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THESIS

HOW MIGHT CIVILIAN TECHNOLOGY FIRMS PLAY A ROLE IN THE DEFENSE INDUSTRIAL BASE GOING FORWARD?

by

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December 2017

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The purpose of this thesis is to explore the competitive business environment of Department of Defense (DOD) vendors and whether the market is favorable for non-traditional, technology-focused companies to enter it. The research question is this: Given past trends in the defense industrial base (DIB), how might civilian technology firms play a role in the DIB going forward? This thesis analyzed numerous reports, papers, newspaper articles, and conference summaries to examine the DIB as a strategic asset, government initiatives for innovation and acquisition reform, trends in contracting data to analyze what DOD is buying and who it is buying from, and finally, think tank assessments of DOD's innovation initiatives. The source material was used to provide background about DOD historical spending trends, consolidation in the DIB, and a brief history of commercial technology companies' interactions with DOD. To analyze the business environment of the defense industry, two well-established models, PESTEL and Porter's Five Forces, were used. Both models clearly pointed to unfavorable conditions for firms seeking to enter the defense industry.

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The purpose of this thesis is to explore the competitive business environment of Department of Defense (DOD) vendors and whether the market is favorable for non-traditional, technology-focused companies to enter it. The research question is this: Given past trends in the defense industrial base (DIB), how might civilian technology firms play a role in the DIB going forward? This thesis analyzed numerous reports, papers, newspaper articles, and conference summaries to examine the DIB as a strategic asset, government initiatives for innovation and acquisition reform, trends in contracting data to analyze what DOD is buying and who it is buying from, and finally, think tank assessments of DOD's innovation initiatives. The source material was used to provide background about DOD historical spending trends, consolidation in the DIB, and a brief history of commercial technology companies' interactions with DOD. To analyze the business environment of the defense industry, two well-established models, PESTEL and Porter's Five Forces, were used. Both models clearly pointed to unfavorable conditions for firms seeking to enter the defense industry.

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LIST OF ACRONYMS AND ABBREVIATIONS

ALU	Army Logistics University
ARRA	American Recovery and Reinvestment Act
ATD	advanced technology development
BBP 1.0	Better Buying Power 1.0
BBP 2.0	Better Buying Power 2.0
BBP 3.0	Better Buying Power 3.0
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BRAC	Base Realignment and Closure
CAGR	compound annual growth rate
CEO	chief executive officer
CFR	Council on Foreign Relations
CIA	Central Intelligence Agency
CSIS	Center for Strategic and International Studies
DARPA	Defense Advanced Research Projects Agency
DIB	Defense Industrial Base
DIUx	Defense Innovation Unit Experimental
DOD	Department of Defense
DOE	Department of Energy
DON	Department of the Navy
FAR	Federal Acquisition Regulation
FPDS	Federal Procurement Data System
FRED	Federal Reserve Economic Data
FY	fiscal year
GAO	Government Accountability Office
GDP	Gross Domestic Product
GPO	Government Publishing Office
LCS	littoral combat ship
NASA	National Aeronautics and Space Administration
NDAA	national defense authorization act

OT	other transaction authority
PESTEL	Political, Economic, Social, Legal, Environmental, Technological
R&D	research and development
ROI	return on investment
SCO	Strategic Capabilities Office
SDD	system development and demonstration
STEM	science, technology, engineering, mathematics
USAF	United States Air Force
USD AT&L	Under Secretary of Defense for Acquisition, Technology, and Logistics
USS	United States Ship

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I. INTRODUCTION

The defense industrial base (DIB) is key source of military and economic strength for the United States. This has been the case since a peacetime industrial base was established after the end of World War II (Watts, 2008, executive summary, para. 1). When the defense industrial base is mentioned today, those who are familiar with the Pentagon likely think about one of five prime contractors with whom the Department of Defense does business. Those contractors are: Boeing, Lockheed Martin, Northrop Grumman, General Dynamics, and Raytheon. While there are certainly other companies who do hundreds of millions or even billions of dollars of business with the Department of Defense (DOD) annually, those companies are either are too small to be considered one of the "Big 5" contractors or do not consider DOD their primary customer. Furthermore, these companies are known for building large end items such as ships, airplanes, vehicles, or weapons.

Ever since the establishment of a peacetime DIB post World War II, there has been debate over the effectiveness and efficiency of the processes DOD uses to procure materiel. One needs to look no further than the 1962 book "The Weapons Acquisition Process: An Economic Analysis" by Merton Peck and Merton Scherer, the 1986 "President's Blue Ribbon Commission on Defense Management" chaired by David Packard, and the 2006 "Defense Acquisition Performance Assessment Report" chaired by Lieutenant General Ronald Kadish, USAF (Ret) to see that procuring defense materiel is under constant analysis. These same sources, in addition to numerous GAO reports discuss DOD's performance in adhering to cost, schedule, and performance targets for major

product acquisitions.[1] The discussion surrounding DOD and the DIB is ongoing and it is critical that professionals continue to point out areas for improvement so that they continue to adapt to provide for the country's needs. In private industry, companies that are unable to adapt do not survive—while the DIB is far from going out of business, the DIB's customer, DOD, has recently been showing signs of dissatisfaction with its traditional suppliers. The best evidence of this is in the Better Buying Power series of initiatives launched by former Undersecretary of Defense for Acquisition, Technology, and Logistics, Dr. Ashton Carter, in 2010 (Carter, 2010). This DOD initiative was quickly followed by updates to Better Buying Power initiative, the launch of a new DOD strategy to combat the threats of the 21st Century, and the opening of multiple DOD organizations seeking to reduce the time DOD takes to procure materiel. In short, the present day is a time that DOD itself has staked as critical to change the way business between contractors and the government is conducted.

When it procures materiel and services, DOD wants what any company wants—the best value for the money spent. Unlike private entities, DOD and its traditional vendors have more regulations, procedures, and policies that are detailed and prescriptive about how business should be conducted as evidenced by the nearly 2,700 pages that make up volumes one and two of the Federal Acquisitions Regulations (FAR). Though DOD has decided it wants to change the way it does business, this does not mean that the companies it seeks to attract as vendors want to engage with DOD because of the burdensome acquisition process. Some defense-focused entities have launched organizations such as DOD's Defense Innovation Unit Experimental (DIUx), Special Operations

[1] Just a sampling from the past two years includes the following: a 2017 report titled "Defense Acquisitions: Assessments of Selected Weapon Programs," a 2016 report titled "Defense Acquisitions: Assessments of Selected Weapon Programs," a 2015 report titled "Defense Major Automated Information Systems: Cost and Schedule Commitments Needed to Be Established Earlier," a 2015 report titled "Ford Class Aircraft Carrier: Poor Outcomes are the Predictable Consequences of the Prevalent Acquisition Culture," and a 2015 report titled "Defense Acquisitions: Better Approach Needed to Account for Number, Cost, and Performance of Non-Major Programs." The point of this short list is not to overwhelm the reader. Rather, it is to show that the discussion of cost, schedule, and performance is taking place often.

Command's Sofwerx, and the Central Intelligence Agency's (CIA) In-Q-Tel in an attempt to attract civilian technology companies to do business with their respective organizations. This is a good first step but a more comprehensive analysis of the business environment surrounding DOD's potential partnership with non-traditional suppliers might be useful.

The aim of this thesis is to analyze the competitive business environment for DOD and non-traditional civilian technology companies using two well-established frameworks. The first is Porter's Five Forces and the second is the PESTEL (Political, Economic, Social, Legal, Environmental, Technological) analysis. Porter stated that:

> Competition in an industry is rooted in its underlying economics, and competitive forces exist that go well beyond the established combatants in a particular industry. Customers, suppliers, potential entrants, and substitute products are all competitors that may be more or less prominent or active depending on the industry. (Porter, 1979, p. 137)

Porter will be used to better understand the economic forces and power dynamics in the traditional defense supplier base and from this understanding produce analysis of whether the conditions might be favorable for commercial technology firms. Porter's model focuses on the power dynamics within an industry and what effects those dynamics might have while PESTEL is focused on macro environmental issues that the firm is unable to control (Investopedia, 2015). This analysis is meant to provide insight into the larger trends affecting the business environment that are largely outside the control of the firm (Oxford College of Marketing, 2016). Taken together, these two analyses will provide a better understanding of the opportunities and challenges facing DOD as it seeks to court new suppliers and change its business model.

The next section of this thesis is a literature review that examines the body of work written on various aspects of the DIB to include the DIB as a strategic asset, government initiatives on innovation and acquisition reform, trends in contracting data, and private assessments of DOD's commitment to innovation.

Section three provides a brief background of trends in the defense industrial base over time. Part 1 looks at spending trends, part 2 deals with consolidation, and part 3 addresses non-traditional commercial vendors' historical collaboration with DOD. Chapter 4 utilizes the previously mentioned Porter's Five Forces and PESTEL to analyze power dynamics and macro business environments surrounding the traditional defense industrial base. The analysis will provide insight into the opportunities and challenges for non-traditional firms in that market. Finally, chapter 5 addresses the findings from the analysis in chapter 4.

Before proceeding, it is important to note the scope limitations of this thesis. It does not intend to offer a comprehensive analysis of the consolidation of the defense and aerospace industry. In his 2008 paper "The U.S. Defense Industrial Base: Past, Present, and Future," Barry Watts does an excellent job of providing an authoritative look at how the industry has consolidated in response to administration priorities (Watts, 2008). Additionally, many commercial financial services firms provide annual reports on industry mergers and acquisitions activities.

This thesis also does not provide an in-depth look at the post-World War II peacetime defense industrial base, though it does offer a summary of trends. Again, Watts 2008 paper and Jacques Gansler's 1982 book, "The Defense Industry" provide ample detail for the reader interested in those topics.

Finally, there are multiple limitations to the models, Porter's Five Forces and PESTEL, used to analyze the industry. For example, Porter provides only a snapshot of the industry and the data being used to analyze it is a few years old (Dälken, 2014). From the insight that Porter is static and not dynamic, "making use of the Five Forces framework does not guarantee a competitive advantage that is inviolable and sustained" (Dälken, 2014, p. 3). Another limitation of the model is that it, "does not assess the resources and capabilities of a company, which are also relevant for analysing the overall profitability" (Dälken, 2014, p. 4). In short, Porter's model has its faults but it is a good starting point to analyze an industry, especially one that has had similar dynamics in the past few decades.

There are also limitations to PESTEL analysis. Similar to Porter, PESTEL only takes a snapshot of the industry in time and this can be problematic especially if the industry changes quickly. Furthermore, PESTEL makes quantitative analysis difficult as most of the factors are qualitative (Yüksel, 2012, p. 2). For example, how does one quantify the political aspect of the analysis? The other main weakness of the framework is its lack of consideration for how the six factors interact amongst themselves (Yüksel, 2012, p. 2). There is the possibility, and even likelihood that developments in one factor, political for example, can directly affect the legal environment which could in turn influence the economic factor. As with Porter, despite the model's shortcomings, it still provides a solid starting point to analyze an industry, especially since that industry has been more static than most over the past few decades.

