secretary for Acquisition, Technology & Logistics) finds a compelling reason to use traditional FAR-based contracts. This forcing function allows DoD components the flexibility to apply traditional rules where warranted but forces their consideration and potential use as much as possible. For programs of a certain size or importance threshold programs, the Under Secretary of Defense for AT&L (or Under Secretaries for R&D and/or A&S) would have authority to review and approve the “exceptions to the rule” made by other DoD components.

iii. Establish a DoD-Wide Commercial Center of Excellence and Develop Best Practices and Processes for Commercial Buying. DoD AT&L should, at the outset, establish a separate commercial contracting office in AT&L (possibly under the auspices of a separate Acquisition Reform function rather than the Defense Procurement Office) to assist DoD components in creatively and flexibly considering whether to use OTAs, commercial item buying or some type of streamlined FAR contracting for a particular acquisition—with an emphasis on speed and introducing as many commercial sector processes as possible.

Under these alternative and more flexible models, DoD can shape to the circumstances of a particular contract more commercially oriented and less onerous rules, technical requirements, technical data rights, and testing parameters; contractors can be evaluated against their compliance with the specific provisions of the OTA-based arrangements. After experience and the development of lessons learned and best practices, a number of tailored OTA and other frameworks can be matured that can be applied, as templates, more broadly at different phases in the acquisition process to achieve better and more timely results.

iv. Require that DoD Components Take into Account the Need for Competition and Participation by Non-Traditional Suppliers in Shaping Long-Term Acquisition Strategies in Market Areas. Certainly, one element of the innovation challenge is the limited number of new defense programs—with large programs like F-35 accounting for a significant portion of the budget, and the consolidated nature of the traditional supplier base, particularly among primes that have authority over these major programs and have a role in deciding what other firms can participate in the program. These market circumstances create barriers to entry for non-incumbents, and especially non-traditional commercial suppliers. While merger reviews is one policy tool to address these issues, another is to shape long term acquisition strategies on the demand-side that, to the extent possible, take into account the need to sustain multiple suppliers and allow onramps for non-traditional suppliers in a particular defense business area

(e.g., unmanned aerial vehicles). The maintenance of competition over time can help to shape a market that offers better prospects of innovative solutions.

v. Streamline and Speed Up DoD Acquisition Processes Across the Board.

Consistent with the President's regulatory reform initiatives and the Secretary of Defense's request that the Department seek efficiencies in core business functions, DoD should, with the next three months, take steps to make leaner its acquisition related processes and practices, including the streamlining of requirements for major acquisition systems and audit functions to test compliance with DoD's cost accounting standards and other DoD contractual standards. Where burdensome steps with little value have been mandated by Congress, the Department should compile a list of such measures to be submitted to the relevant congressional committees for their consideration along with recommended fixes. The Department's leadership should not shy away from seeking these types of changes under the guise that it is "too hard" or will run into political opposition. Since existing laws are part of the problem, they need to be part of the solution.

4. Broaden the Use of Non-Traditional Modalities of Accessing Commercial Technology

i. Meaningfully Expand the Role of Venture Capital in Defense Markets. DoD should more broadly utilize and sizably fund venture capital models to access newly developing commercial technology. While the existing venture capital funds—the Army's Onpoint and CIA's In-Q-Tel—are useful, they are too narrowly focused on their own customer's needs and not sufficiently funded. Given the range of potential technologies and industries, DoD should:

- 1) establish a defense-related fund or designate one or more existing private funds that meet certain parameters as such a fund (e.g., that invests more than 50% in business areas with DoD customers);
- 2) provide these funds in the range of \$500 million-\$1 billion per annum in funding for equity investments, loans, and other arrangements; and
- 3) establish a liaison function at DoD to work with and transition the technologies developed by these funds into DoD programs (with DIUx a possible candidate to provide this liaison function).

