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Independent Resesarch and Development (IR&D)
The Challenges Continue

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Executive Summary

For nearly 80 years, defense policy makers have worked to develop and refine policy that incentivizes firms to undertake independent research and development (IR&D), defined by the Department of Defense (DoD) as research and development that is not sponsored, or required, in the performance of a contract or grant, but that is ultimately recovered through the firm's overhead rate. As enacted, IR&D policy permits investment in four areas: basic research, applied research, development, and systems and other concept formulation studies. To qualify as IR&D, the firms' effort must be of potential interest to the DoD. Beginning in 1996, firms could seek reimbursement for up to 100% of their IR&D investment. Today, the DoD reimburses defense and commercial firms nearly $4 billion annually for their IR&D efforts (Erwin, 2015a).

The objective of IR&D policy is to support the emergence of transformative defense technologies in the absence of a traditional market. However, some recently-proposed changes to IR&D policy call for increased oversight procedures, sparking considerable debate over just how "independent" such research efforts should be. Indeed, there is legitimate concern that the policy changes could stifle private-sector innovation by derailing promising lines of research that may have significant, if not clearly discernable, defense applications.

These changes come at a time in which the nation faces new challenges that jeopardize its superiority, demanding a renewed commitment to innovation generally. These challenges include adversary adaptation, budgetary constraints, and the loss of domestic technical capabilities.

Firms that specialize in the design and production of weapons systems and other defense goods are limited in their ability to recoup their R&D costs through traditional means—i.e. spreading them across their product portfolio. Competitive commercial firms, for their part, may shy away from investments in technology innovation if they cannot obtain a monopoly. Firms are more likely to invest in developing upgrades and complementary products for in-use technologies in an effort to win contracts. These modifications result in incremental innovation, as opposed to a paradigmatic shift.

Outside of the IR&D program, defense firms also self-fund internal R&D efforts. Across the board, however, defense contractors spend a fraction of typical private sector R&D spending.

Relatively low levels of self-funded R&D by defense firms is increasingly worrisome in that the U.S. government has reduced its R&D expenditures, particularly in the area of defense. These two trends highlight the importance of maintaining a strong IR&D program.

The structure, regulations, and total amounts allowed for IR&D have evolved throughout the 20th and 21st centuries. By the 1980s, reporting requirements had developed into a burden on both the contractors and the military evaluators, leading the DoD to limit its technical exchanges with industry beginning in the 1990s, not only to reduce this burden, but to ensure independence of IR&D. However the result has been "a loss of linkage between funding and technological purpose" (Mullin, 2011).

It is clear that IR&D policy has been informed by two competing philosophies: 1.) that truly remarkable innovation occurs in an unconstrained environment and 2.) that some constraints are necessary to focus innovation in order to derive practical applications, especially in times of significant DoD budget reductions. To this day, policy continues to oscillate between these philosophies as policymakers strive to achieve a better balance between firms' autonomy and government involvement in an effort to deliver transformative defense innovation. Not without cause, critics tend to recast this objective as a case of Government wanting "to have its cake and eat it too."

The IR&D program is, in large part, the product of legal battles between the government and defense contractors over terms that, in some cases, are open to interpretation. For instance, debate raged for decades over the definition of "implicit" contract requirements and whether such requirements were reimbursable as IR&D.

It was not until 2005 that the judiciary provided more definitive guidance. Mitsubishi Heavy Industries (MHI) of Japan contracted with ATK Thiokol (ATK) for a type of solid rocket motor that ATK had produced for nearly fifty years. However, the modified version sought by Mitsubishi had not been fully developed. ATK agreed to internally fund the effort to modify the motor, charging the development costs as IR&D, to be applied to the firm's overhead rate on government contracts.

The Federal Circuit Court ruled that "required in the performance of the contract" should be understood to mean "a requirement of the contract"—i.e. an explicit requirement contained in the statement of work. Thus, costs unassociated with written contract requirements may be allocated as IR&D. To this day, the government and private industry rely on this legal interpretation.

As a result of this landmark ruling, there are fewer strings attached to firms' use of IR&D funds. Perhaps it is no surprise, then, that the DoD has attempted to rebalance the IR&D equation by imposing some constraints in order to stimulate the development of technologies with defense applications. These constraints come in the form of new policies: tracking firms' IR&D expenditures; obtaining rights to their intellectual property; and requiring firms to enlist a DoD "technical sponsor" for their IR&D projects prior to their initiation. Although well-intentioned, these policies present challenges.

The Defense Innovation Marketplace (DIM), a database, was launched in 2012 in an effort to streamline communication between the DoD and the defense industrial base and to increase DoD visibility into IR&D projects. Unfortunately, many firms fear that by using the DIM, their proprietary data will be made vulnerable to intrusion by other firms. This fear stems, in part, from the fact that firms use the portal for two purposes—to report their proprietary IR&D summaries as required, but also to display innovations that they may want to sell to government buyers (Council of Defense and Space Industry Associations [CODSIA], 2012). According to CODSIA (2012), "there is the possibility that the proprietary IR&D summaries could be confused with the innovations being marketed for sale" (p. 2). As a result of this perceived insecurity, firms also worry that their information may be used by DoD acquisition professionals in a misguided attempt to incite competition in order to bring down the cost of new innovation.

More generally, firms worry that their intellectual property (IP) and data rights may be subject to new laws and regulations—perhaps with good reason. As recently as 2011, the language of the National Defense Authorization Act (NDAA) appeared to state that the DoD retained all technical data rights associated with IR&D-funded programs. The language was clarified in the 2012 NDAA, which adopted previous descriptions of IR&D as a "private expense." It remains unclear whether the 2011 version represented an attempt to change the law. George Winborne, Intellectual Property Counsel for the U.S. Army Materiel Command, noted that the change

"might have been someone's response to the Federal Circuit's ruling in *ATK Thiokol*" (American Bar Association, 2011).

Recently, the DoD considered a new regulation, included in Better Buying Power 3.0, whereby firms would be required to enlist a technical sponsor from the DoD, presumably a military service of defense agency prior to initiating an IR&D project. Perhaps not unexpectedly, firms and industry associations reacted strongly, arguing that "micromanaging company investments would be counterproductive and a drag on innovation" (Erwin, 2015b, p. 1). One industry representative asserted that "Having the government dictate exactly what it wants kind of takes the 'I' out of IR&D" (Erwin, 2015b, p. 2).

This is not to say that the IR&D program could not benefit from more interaction between the DoD and industry. Indeed, defense firms "lack in-depth access to DoD key requirements which would enable them to focus their S&T and IRAD spending" (Defense Business Board, 2015). Yet because the DoD relies heavily on inflowing information (e.g. so-called transparency databases and reporting requirements), and less on outflowing information (e.g. an articulated technology strategy), "failure to communicate" is often cited, both generally and within the context of IR&D, as a major barrier to strategic investments in technology.

In addition to these specific program challenges that threaten to limit innovation, there are a number of additional challenges, including disturbing trends, inefficiencies, and enterprise-wide problems that decrease the potential effectiveness of the IR&D program.

First and foremost, firms are investing less in IR&D than in years past. In fact, a Defense News analysis of R&D spending by top defense contractors shows independent IR&D spending "declined by nearly a third in percentage terms from 1999 to 2012" (Fryer-Briggs & Weisgerber, 2013). It is possible that two trends are partially responsible for decreased IR&D investment: increased spending on bid and proposal (B&P) costs and the use of the Lowest Price Technically Acceptable (LPTA) source selection process.

Recently, the DoD has increased reliance on Indefinite Quantity/Indefinite Delivery (ID/IQ) contracts, which requires companies to bid for a parent contract and, if awarded, compete for individual task orders. 'Twice-bidding' has increased the amount firms spend on B&P per unit of

business. Given that B&P costs and IR&D costs accumulate to the same indirect cost pool, it is reasonable to assume that increased spending on B&P may reduce IR&D, given pressure to maintain a competitive overhead rate.

Regarding LPTA, critics have noted that its use creates "a race to the bottom" as contractors work to provide cheaper, and ultimately, less effective systems. As LPTA became more common, firms reduced staffing and overhead costs (including, it seems, IR&D), focusing less on innovation and more on the pursuit of low-cost technologies and upgrades to existing systems. As a result, IR&D spending, itself, may have been directed at developing less innovative, less costly systems.

The preference to self-fund R&D represents an additional challenge. Some firms prefer to rely on self-funded "internal" research programs so as to retain full control of the research output. Some firms have expressed the view that export controls and government intellectual property rights act as disincentives to developing IR&D-funded systems. Required reporting through the Defense Innovation Marketplace for IR&D-funded projects serves as another disincentive.

The decision to remove projects from the IR&D program may have significant implications for U.S. national security. First, internally funded research may progress more slowly given the increased risk borne by the firm and reduced expected return. Second, in removing their programs from the IR&D program, firms are further weakening communication with the DoD. This could lead to products that are of less strategic value to the DoD, and that take longer or are more expensive to develop and acquire.

The DoD also faces several structural challenges with regard to human capital, including a fragmented workforce, an aging workforce, and a lack of coordination (Defense Business Board, 2015). These challenges impact IR&D policy given that the DoD intends to become more involved in project oversight, approval, and tracking—areas that entail a larger number of adequately trained personnel.