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II. RESEARCH APPROACH AND LITERATURE REVIEW

In May 2017, the United States Army Logistics University (ALU) published a bibliography consisting of 54 books, documents, and internet resources (mostly GAO and various think tank reports), 39 periodical articles, and 5 multimedia (interviews and panels) that address different aspects of the defense industrial base (United States Army Logistics University Library [ALU], 2017). The bibliography consists primarily of resources published after 1994 and served as a helpful starting point to find literature on the industrial base (ALU, 2017). The literature covers a breadth of topics including:

- Strategically focused assessment or analysis of the DIB
- Government strategy and initiatives: 3rd Offset Strategy, Better Buying Power 1.0, Better Buying Power 2.0, and Better Buying Power 3.0
- Contracting trends and acquisition trends that use contracting data to see what/how DOD is buying
- Innovation in DOD

These assessments are all important, and provide considerable insight into the specific topics they address. What seems to be missing, and what this thesis attempts to address, is an analysis of what the spending trends, government policies and initiatives, contracting data, etc., taken together, say about the competitive business environment of the DIB and whether or not that environment *is likely to attract more firms to compete*. To date, most GAO and think tank assessments assess competition by asking whether or not a contract is competitively sourced by soliciting and receiving offers from two or more firms (Manuel, 2011). As a result, the government definition of competition is narrow. This thesis attempts to broaden the analysis of competition and discuss the forces that affect the business environment.

A. THE DEFENSE INDUSTRIAL BASE AS A STRATEGIC ASSET

As a quick database search (and combing through thousands of footnotes) shows, there are a few strategic assessments of the defense industrial base. There are fewer academic scholarly works, and those that do exist were largely written in the aftermath of the Cold War and address the DIB from the angle of a national strategy. For example, Jacques Gansler's 1987 work, "Needed: A U.S. Defense Industrial Strategy" was written just two years after the peak of the Reagan defense buildup and on the back end of the Cold War. His work addresses exactly what the title suggests: how the United States can shape the DIB using an approach that defines what outcomes the nation needs from it. A similar work by Friedberg, "The Strategic Implications of Relative Economic Decline," published in 1989, also assesses how the United States' declining share of the global economy can affect national strategy and the DIB. A more recent work by Dunlap (2011) addresses the military industrial complex circa 2011 and makes the case that it is weaker than it has been in the past, despite the surge of defense spending in the 2000s. Finally, other academic titles have evaluated China's defense industrial base (outside the scope of this thesis) such as the book chapter titled, "China's defence industries: Change and continuity" published in the 2009 book, "Rising China" (Bitzinger & Boutin).

There are also other non-scholarly works that are recognized as authoritative sources on the defense industrial base like Jacques Gansler's 1982 book, "The Defense Industry" is one. Another possible candidate is the Council on Foreign Relations (CFR) 1999 book, "Arming the Future: A Defense Industry for the 21st Century" though this book focuses on the mergers and acquisitions of the 1990s and its possible effects to include: The Pentagon losing buying power, more federal oversight of the industrial base, and cooperating with our allies in weapons development (The Council on Foreign Relations [CFR], n.d.). The topic of consolidation has been covered extensively and there are more contemporary analyses of the areas covered by CFR's publication. In the search for literature, the most recent and comprehensive strategic analysis of the

industrial base is Barry Watts 2008 Paper, “Strategy for the Long Haul, The U.S. Defense Industrial Base: Past, Present, and Future.” Watts makes use of Gansler’s work on multiple occasions and covers, at times from a higher level, CFR’s work. His paper seeks the answer to two broad questions:

- “What kind of defense industry is in the best interests of the United States, today and in the future?”
- “If the defense industry best suited to cope with the challenges of the decades ahead is substantially different from what it is today, what steps might be taken to begin bringing about the required transformation?” (Watts, 2008, p. 3).

Watts’ work does not offer any silver bullet solutions but it does offer insightful questions and potential areas for improvement that should be thoroughly debated amongst policy makers. For example, one of the principals he outlines in dealing with risk and uncertainty is to, “Maintain dominance in critical areas of military capability” (Watts, 2008, p. 65). Most readers would be tempted to assume that this is a forgone conclusion; however, Watts cites sources going back decades that have urged DOD to develop a buying strategy that can be implemented across administrations. Furthermore, Government Accountability Office (GAO) has addressed the need for a strategy in various areas of the industrial base and has written reports such as, “Defense Infrastructure: Management actions needed to ensure effectiveness of DOD’s risk management approach for the defense industrial base,” “Department of Defense: A department-wide framework to identify and report gaps in the defense supplier base is needed,” and “Defense business transformation: Improvements made but additional steps needed to strengthen strategic planning and assess progress.” The literature agrees that the government should take a long-term strategic approach to the materiel it buys and mitigate administrations from acting on near-term political whims.

With regard to the future of the industrial base, there also seems to be an agreement that the United States government is going to need to take a more active role in shaping the industry. The rapid consolidation of more than 30 prime contractors into just 5 in the 1990s and 2000s is now thought to be detrimental to competition and innovation and has left the government with fewer options for materiel acquisition. The extent of intervention varies from the possibility of maintaining the status quo of laissez-faire mentality to a return to government arsenals (Watts, 2008, p. 81–82). There does not seem to be serious consideration of a return to government arsenals and 1990s-style laissez-faire is now eschewed. Watts' second framework involves heavier government intervention in mergers and acquisitions though my review did not find an existing defense strategy that can serve as a basis for approval or denial (Watts, 2008, p. 81). The most widely studied of Watts' (2008) recommendations is if the federal government used, "its product preferences, buying practices, and industrial policies to alleviate the impediments to the type of industry political leaders and government bureaucrats desire" (p. 81). A quick glance at ALU's compilation of references on the industrial base shows that many reports address each of the government's preferences, buying practices, and industrial policies separately. These papers, while not comprehensive, certainly spark needed debate over the policies and procedures needed to shape the industrial base but they are written by stakeholders with different interests and therefore do not address most critical component of the approach in that it, "would require disparate government stakeholders to reach some degree of consensus on the desired industry capabilities and structure" (Watts, 2008, p. 81).

B. GOVERNMENT INITIATIVES FOR ACQUISITION REFORM AND INNOVATION

On June 28, 2010, then Under-Secretary of Defense for Acquisition, Technology, and Logistics (USD AT&L) Dr. Ash Carter, signed a memorandum for acquisition professionals titled, "Better Buying Power: Mandate for Restoring Affordability and Productivity in Defense Spending" (Carter, 2010, p. 1). The

implementation directive,[2] commonly referred to as Better Buying Power 1.0 (BBP 1.0) was published in November 2010 and contains five main objectives:

- Target affordability and controlling cost growth
- Incentivize productivity and innovation in industry
- Promote real competition
- Improve tradecraft in services acquisition
- Reduce non-productive processes and bureaucracy (Carter, 2010, p. 1)

Two years later, in November 2012, the new USD AT&L, Mr. Frank Kendall III published an updated version of the initiative titled "Better Buying Power 2.0" (BBP 2.0). The objectives were largely the same with some key differences:

- Achieve affordable programs
- Control costs throughout the product life cycle
- Incentivize productivity and innovation in industry and government
- Eliminate unproductive processes and bureaucracy
- Promote effective competition
- Improve tradecraft in acquisition of services
- Improve the professionalism of the total acquisition workforce (Kendall III, 2012, p. 2)

[2] Note that the implementation directives are different from the white papers. The white papers serve as more general guidance and are addressed to the defense acquisition workforce. The implementation directives are addressed to the secretaries of the military departments, defense agency chiefs, and USD AT&L direct reports and specify actions that the addressees should take in implementing the guidance set forth in the white paper or elsewhere. The implementation directives are typically longer and have deadlines associated with various tasks.

There were not many significant changes between the first and second iterations of better buying power though the focus on improving "the professionalism of the total acquisition workforce" and seeking to "incentivize productivity and innovation in government" shows an even sharper focus on improving the government's people and processes (Kendall III, 2012, p. 2). On September 19, 2014, the white paper outlining Better Buying Power 3.0 (BBP 3.0) was published by Mr. Frank Kendall. The white paper has outlines BBP 3.0's "new emphasis on initiatives that encourage innovation and promote technical excellence with the overarching goal of ensuring that the United States' military has the dominant capabilities to meet future national security requirements" (Kendall, 2014, p. 2).

Just two months later, on November 15, 2014, then-Secretary of Defense Chuck Hagel gave his Third Offset[3] Speech at the Reagan National Defense Forum (Hagel, 2014). The essence of an offset strategy is laid out in footnote 2 as Secretary Hagel nicely summed up the basis for the initiative. Third Offset has three main thrusts:

- Long Range Research and Development Planning Program that will identify long-term promising technologies but also focus, in the medium term, on recruiting more talent into the government workforce
- Defense Innovation Initiative which focuses on "operational concepts" and how DOD approaches warfighting

[3] The term "third offset" is used because this is the third time, officially, that the United States has sought to develop warfighting capabilities in an asymmetric manner. In his speech, Hagel states, "In the 1950s, President Eisenhower successfully offset the Soviet Union's conventional superiority through his New Look build-up of America's nuclear deterrent. In the 1970s, Secretary of Defense Harold Brown, working closely with Undersecretary – and future Defense Secretary – Bill Perry, shepherded their own offset strategy, establishing the Long-Range Research and Development Planning Program that helped develop and field revolutionary new systems, such as extended-range precision-guided munitions, stealth aircraft, and new intelligence, surveillance, and reconnaissance platforms" (Hagel, 2014, p.s 4–5). An offset strategy is one that does not attempt to match an adversary, "tank-for-tank or soldier-for-soldier" rather it seeks to, "combined these new systems and technologies with new strategic operational concepts" in a manner that gains an advantage for the U.S. military (Hagel, 2014, p. 5).

- Streamlining DOD business practices to include more financial accountability and reforming the acquisition process (BBP initiatives) (Hagel, 2014, p. 5–8)

There were two main forces that drove DOD to develop this strategy. The first was the continuing fiscal restraints in place since the passage of the Budget Control Act in 2011 combined with Congress' inability to pass a budget (Hagel, 2014, p. 5). Secretary Hagel understood that starting large programs that span decades (for example another F-35 type major acquisition) would not be something Congress would be in a position to support. The second force was the emergence and re-emergence of adversaries and potential adversaries who would seek to compete with the United States on different levels of war. The United States must be simultaneously ready to deter a conventional peer (Russia, China), deal with nuclear and non-nuclear regional threats (North Korea and Iran, respectively), and provide stability in ungoverned spaces that non-state actors seek to exploit (Syria, Iraq, Afghanistan for example).

On April 9, 2015, Mr. Kendall published the implementation directive for Better Buying Power 3.0 (BBP 3.0), again largely the same as BBP 2.0, but with "stronger emphasis on innovation, technical excellence, and the quality of our products" (Kendall, 2015, p. 1). BBP 3.0 introduced only two changes as compared to BBP 2.0. Instead of "controlling costs throughout the product life cycle," the new goal is, "achieve dominant capabilities while controlling life cycle costs" (Kendall, 2015, p. 2). Furthermore, "incentivizing productivity and innovation in industry and government" was split into emphasizing productivity in one bullet and innovation in another (Kendall, 2015, p. 2). This is consistent DOD's push to be more innovative.

Finally, on April 23, 2015, then-Secretary of Defense Ashton Carter gave a speech at Stanford titled, "Rewiring the Pentagon: Charting a New Path on Innovation and Cybersecurity" (Carter, 2015). In this speech, Secretary Carter addressed the sometimes-cozy-sometimes-cold relationship between DOD and

Silicon Valley. He also emphasized how many of the problems facing the government and DOD are not unique to public institutions and as such, represent opportunities to work together (Carter, 2015, p. 4). In the speech, Secretary Carter outlined some of DOD's goals such as making it easier for innovative, non-traditional defense companies to do business with DOD, attracting talented individuals to work with or for the government in technologically-focused areas, and emphasizing DOD's focus on cybersecurity while framing the problem as shared between government and private corporations (Carter, 2015).