Financing approaches like the use of government loan guarantees could be used creatively to establish additional investment vehicles at more limited cost to DoD. While DoD has put its toe in the waters by making a small investment in In-Q-Tel, this is insufficient to achieve meaningful results. The new DoD funds should be directed to review firms that have successfully utilized SBIRs funding to determine if additional mezzanine funding would be useful to continue the development of their technology for war fighting purposes. This would allow DoD to better facilitate the transition of firms with valuable ideas that have exhausted their SBIRs opportunities and are in need of additional funding.

ii. Create Funded Centers of Excellence in Targeted Firms and Universities. Rather than have DoD's laboratories hire scientists and engineers on the west coast or elsewhere and expand their footprint in different regions or sectors, DoD should competitively offer multi-year funding for targeted research at particular private companies in certain domain areas of

interest to DoD and possibly to industrial or industrial-academic consortia. Firms would bid to allow its technical personnel participate in these programs. This would allow DoD to access a core group of talented private sector scientists and engineers spend a portion of their time for an extended period (not just a year or two) working on specific defense challenges. For the companies and academic communities involved, its employees would be able to develop broader domain expertise from working on defense problems that could cross-fertilize its commercial work while possibly leading to ideas that could result in both commercial and defense innovation.

iii. Broaden the Availability of the SBIR Program and Create Better Metrics for Tracking Its Success. DoD units should be afforded the discretion to give larger SBIR phase two grants (beyond the current \$1 million threshold) in order to facilitate the development of particularly promising technology. Moreover, consideration should be given to affording DoD units the discretion to include firms that are close to but exceed the current “small” threshold which have meaningful technology that warrants development. There is no magic to this standard, and this type of an arbitrary benchmark should not serve as a deterrent to meaningful innovation. Also, DoD should work to provide access to mezzanine funding for the transition from Phase II (Concept Demonstration) to Phase III (Commercialization) (using the equity funds discussed above), and also provide more hands-on assistance to Phase II graduates reaching out to defense companies with their technology. Also, DoD should develop better metrics for assessing the success of the SBIR program with regard to the number and quality of the technologies transitioning into defense programs.

5. *Adopt a Series of Measures to Cultivate a More Risk-Taking, Entrepreneurial DoD Culture and Better Facilitate Transition of Technology to the War Fighter*

i. Integrate DIUx into the Defense R&D Ecosystem. DIUx should be put under the supervision of the Under Secretary (R&D), its program efforts should be de-conflicted with other DoD research units, and its funding should be expanded to \$250 million (with the ability to seek matching funds from private sector participants who receive large contracts.)

The integration will not only sustain DIUx, but move it beyond the pilot stage and enhance its ability to act as a conduit and bring innovative commercial technology into the defense R&D ecosystem. This higher level of investment allows DIUx to leverage its resources and get a better return on the additional staff resources it has deployed. It also incentivizes other DoD R&D units to work collaborative with DIUx to benefit from its broader funding, potentially facilitating the transition of its projects to DOD customers. In this way, the shiny new DIUx “rowboat” will be better able to scale up and have a better chance to help reorient the overall R&D carrier.

The additional funding also will allow DIUx to play a role for firms that are no longer “small,” and cannot qualify for a SBIRS grant but nevertheless are relatively small firms with potentially valuable technology for the war fighter.

ii. Create a Separate Fund for Competitive Developmental Prototyping (Prototyping Fund) with Flexible and Sizable Multi-Year Funding—\$750 million—\$1 billion per annum. The Under Secretary of Defense for R&D, through its Office of Emerging

Capability and Prototyping (ECP), should administer the fund, initiate competitive prototyping in targeted areas, and consider, on a competed basis, bottom up requests for prototyping from both DoD components and industry. DoD should utilize its flexible authority to allocate resources across domains to promising prototype efforts in real time, and assign prototype agents in various DoD components to manage these projects.

Notwithstanding the clear desirability of more prototyping, little has been done to meaningfully move this agenda forward—especially from a funding standpoint. In an era like this one, with a broad, uncertain threat environment and rapid technological change, it makes little sense to invest now in volume production of new systems (especially for ground warfare) which could potentially become rapidly obsolescent (even while in development). Thus, it is better to invest in a range of concepts and technologies procured in limited numbers, and engage in operational testing and evaluation.