Over the course of decades, the government has worked to shape IR&D policy in an effort to maximize the emergence of transformative defense innovations. However, government seems to have lost sight of the fact that innovation is inherently unpredictable, progresses through fits and

starts, and may not be naturally responsive to government intervention. Thus, it has been difficult to discern which policies are having a positive impact, leaving them open to endless revision and, in some cases, reversal. As a result, defense firms have come to view the government's IR&D policy approach as erratic.

We have developed three central recommendations: promote stability and consistency in the IR&D program; promote creative solutions to strategic threats; and improve IR&D inputs and outputs.

Promote Stability and Consistency in the IR&D Program

- *Maintain current legal interpretations*

  With regard to implicit and explicit requirements, in particular, the government should affirm the Court's decision in *ATK Thiokol v. United States* by reimbursing firms for effort that may be implicitly required by an existing contract so long as the effort is not required by a written *requirement of the contract*. The government should also remain consistent in its assertion that IR&D constitutes a private expense; as such, the government has only limited rights to technical data associated with IR&D outputs.

- *Alleviate industry's IP concerns*

  Understandably, defense contractors have major concerns regarding the security and integrity of their intellectual property. Part of this fear revolves around the submission of proprietary data to government, while other fears are related to Congressional inquiries and changes to data rights regulations. The DoD must make a concerted effort to understand contractor concerns and clarify their rights. Growing IP concerns are both indicative of, and lead to, distrust between the two sectors. Unresolved, these concerns will hamper effective collaboration.

- *Ensure security of contractor-provided data*

  The DoD must respond to contractor fears regarding the security of proprietary data that is submitted to the DoD by conducting a thorough review of platforms, web portals, and databases that store firms' private data. The DoD should clearly communicate its safety assessments to IR&D program participants.

Promote Creative Solutions to Strategic Threats

- *Communicate a unified technology strategy*

  IR&D policies have tended to constrain innovation (e.g. implicit vs. explicit requirements, proposed "technical sponsor" requirement, reporting requirements) to the extent that they may hinder technical advancement rather than achieve their intended purpose—facilitate technologies with defense applications. Simply stated, the DoD should rely more on the outflow of information, rather than inflow, to guide IR&D policy.

- *Ensure independence of IR&D efforts*

  Along these same lines, the DoD should not impose DoD sponsorship requirements for IR&D, the goal of which is to encourage creative solutions to long-term security challenges. With notable exceptions, DoD agencies are focused on meeting near-term requirements through more conventional approaches.

- *Minimize reporting requirements*

  The DoD must clarify the purpose of the Defense Industry Marketplace and the rules and regulations that govern its use. There is reason to believe, given the composition of the current workforce (skills and number) that personnel will be unable to digest, let alone use the information in a meaningful way. If this is the case, then the DIM represents yet another reporting burden, a potential information security vulnerability, and, for the DoD, an unnecessary expense.

Improve IR&D Program Inputs and Outputs

- *Incentivize firms to increase IR&D spending*

  Promoting the continuity of the IR&D program while eliminating rules and regulations of little value will go a long way toward incentivizing firms to spend more on IR&D. In addition, reducing the use of LPTA source selection will signal to firms that the DoD is more interested in value for money than the bottom line, which will encourage an innovative approach to technology across the DoD. Finally, little is known about the effect that the growth of B&P costs has had on IR&D. The DoD should undertake a study aimed at determining whether IR&D and B&P should accumulate to separate cost pools.

- *Invest in the acquisition workforce*

  In order to effectively develop the required human capital for the modern acquisition environment, we believe that DoD must enhance its recruitment processes; improve the hiring process; strive for quality not quantity; provide competitive wages; incentivize employees to improve performance; and incentivize employees to undertake additional training and education.

- *Develop metrics*

  The government should work to develop basic metrics that allow it to track its return on investment and provide an "innovation baseline" that firms can use to measure their IR&D performance against competitors, in terms of spending and program results. Providing firms the flexibility to initiate their own programs, free of burdensome regulations and approval processes, is not to suggest that firms should not be held accountable for the results of their IR&D programs.

Innovation is essential to our military's continued technological superiority. However, the growing capabilities of our adversaries, defense budget reductions, and low levels of R&D spending by government and the private sector have conspired to weaken our military advantage. For over 80 years, IR&D policy has recognized the integral role played by private industry in creating innovation—a role that has grown significantly relative to that of government. However, there are clear indications that current policy is not optimized to fully leverage the innovative capacity of the private sector.

I. Introduction

"We all know that DoD no longer has exclusive access to the most cutting-edge technology or the ability to spur or control the development of new technologies the way we once did."

Secretary of Defense Chuck Hagel, Nov 15, 2014

It is clear that government-led programs no longer drive technological innovation as they have in the past; rather, the commercial sector tends to produce much of today's cutting-edge (and, increasingly, globally-available) technology. As a result, it is now widely recognized that the United States military is at risk of losing its technological superiority. Given this new reality, then-Secretary of Defense Chuck Hagel announced in November of 2014 the implementation of the Defense Innovation Initiative (DII), an ambitious DoD-wide effort "to identify and invest in novel ways that sustain and advance the Department's military superiority and improve business operations throughout the Department" (Pellerin, 2012, p.1).

This objective is reflected in the recently-released third iteration of Better Buying Power (the DoD's set of fundamental acquisition principles to achieve greater efficiencies through affordability, cost control, and process streamlining), which places stronger emphasis on innovation and technical excellence. The release of BBP 3.0 prompted proposed changes to Independent Research and Development (IR&D) policy, including, most notably, the implementation of enhanced contractor oversight procedures, leading to considerable debate over just how "independent" such research efforts should be.

Recognizing that the defense market is characterized by one buyer (the government) and multiple sellers, the objective of IR&D policy is to support the emergence of transformative defense technologies in the absence of a traditional market. For nearly 80 years, defense policy makers have worked to develop and refine policy that incentivizes firms to undertake independent research and development, defined by the DoD as research and development that is not sponsored, or required, in the performance of a contract or grant, but that is ultimately recovered through the firm's overhead rate (that is applied to firms' contracts/grants with the government). The DoD reimburses defense and commercial firms nearly $4 billion annually for their IR&D efforts (Erwin, 2015a).

Though it is understandable that the DoD wants more insight into how companies are using their IR&D funding, especially in light of continuing budgetary pressure, there is legitimate concern that policy changes could stifle private-sector innovation by derailing promising lines of research that may have significant, if not clearly discernable, defense applications.

IR&D policy has long been a bone of contention for government and industry. For instance, controversy over the meaning of the phrase "research and development *not required in the performance of the contract*" has been an issue for decades. Virtually all large projects entail research that is not directly required, but nevertheless implicit, in the requirements set forth by the contract. The DoD has tended to view the costs associated with such research as unallowable—i.e. nonreimbursable—while the judiciary has sided with firms seeking reimbursement. Critics have asserted that the DoD's narrow interpretation discouraged some firms from doing business with the DoD.

This is not to suggest that striking the right balance between government influence over R&D and private-sector autonomy is an easy task—but it is an essential one, in light of the challenges facing U.S. national security. As one observer notes, the DoD faces "seemingly conflicting pressures" to "step up its technology game but also stay out of political pressure for taking risks with taxpayer funds that may not pan out" (Erwin, 2015c, p. 2). This report explores how to best achieve the right balance in order to preserve U.S. technological superiority.

Report Approach

Although the United States remains at the forefront of the world's advanced nations with regard to technological and military strength, this gap is rapidly shrinking. The United States may need to reconsider *how* we fund innovation so that it is both pioneering and cost-effective. In the next section, we explore the challenges to national security that demand a renewed commitment to funding technological innovation. In Part III, we provide a brief background of the IR&D program. In Parts IV and V, we discuss challenges that the program has encountered. In Part VI, we provide our recommendations and our concluding remarks.

Note on Methodology

This report relies, in part, on information gathered from interviews with personnel from three major defense firms as well as a former Senate staffer and an OSD official with extensive experience in IR&D administration and policy. Defense firm personnel provided their valuable perspectives on a number of issues; generally, however, these personnel refrained from providing specific details of their firms' IR&D programs, which they considered to be sensitive and proprietary. Nevertheless, in an effort to solicit candid responses and because several interviewees requested that they not be named or cited in this report, all interview citations have been anonymized. The former OSD official is designated as F.O., the former Senate staffer as F.S., and the defense firm personnel as D.F.

II. Background

Historically, U.S. military superiority has relied primarily on technological advantage, as opposed to numerical superiority. In the years following World War II, the nation's leaders sought to develop an international system with American power at its core. Cold War tensions and the resulting arms race led to the development of a permanent defense industrial base in order to equip the military forces with technically superior weapon systems. Today, as in the 1950s, the U.S. defense industry is composed of for-profit companies that produce the weapons used by the U.S. military services and many allied nations.

In order to maintain an innovative industrial base, continued investments in research and development are essential. Encouraging technological progress in the United States has been a crucial "hedge against technological breakthroughs" abroad (U.S. Congress, 1992). Should a potential adversary engineer a capability designed to exploit the weaknesses of our technology (or should it engineer a game-changing system), U.S. innovation can serve as a counter-weight to its strategy and systems, reducing an adversary's potential advantage or incentive to engage in conflict. As an added benefit, the DoD's technological superiority objectives have led it to be a "first buyer" for many of the most important commercial technological advancements of the 20th century; these included semiconductors, communication satellites, jet engines, the Internet, and global positioning systems.