All four of these (BBP 3.0 white paper, 3rd Offset Strategy, BBP 3.0 implementation directive, and Secretary Carter's speech) had a singular focus: innovation. Innovation in government processes, cybersecurity, private industry, warfighting strategy, acquisition, and how DOD approaches the private sector were all addressed, attempting to drive outdated DOD thinking in select areas towards the modern age and pushing the Department to adapt.

C. TRENDS IN CONTRACTING DATA SHOW WHAT DOD IS BUYING

Utilizing contracting data to analyze DOD spending is difficult. There is publicly available data the Federal Procurement Data System (FPDS) however it is not complete. This thesis utilizes data and analysis from multiple Center for Strategic and International Studies (CSIS) reports on contracting data and defense acquisition trends. Since it relies entirely on the methodology of a third party, it is important to note the limitations to FDPS data and CSIS reports.

The first limitation is, "contracts awarded as part of overseas contingency operations are not separately classified in FPDS. As a result, we do not distinguish between contracts funded by base budgets and those funded by supplemental appropriations" (Berteau et al., 2014, p. 29). This limitation can make it difficult to ascertain DOD's base funding level that it would have regardless of whether or not the country was engaged in conflicts. The second is, "FPDS includes only prime contracts, and the separate subcontract database has historically been radically incomplete, accounting for less than half of the

expected obligations. Therefore, only prime contract data are included in this report" (Berteau et al., 2014, p. 29). From the standpoint of overall DOD contracts, this should not affect top-line data because the prime contractors use the money from their contracts to subcontract projects. This limitation does make it difficult to gauge small business participation, map a supply chain, and understand the competitive environment in the subcontractor market. As such, data on subcontractors could substantially improve an analysis of the business ecosystem at the smaller firm level.

The third limitation is that FPDS only includes unclassified contracts. CSIS assumes that "few, if any, classified contracts are in the database" (Berteau et al., 2014, p. 29). Furthermore, CSIS states, "For DOD, this omits a substantial amount of total contract spending, perhaps as much as 10%. Such omissions are probably most noticeable in R&D contracts" (Berteau et al., 2014, p. 29). This is the most important limitation to contracting data. Because this thesis seeks to understand the business environment surrounding DOD-Silicon Valley cooperation, there could be billions of dollars of contracts unaccounted for in the data. Some of these contracts could be in areas that Silicon Valley has expertise such as machine learning, information technology, autonomy, and space.

Another limitation is, "classifications of contracts differ between FPDS and individual vendors. For example, some contracts that a vendor may consider as services are labeled as products in FPDS and vice versa. This may cause some discrepancies between vendors' reports and those of the federal government" (Berteau et al., 2014, p. 29). This limitation does not significantly affect understanding the competitive environment. While the market for government products and services is different with regard to the vendors and market share, the Big 5 and others have been divesting services businesses recently (Hunter et al. 2016, executive summary, p. XV–XVI).

From the 2016 report on federal R&D contracting, the last limitation involves FPDS being consistently updated. For example, "FPDS data from past years are continuously updated over time. While FY2007 was long closed, over

$100 billion worth of entries for that year were modified in 2010" (Ellman et al., 2016, p. 61). This speaks to the opening statement of this section regarding auditability and DOD. $100 billion worth of entries, even over a long time span like a decade, are still material in amount and could cause inaccuracies in the assertions made using contracting data.

Despite these limitations and shortcomings, contracting data, even if partially accurate, does provide insight into how DOD spends money. There are five main reports used in this thesis. The first is a CSIS report from 2013 that has federal contracting data from 2000 through 2012 and the second is the follow-up to that report published in 2014 that analyzes the data from 2000 through 2013. Another report, published in 2016, analyzes federal research and development contracting from 2000 through 2015. The last two reports, published in 2016 and 2017 analyze federal acquisition trends in the year immediately preceding the report (for example, the report published in 2017 analyzes trends from 2016). while the last report considered analyzes defense acquisition trends and was published in 2017.

The final note for contract data is the time frame. As shown in section three, defense spending often grows for 5 to 10 years and then falls for a similar period of time (Watts, 2008). This thesis does not consider contracting data from before the year 2000 because there have been two clear periods of rising and falling defense spending since then. After the attacks of September 11, 2001, defense spending rose until it peaked somewhere between 2008 and 2011 and has been falling since that time (Hunter et al., 2016, executive summary p. VIII). The more recent contracting data offers a better look at the current business environment and older contracting data would be complicated by the numerous mergers and acquisitions in the defense industry.

D. THINK TANK ASSESSMENTS OF DOD'S INNOVATION INITIATIVES

The final segment of the literature review involves works that assess innovation in DOD. This thesis relies on two main reports and another summary

of panelists opinions at a conference. The first report, written by Andrew Hunter of CSIS in September of 2015 is titled, “Keeping the Technological Edge: Leveraging Outside Innovation to Sustain the Department of Defense’s Technological Advantage.” The second, written by Jeffrey Bialos in February 2017 titled, “Against the Odds: Driving Defense Innovation in a Change-Resistant Ecosystem.” The panelist summary took place on October 28, 2016 and was analysis of the Third Offset Strategy laid out by Secretary Hagel in 2014.

All three authors agree that the Department of Defense needs to do a better job of accessing non-traditional DOD companies, outside DOD innovation, and partner with and adopt allied foreign technologies. Hunter frames the issue of DOD accessing some commercial technologies:

> While many parts of DOD are highly conversant with the latest advances in technology, this awareness is not universally shared by critical elements of the acquisition, resource, and requirements communities. DOD should create and share a better knowledge base of emerging technologies and processes across the Department. (Hunter et al., 2015, executive summary, p. vii)

This provides specificity when discussing DOD and outside innovation as often times, as Bialos points out, there is a perception that DOD and innovative industry do not partner on major technological endeavors (Bialos et al., 2017, p. 23). It would seem these authors agree that the disconnect is smaller than the Department itself assesses and if there is a disconnect, it is confined to certain personnel.

Both authors and almost every panelist at the CSIS event acknowledged a need to utilize more flexible acquisition terms, get away from Federal Acquisition Regulations (FAR) based acquisition, and take more calculated risks in the acquisition process. As stated by Rear Admiral Manazir, “If the military services are always aiming to design the perfect solution and are designing for zero risk, operational risk will increase dramatically while they futilely waited to achieve perfection” (Hicks et al., 2017, p. 9). Furthermore, “Su Jin Chang, a Principal at the Center for Acquisition Management Sciences in The MITRE Corporation,

cited a related issue: government contracting officers are incentivized to be risk-averse because they are measured by a standard of 'perfect is better than protest.'" (Hicks et al., 2017, p. 9). Reducing these barriers would also help DOD access more privately funded R&D projects. For example, Bialos adds to the conversation by saying that DIUx, and its commercial solution opening (that helps enable access to privately funded R&D) is a great idea in terms of using more flexible contracting processes. However, he also points out that DIUx, as a small entity with funding in the tens of millions, is unlikely to change the mentality of the federal research and development ecosystem with funding in the tens of billions of dollars (Bialos et al., 2017, p. 62).

Another area of agreement was the need to leverage foreign commercially-available technologies, though the extent of their use is disputed. While Hunter's CSIS report did not specifically address foreign technology, seeking technologies outside of DOD's typical vendor sphere would suggest at least limited advocacy. Bialos and the CSIS panelists both strongly encouraged shared technological development with allies. Bialos advocates for increasing funding for joint and coalition research and development programs, allowing DARPA to access "early stage foreign innovation," and even bringing foreign scientists and entrepreneurs to the United States for 1–3 years that they could spend in residence at, "U.S. universities, private sector firms, DOD laboratories and other appropriate venues to pursue work on a collaborative basis with U.S. counterparts" (Bialos et al., 2017, p. 81). By far, Bialos offered the most optimistic and specific pushes towards tapping foreign innovation.

The last, and possibly most critical piece of the literature is Bialos' recommendation to adopt an actual research and development strategy. The first recommendation in the executive summary of his 100-page report states,

> 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. (Bialos et al., 2017, executive summary, p. x)

Similar to how Watts suggests that DOD needs an overall strategy in how it makes its investments, Bialos is even more specific stating that DOD needs an investment strategy. He is advocating for DOD to adopt the same outlook that a large venture capital firm would have with regard to its investments. The venture capital firm would not simply throw millions of dollars around without at least understanding the business case behind the investment. Similarly, DOD should evaluate the military case for the technology and spread its investments based on the time frame and ability for them to come to market.

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III. TRENDS IN THE DEFENSE INDUSTRIAL BASE: 1945–2016

Universally encountered in the research surrounding the defense industrial base (DIB) are defense spending and industry consolidation. The timeframe over which defense spending is analyzed tends to start during or immediately after World War II. This section looks at U.S. defense spending from World War II to the present and analyzes subtopics of defense spending on research and development (R&D) as well as defense spending growth despite a shrinking number of personnel. The second section addresses consolidation and how DOD can only choose from, in some cases, one or two contractors to build assets and also trends in contracting with businesses of varying size. The section concludes with a quick look at the history of DOD partnership with commercial industry.

A. U.S. DEFENSE SPENDING TRENDS WORLD WAR II—PRESENT

Looking back to World War II, the United States has, at times, spent a considerable amount of gross domestic product (GDP) on national defense as shown in Figure 1. In 1941, it spent just about 5% of GDP on defense and in 1942, just one year later, that figure had increased to between 15% and 20% and by 1945, it peaked at over 40% (Chantrill, 2017, chart).

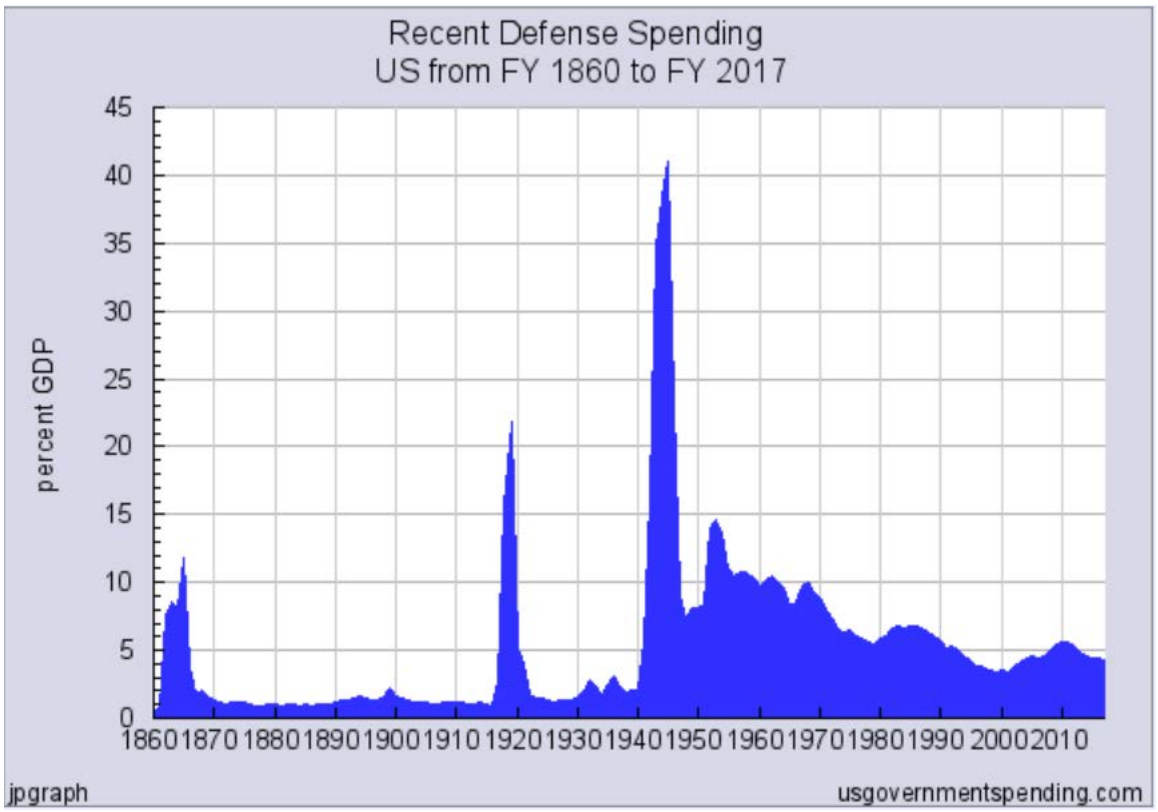

Figure 1. U.S. defense spending as a percentage of GDP. Source: Chantrill (2017).