Especially in an era of fiscal restraint where we have a continued high tempo of operations and have limited funding for significant force modernization, now is arguably the right time to experiment rather than develop expensive new systems. And historically, periods of limited resources have tended to be marked by significant innovation.”

Thus, by putting this sizable fund at the USD R&D level and forcing a competition for resources, this approach can potentially ensure a holistic, DoD-wide evaluation of prototyping and allocate resources accordingly, and also can help to overcome the cultural resistance to change and risk-averse behaviors we have seen in various DoD components and industry.

Indeed, prototyping allows scientists and military operations personnel to work together to test new ideas in the field—which can generate the type of innovations we are looking for.

Moreover, DoD can push forward prototypes that otherwise might be left on the drawing board in the various armed services. At the same time, putting the management of these projects in the various DoD components can help to foster interest in these new technologies in each operating community that will experiment with these prototypes. This new path is a more cost-effective approach to get the benefit of new technologies and capabilities, commercial and otherwise, without establishing additional major defense acquisition programs.

iii. Create a Commercial Prototyping/Demonstration On-Ramp and Require, As a Default Rule, the Use of OTAs or Other Alternative Arrangements. DoD could set aside a significant portion of the proposed DoD Prototyping Fund to create a special prototyping on-ramp for commercial technologies and non-traditional firms that can be managed by DIUx.

Specifically, as discussed above, commercial firms as well as other firms can bring forward an idea for prototyping that DoD would evaluate and, if there is interest, enter into an arrangement for the development of a prototype. As a default rule, the USD R&D should require a presumption that individual DoD components will utilize commercial buying (OTAs or other commercial arrangements) for such prototypes proposed by commercial and other non-traditional defense firm unless there is a compelling reason to the contrary, and such exceptions shall be reviewed and finally determined by the USD (R&D).

iv. Establish a DoD-Wide Technology Transition Review Board to Ensure Focused Decisions on Whether to Graduate Technologies from the Lab to the War Fighter. To ensure that technologies potentially valuable to the war fighter, DoD should establish a Technology Transition Review Board that would help address whether technologies should graduate to production. Specifically, the Board shall be chaired by the Deputy Secretary of Defense, and shall include the USD (R&D) and the USD (A&S) as well as representatives from each relevant DoD component, including the armed services. The Board shall meet twice a year and consider the trajectory of technologies identified for consideration by any members of the Board. This approach allows a holistic decision process on transitioning technology—with decisions made “eyes wide open.” The ECP office would staff the Board’s work and be the focal point for identifying technologies that warrant the Board’s consideration. In some cases, moving to prototypes may be a solution to move the technology forward if warranted.

While there is a range of programs that offer funding to facilitate the transition, most of them offer limited funding for small firms or more mature technologies. Thus, the idea of this effort is to bring a high level focus on meaningful technologies that appear to warrant consideration and have slipped through the cracks—either because the customer community is resistant, the relevant program office does not wish to fund the technology and so forth. This type of Board could help to “force” through the system the next SpaceX type offering or the next UAV-type capability that threatens an existing operational paradigm.

v. Inserting New Technology into Existing Programs; Forcing Consideration by Program Managers at Major Milestones. This is perhaps the most challenging area given the inherent structure of the acquisition system for these later phases, which necessarily focuses on affordability, technical performance, producibility, and timeliness and has far less tolerance than earlier stage efforts to take risks and evaluate immature technologies. Injecting new or upgraded technologies at this phase is often difficult to justify. To address this issue, AT&L should require focused consideration of technology insertion at all major milestones on programs (whether major programs or other programs managed by the individual DoD components), with reporting on such reviews (noting the technologies considered for insertion, whether it will be inserted or not, and the benefits, costs and risks associated with such insertion or non-insertion).¹⁴²

vi. Require, With Forcing Functions, Broader Use of Open Architecture. The Under Secretary of Defense for AT&L (and its statutory successors) should require that new defense systems be designed and implemented with open system architecture absent a finding by the head of acquisition in the particular DoD component that open architecture is not in the public interest (which finding is subject an override by the Under Secretary of Defense for AT&L, or the Under Secretaries for R&D and A&L under new legislation).¹⁴³ As noted above, open

¹⁴²In the 2017 National Defense Authorization Act, Section 849, Congress established several measures to partially address this issue, including a pilot program for legacy programs cost savings associated with the introduction of commercial items and technology.