More broadly, it has been widely observed that technological progress is responsible for about half of the growth of the U.S. economy, and is the primary driving force behind long-term economic growth and the resulting increases in the standard of living (Schact, 2006). Thus, government investments in innovation have also served to ensure economic security, an important element of U.S. national security.

Technological advantage remains the centerpiece of U.S. military strategy to this day. In fact, a major objective of defense policy is to "maintain at least a one-generation lead over potential adversaries" in "critical technologies and components" (DoD, 2005). However, the means of ensuring this superiority have changed dramatically over time, as the DoD relinquished most of

its role in direct research and systems engineering to the private sector, promoting competition among the firms to acquire superior systems, at the best value.

Finally, there was a contraction of the defense industrial base. Following the Cold War, with the accompanying decrease in defense spending, the DoD encouraged the consolidation of the defense industry (then consisting of some fifty firms) in order to improve industry efficiency through combined operations in sales, purchasing, and overhead allocations. By the start of the new millennium, only a handful of large defense firms remained.

The Innovation Imperative

It is against this backdrop that defense policy makers have developed, altered, and refined policy that incentivizes firms to undertake independent research and development. Today, however, the nation faces new challenges that jeopardize its superiority, demanding a renewed commitment to innovation generally, and to the various initiatives that fund research in particular (IR&D is an important element). These challenges include adversary adaptation, budgetary constraints, and the loss of domestic technical capabilities.

Adversary adaptation

The global diffusion of technology is providing adversaries with the means to undermine American military systems. Even militants with minimal training have been successful in this regard: Insurgents in Iraq used cellular phone technology to trigger roadside bombs, and Al-Qaida cells in Afghanistan rely on the Internet to provide secure communications and access to satellite imagery.

At the same time, rapidly-modernizing states are finding new ways to improve upon existing threat detection systems in order to thwart our technological dominance by harnessing evolving military and commercial technologies for their own global power projection. According to Kendall (2014) “Potential adversaries have had decades to study the American way of war and to develop and field systems and tactics designed to defeat American forces…our technological superiority is [no longer] assured, and in fact is being challenged very effectively right now” (p. 3).

Given the rapid rate of technological innovation in global commercial markets, weapon system "lock-in" is increasingly problematic. In many instances, new military systems and components are designed to complement existing systems, some of which were developed decades ago. Accordingly, new systems are acquired not solely out of preference for their inherent properties, but because they can be integrated with existing systems. Needless to say, lock-in impedes system designers from engineering technological breakthroughs. Meanwhile, potential adversaries are able to anticipate minor technological updates and upgrades to existing systems, rendering advancements less effective from a strategic standpoint.

More generally, it has been observed that globalization allows less industrialized countries to bypass outdated technology and infrastructure—for example, a poor country need not build an expansive landline telephone network to take advantage of cellular communication. In fact, a country that starts development with a blank slate is better positioned to maximize the efficient use of cutting-edge technologies, in that it does not have to incorporate them into existing networks and infrastructures. Today, less-developed nations are able to match—and in some cases overtake—developed countries, including the United States, in some fields of science and technology. Recognizing this new reality, the DoD (2014) released the following statement: "While the global technology landscape indicates that the United States should not plan to rely on unquestioned technical leadership in all fields, the Department must ensure that technological superiority is maintained in areas most critical to meeting current and future military challenges."

Ultimately, if the United States wishes to maintain its technological superiority, it will need to develop entirely new systems and components that operate in ways that its potential adversaries will have difficulty anticipating and countering.

Budget constraints

After thirteen years of war in Afghanistan, and eleven in Iraq, the United States has begun to decrease defense spending. Furthermore, the passage of the Budget Control Act of 2011 has led to $85.4 billion in automatic spending cuts in 2013, with half coming from DoD spending (Edelberg, 2013). As in the past, when military budgets decrease following conflict, personnel and current technology programs receive the funding priority, while research and development

"typically [become] the first casualty of peace (Schwartz & Harrison, 2014, p. 1). This is problematic in that building military potential in the form of economic and technological strength is crucial during periods of calm, in order to reduce the possibility of threats from abroad (U.S. Congress, Office of Technology Assessment, 1992). For this reason, periods of peace represent an important opportunity to invest in technological advances—that is, to use "peace to prepare for the next conflict" (Schwartz & Harrison, 2014, p. 1).

A tendency to decrease R&D spending during time of peace has diminished the capacity of the U.S. government and its contractors to produce technological breakthroughs. Ultimately, if the DoD plans to maintain technological superiority as a fundamental element of its global power projection, it will need to prioritize research and development. Fortunately, the DoD's renewed emphasis on innovation (envisioned in BBP 3.0) suggests that funding for R&D will continue, even in light of anticipated sequestration spending cuts scheduled to occur in the beginning of fiscal year 2016.

Loss of domestic technical capabilities

Over the past several decades, the DoD has devolved many non-inherently governmental duties to contractors. These included conducting R&D, using organic engineering capabilities and expertise. As a result, the DoD now relies, to a large extent on, contractors to engineer technological breakthroughs (House Armed Services Committee, 2012).

Contractors, however, have a vastly different structure than government entities. Not only are they profit driven, but they are also reluctant to assume high levels of risk. As Congressional and executive-level decisions on DoD spending change on a year-to-year basis, shifting budget, contract, and spending priorities significantly impact the cost calculations and investment decisions of private-sector contractors. As a result, firms are much more likely to rely on advances in technology that can guarantee returns on investment. For example, firms are more likely to release updates for technological systems for which component parts are already available rather than developing new, potentially more innovative, systems.

Consequently, the United States "could lose the indigenous ability to produce goods and services for technological superiority" (House Armed Services Committee, 2012, p. 2). Some argue that contracting officers within military procurement have, in fact, already lost that knowledge, as

many administrative contracting officers lack the expertise to fully understand the research and development initiatives pioneered in the private sector in order to fully evaluate them (Pellerin, 2012).

More broadly, the loss of manufacturing capability is frequently followed by the loss of design and innovative capabilities for the affected industry segment. One only need look at the personal computer (PC) to understand how the initial outsourcing of the assembly of printed circuit boards led to the pursuit of higher-value-added work, including the assembly of the complete product. Eventually, these firms assumed design-engineering tasks; today, virtually all Windows notebook PCs are designed and manufactured overseas. The same type of migration is apparent in other industries and products—consider, for example, the offshore Boeing composite work on the 787.

IR&D can help maintain domestic design capability

ITT Defense, a contractor, relied on IR&D funding to develop a better defense system for military helicopters. The new low-power laser jams enemy missile launchers. The Lexington Institute, a non-profit public policy think tank, described the new technology as a "breakthrough" that offers unexpected additional benefits, including the provision of "secure communications at higher data rates and longer distances than are typical to helicopter crews" (Thompson, 2011, p.1) Without specific reference to IR&D policy, the article stated that firms that are "wedded to particular solutions and suppliers often take a narrower approach aimed at leveraging their existing franchises, and thus fail to generate the best options" (p.1) The article noted that ITT "has avoided that kind of bias, and instead looked for the best ideas and talent" to meet requirements (p.1). This characterization of ITT's helicopter defense system illustrates the goal of IR&D policy, even when considering the final outcome: ITT Defense lost the competition for the Common Infrared Countermeasure System; contracts were awarded to Northrop Grumman and BAE systems (Cheng, 2014). In this instance, and in many others, IR&D policy proved successful in promoting competition among firms to design innovative technological solutions to operational problems while, at the same time, encouraging the growth of a vibrant technical base that is prepared to meet the challenges of an uncertain future.

Given current domestic budgetary realities and the pace of foreign technological innovation, the DoD must rely on the global market in order to meet its acquisition objectives. Moreover, the globalization of the defense industry offers benefits such as economies of scale, global

competition, and comparative advantage (acquiring "best in breed"). However, there is concern that the DoD and American industry might be unable to judge the quality of foreign-produced goods, or that in the event of a crisis, the United States might find it very difficult to transfer production to the domestic industrial base. Clearly, the United States must continue to invest in innovation, not only to derive new technologies, but to ensure that it retains the ability to design and produce certain critical technologies.

The IR&D Imperative

Innovation, by its very nature, is unpredictable; and the government is often not in the position to articulate its need for a technology until a rudimentary version of that technology comes into existence. Accordingly, the government has sought to create an environment that facilitates the emergence of inventive, creative solutions that strengthen national defense.

The DoD cannot rely on market forces alone to deliver these solutions. The defense industry is a monopsony, consisting of one large buyer—the DoD. Additionally, the high level of risk and uncertainty involved in designing new systems—complemented by the government's deep level of input, design, and contract oversight—vastly overstep the boundaries between the simple 'buyers' and 'sellers' that ordinarily define a free market (Watts & Harrison, 2011). The bottom line is that firms that specialize in the design and production of weapons systems and other defense goods are limited in their ability to recoup their R&D costs through traditional means—i.e. spreading them across their product portfolio.