World War II was certainly an anomaly even when compared to World War I and this makes sense—the United States got involved earlier and committed more resources to World War II than it did in World War I. The trends also show that the United States' thinking on defense spending changed dramatically after World War II. Before 1941, the country only spent more than 1% to 2% of GDP on defense on three occasions: The War of 1812 from 1812 through 1817, the American Civil War from 1861 to 1868, and World War 1 from 1917 to 1921 (Chantrill, 2017, chart). What these spending trends show is that the United States did not maintain a large, active, federal peacetime military when it was not involved in a major conflict. The numbers also show the United States did not spend significant amounts of money on military-related research and development. It only raised armies and procured materiel as needed for war and did so only after war had been declared.

To bring the country out of the Great Depression, President Franklin Roosevelt engineered a federal government spending campaign the likes of which the United States had never seen before (Chantrill, 2017, para. 2 & chart 2.21). The increased spending in domestic areas followed by the need to rapidly build up the military for World War II resulted in unprecedented overall federal spending. The trend of increased spending on defense continued even after a massive demobilization post World War II. Defense spending as a percentage of GDP never dropped below 7% until 1970 (Chantrill, 2017, table). Spending 7% or more on defense was maintained through 1970 despite a rapidly growing economy that expanded at a sustained rate of more than 3% (Bureau of Economic Analysis [BEA], 2017). Economic growth could have resulted in a decline in defense spending as a percentage of GDP but it did not, suggesting DOD enjoyed ample resources until the United States decided to scale back its operations in Vietnam.[4]

From 1968 to 1975, defense spending declined significantly as a percentage of GDP decreasing from 10% in 1968 all the way down to a post-World War II low of 5.46% in 1979 (Chantrill, 2017, chart). This period is especially significant because the United States was still at war with Vietnam through 1975 which means spending was being cut despite being involved in a major conflict. Furthermore, there were two recessions in this period: the first was in 1970 and the second was from 1973 to 1975 (Federal Reserve Economic Data [FRED], 2017). This is especially troubling because defense spending was a lower percentage of a lower real GDP figure due to the recession—defense was getting a smaller portion of a smaller pie. Though spending started to increase from 1979 to 1980, the country was again in recession for two quarters of 1980

[4] Note that while the growth from 1945 to 1970 was 3.01%, this includes an outlier year, 1946, where GDP declined by 11.6%. The decline in GDP was due to the massive demobilization that resulted from the end of the war in September 1945. If the number is excluded as an outlier, average GDP growth is 3.44%. The point being made here is that the rapid pace of economic growth alone could have forced defense spending as a percentage of GDP to decrease well below 7%. A related point is that when defense spending decreases as a percentage of GDP, this does not always reflect less spending, simply the pace of defense spending may fail to keep up with the pace of growth in the economy.

and again from 1981 to 1982 meaning defense spending was not necessarily increasing, it was getting the same amount but the economy was shrinking causing the percentage spent on defense to increase (FRED, 2017).

The election of Ronald Reagan coincided with a rebound in the economy and his policies increased defense spending significantly. Figure 2 shows the increase in real defense spending from a low point of $350 billion in 1974–75 to a high point of nearly $550 billion in 1984–85[5] (Watts, 2008, p. 21). Spending as a percentage of GDP however, moved only slightly due to the rapid economic expansion between 1981 and 1989 when the economy grew an average of 3.5% per year (BEA, 2017). In fact, from the 1981 low point of 6.03%, the highest spending ever got as a percentage of GDP during the Reagan administration was 6.84% in 1986 at which point it subsequently declined back to 6.06% in 1989 when Reagan left office[6] (Chantrill, 2017, table).

[5] Note that the dollars in Figure 2 are in billions of FY2009 dollars.

[6] It is no coincidence that 1986 was the high point of defense spending in terms of GDP. 1986 was a year of change for the defense business starting with the Packard Commission report in June of 1986, which detailed the excesses of defense spending. The reforms made DOD more accountable for how it spent its money, and as can be seen in Figure 2, resulted in less money being spent on defense.

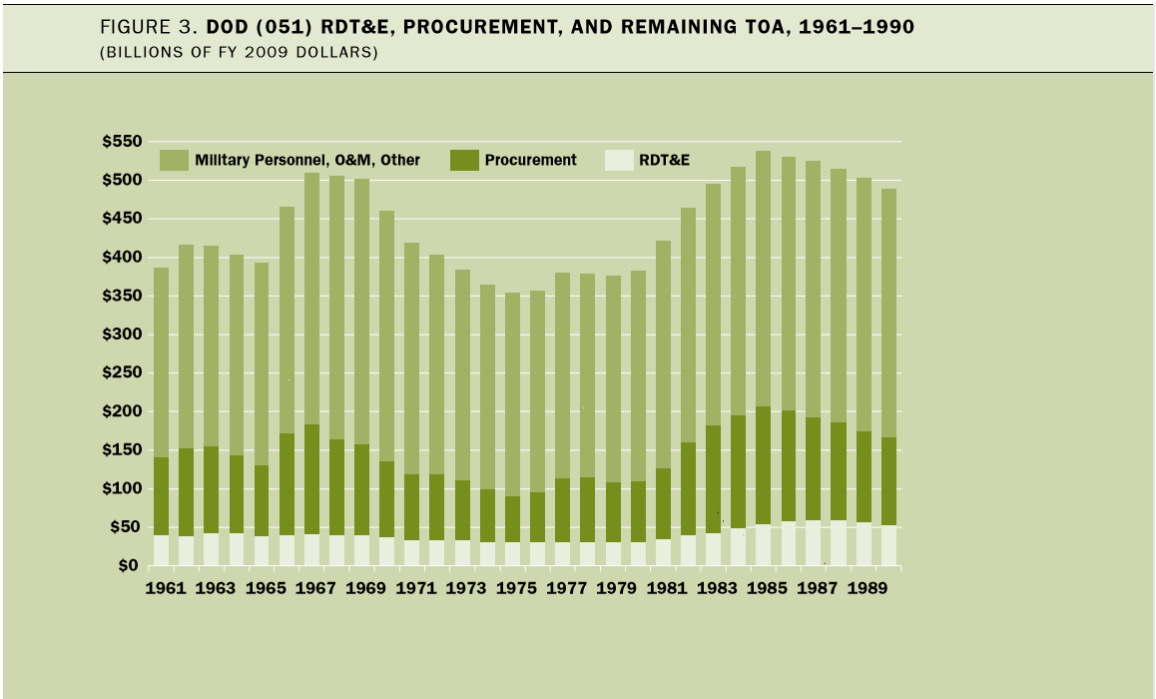

Figure 2. U.S. defense spending 1961–1990. Source: Watts (2008).

Though spending was declining from 1985 to 1990, both as a percentage of GDP and in real dollar amounts, the collapse of the Soviet Union in 1991 and the election of President Bill Clinton in 1992 aligned to depress defense spending to levels not seen since before World War 2 (Watts, 2008, p. 28). From 1993 to 2000, defense spending as a percentage of GDP decreased from 5% to around 3.49%, the lowest level since 1940 (Chantrill, 2017, chart). Multiple factors accounted for the decline. First, the economy grew at nearly 3.9% from 1993 to 2000 so even if there had been no cuts to defense spending, it still would have fallen as a percentage of GDP, but not as dramatically (BEA, 2017). The second factor was the end of the First Gulf War when the United States predictably reduced spending on defense as it did after most other major wars. Figure 3 shows the decline in spending in constant 2009 dollars.

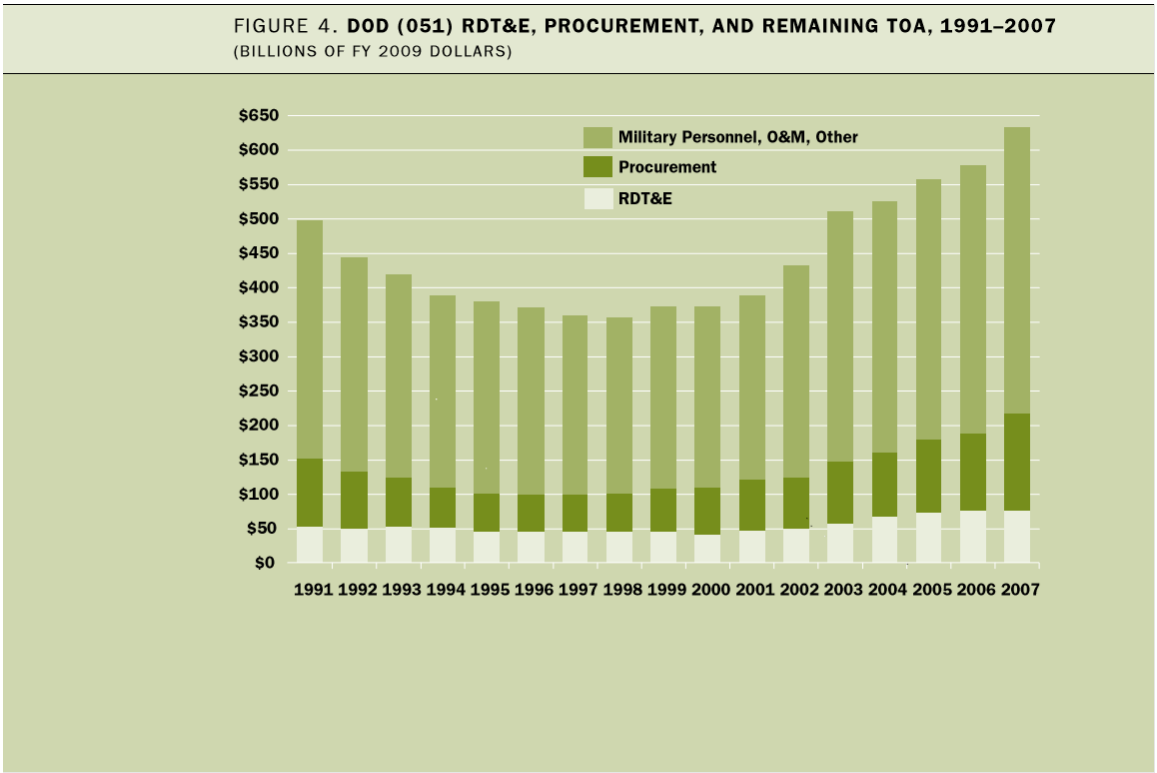

Figure 3. U.S. defense spending 1991–2007. Source: Watts (2008).