¹⁴³To address the same issues, the recently enacted National Defense Authorization Act of 2017, Subtitle B, section 805, requires, among other things, that any major defense acquisition program that receives Milestone A or

systems architecture and the adoption of modular approaches can be an effective tool to allow the more rapid insertion of innovative commercial technology into complex defense systems and can also generate affordability. And, some progress has been made in moving in this direction in recent years. However, there has been some institutional reluctance to shift to open architecture by DoD components and their contractors and in some cases, especially with respect to legacy systems, the shift may not be legitimately justified from a cost/benefit standpoint.

This recommendation thus proposes a forcing function: a presumption in favor of its use that can only be overcome by a compelling finding of the senior acquisition executive in a DoD component (e.g., the Assistant Secretary of the Air Force for Acquisition, Logistics and Technology) that open architecture is unwarranted. Additionally, the Under Secretary of Defense for AT&L (and statutory successors) would reserve the right to override the exception finding by the head of each DoD component on a case-by-case basis.

Thus, this recommendation moves toward the use of open architecture but affords some flexibility to allow judgments to the contrary where sufficiently warranted that a senior executive who would be willing to waive the requirement.

6. *Develop Incentives and Evaluation Metrics to Enhance the Critical Role of Prime Contractors in Accessing and Transitioning Commercial Technology*

In evaluating the engagement between DoD and the commercial sector, analysis often overlooks the central role and responsibility of prime contractors on defense programs under our current acquisition system. Prime contractors are tasked to provide “best value” solutions to DoD customers and, in so doing, should be “hunter/gatherers” of advanced commercial technology and make reasoned decisions whether to transition such technology into their program (often made through make/buy decisions). Thus, the Department should take steps to incentivize this role and develop metrics to evaluate the primes’ performance. Specifically, such steps should include among others:

i. Require Commercial Technology Plans. Primes should be required to develop a Commercial Technology Plan, both generally and specific to major programs, and should submit this plan in response to requests for procurement (just as they prepare small business plans). The plan should focus on the company’s efforts to attract and access commercial technology, to evaluate its insertion into programs, and to insert it where appropriate. It can include their proposed efforts to reach out to small commercial firms through various new forms of engagement.

Milestone B approval after January 1, 2019, “shall be designed and developed, to the maximum extent practicable, with a module open system approach.” It also requires that the Director of Cost Assessment and Performance Evaluation ensure that, in analyzing alternatives for major defense programs, consider “evolutionary acquisition, prototyping, and a modular open system approach.” The proposal herein goes beyond this constructive approach in two respects. First, it establishes a clear procedural forcing function rather than only discretionary language that can help to overcome institutional resistance to reform. Second, it extends the requirement beyond major systems to all new systems.

ii. Require Prime Contractors to Adopt a Presumption in Favor of Using Commercial Buying in Areas Where Commercial Capability is Better Value. DoD also should put in place more robust policies and processes in certain capability areas to ensure that primes use commercial item authority on programs for purchases from commercial vendors, including a default rule in favor of such buying and a requirement that primes must seek exception approval from the program office where not using commercial item buying. Similarly, primes should be delegated OTA authority to enter into such arrangements where commercial item buying authority is not applicable or appropriate in the circumstances.

iii. DoD Reform of the Requirements Process Can Facilitate Commercial Engagement by Prime Contractors. The military services can facilitate this process by reforming the manner in which they write and use Operational and Tactical Requirements Documents (ORDs and TRDs), which are, in effect, the blueprints or specifications that the services provide to industry when soliciting new weapon systems. Ideally, these documents should be descriptive and effects oriented, telling industry in broad terms what performance outcomes it wants from the new systems; industry would then creatively develop solutions to the requirement.