IR&D is, in a sense, a market intervention designed to encourage the defense industry to invest more in self-funded research and development, by providing partial remuneration to reduce the associated costs. According to Deavy and Stein (1993), "Permitting contractors to recover allowable IR&D costs through negotiated overhead rates [is] intended to mirror, for defense contractors, the circumstances under which firms selling in commercial markets recover their R&D costs in the prices they charge."

Outside of the IR&D program, defense firms self-fund internal R&D efforts, particularly those firms with commercial sales. For example, Boeing allocated $3.1 billion to self-funded research and development in 2013, of which it invested $1.8 billion into its commercial aviation division

(Weisgerber, 2014). Lockheed Martin, primarily a defense contractor, spent $700 million on internal research and development in 2013 (Clark, 2014). Across the board, however, defense contractors "spend less than 2 percent of their revenues on self-funded R&D, a fraction of typical private sector R&D spending" (Schwartz & Harrison, 2011; see Figure 1).

Rank	Company	2010 $Millions	As a Percent of Sales	Rank	Company	2010 $Millions	As a Percent of Sales
1	Roche Holding	$9,646	21.1	11	Intel	$6,576	5.1
2	Pfizer	$9,413	13.9	12	Panasonic	$6,176	13.9
3	Novartis	$9,070	17.9	13	GlaxoSmithKline	$6,127	17.9
4	Microsoft	$8,714	14.0	14	Volkswagen	$6,089	14.0
5	Merck	$8,591	18.7	15	IBM	$6,026	18.7
6	Toyota	$8,546	3.9	16	Sanofi-Aventis	$5,838	3.9
7	Samsung	$7,873	5.9	17	Honda	$5,704	5.9
8	Nokia	$7,778	13.8	18	AstraZeneca	$5,318	13.8
9	General Motors	$6,962	5.1	19	Cisco Systems	$5,273	5.1
10	Johnson & Johnson	$6,844	13.8	20	Siemens	$5,217	13.8

Figure 1. Top 20 International Corporate R&D Budgets (Jaruzelski, 2011)

Moreover, directly-funded R&D programs in both sectors tend to focus on near-term solutions, or products for which there is clear demand. Private contractors are more likely to invest in developing upgrades and complementary products for in-use technologies in an effort to win contracts. These modifications result in incremental innovation, as opposed to the adoption of technologies that enable a paradigmatic shift (Brumer, Kaufman, & and Tucci, 2003). However, a continual dependence on incremental shifts in technology can miss the leap-ahead breakthroughs (e.g. stealth), as well as allow for potential adversaries to more readily adapt their systems to counter U.S. capabilities. Contractors are incentivized to "play it safe" when it comes to uncertainty, in order to meet revenue targets, leading to the prioritization of near-term gain over long-term wins that may or may not occur.

For instance, Lockheed Martin allocates approximately 60% of its internal research and development budget to research that is expected to have "an impact on a program within 12 months," (Lockheed Martin, 2005). These projects, driven by a "requirements pull," are designed to make a near-term impact on expected profitability, meet a set of defined requirements, and improve on existing technology. The remainder of Lockheed's R&D budget is divided among "technology push" projects that have the potential of upending existing systems (Lockheed Martin, 2005).

Relatively low levels of self-funded R&D by defense firms is increasingly worrisome in that the U.S. government has reduced its R&D expenditures, particularly in the area of defense (see Figure 2). These two trends highlight the importance of maintaining a strong IR&D program.

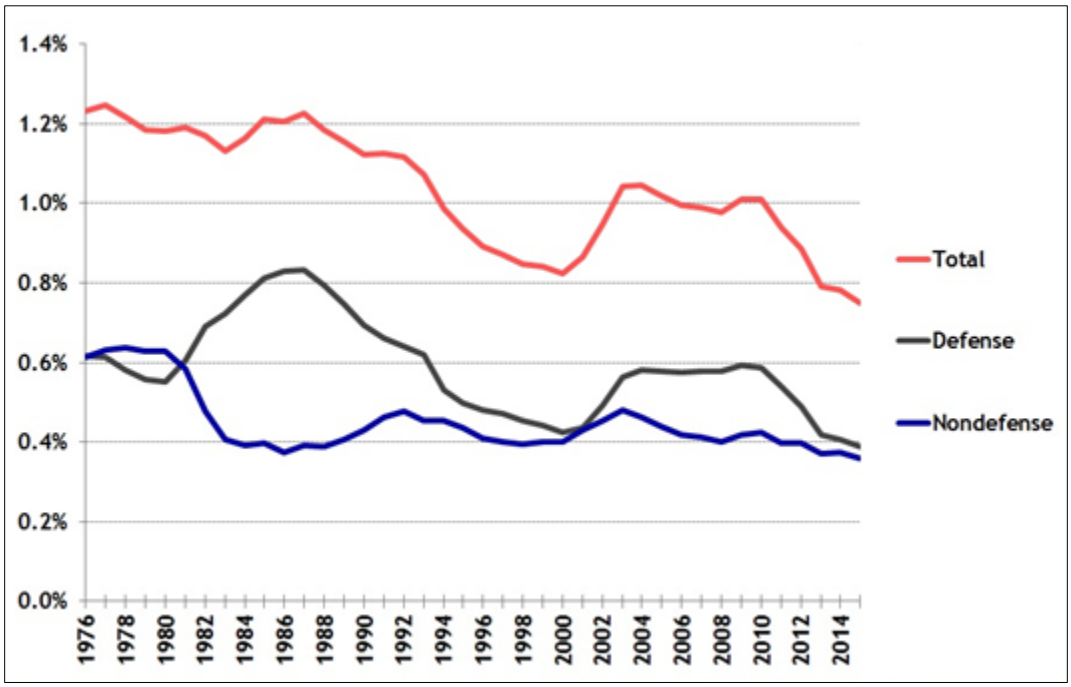

Figure 2. Trends in Federal R&D (% of GDP)

Note. The information in this figure came from the following sources: 1976 to 1994—The National Science Foundation, 1994; 1995-2014— the American Association for the Advancement of Science, 2014. GDP figures are from U.S. Government, 2015.

Even in instances where a commercial market for a given defense product exists, it should be recognized that the structure of commercial markets promotes—but also limits—innovation. Generally, firms shy away from investments in technology innovation—which requires the

acquisition of new information—if they cannot obtain a monopoly. In general, information holds the following properties:

- Information is more profitable when it is protected, but more useful to society when it is shared;
- innovation is more valuable to society as a whole than to an individual; and
- information is free, experiences diminishing returns, and has a high likelihood of being shared; making it difficult to capture value (Cozzarin, 2008).

Because information is "not only the product of inventive activity, [but] also an input", it is most useful to society when it is freely and widely shared, and used to develop new information (Arrow, 1962). Hence at its maximum utility, information production is not profitable to the firm.

From a more practical standpoint, firms resist incorporating new technology into their designs because their engineers face firm schedule constraints. Rather, firms often incorporate user feedback and minor upgrades into their products, through the release of periodic increments in response to near-continuous customer demand. According to Gomory (1989), "engineers need new ideas that snap into the skills they already have" (p. 102).

Commercial sector investment in innovation is a balancing act: firms must invest in some level of innovation or risk falling into an "innovation death spiral," which, according to Allen (2011), occurs when "a company gets stuck throwing all its resources at incremental innovation" (p. 2), leading to its exit from the market.

Recognizing that the private sector (as opposed to government) is better positioned to advance technology, the IR&D program distinguishes itself from directly-funded R&D in that it is designed to promote firm-driven, forward-thinking solutions to the nation's greatest security challenges. Deavy & Stein (1993) suggest that the IR&D mechanism "recognizes that technology-based firms must invest in R&D to ensure their continuing capability to produce new and improved products and processes, and that the costs of doing R&D are legitimate costs of doing business." Without IR&D, defense innovation would surely decline. Econometric analyses (e.g. Diamond, 1999) provide no indication that government funding of science and technology

"crowds out" corporate R&D funding. As a result, private sector funding should not be expected to replace reductions in government R&D spending.

III. IR&D Program

In an effort to ensure the nation's technological superiority, Congress initiated the IR&D program to help support independent research undertaken by private military contractors. For nearly 80 years, firms have been allowed to recover a portion of their research and development costs as part of the general and administrative expenses charged to existing contracts with government. Today, the DoD reimburses the defense industry between $3 and $4 billion a year for independent research and development (IR&D) costs (Pellerin, 2012). In addition to funding research directly, the IR&D program is one of several other programs, such as the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, designed to support the research, development, and commercialization efforts of military contractors.

To qualify as IR&D, a firm's effort must fall within one of four categories: basic research, applied research, development, or systems and other concept formulation studies (FAR, 2014). These efforts cannot be sponsored by a grant or be required in the performance of a contract. In addition, they must be of potential interest to the DoD. Qualifying efforts include those which

- Enable superior performance of future U.S. weapon systems and components;
- Reduce acquisition costs and life-cycle costs of military systems;
- Strengthen the defense industrial and technology base of the United States;
- Enhance the industrial competitiveness of the United States;
- Promote the development of technologies identified as critical;
- Increase the development and promotion of efficient and effective applications of dual-use technologies; or
- Provide efficient and effective technologies for achieving such environmental benefits as: Improved environmental data gathering, environmental cleanup and restoration, pollution reduction in manufacturing, environmental conservation, and environmentally safe management of facilities (DFARS 231.205-18).