The gutting of the defense budget was reversed in 2001 and escalated in 2003 as the conflicts in Afghanistan and Iraq became more intense. Briefly, from 2009 to 2012, spending on defense as a percentage of GDP eclipsed 5% though that is partly due to the Great Recession when real GDP fell for four consecutive quarters in 2008 and 2009 (Chantrill, 2017, chart) (FRED, 2017). Another contributing factor was the American Recovery and Reinvestment Act (ARRA), passed in 2009 by President Barack Obama. Federal spending increased from $2.98 billion in 2008 to $3.52 billion in 2009 to $3.6 billion in 2011 and part of this money went to DOD (United States' Government Publishing Office [GPO], 2017). Even though budgets were expanding, much of the money was being spent on personnel and immediate needs for the war, not to fund future projects as evidenced by declining DOD contract obligations. As pointed out by the Center for Strategic and International Studies (CSIS) in 2017, "This continued decline in contract obligations is reflective of the continued trough in DOD's development

pipeline for major weapons systems" (Center for Strategic and International Studies [CSIS], 2017, p. 5). An example of the increased spending on immediate needs and non-equipment related expenses is the Army increasing its active forces from 481,000 in 2001 to 565,000 in 2011 while the Marine Corps increased from 173,000 to 201,000 over the same period (Defense Manpower Data Center [DMDC], 2017b,c).

The current position DOD and the industrial base finds itself in is precarious. Though the United States has withdrawn a bulk of its combat forces from Iraq and Afghanistan, as evidenced by the current administration's decision to send additional troops to the region, the country is still faced with needing to maintain an enduring presence there (Rucker, P. et al., 2017). In addition to the demands of small scale regional conflicts, it now faces the need to ensure freedom of the seas in Asia as well as to ensure resurgent Russian aggression as seen in Georgia in 2008, the Ukraine in 2014, and Syria in 2015 (*British Broadcasting Corporation* [BBC], 2015) (Thompson, 2017) (*Cable News Network* [CNN], 2017). Simply put, the demands on the military are not decreasing as they have after other wars in the past, the need for investment in future technologies is expanding as technological development is happening faster, and DOD faces a shrinking budget.

1. DOD Spending Less on Contracted Research and Development

One concerning trend in what DOD spends money on is the severe decrease in spending on research and development. As the report about defense acquisition trends for 2016 notes, "This is particularly worrisome because defense R&D has historically seen a cycle where investments made in growth periods show results during subsequent drawdown periods" (CSIS, 2017, p. 21). Figure 4 shows the buildup in research and development (R&D) during the Iraq and Afghanistan Wars through 2009 and then the massive cuts that ensued through 2015, the most recent year for which data was available (CSIS, 2017, p. 21). A quick analysis shows that DOD made massive cuts in its System

Development & Demonstration (SDD) and Advanced Technology Development (ATD) amounts, reflecting the absence of new major program starts (CSIS, 2017, p. 10). DOD did however preserve its Basic Research and Applied Research amounts. A positive here is that despite the deep cuts, DOD has been making investments in technologies that are premature but that could show promise in the future.

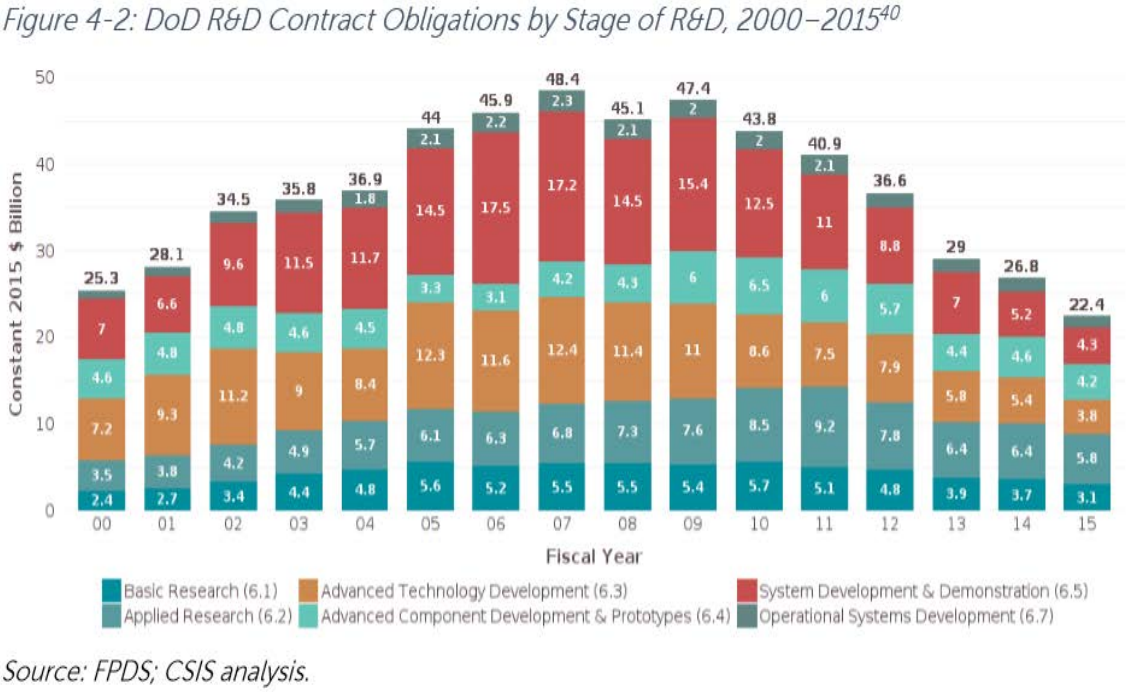

Figure 4. DOD R&D contract obligations by stage of R&D 2000–2015. Source: CSIS (2017).[7]

2. DOD Personnel Spending Growing Faster Despite Shrinking Force

One interesting observation of DOD spending since 1976 (the first year for which data is available) is the pace at which personnel, operations and

[7] As noted by CSIS in their report, there are a few limitations to the contract data. One is that the data source, FPDS only includes prime contract data, not subcontractors' data. If subcontractor data were included, the numbers could be higher. The second limitation is the data only includes unclassified contracts.

maintenance (O&M), and procurement have grown historically versus current growth (2000 to 2016).[8] Table 1 shows the nominal amounts spent in each of the three categories in 1976, 2000, and 2016 as well as the compound annual growth rates (CAGR) for each category for the associated time periods. As shown, the growth rates of personnel spending and procurement spending are well above the historical averages while O&M spending growth is less than the historical average.

Table 1. Defense spending by appropriation 1976–2000.
Adapted from U.S. Government Publishing Office (2017).

Function and Subfunction	1976	2000	2016	CAGR 1976–2016	CAGR 2000–2016
050 National Defense:					
Military Personnel	32,912	73,838	145,447	3.78%	4.33%
Operation and Maintenance	28,731	108,724	245,147	5.51%	5.21%
Procurement	20,991	54,972	118,894	4.43%	4.94%

The focus here is on the personnel spending growth. Table 2 shows the decrease in active duty personnel from 1976 through 2016. In June of 1976,

[8] Note the following definitions from Defense Acquisition University (DAU). "Procurement appropriations are used to finance investment items, and should cover all costs necessary to deliver a useful end item intended for operational use or inventory. Items classified as investments and financed with Procurement appropriations include those whose system unit cost exceeds $250K; all centrally managed end items not purchased from Defense Working Capital Funds, regardless of unit cost (e.g., handguns); purchases from the Defense Working Capital Fund furnished as part of a system acquisition, system modification, major service life extension program and initial spares" (Defense Acquisition University [DAU], 2017, General Information, para. 4). "O&M appropriations traditionally do not finance investments, but rather those things whose benefits are derived for a limited period of time, i.e., expenses. Examples of costs financed by O&M funds are headquarters operations, civilian salaries and awards, travel, fuel, minor construction projects of $1M or less, expenses of operational military forces, training and education, recruiting, depot maintenance, purchases from Defense Working Capital Funds (e.g., spare parts), base operations support, and assets with a system unit cost less than the current procurement threshold ($250K)" (DAU, 2017, General Information, para. 5). "MILPERS appropriations are used to fund the costs of salaries and compensation for active military and National Guard personnel as well as personnel-related expenses such as costs associated with permanent change of duty station (PCS), training in conjunction with PCS moves, subsistence, temporary lodging, bonuses, and retired pay accrual" (DAU, 2017, General Information, para. 6).

there were almost 2.1 million active duty military members while in September of 2016, there were just over 1.3 million active duty personnel, a decrease of 38%.

Table 2. DOD active duty forces 1976–2016. Adapted from Defense Manpower Data Center (2017a,b,c).

Jun-1976	Sep-1985	Sep-1995	Sep-2005	Sep-2010	Sep-2016
2,081,910	2,151,032	1,536,138	1,386,407	1,430,552	1,301,308

The takeaway is that the military has experienced a decrease in personnel since 1976 but has simultaneously seen its personnel costs increase. This paper will not attempt to isolate the reason for this but there are a few possibilities. One is that after the Vietnam War, the United States decided to maintain a professional, all-volunteer military. Professionals typically command higher payment than non-professionals. Another possibility is that the private sector, especially for college-educated military members, can offer higher salaries as compared to the government which is limited by law. To compensate for this, Congress increased military pay and benefits to ensure the military remained a competitive employer. Yet another possibility is that the modernization of the U.S. military force, combined with the reduction in the number of large warfighting assets the military owns (ie: ships and airplanes) has resulted in equipment that requires fewer personnel.

B. CONSOLIDATION IN THE DEFENSE INDUSTRIAL BASE

Consolidation of the industrial base has been a major concern and the topic of numerous studies over the past decade. As shown in Figure 5, It is well known that from the period beginning in 1993 through 2007 that 30 major DOD prime contractors consolidated down to just 5 (Watts, 2008, p. 32). The consolidation coincided with a significant decrease in defense budgets, however; there is more to the industry consolidation than just the shrinking budgets.