Today, in actuality, the ORD and TRD tend to be highly prescriptive, telling industry not only what a new system should be able to do, but how it should do it. This is much like a person who hires an architect to design a house, but instead of telling him the desired size of the house, the number of bedrooms and bathrooms, etc., also tells him how the house should be framed, plumbed and wired. This tends to result in “look-alike” solutions, as offerors try to meet the specified requirements, but also limit the scope of the solution to that which the people writing the requirements can imagine—and their imaginations tend to be limited to those systems they already have, and with which they are familiar. Thus, the requirements process tends to dampen the ability to include new commercial innovation on programs.

iv. Add New Evaluation Metrics in RFPs on Technology Gathering/Insertion and Open Architecture. In requests for procurement for programs of record, DoD components should add to its evaluation metrics: 1) a factor that considers the projected performance of each bidder in developing or providing recently developed commercial technology for the program; 2) a sub-factor on past performance that analyzes the prime contractor’s history on technology gathering and insertion; and 3) a sub-factor on past performance that analyzes for their ability to *design and sustain* open architecture on complex systems.

DoD should develop proper metrics to utilize in evaluating the performance of defense primes in this area and make those metrics known to contractors, and also can and should take the performance of primes in this area into account in setting award fees on programs.

7. Enhance DoD’s Access to Foreign Ideas and Talent in the R&D Process

DoD should adopt a policy that encourages, and increases funding for, its S&T community, and broader R&D elements, to access and fund promising foreign talent and ideas, either through traditional “top down” approaches—such as through government to government arrangements, CRADAs, grants, contracts, OTAs, and venture capital mechanisms—or through “bottom up” industrial cooperation between U.S. and foreign parties. Given the increasing

innovation abroad (as reflected in R&D funding flows, numbers of patents and scientists with advanced degrees), this increased access is no longer a luxury but a necessity to ensure we are able to draw upon the best ideas for new military capabilities and avoid technological surprise. DoD should use its “bully pulpit” to broadly disseminate this policy and ensure its implementation throughout DoD and encourage U.S. firms to consider bottom up transnational industrial cooperation with businesses and universities. The policy would include, among others, the following specific elements:

- a. Increase by \$250 million funding for S&T international engagement (grants, investments, and joint projects) so that DoD can get a sufficient return on its sizable S&T international infrastructure and better access foreign firms and entrepreneurs through various arrangements (seeking partner contributions from participating governments or companies where appropriate)
- b. Create a DARPA Early Stage Foreign Innovation Window to access foreign innovation not mature enough for the Foreign and Comparative Test Program, which focuses on mature technologies, and authorize \$100 million per annum for this effort (essentially along the lines of offering SBIR-types grants)
- c. Significantly expand funding for the existing Coalition Warfare Program (to \$500 million from its low level today) and add a focus on prototyping in order to strengthen our efforts to work with allies on advanced coalition capabilities, and leverage that effort through contributions made by foreign partners
- d. Create a program to have foreign scientists and entrepreneurs in residence for 1-3 year periods at U.S. universities, private sector firms, DoD laboratories and other appropriate venues to pursue work on a collaborative basis with U.S. counterparts;
- e. Make a concerted effort to draw on Japanese commercial technologies through using all the commercial buying tools and authorities available to Do (while addressing U.S. concerns over Japanese technology security in a practical fashion)
- f. undertake substantial technology transfer reform to support this agenda, including streamlined export licensing, broader release policies vis-à-vis close allies, and the elimination and consolidation of various DoD committees that oversee technology transfer

8. Curtail and Re-examine the Role of DoD Laboratories

i. Seriously Evaluate Options for the National Laboratories and Federally Funded Research and Development Companies—a BRAC-Type Exercise. The new Administration should immediately conduct a full assessment of the national laboratories and FFRDCs and examine, among other things, whether there is duplication with private sector research, and whether options like downsizing, streamlining or privatization are warranted.

The goal is not only to get a better return from our DoD labs and FFRDCs (i.e., how to improve those capabilities) but to assess whether we can get a better return from applying some of the existing funding (\$30 billion in the case of labs) to other potential sources of innovation.