Provided that one or more of these criteria are met, IR&D costs are generally allowable as indirect costs applied as a rate to contracts and grants with the government.

Program Evolution

The origin of the IR&D concept can be traced to the 1930s. Lacking a competitive market to constrain manufacturers' profits, the Government established a ten-percent-of-total-contract-price profit cap on military ships and aircraft (Nackman, 2012). In determining the contract price, the Government permitted the manufacturer to include a percentage of research and experimental development…on the principle that these activities are usually maintained and apart from current manufacturing operations" and provided that "the cost of these activities are deferred or capitalized with a consistent plan."

The structure, regulations, and amounts allowed have evolved throughout the 20th and 21st centuries. As the commercial sector evolved into the primary source of technological innovation, debate began over how to best harness this innovation. Following World War II, research and development had to be related to specific programs of interest to the funding agency. "General research expenses" were not allowed unless specifically provided for in the contract (Camm, 1989). The structure, regulations, and amounts allowed have evolved throughout the 20th and 21st centuries.

After the Soviet launch of Sputnik in 1957, the U.S. government began to rethink its level of support for IR&D (Camm, 1989). From the 1960s through the late 1980s, the DoD negotiated total allowable amounts of IR&D with contractors, setting a ceiling based on defense sales and expenditures. However, it was difficult to quantify the impact of this policy on firm's future IR&D investment. Some saw the cost ceiling as little more than a lump-sum grant that created few incentives for firms to expand investment in IR&D (Camm, 1989).

In any case, these negotiations, known as tri-service reviews, provided a face-to-face exchange of information that allowed for in-depth question and answer sessions. As a result, DoD professionals gained better understanding of contractors' IR&D efforts (Interview F.O., 2014), while contractors were able to gauge the DoD's interest in these efforts. However, the process

was very time and labor intensive and, it appears, impacted the independence of contractor investment decisions.

Program Restructuring

By the 1980s, the reporting requirements had developed into a burden on both the contractors and the military evaluators. The DoD reduced its technical exchanges with industry beginning in the 1990s, not only to reduce this burden, but to ensure independence of IR&D.

In 1992, Congress made significant updates to the National Defense Authorization Act (NDAA), which modified the management and structure of the IR&D program. The 1992 FAR/DFARS eliminated advance agreements, and enabled contractors to gradually increase (by 5 percent each year) their reimbursable IR&D. Following a period of three years, all of a firm's IR&D costs were allowable as overhead costs, provided that the IR&D activities were of "potential interest to the DoD" (GAO, 1992). Beginning in 1996, all contractors could receive reimbursement for up to 100% of their costs without having to gradually increase their reimbursement rate.

The 1992 law renewed the need for annual reporting, and specified that the director of defense for research and engineering would bear responsibility for establishing a regular method of communication between the DoD and contractors on planned future needs and technical project descriptions (GAO, 1992). Furthermore, the law barred DoD professionals from directly interfering with contractors' private IR&D investments (Interview F.O., 2014). Firms' reactions were mixed: some saw it as a Congressional overreaction to allegations that DoD program offices were "directing" firms' IR&D, while others indicated that they were eager to see the end of the tri-service review process because it was time and labor intensive and, possibly, poorly managed (Interview F.O., 2014). However, according to Defense Acquisition Regulations System 48 CFR Part 231, drafted in 2011, the result has been "a loss of linkage between funding and technological purpose" (p. 2).

IV. Structural Challenges

It is clear that IR&D policy has been informed by two competing philosophies: 1.) that truly remarkable innovation occurs in an unconstrained environment, and 2.) that some constraints are necessary to focus innovation in order to derive practical applications, especially in times of significant DoD budget reductions.

To this day, policy continues to oscillate between the two aforementioned philosophies as policymakers strive to achieve a better balance between firms' autonomy and government involvement in an effort to deliver transformative defense innovation. Not without cause, critics tend to recast this objective as a case of Government wanting "to have its cake and eat it too."

Implicit vs. Explicit Requirements

The IR&D program is, in large part, the product of legal battles between the government and defense contractors over terms that, in some cases, have been open to interpretation. Debate raged for decades over the definition of "implicit" contract requirements and whether such requirements were reimbursable as IR&D.

In a False Claims Act case, in 2003, the firm Newport News Shipbuilding was accused of inappropriately charging as IR&D design work for double-hulled commercial tankers. The firm claimed that the work was "generic" and that it charged its customers only for the design work explicitly required by the contracts. Based on the "plain language" of the IR&D definition provided by the FAR, the district court ruled that efforts "required in the performance of a contract" must be read to include efforts which are not explicitly stated in the contract, but are nonetheless required by it." The court went on to state that the FAR regulation "does not allow charging of research and design efforts as IR&D simply because they are a benefit to more than one existing contract" (Manos, 2003).

In 2010 the court reached a very different conclusion in the matter of *ATK Thiokol, Inc. v. United States*. In 1997 Mitsubishi Heavy Industries (MHI) of Japan contracted with ATK Thiokol (ATK) for a type of solid rocket motor that ATK had produced for nearly fifty years. However, the modified version sought by Mitsubishi had not been fully developed. ATK agreed to

internally fund the effort to modify the motor, charging the development costs as IR&D, to be applied to the firm's overhead rate on government contracts.

The government based its objection on the *United States v. Newport News Shipbuilding* ruling, and argued that the costs in question were implicitly required and, therefore, could not be allocated as IR&D. In this instance, however, the Federal Circuit Court did not find the earlier court's "textual argument [to be] particularly persuasive," asserting that, on its face, "required in the performance of a contract" is ambiguous with regard to implicit and explicit costs (*ATK Thiokol, Inc. v. United States*). To reach its decision, the court relied on Cost Accounting Standard (CAS) 402 which relates to a firm's bid and proposal (B&P) costs. CAS 402 distinguishes proposal costs that are "specifically required by" an existing contract from those that "do not result from such specific requirements." The effect of CAS 402, according to the court, is "to equate the B&P definitional exclusion of proposal costs that are 'required in the performance of a contract' with the category of costs that are 'specifically required by the provisions of a contract'" *(ATK Thiokol, Inc. v. United States*)

Because the FAR definitions of IR&D and B&P contain the same exclusionary clause—in the case of B&P, costs incurred in preparing, submitting, and supporting bids and proposals that are "not required in the performance of a contract"—the same interpretation should apply to IR&D with regard to allowable costs. Treating IR&D costs differently would result in a "construction in which identical regulatory language—"required in the performance of a contract"—would be interpreted differently for IR&D than for B&P." Accordingly, the Court ruled in favor of ATK.

To this day, the government and private industry rely on this legal interpretation. In defending the ATK decision, Nackman (2012) points out that it permits firms that produce defense goods (for which there may be a limited market) to recoup their R&D investments without placing the cost burden on the "first buyer" (be it a government agency or commercial firm), thereby promoting technologies that otherwise may have never been initiated. To use Nackman's analogy, the first buyer of an Apple iPad 2 pays just over $800—not $144 million, the figure that includes R&D. Of course, each customer partially reimburses the R&D expenditure when they purchase a new Apple product.

As a result of this landmark ruling, there are fewer strings attached to firms' use of IR&D funds. Perhaps it is no surprise, then, that the DoD has attempted to rebalance the IR&D equation by imposing some constraints in order to stimulate the development of technologies with defense applications. These constraints come in the form of new policies: tracking firms' IR&D expenditures; obtaining rights to their intellectual property; and requiring firms to enlist a DoD "technical sponsor" for their IR&D projects prior to their initiation. Although well-intentioned, each of these policies presents challenges. We explore these challenges below.

Visibility vs. Data Security

In 2010, Better Buying Power (BBP) 1.0 identified reinvigoration of IR&D as a priority goal. Together, the DoD and industry identified the lack of communication as a major barrier to the effectiveness of the IR&D program (Defense Innovation Marketplace, 2015). The Defense Innovation Marketplace (DIM) was launched in 2012 in an effort to streamline communication between the DoD and the defense industrial base and to increase DoD visibility into IR&D projects. DIM, a component of the Defense Technical Information Center (DTIC) web portal, is password-protected and can be accessed by government acquisition professionals, and contractors managing their IR&D project updates.

The database provides search functionality for DoD acquisition professionals, enabling them to identify and support ongoing IR&D projects of strategic interest to current and projected military strategy. The marketplace is supported by a DFARS amendment, effective January 30, 2012, that requires major contractors to report their IR&D projects through the web portal (Federal Register, 2012). Firms must submit detailed descriptions of IR&D projects using the DIM database "annually and when the project is completed" in order to be reimbursed.

Unfortunately, many firms fear that by using the DIM, their proprietary data will be made vulnerable to discovery by other firms (Interview D.F., 2014). This fear stems, in part, from the fact that firms use the portal for two purposes—to report their proprietary IR&D summaries as required, but also to display innovations that they may want to sell to government buyers (CODSIA, 2012). According to CODSIA (2012), "there is the possibility that the proprietary IR&D summaries could be confused with the innovations being marketed for sale" (p. 2). As a result of this perceived insecurity, firms also worry that their information may be used by DoD

acquisition professionals in a misguided attempt to develop and/or increase competition in order to bring down the cost of new innovation (Interview D.F., 2014). Some companies have even indicated that they may cease R&D activities that rely on government funding, transferring their research and development to a commercial division or self-funding them entirely (Interview D.F., 2014).