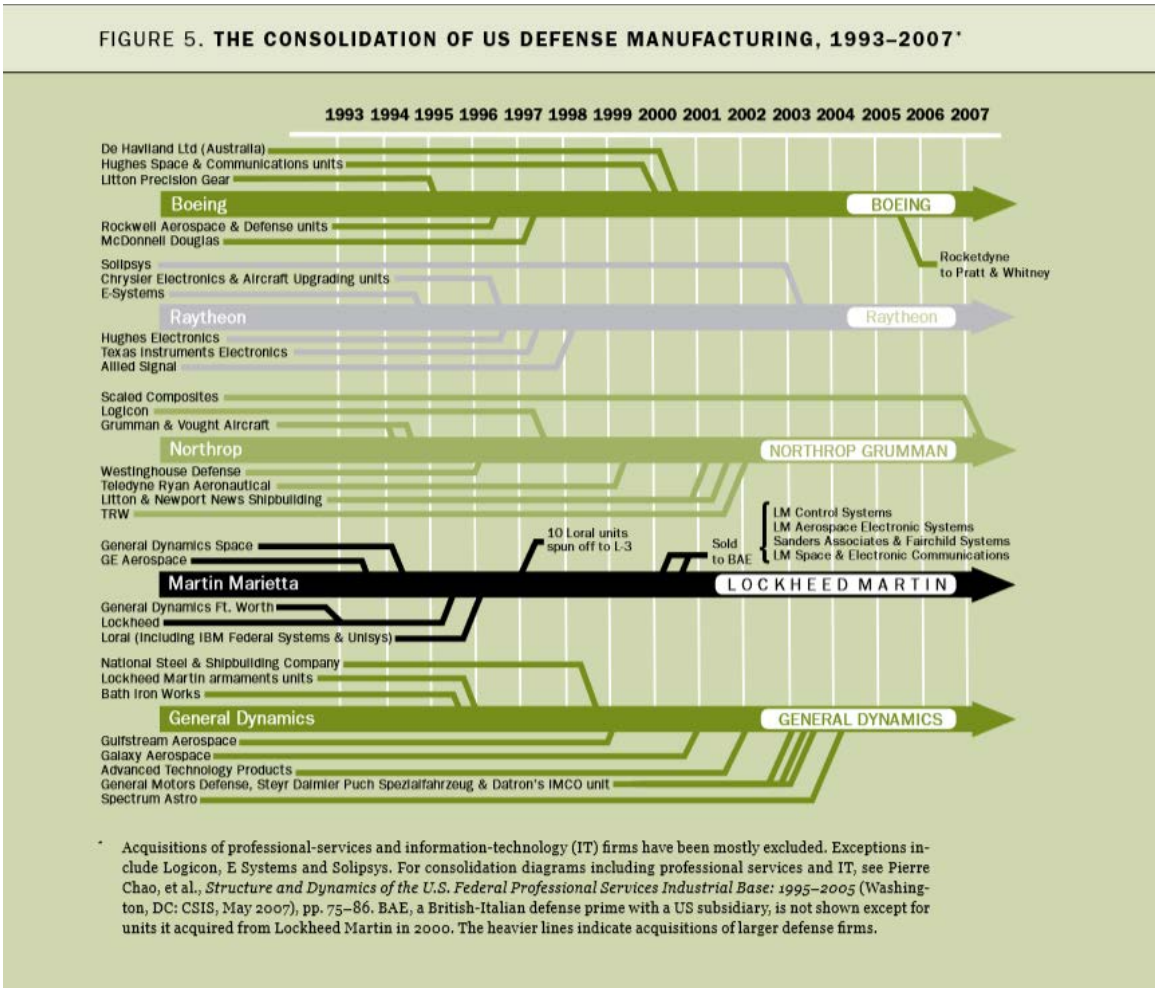

Figure 5. Consolidation of DOD prime contractors. Source: Watts (2008).

1. DOD Can Only Choose from One or Two Companies to Build Some Materiel

There are three main areas in which the government has between one and three suppliers and they are: manned, fixed-wing combat aircraft, armored vehicles, and naval ships (to include submarines) (Watts, 2008, p. 37–38). For manned, fixed-wing combat aircraft, the supplier base is down to three: Lockheed Martin, Boeing, and Northrop Grumman (Watts, 2008, p. 37–38). For armored vehicles, the supplier base of the larger systems like M1 Abrams tanks and Bradley fighting vehicles, consists of General Dynamics and British Aerospace Systems (BAE for short) (Watts, 2008, p. 37–38). Finally, in shipbuilding, there

are two main competitors: Huntington Ingalls Shipyards (previously a part of Northrop Grumman) and General Dynamics[9] (Watts, 2008, p. 37–38).

2. Share of Defense Contracts

As a result of the consolidation, many may believe that the Big 5 contractors (Boeing, Lockheed Martin, General Dynamics, Raytheon, and Northrop Grumman) have gained an increasing share of DOD contracts. In fact, the data does not support that claim. As Figure 6 shows, the Big 5 and medium-sized firms have seen a decline in their share of contracts since 2000 while large contractors and small contractors have seen an increase[10] (CSIS, 2017, p. 64). Figure 6 shows just how variable the share of the market for firms can be. It is especially interesting to note how medium contractors, at one point, held a larger market share than even large firms, but that gap was quickly erased and there is about 7% difference in share between the second and third spots. One trend that is easy to spot is the increased market share for small firms which his likely due to policies that promote small businesses (CSIS, 2017, p. 111).

[9] Note that at the time of Watts' report, Huntington Ingalls was still a part of Northrop Grumman. In 2011, Northrop spun off Huntington Ingalls for numerous strategic reasons, though chief among them was how badly the shipbuilding division was struggling (Drew, 2011). Though Watts does not break down the shipbuilding business into more categories, for example, submarines, aircraft carriers, and other surface ships, it is important to note that aircraft carrier and submarine production are even more concentrated. New submarines are built mostly by General Dynamics Electric Boat with some work subcontracted out to Huntington Ingalls (Lessig, 2017, para. 5). For aircraft carriers, the situation is worse. Huntington Ingalls is the only producer and the shipyard these ships are built in, Newport News Shipbuilding, "is the sole designer and builder of aircraft carriers for the U.S. Navy" (Newport News Shipbuilding, 2017)

[10] "To evaluate this impact, CSIS looks at DOD contract obligations to different size categories of vendors: Small, Medium, Large, and the Big 5. Small is defined by the government's classification, with a couple of adjustments that leave CSIS's small business participation shares consistently 2–4 percentage points below what DOD reports. Large is defined as any vendor with over $3 billion in annual revenue from all sources, not just government contracting. A Medium vendor is any vendor that is neither small nor large. And the Big 5 vendors, separated out from large, are vendors that are consistently and by far the largest players in the defense contracting market: Lockheed Martin, Boeing, Northrop Grumman, General Dynamics, and Raytheon" (CSIS, 2017, p. 63).

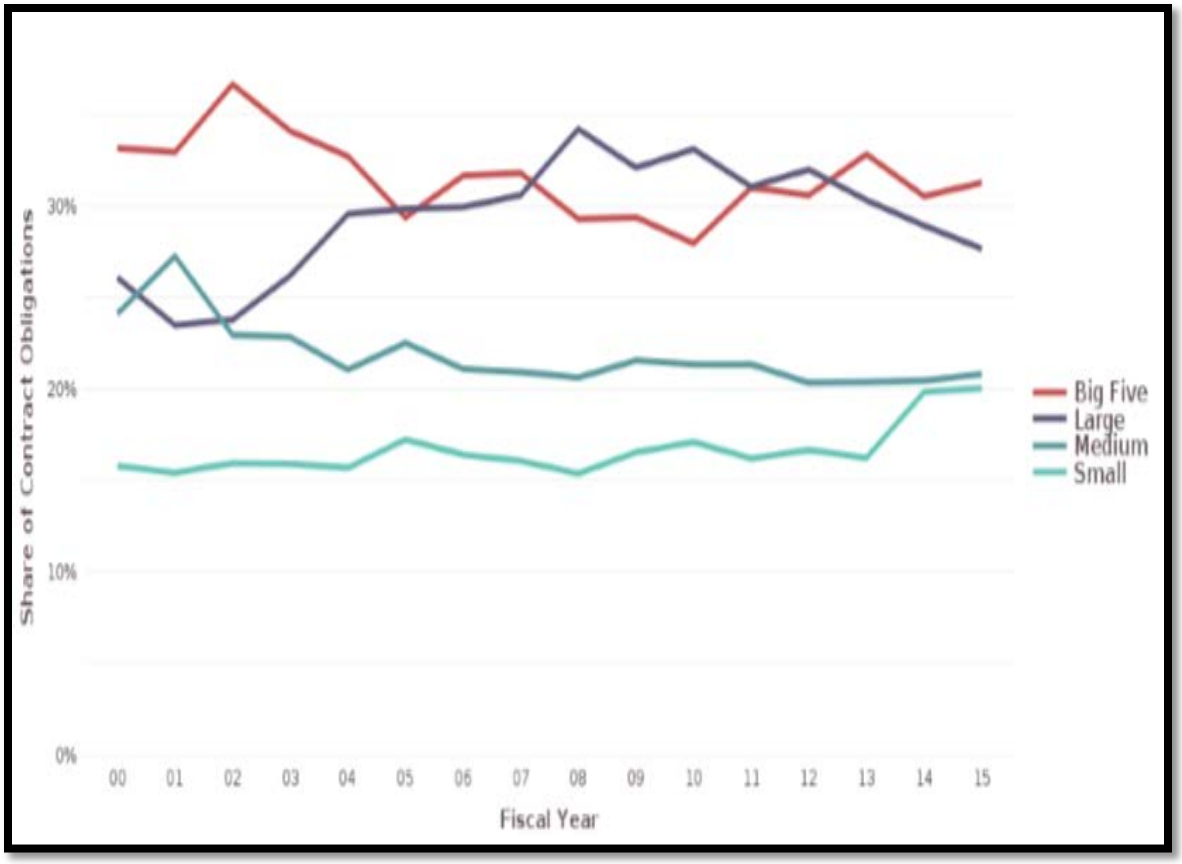

Figure 6. Defense contract obligations by size of vendor, 2000–2015. Source: CSIS (2017).

The perception that consolidation has led to an increasing share of DOD contracts for the Big 5 firms is likely driven by these firms increasing share of DOD contracts for products (as opposed to services). After experiencing a significant decline in market share from 2000 to 2009, the Big 5 increased share from 35% in 2009 to nearly 45% in 2015 though it is important to note that from 2000 to 2015, the share was constant (CSIS, 2017, p. 68). Also interesting is that the Big 5's share of defense R&D contracts has plunged since 2000. In 2000, the Big 5 had a 50% share which it subsequently increased to more than 60% in 2006, yet in 2015 the share was just over 30% (CSIS, 2017, p. 65).

Market share trends in DOD contracts are simultaneously sticky (do not change much) and inconsistent. With regard to the stickiness, much of the

literature on the trends concludes that overall, there are no clearly defined trends and that the range of market share remains relatively constant over time. As shown in Figure 6, from 2000 through 2015, no one segment in the market increased or decreased by more than 5%. What this simplification leaves out is that throughout the period, there was significant variation in market share. This suggests that the market is intensely competitive but the Big 5's recapture of market share since 2009 also shows that the government cannot afford to let any of them fail due to these firms' strategic importance. This theory is partially supported by contracting data that shows that from 2000 to 2013, the share of contracts for which there was no competition increased from 37.7% to 43% while the share of no competition or single offer increased from 45.6% to 50.5% (Berteau et al., 2014, p. 18). In summary, competition has occurred and the Big 5 have at times felt pressure, but the reality is that some of the products and services they provide can only be produced by them for various reasons, all but guaranteeing them a significant market share for years to come.

C. HISTORY OF NON-TRADITIONAL DEFENSE FIRMS PARTNERING WITH DOD

The last section leads well into another trend that has been evolving slowly but has recently received more attention. The Department of Defense and defense industrial base firms have been involved, directly or indirectly, in numerous innovative and highly technical projects. The examples are too numerous for an exhaustive list and Jeffrey Bialos' 2017 report, "Against the Odds: Driving Defense Innovation in a Change-Resistant Ecosystem" describes the public private relationship well.

> 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] Spinoffs have been considerable and important. (Bialos, 2017, p. 21)

This establishes that private industry and public entities have worked well together, with significant benefits for society, at times. It appears that the relationship was driven at least partially by the market DOD provided, which was more attractive in the past than it is today.