The convergence of several dynamics indicate that, over time, DoD should lessen our reliance on government laboratories as a source of innovation. Specifically, these dynamics include:

- 1) the challenges of attracting the best and brightest talent to our government labs in light of the fact that an increasing per cent of research and development is done in non-governmental fora (either the private sector or academia) that offer attractive opportunities to participate in cutting edge research at better compensation levels;
- 2) given the far larger funding of private sector R&D, the likelihood that some of the activities in our defense laboratories may duplicate ongoing activity in the private sector;
- 3) the existence of a certain degree of lethargy or inertia in the lab's aging work force, which is less like to be a lead source of innovation in the future; and
- 4) the aging of the laboratories' infrastructure and the need for new investment to modernize and sustain these facilities.

With respect to FFRDCs and labs, consideration should be given as well to raising the commercial ceiling, i.e., the amount of business they can solicit from the private sector. This could increase the exposure of their personnel to the commercial sector, and allow them to assimilate more of a commercial mindset.

ii. Triage Approach—Immediately Cut Laboratory Spending on Scientists and Engineers by 5%. In the interim, based on the reasonable assumption that some portion of the expenditures for DoD laboratories are better off being spent elsewhere, DoD should cut the S&T funding for the DoD laboratories by 5%, freeing up funding that can be re-allocated to other S&T mechanisms, and direct that the decrease come entirely from a reduction in force (on a performance basis if legal authority permits this approach). This will force DoD S&T components to make a down payment on inevitable downsizing and accelerate the process of shifting resources to alternative S&T uses.

9. Incentivize Enhanced Defense Industry S&T Activity

i. DoD Should Encourage Greater Defense Industry Spending on IR&D. DoD cannot require defense firms to increase their spending on IR&D, but DoD, as the protector of the public fisc and main funder of industry R&D, has every right to use its moral suasion to encourage these firms to invest more in the public interest as well as their own interest. While some progress has been made here in the last few years, there is more room for IR&D growth, to be sure, that would also enhance the competitiveness of these important firms for the future. DoD also should consider whether, in consultation with other federal departments, to adopt changes in accounting practices to treat R&D investments (or at least some portion thereof) as assets rather than pure expenses in order to incentivize R&D increases.

ii. Adopt a Rule of Thumb to Encourage More Private Sector Focus on Longer Term, Force of the Future, Development. To ensure that a sufficient portion of IR&D spending is properly focused on future development rather than more short term incremental development or customer directed development, DoD should create a rebuttable presumption that firms will spend at least 1/3 of their IR &D spending on the force of the future (i.e., on development work that is unlikely to generate revenues for the next five years), which

presumption can only be rebutted by a compelling reason to focus on shorter term projects. When firms present their IR&D spending to DoD, they can brief DoD at that time on whether their spending is consistent with the 33% rule and, if not, what the basis was for departing from the presumption.

iii. DoD Should Provide Top-Level Guidance on Key Areas for Investment.

Providing a select number of areas on which firms can focus IRAD spending accomplishes several things. First, it addresses an industry concern that DoD is not providing them guidance except laundry lists that make it hard to set priorities. Second, top level guidance can help to mitigate the pressures from particular programs or DoD components to press firms into spending on shorter term needs rather than long term DoD-wide needs.

* * *

In sum, none of these measures are in and of themselves “game changers.” It will take a sustained commitment by DoD leadership and years of execution to see meaningful progress in this area. But these measures begin to move the direction of the S&T enterprise and our acquisition system writ large toward attracting more non-traditional, increasingly important sources of innovation, better transitioning technology to the war fighter and changing DoD’s internal culture so as to breed more receptivity toward new ideas and hasten the pace of its acquisition processes.

***Against the Odds* Driving Defense Innovation in a Change-Resistant Ecosystem**

Jeffrey P. Bialos

**Christine E. Fisher and Stuart L. Koehl,
Co-Contributors**

“To put it bluntly, we need to find a way to make it less Herculean for innovative change to flourish in our armed forces. ... If you seek to help solve one of our most vexing Defense problems, I highly recommend reading ***Against the Odds—Driving Defense Innovation in a Change-Resistant Ecosystem.***”

from the Special Foreword by

The Honorable David (“Dave”) Oliver, Jr.
Rear Admiral (Ret.)
Trinidad, California



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