Recently, the Defense Business Board (2015) described general DoD spending patterns as "uncoupled from services' needs" because "processes are sub-optimized" (Defense Business Board, 2015). Within the structure of government-funded innovation programs, multiple initiatives are in place. The Small Business Innovative Research (SBIR) and other IR&D programs fund various types of research simultaneously (Brumer, Kaufman, & and Tucci, 2003). These programs do not necessarily work together, and each is relatively small, leading to "a piecemeal solution to a more systemic problem" (House Armed Services Committee, 2012).

However, it is unclear whether the already-unpopular DIM will enable the DoD to promote IR&D projects that are complementary and of strategic value, or if the DIM is, itself, a "sub-optimized process." It is important to recall that contractors working for the DoD grapple with enormous complexity, including constantly evolving requirements, procurement regulations, contract award processes, bid requirements, compliance with the government's socio-economic goals and regulations (House Armed Services Committee, 2012), and an increasing number of reporting requirements. To some critics, the DIM represents yet another layer of bureaucracy (Gouré, 2011).

Defense Applications vs. Intellectual Property Rights

Competition between defense contractors for new business is intense. Reliance on a single buyer (the DoD), long contract-and-delivery times, fewer initiatives on account of budget constraints, and the inter-related nature of technological systems conspire to encourage a winner-take-all competitive environment. A single win (e.g. the F-35 Joint Strike Fighter) can result in a guaranteed multi-year income and long-term competitive advantage for a company. As a result, companies tend to fiercely defend their intellectual property (IP); especially their IR&D programs, for fear a potential leak could result in the loss of millions of dollars.

Under the law, the DoD has unlimited rights for systems acquired with government funds. However, a firm's IR&D investment is a category of indirect cost, expressed as a percentage of the cost of the contract with government. Thus, a firm's IR&D is treated as a private expense for intellectual property purposes (Lovells, 2012). As such, the government has only limited rights to the technical data associated with the item, component, or process (DFARS 252.227-7013).

Intellectual property and government contracts

Firms conducting business with the government often voice concern over the security of their intellectual property, specifically their technical data (i.e. any recorded data of a scientific or technical nature). Only under special circumstances do firms conducting business with the DoD retain exclusive control over this data. Rather, it is subject to a "source of funds determination." The government has *limited rights* to items, components, and processes that are developed exclusively at private expense (including IR&D). *Unlimited rights* applies to items, components, and processes developed exclusively at government expense, and *Government purpose* rights applies when funding is mixed. The Judge Advocate General's Contract Attorney's Deskbook (2015) defines each of these categories of rights as follows.

Limited

Limited rights provide the Government with unlimited in house rights but restrict the Government from releasing or disclosing the technical data outside the Government except in limited circumstances. The two most common circumstances where outside disclosures are permitted are disclosures necessary for emergency repair and overhaul, and disclosures to covered government support contractors.

Unlimited

Unlimited rights provide the Government with the rights to use, modify, reproduce, perform, display, release, or disclose technical data in whole or in part, in any manner, and for any purpose whatsoever, and to have or authorize others to do the same.

Government Purpose

Government purpose rights provide the Government with unlimited in house rights and allow the Government to release or disclose the technical data outside the Government and authorize third parties to use, modify, reproduce, release, perform, display, or disclose the technical data for government purposes.

Still, firms worry that their IP and data rights may be subject to new laws and regulations—perhaps with good reason. As recently as 2011, the language of the National Defense

Authorization Act (NDAA) appeared to state that the DoD retained all technical data rights associated with IR&D-funded programs. Section 824 of the 2011 NDAA stated that "amounts spent for independent research and development and bid and proposal costs shall not be considered to be Federal funds for the purposes of paragraph (2)(B), but shall be considered to be Federal Funds for the purposes of paragraph (2)(A)."

Paragraph (2)(A) explained that "In the case of an item or process that is developed…exclusively with Federal funds…the United States shall have the unlimited right to (i) use technical data pertaining to the item or process; or (ii) release or disclose technical data to persons outside the government or permit the use of the technical data by such persons."

Needless to say, the language contained in Section 824 is ambiguous if not contradictory. The language was clarified in the 2012 NDAA, which adopted previous descriptions of IR&D as a "private expense." It remains unclear whether the 2011 version represented an attempt to change the law. George Winborne, Intellectual Property Counsel for the U.S. Army Materiel Command, noted that the change "might have been someone's response to the Federal Circuit's ruling in *ATK Thiokol*" (American Bar Association, 2011).

It is not surprising, then, that some firms have expressed fear that intellectual property (IP) laws may change, or that the DoD may seek to obtain IP rights to a product or technology, with contractors stating that they simply "don't know for sure" (Interview D.F., 2014). Moreover, the fact that commercial rights to a technology may be usurped by the DoD at any time for national security reasons, while an essential stipulation, contributes to contractor uncertainty.

Government Approval vs. Contractor Autonomy

Recently, the DoD considered a new regulation whereby firms would be required to enlist a technical sponsor from the DoD, presumably a military service of defense agency prior to initiating an IR&D project. Perhaps not unexpectedly, firms and industry associations (notably, the Aerospace Industries Association) reacted strongly, arguing that "micromanaging company investments would be counterproductive and a drag on innovation" (Erwin, 2015b, p. 1). General Michael Williamson, military deputy to the secretary of the Army for acquisition, logistics, and technology, in addressing the proposed regulation, stated that "it becomes an imperative for us to be able to not only look at promising technologies that industry is looking at, but also create a

mechanism for the Department of Defense to interact with our industry partners so we can demonstrate our significant interest in specific areas" (Erwin, 2015b, p. 2).

One industry representative asserted that "Having the government dictate exactly what it wants kind of takes the 'I' out of IR&D" (Erwin, 2015b, p. 2). Though this representative may be overstating the case, it is clear that the DoD's position—that firms may only undertake IR&D projects at the discretion of the DoD—was tantamount to eliminating the IR&D concept, albeit through strengthening existing R&D categories. Moreover, because many potential sponsors prioritize current programs, there is reason to believe that the IR&D program would shift its focus to meeting near-term requirements. At the same time, firms would have an incentive to "shop" for sponsors willing to provide the IR&D program designation to low-risk projects. Fortunately, in August of 2015, Secretary of Defense Carter reversed his position on the technical sponsor requirement following the negative reaction. Carter stated that industry believed that the requirement would lead to firms' loss of freedom to make their own IR&D investment decisions," adding that "that was never my intent" (Erwin, 2015c, p. 2).

This is not to say that General Williamson's assertion regarding better communication was misplaced. Defense innovation could certainly benefit from more interaction between the DoD and industry. In fact, Better Buying Power 1.0 highlighted the communication challenge that DoD and contractors face when attempting to communicate defense buying needs and strategy across various military departments, organizations, and research lines. Defense firms "lack in-depth access to DoD key requirements which would enable them to focus their S&T and IRAD spending" (Defense Business Board, 2015). Though the DoD relies on a close relationship with private contractors to develop warfighting technologies, it does not clearly communicate its needs and top priorities with those contractors. As a result, the partnership faces real challenges in developing and delivering new technologies.

In theory, companies would appreciate more dialogue with the DoD, its primary customer (Interview F.S., 2014). Understanding the needs and priorities of the DoD is regarded by industry as a form of market intelligence, which companies can use to make investment decisions in order to obtain competitive advantage. Previously, the tri-services process, abolished in the 1990s, existed as a formalized in-person information exchange. It is unclear whether the BBP initiative,

its vision, and regulations will suffice in improving the relationship between contractors and the DoD. Certainly, the technical sponsor requirement was a step in the wrong direction.

V. Additional Challenges

In addition to the specific program challenges that threaten to limit innovation, there are a number of additional challenges, including disturbing trends, inefficiencies, and enterprise-wide problems that decrease the potential effectiveness of the IR&D program.

DoD Lacks Focus and Strategy

According to the Defense Business Board, industry has proven that "commercial S&T priorities and investments are strategy-driven," and yet "there is no clear S&T strategy or set of priorities at OSD or Military Department Levels" (Odeen et al., 2014). Findings such as these have been corroborated by numerous sources, including the House Armed Services Committee, which found that "DoD lacks a clearly articulated strategy that would provide a corporate visions of DoD's future technology needs," which "makes it difficult for the industry to have visibility into the future developmental needs of DoD and makes it challenging for both industry and the government to make investment decisions" (House Armed Services Committee, 2012).

It is often said that effective communication is a two way street, and that a successful conversation relies on alternating outflowing and inflowing communication. The DoD has encouraged industry to strengthen its commitment to IR&D for decades. Yet because the DoD relies heavily on inflowing information (e.g. so-called transparency databases and reporting requirements), and less on outflowing information (e.g. an articulated technology strategy), "failure to communicate" is often cited, both generally and within the context of IR&D, as a major barrier to strategic investments in technology (Interview D.F., 2014).

Decline in IR&D Spending

In 2014, the Department of Defense was spending approximately $4 billion a year on IR&D, with over half of the funds going to major prime contractors (Kendall, 2014). At first glance, IR&D and bid and proposal (B&P) spending (which accumulate to the same cost pool) seem to be on the rise, following general DoD budget trends (see Figure 3).