As Bialos showed, the amount of research and development conducted by the government versus the private sector has changed dramatically over time. In 1953, all federal government R&D was about 0.75% of U.S. GDP while private sector R&D was 0.6% of GDP (Bialos, 2017, p. 12). This changed rapidly until the mid-1960s when government R&D reached nearly 2% of GDP while private sector R&D had increased to slightly exceed 0.8% of GDP (Bialos, 2017, p. 12). From the peak in the mid-1960s, federal R&D declined to just less than 0.8% in 2013 while privately funded R&D had increased to 1.8% of GDP (Bialos, 2017, p. 12). What this shows is that by size of the market alone, the federal government used to provide more resources for innovators of all disciplines to research their ideas than did private industry. The government and defense industrial base contractors attracted the best and the brightest minds because they had the resources to support their research. This is the opposite of the prevailing view today which is that doing business in the DOD acquisition system takes too long and stifles innovation. Secretary of Defense Ash Carter was asked after his 2015 speech at Stanford, "What's in it for Silicon Valley? Why enter DOD's acquisition system.?" (Munsil and Ewing, 2015, p. 4). The Secretary's response was, "Well, I hope you [Silicon Valley] don't have to enter DOD's acquisition system" (Munsil and Ewing, 2015, p. 4).

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IV. THE BUSINESS ENVIRONMENT FOR DOD—SILICON VALLEY COOPERATION

This section of the thesis uses two frameworks for analyzing business environments and applies them to the defense business ecosystem. The first, Porter's Five Forces, is meant to assess the power dynamics of the industry. The second, PESTEL (Political, Economic, Social, Technological, Environmental, and Legal) evaluates the macro environment and forces that affect the industry over which firms have little control. In this thesis, the legal component of PESTEL was excluded due to significant overlap between the political and legal forces. The overlap and reason for exclusion is described in more detail in the introduction to the PESTEL section.

A. USING PORTER'S FIVE FORCES TO ASSESS SILICON VALLEY COMPANIES ENTERING DOD MARKET AS A LARGE CONTRACTOR

1. Market Competition

Market competition amongst existing competitors in the large prime contractor space is quite intense. As defined by the Center for Strategic and International Studies (CSIS), "Vendors with annual revenue of more than $3 billion, including from nonfederal sources, are classified as large" (Berteau et al., 2014, p. 30). Medium and small vendors are excluded from this analysis for two reasons. The first is the definition of a medium-sized firm is, "Any vendor assigned a unique identifier by FPDS but is neither small nor large," which is broad and these firms are numerous (Berteau et al., 2014, p. 30). The second reason is that the United States government has policies that favor small businesses and target certain levels of participation.

One condition for competition in Porter's framework is, "competitors are numerous or are roughly equal in size and power" (Porter, 1979, p. 142). The way the industry has consolidated over the past two to three decades shows a growing trend of less competition. While the number of large vendors may still be

numerous, the consolidation of approximately 30 prime contractors into 5 during the recent timeframe has resulted in a new tier of firms, the Big 5. The Big 5 have more power in the defense industry than do the second tier of large firms. The evidence for this is in contract obligations. In 2013, the Big 5 accounted for almost 30% of DOD contracts while the top 20 firms accounted for about 46.5% of DOD contracts (meaning the next 15 largest firms by contract dollars accounted for half of the Big 5's total contracts) (Berteau et al., 2014, p. 23). Essentially, while there may be numerous large contractors which would promote competition, the existence of a separate tier of large firms suggests less competition.

In the defense industry, switching costs and product differentiation are high. The process by which DOD acquires large major end-items like trucks, airplanes, tanks, ships, and precision munitions can span decades. For example, DOD awarded the first prototype contracts for the F-35 in 1996 and the first squadron was not declared initially operationally capable until 2015 (Lockheed Martin, 2017). Because the process to design, produce, and test these aircraft is long, the cost of developing new aircraft (which is a switching cost) is high. Once a design is chosen as the winner, it typically stays in service for between two and four decades or longer.[11] The cost to switch before the end-item's service life is up is the cost of starting a new program as compared to the cost of making upgrades to the existing platform. High switching costs are anti-competitive and act as a deterrent for DOD to switch suppliers if it is receiving sub-par performance.

[11] For example, the B-52 Stratofortress has been in service for more than 60 years though it has been upgraded multiple times during its service life (Boeing, 2017).

It is difficult to analyze the differences between the strategy and culture of major defense competitors.[12] In some respects, they are all forced to compete similarly because the acquisition process is the same for every large firm. Because the industry is highly mature, the surviving firms have institutional knowledge about which strategies are the most effective to compete and are not highly differentiated. Additionally, many firms have made protesting contract awards an important component of their strategies (Watts, 2008, p. 59). Because firms believe this is a profitable strategy, many use it, pointing to less differentiation in how firms view strategic competition within the acquisition process. However, there are likely differences in how firms compete for different classifications of materiel—for example, the culture of firms building submarines is likely very different from the culture of firms building land vehicles due to the heightened safety and security concerns for undersea vehicles[13] (Barry D. Watts, interview with author, November 8, 2017). These differing aspects of the industry make it difficult to assess whether or not culture and strategy point to more or less competition.

An indicator that the market is competitive is the slow industry growth. As seen in Watts' 2008 paper, real DOD spending, in FY 2008 dollars has

[12] Strategy and culture and often referenced together and can be confused if one is not clear about the differences. Henry Mintzberg summarizes strategy (strategic thinking) well, saying the, "strategy-making process should be: capturing what the manager learns from all sources (both the soft insights from his or her personal experiences and the experiences of others throughout the organization and the hard data from market research and the like) and then synthesizing that learning into a vision of the direction that the business should pursue" (Mintzberg, 1994, p. 107). On the other hand, organizational culture is, "the beliefs, values, norms, customs, and practices of the organization (Ott, 1989). Language and symbols are important elements of culture. Within organizations, cultures are often expressed as assumptions-beliefs that define 'the way we do things here.'" (McCurdy, 1992, p. 189).

[13] During a thorough literature review, there was not a single paper or analysis of the cultural differences between major defense contractors. This would be an interesting area for further research because there may be a tendency to assume that, for example, United Technologies, General Atomics, and L3 Communications have similar cultures within their defense business units. This may or may not be the case. That said, it does seem plausible that firms designing highly-secure communications equipment would have a different culture and personnel when compared to firms designing precision munitions. This may stem from the difference in the use of the product (the communications firm viewing itself as an enabler of something important yet harmless on its own merit while the firms designing munitions focus on lethality could attract different employees) or other cultural factors.

experienced multiple peaks and troughs (Watts, 2008). The troughs in spending, such as during the mid-1990s, regress the level of real spending back to amounts not seen since the 1950s. These types of fluctuations in the total market size lead to periods of aggressive competition and consolidation when the market shrinks. Furthermore, the peacetime defense industry has been around for over seven decades, making it a more mature industry.

Another aspect of the market that suggests it is highly competitive is the high fixed costs to enter it, especially the market for physical materiel. For example, shipbuilding and making airplanes both require significant levels of capital investment in large facilities and highly specialized machinery. Additionally, some personnel working on sensitive projects need advanced security vetting which is expensive. These high costs and specialized requirements for personnel tend to keep existing competitors in the market (whether on their own or through mergers), raising the level of competition. The best example of this is how more than thirty prime contractors have consolidated into just five over the past two decades (Watts, 2008).

Related to high fixed costs are the also prohibitive exit barriers. The assets these firms build like warships and fighter jets are unique with no market aside from the United States government. The federal government would also act as an exit barrier, if for example a large or Big 5 contractor decided it wanted to re-focus its business on commercial technology.[14] While it is highly unlikely that a major defense contractor would try to exit the defense industry, it is still worth noting because the high exit barrier may actually dissuade firms from entering the market in the first place. In this scenario, the government represents risk because it can complicate the process of divesting a business unit that sells to DOD or limit a company's ability to market proprietary technology in the commercial market.

[14] Studies by Watts and Gansler discuss if and how the federal government could be more involved in shaping the DIB as part of a national strategy.

In the defense industry, capacity comes in surges, again a key identifier of a competitive market. One has to look no further than the increase in defense spending when the United States goes to war. A prime example of capacity surge in the industry was the rapid development and fielding of the Mine-Resistant Ambush Protect (MRAP) for the Iraq and Afghanistan War. Furthermore, high-cost war-time consumables such as precision guided munitions and lower-cost items like machine gun ammunition point to the surge capacity characteristic of the industry. Though not typical of the most recent wars, large physical materiel has also been produced in surge capacity, as was the case with airplanes, ships, and tanks during World War II.

When taken together, one gets a fairly clear picture of the competitive environment with a caveat. The market appears to be highly competitive though the development of the Big-5 tier of firms has made the procurement of large end-items competitive to the point where their behaviors damage competition (Watts, 2008, p. 59). The exit barriers, high fixed costs, and slow industry growth have also made the market among existing competitors highly competitive.

2. Potential of New Entrants

Assessing the threat of new entrants is an exercise in evaluating the barriers to entry that exist for potential new entrants (Porter, 1979). When evaluating the threat of new entrants, there are six considerations:

- Economies of scale
- Product differentiation
- Capital requirements
- Cost disadvantages independent of size
- Access to distribution channels
- Government policy (Porter, 1979)

With regard to economies of scale, there are significant barriers for large companies seeking to enter the market. As seen from 2000 to 2013, the percentage of contracts, “obligating $500 million or more has increased fairly steadily, from 11 percent in 2000 to 24 percent in 2013” (Berteau et al., 2014, p. 28). Though cash flow is the lifeblood of every firm, revenue is a driver of cash flow and the largest contracts represent more revenue and would be attractive to prospective entrants. To win these contracts, firms need to show they have the production capacity required to deliver products that meet the specified technical requirements. Building production capacity is expensive—the facilities required to build weapons, airplanes, ships, and even software are large and the tools used are bespoke.

Product differentiation is an interesting component of the DIB. On one hand, the end user (military personnel) could not care less who makes the materiel, just that it works. On the other hand, the defense professionals buying materiel know that different businesses have varying degrees of performance reputations. For example, there are three remaining companies that manufacture manned fixed-wing aircraft: Boeing, Lockheed Martin, and Northrop Grumman (Watts, 2008). Of these, Lockheed has designed both of the United States’ fifth generation fighters, the F-22 and F-35 (Lockheed Martin, 2017). Meanwhile, Boeing was not the original designer of any of the active service fighters it maintains such as the McDonnel Douglas F-18 and McDonnel Douglas F-15 and Northrop Grumman has not introduced a manned aircraft since the B-2 Spirit in 1997 (Boeing, 2017). This is just one example that shows that Lockheed Martin has been the clear favorite for developing fighter aircraft over the past two decades so there is a degree of brand recognition in that specific segment of the aircraft industry. In sum, brand recognition, supported by past performance, within specific segments of defense contracting acts as a barrier to entry.

The capital requirements to enter certain segments of the defense industry are also prohibitively high. Again, building ships, airplanes, tanks, and precision munitions requires large facilities and specialized equipment that is expensive.

While these areas of the defense industry are capital intensive, some of the areas civilian technology firms may seek to enter have overlap with their current commercial products, making entry less capital-intensive. For example, the commercial companies currently pushing autonomous technology in vehicles such as Uber, Tesla, and Alphabet have the in-house knowledge required to continue maturing the technology. While it is unlikely that any of these companies would design and manufacture a military vehicle, there is a possibility that any one of them could be recruited as a large subcontractor, similar to how Lockheed Martin, for example, uses Pratt and Whitney for the F-22 engine (Lockheed Martin, 2017). In sum, certain sub-segments of the defense industry do not have high capital requirements and these are the most likely entry points for commercial firms.