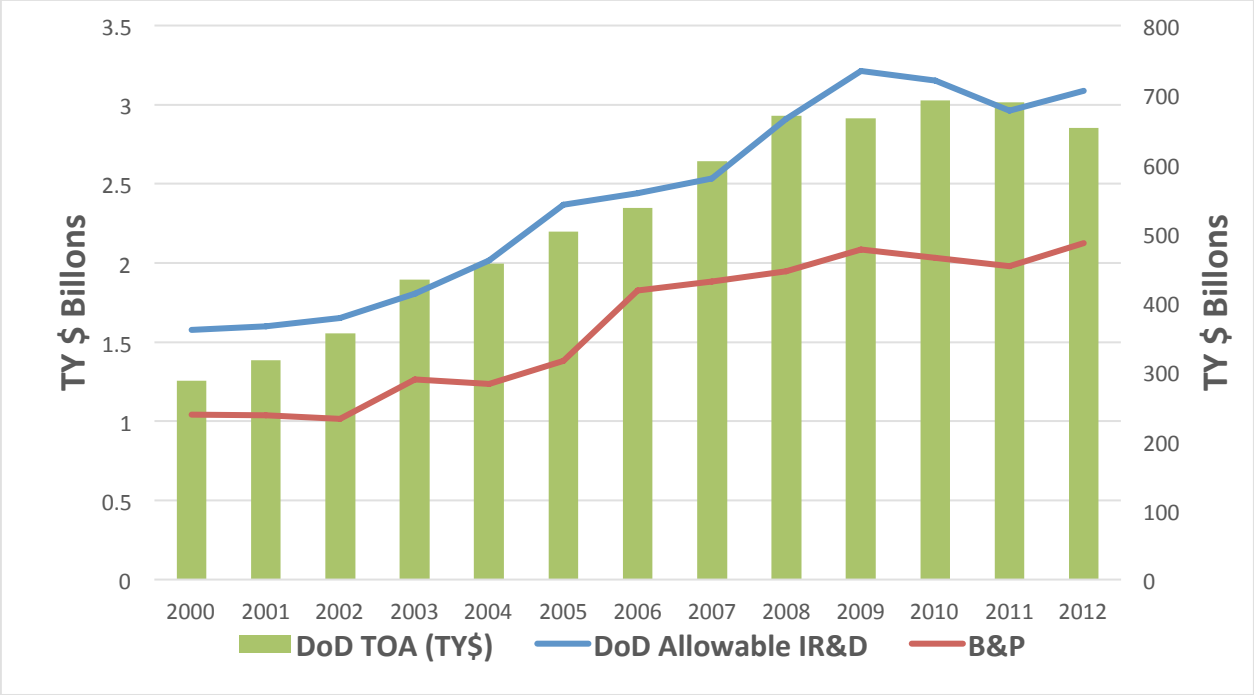

Figure 3. IR&D and B&P Spending (TY$ Billions)

Note. The information in this figure came from the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, 2012

When taken as a percentage of sales to the DoD, however, it becomes clear that firms are actually investing proportionately *less* on IR&D than in years past, which may be cause for concern (see Figure 4). In fact, A Defense News analysis of R&D spending by top defense contractors shows independent IR&D spending "declined by nearly a third in percentage terms from 1999 to 2012" (Fryer-Briggs & Weisgerber, 2013)

For example, in 1999, the five largest U.S. defense contractors: Boeing, L-3 Communications, Lockheed Martin, Northrop Grumman, and Raytheon, "spent a combined $2.4 billion of IR&D," a number that reached $3.3 billion by 2012, "almost perfectly matching inflation" (Fryer-Briggs & and Weisgerber, US Giants Skimp on Research, Development, 2013). IR&D spending, however, has not matched combined defense revenues for the same contractors, a figure that increased from $70.8 billion in 1999 to $142.6 billion in 2012 (Fryer-Briggs & Weisgerber , 2013). "Actual spending didn't fall, but as more money poured in, very little was directed toward IR&D" (Fryer-Briggs & Weisgerber, 2013). Though the DoD has been working to encourage defense contractors to allocate more money towards IR&D, trends in spending have yet to noticeably increase.

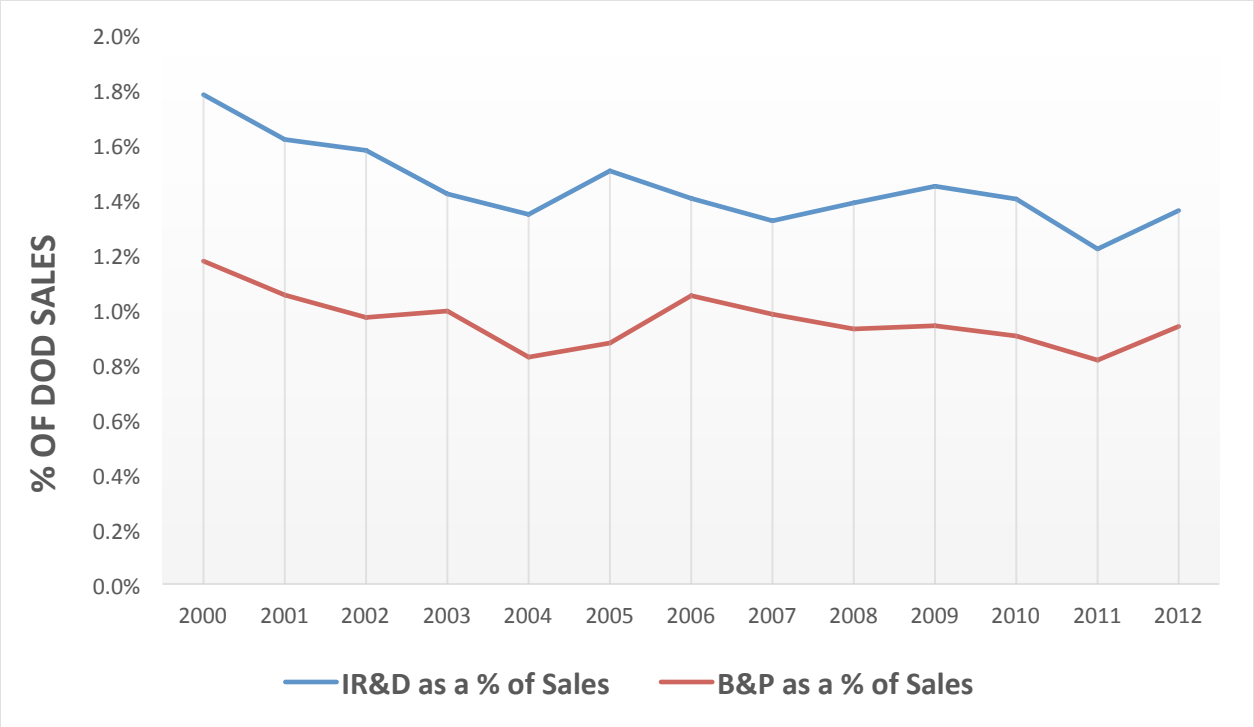

Figure 4. IR&D and B&P as a % of DoD Sales

Note. The data for this figure came from the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, 2012

This relative decline in IR&D spending may be more severe than indicated in Figure 4. As of 1992, B&P costs and IR&D costs have accumulated to the same indirect cost pool. This makes some sense given that companies often budget for both costs through the same internal business mechanism. However, there is reason to suspect that increases in firms' B&P spending have begun to displace IR&D.

Recently, the DoD has increased reliance on Indefinite Quantity/Indefinite Delivery (ID/IQ) contracts, which requires companies to bid for a parent contract and, if awarded, compete for individual task orders. 'Twice-bidding' has increased the amount firms spend on B&P per unit of business (Interview F.O., 2014). It is reasonable, then, to assume that increased spending on B&P may reduce IR&D, given pressure to maintain a competitive overhead rate.

It is also important to note that defense procurement is a cyclical business, with highs and lows following congressional budgets and foreign wars. IR&D may decline in tighter fiscal environments, as firms spend more on B&P in an effort to win a declining number of

government contracts. However, without a tracking mechanism, it is difficult to draw any firm conclusions.

Finally, the increased use of the Lowest Price Technically Acceptable (LPTA) source selection process over that last decade has reduced firms' incentive to innovate (Gansler & Lucyshyn, 2013). When LPTA is used to acquire defense products, the government selects the lowest-priced proposal that meets a minimum set of technical requirements. In other words, there is no room for "value-added" solutions.

Critics (in both government and industry) have noted that, in effect, LPTA creates "a race to the bottom" as contractors work to provide cheaper, and ultimately, less effective systems. As LPTA became more common, firms reduced staffing and overhead costs (including, it seems, IR&D), focusing less on innovation and more on the pursuit of low-cost technologies and upgrades to existing systems. As a result, IR&D spending, itself, may have been directed at developing less innovative, less costly systems.

Fortunately, it appears that the DoD has begun to move away from LPTA. In a March, 2015 memo Under Secretary Frank Kendall asserted that LPTA "has a clear, but limited place in the source selection best value continuum" (Lohfeld, 2015).

Preference to Self-Fund R&D

Some firms prefer to rely on self-funded "internal" research programs so as to retain full control of the research output. These firms may wish to explore new markets, the potential for product export, or other possibilities that are constrained by DoD regulations (Interview F.O., 2014). If a firm believes that it may have a technology "you could make money on," it may refrain from developing that product for the DoD. Some firms have expressed the view that export controls and government intellectual property rights act as disincentives to developing IR&D-funded systems (Interview F.O., 2014). Required reporting through the Defense Innovation Marketplace for IR&D-funded projects serves as another disincentive. Some firms believe that the information that they submit to government transparency databases may signal to competitors a new technical advance (Interview F.O., 2014).

The decision to remove projects from the IR&D program may have significant implications for U.S. national security. First, self-funded research may progress more slowly in comparison with jointly-funded research given the increased risk borne by the firm and reduced expected return. Second, in removing their programs from the IR&D program, firms are further weakening communication with the DoD. This could lead to products that are of less strategic value to the DoD, and that take longer or are more expensive to develop and acquire.

Human Capital Deficiencies

The DoD also faces several structural challenges with regard to human capital, including a fragmented workforce, an aging workforce, and a lack of coordination (Defense Business Board, 2015). These challenges impact IR&D policy given that the DoD intends to become more involved in project oversight, approval, and tracking—areas that entail a larger number of adequately trained personnel.

The defense workforce is fragmented, spread thin, and struggles to foster effective collaboration between program and contract staff (House Armed Services Committee, 2012). The defense acquisition workforce has been shrinking since the end of the Cold War; and all in all, there are "simply not enough acquisition personnel in the Department of Defense" (House Armed Services Committee, 2012).

Furthermore, a fragmented workforce cannot communicate to share lessons learned from various technology and acquisition initiatives, coordinate on bringing new technology to market, or adequately train new professionals. Defense contractors are also experiencing the beginnings of a human capital crisis.

As baby boomers begin to exit the workforce in growing numbers, contractors must hire and train replacements, but all too often, seasoned professionals are being replaced with relatively green hires. In 2009, the Obama administration announced plans to increase "the size of the organic Defense Acquisition Workforce (DAW) by 20,000 employees," a goal that is on track to be met in 2015 (DoD, 2010). As noted in a 2009 RAND report, however, "It is unclear that increasing the size of the acquisition workforce will improve acquisition outcomes" as employees may still lack necessary skills and experience (Gates, 2009).

New recruits will take years to make acquisition and investment decisions with the same level of experience and insight gained by their predecessors. Furthermore, there is increasing concern over the lack of students focusing on STEM (science, technology, engineering and math), and the impacts that this will have on the future of the industry (Fryer-Briggs & Weisgerber, 2013).

VI. Recommendations & Conclusion

Over the course of decades, the government has worked to shape IR&D policy in an effort to maximize the emergence of transformative defense innovations. However, government seems to have lost sight of the fact that innovation is inherently unpredictable, progresses through fits and starts, and may not be naturally responsive to government intervention. Thus, it has been difficult to discern which policies are having a positive impact, leaving them open to endless revision and, in some cases, reversal. As a result, defense firms have come to view the government's IR&D policy approach as inconsistent (Interview, F.O., 2014).

Based on the challenges identified in sections IV and V, we believe that IR&D policy should be narrowly focused on creating an environment, marked by a sense of continuity, that facilitates inventive, creative solutions to strategic threats, unencumbered by policies that have little discernible impact. At the same time, the government should work to develop some basic metrics that allow it to track its return on investment and provide an "innovation baseline" that firms can use to measure their IR&D performance against competitors.

Recommendations

We have developed three central recommendations: ensure the continuity of the IR&D program; promote creative solutions to strategic threats; and improve IR&D inputs and outputs.

Promote stability and consistency in the IR&D Program

- *Maintain current legal interpretations*

  Longstanding disagreement over what constitutes IR&D and what does not has negatively impacted industry's perception of the IR&D program. It is not an oversimplification to suggest that firms may be spending too much valuable effort trying to understand what qualifies as innovation rather than innovating. With regard to implicit and explicit requirements, in particular, the government should affirm the Federal Circuit Court's decision in ATK Thiokol v. United States by reimbursing firms for effort that may be implicitly required by an existing contract so long as the effort is not required by a written requirement of the contract. The government should also remain consistent in its

assertion that IR&D constitutes a private expense; as such, the government has only limited rights to technical data associated with IR&D outputs.

- *Alleviate industry's IP concerns*

  Understandably, defense contractors have major concerns regarding the security and integrity of their intellectual property. Part of this fear revolves around the submission of proprietary data to government, while other fears are related to Congressional inquiries and changes to data rights regulations. The DoD must make a concerted effort to understand contractor concerns and clarify their rights. Growing IP concerns are both indicative of, and lead to, distrust between the two sectors. Unresolved, these concerns will hamper effective collaboration.

- *Ensure security of contractor-provided data*

  The DoD must respond to contractor fears regarding the security of proprietary data that is submitted to the DoD by conducting a thorough review of platforms, web portals, and databases that store firms' private data. The DoD should make the results available to IR&D program participants. DoD leadership should also clearly communicate the importance of protecting proprietary IR&D information to all DoD employees with access to that data.

Promote Creative Solutions to Strategic Threats

- *Communicate a unified technology strategy*

  IR&D policies have tended to constrain innovation (e.g. implicit vs. explicit requirements, proposed "technical sponsor" requirement, reporting requirements) to the extent that they may hinder technical advancement rather than achieve their intended purpose—facilitate technologies with defense applications. The key is to differentiate between issuing constraints and providing direction. Encouraging innovation does not require that the DoD adopt a hands-off approach. In fact, the DoD must provide better guidance. The DoD should articulate a unified technology strategy so that firms can develop innovative solutions to meet DoD objectives. Simply stated, the DoD should rely equally on the outflow of information, rather than just the inflow, to guide IR&D policy.

- *Ensure independence of IR&D efforts*

  Along these same lines, the DoD should not impose DoD sponsorship requirements for IR&D, the goal of which is to encourage creative solutions to long-term security challenges. With notable exceptions, DoD agencies are focused on meeting near-term requirements through more conventional approaches.

- *Minimize reporting requirements*

  The DoD must clarify the purpose of the Defense Industry Marketplace and the rules and regulations that govern its use. Failure to do so will result in speculation and confusion. It is important to recall that the DoD already tracks IR&D expenditures through accounting processes that require firms to provide basic project information. The DIM may be a useful tool if it provides government acquisition personnel with relevant information that permits strategic technology planning—e.g. coordinating complementary R&D programs across the DoD. However, there is reason to believe, given the composition of the current workforce (skills and numbers) that personnel may be unable to fully digest and use the information in a meaningful way. If this is the case, then the DIM represents yet another reporting burden, a potential information security vulnerability, and, for the DoD, an unnecessary expense.

Improve IR&D Program Inputs and Outputs

- *Incentivize firms to increase IR&D spending*

  Promoting the continuity of the IR&D program while eliminating rules and regulations of little value will go a long way toward incentivizing firms to spend more on IR&D. In addition, reducing the use of LPTA source selection will signal to firms that the DoD is more interested in value for money than the bottom line, which will encourage an innovative approach to technology across the DoD.

  Finally, little is known about the effect that the growth of B&P costs has had on IR&D. Given that both expenditures accumulate to the same indirect cost pool, there is reason to speculate that B&P has displaced IR&D to some extent. Moreover, it should be noted that firms are competitive with regard to their internal cost structures. Currently, the amount a firm spends on IR&D is obfuscated by its B&P costs. Firms lack clear visibility into their

competitors' IR&D. The DoD should undertake a study aimed at determining whether IR&D and B&P should accumulate to separate cost pools. Separating the two may spur IR&D rate competition.

- *Invest in the acquisition workforce*

  Recent IR&D policies have been designed to focus innovation in order to derive practical defense applications. These polices, though well-intentioned, may not achieve their objectives, in part, because the DoD's acquisition workforce often lacks the necessary skills and experience required for the modern acquisition environment. To remedy this, we believe that DoD must enhance its recruitment processes; improve the hiring process; strive for quality not quantity; provide competitive wages; incentivize employees to improve performance; and incentivize employees to undertake additional training and education.

- *Develop metrics*

  The government should work to develop basic metrics that allow it to track its return on investment and provide an "innovation baseline" that firms can use to measure their IR&D performance against competitors, in terms of spending and program results. Providing firms the flexibility to initiate their own programs, free of burdensome regulations and approval processes, is not to suggest that firms should not be held accountable for the results of their IR&D programs. That said, the DoD must ensure that the metrics take into account the unpredictable pace and magnitude of innovation so as to avoid encouraging smaller innovations at the expense of technological breakthrough. Formulating these metrics will require a thoughtful, nuanced approach.

Conclusion

Innovation is essential to our military's continued technological superiority. However, the growing capabilities of our adversaries, defense budget reductions, and low levels of R&D spending by government and the private sector have conspired to weaken our military advantage. For nearly 80 years, IR&D policy has recognized the integral role played by private industry in developing ground-breaking technologies and systems—a role that has grown significantly relative to that of government. However, there are clear indications that current policy is not

optimized to fully leverage the innovative capacity of the private sector. Firms' intellectual property concerns, burdensome reporting requirements, and constant changes to regulations are notable barriers in this regard. Working with industry, the government can improve IR&D policy. During this critical period, the imperative to do so is clear. We hope that this report has provided a way forward.

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