The non-cost disadvantages are perhaps the most important barrier to entry for any firm seeking to do business in the defense industry.

> DOD has challenges assimilating outside direct innovation for both cultural and structural reasons. Culturally, there is a “not invented here” syndrome that discounts technology and solutions that do not derive directly from DOD needs. Interviews suggested that there is a belief in many places in the Department that military and Departmental needs are so unique that only purpose-built approaches are appropriate. (Hunter et al., 2015, p. 23)

If this attitude is pervasive in the industry and amongst procurement professionals, it would be hard for any firm, regardless of its level of competence, to overcome.

Distribution channels for potential entrants could serve as another effective barrier to entry. The physical channels of distribution are not at stake here, rather the manner in which a company becomes a DOD vendor can be quite complicated. For example, navigating the lobbying scene and power dynamics in the political sphere is different in the defense industry than Silicon Valley which is relatively unregulated. Many firms have business units and personnel that are experts in the defense acquisition process and compliance

teams that advise them on the unique requirements of doing business with DOD. In addition to the government-imposed requirements, vendors already in the defense industry have established firms they work with. Breaking into a market that already has reputable vendors and strong supplier-customer bonds can be quite difficult. As a result, it is likely that accessing the powers that control distribution channels in government and persuading mature defense contractors to switch suppliers would act as a barrier to entry.

The final aspect of the potential of new entrants to consider is government policy. This area will be thoroughly explored in the PESTEL framework but a quick glance at the 2,600 pages of Federal Acquisition Regulations (FAR) are an indication that the industry is highly regulated. In addition to the FAR which only regulates procurement, there are government export controls on certain technologies deemed critical which limits the market a company can access to profit from its innovation (Bialos, 2017, exec summary xi). The government also requires employees on sensitive and classified projects to acquire security clearances which further limits some firms from working in the defense industry. As is evident from just a cursory analysis, government policy limits and deters new entrants into the defense industry.

When evaluating the threat of new entrants as a whole, the assessment is that the threat is low due to high barriers to entry. Many of the evaluated aspects suggest that entering the defense industry would be costly for most firms. Even if the firm has relatively few costs to enter in an area of commercial overlap, overcoming the non-cost barrier of the “not-invented here” mentality would likely be quite difficult. If large prime contractors were unwilling to incorporate non-traditional vendors as sub-contractors, this would require potential entrants to directly enter as prime contractors themselves. It is unlikely that high-profit margin firms in the technology space would want to subject themselves to a cumbersome acquisition process where their inventions have a limited market in order to make less money.

3. Power of DOD Suppliers

One key aspect of the defense industry with regard to the power of suppliers is that the supplier group for many important end-items is small. This has been discussed previously with regard to aircraft but also applies to shipbuilding where there are effectively two suppliers, Huntington Ingalls and General Dynamics Electric Boat (Watts, 2008). Watts seems to suggest that the government will likely need to take a more hands-on approach to managing these critical areas of the DIB that only have a few suppliers (Watts, 2008). This points to suppliers having considerable power because the suppliers' customer cannot afford for them to go out of business. However, the fact that these suppliers sell almost exclusively to the government, if it is to be viewed as one entity, limits their power. In fact, the suppliers are limited on their profit margin by law when negotiating contracts (Chandler, 2016). Despite only having one customer that statutorily limits profit, suppliers still have some power in negotiations but they do not dominate the buyer.

Because switching costs are high for certain items, suppliers can exert some power over DOD. As discussed earlier, DOD cannot switch suppliers in the middle of building a jet fighter because it is simply too expensive nor can it decide it no longer likes a product and replace it easily. DOD cannot decide tomorrow it no longer wants the F-18D and have a replacement for it in a couple years—the best it can do is decide on an upgrade package which can still take years to develop and install across the fleet. DOD can also cancel a contract at any time for convenience which gives it some power over suppliers but doing so leaves capability gaps and vulnerabilities in national security. The highly regulated aspect of the market also makes switching difficult as seen in the bid protests launched by firms that lose contract awards.

A check on supplier power is that they do have to compete with one another during the contract award process. DOD typically tries to have at least three contractors bid on a project. DOD also competes prototypes against one

another as it did with the F-35 program when Lockheed and Boeing both developed prototypes (Lockheed Martin, 2017). This requirement, combined with other factors (such as the infrequent development of large end-items) has encouraged perverse incentives among contractors, namely that they underbid the contracts which then exceed initial cost projections (Barry D. Watts, interview with author, November 8, 2017). While the contracting process checks supplier power, after the contract has been awarded, supplier power is checked by the government's right to cancel a contract and regulations limiting the company from making excessive profits. Furthermore, if the supplier performs poorly, its track record will be considered the next time it bids for a contract, making DOD less likely to award it the contract.

Further limiting supplier power is that DOD is often the only customer for a large portion of the supplier's revenue. Any time a company has only one or a few major sources of revenue, it cannot afford to lose that customer and wants to ensure it remains healthy. In the case of the federal government, the entity's size is such that actions by singular suppliers are not substantial enough to assist or detract from the customer's overall health. For example, even though Lockheed Martin $29.243 billion in contracts with DOD in 2015, this represented only 0.8% of total federal government expenditures of $3.688 trillion and this amount is more than double the next highest vendor, Boeing (CSIS, 2017, p. 73) (GPO, 2017).

The last consideration for supplier power is if, "It poses a credible threat of integrating forward into the industry's business" (Porter, 1979, p. 140). DOD's business is war and though DOD did outsource some of the fighting of war in Iraq and Afghanistan, it is highly unlikely that a firm like L3 communications, United Technologies, or General Dynamics will suddenly gain the authorization or willingness to put their employees in harm's way to fight.

Overall, the power of suppliers is moderate to low. There is no area where suppliers have an absolute advantage because even if there are only two or three suppliers, they all sell to the same customer which is considerably larger

than they are. The monopoly buyer power of DOD is the defining characteristic when evaluating suppliers' power. The check on this power is in the form of numerous rules and regulations that require DOD to adhere to what is supposed to be a transparent acquisition process. The fact that the monopoly buyer writes its own rules (that suppliers must abide by) gives it power over suppliers. The power DOD has over the industry is likely a deterrent to new entrants, especially large firms because compared to DOD, even the largest firms (by sales) are small in comparison.

4. Power of the Customer (DOD)

Though the last section concluded that the supplier group lacked power in the industry, it is still important to identify the source(s) of buyer power. In the case of an ordinary monopoly buyer, the buying firm may seek to make its suppliers compete heavily on cost to the point where some go out of business and cheaper firms take their place. DOD should not have an interest in putting its suppliers out of business as that would result in serious damage to national security.

One of the main sources of DOD's power is that it buys in bulk and it buys from an industry with substantial fixed costs. Order numbers for airplanes, munitions, conventional guns and mortars, and vehicles often number in the hundreds for the multi-million dollar pieces of equipment to tens of thousands for less expensive items. Buying in bulk benefits DOD and its suppliers because the supplier learns as it manufactures more and more and is able to reduce production times (and costs) as a result. Bulk buying does, however, reduce the profit margin of the supplier as DOD pays less and less for each successive lot of products. DOD's suppliers' high fixed costs also give DOD power over them, though not as much as it would have in a scenario where there were more suppliers.

The relationship between DOD and its suppliers is more symbiotic because there are not numerous suppliers that can easily and willingly take the

place of a firm that could go out of business. As explored by Watts in 2008, the government likely needs to take a more active and thoughtful approach to shaping the defense industrial base in order to sustain its long-term health (Watts, 2008). Buyers in a powerful position do not have to consider the health of their suppliers so in this case, the co-dependent nature limits buyer power. In a commercial setting, assuming there were numerous suppliers, the buyer could push a firm to reduce costs to the point where it loses money and that firms may go out of business and another could take its place.

According to Porter, buyers are powerful if, “The products it purchases from the industry form a component of its product and represent a significant fraction of its cost” (Porter, 1979, p. 141). It is certainly the case that the products DOD purchases form a significant portion of its end product because the Department’s end-product is readiness to fight wars. The $272.286 billion obligated to defense contractors in 2015 represented about 46.5% of the $585 billion of net defense obligations, showing that the products and services purchased represent a substantial cost to DOD (CSIS, 2017, p. 7). DOD is extremely price sensitive because of the statutorily limited amount of money it is authorized to spend each year. The limited amount of money combined with a mentality of not wasting taxpayer dollars drives DOD to seek ways to drive down costs.

Porter also states that low-profit industries incentivize buyers to lower purchasing costs. In this case, the buyer does not make profit which should give the buyer a lot of leverage. The picture is more mixed than this simplistic analysis. Because the buyer does not have to consider profit margin, it makes it very difficult for DOD to know if it is paying too much. Costs in the industry are difficult to compare with other industries because of the highly technical nature and increased security needs for defense. Commercial companies are able to use a return on investment (ROI) calculation in the form of a discounted present value analysis to examine whether or not a project clears its required rate of return on capital. DOD can only assess readiness, a qualitative variable, when

analyzing ROI. DOD has attempted to compensate for its lack of objective metrics to evaluate project costs by writing standard profits, fees, and reimbursement rates into contracts. However, as Pierre Chao aptly stated in 2013, “Culturally we have evolved to a point where the system would rather pay $1 billion and 5% profit for a defense good, than $500 million and 20% profit” (Chandler, 2016, p. 1). DOD as a no-profit industry would seem to be a buyer’s dream, especially a buyer with the size and power that DOD has. However, due to the lack of objective metrics for evaluating profits and ROI, DOD actually has diminished buying power than it otherwise might.

Another aspect of buyer power depends on how important the quality of the supplier’s product is to the buyer. In this case, high-end weapons, aircraft, and software must be of the highest quality and are subject to uniquely rigorous tests when compared to their commercial counterparts. For example, even something as simple as a pistol or a rifle meant for military use must be more survivable than weapons issued to civilians. It must not corrode in a humid, wet environment, it must fire with sand in the chamber, and it should continue working even after being dropped or thrown. Similarly, software that runs in an aircraft must function at high speeds, low temperatures, and anywhere in the world. In short, the survivability requirements for items manufactured for DOD are higher than for commercial products. This is a serious limitation on buyer power and DOD has, over the years, incurred billions of dollars in cost overruns to ensure the performance of the products it buys. DOD recognizes this and has even passed legislation in 1994 and 1996 to increase its purchases of commercial-off-the-shelf items (Serbu, 2017, para. 7).

Another factor that limits DOD’s buying power is that the Department cannot make the supplier’s products. The government has not made war materiel on a large scale since World War II and the arsenals had, “problems keeping pace with technological change” and there has been, “perceived superiority of commercial sources” (Watts, 2008, p. 69). Though defense leaders consistently attack private industry for exceeding cost and schedule, there is little debate that

the innovations that stemmed from the military or a military-affiliated projects have not benefitted society at large. In a discussion about Newport Torpedo Station and government arsenals, Watts states:

> Among other things, the U.S. military-industrial complex that emerged during the 1950s contributed to the development of modern digital computers, successfully orbited the first reconnaissance satellites, put a man on the moon, made stealthy aircraft practical, and played a pivotal role in developing the Worldwide Web.169 It is extremely difficult to envision such innovations emerging from de facto government arsenals such as the Newport Torpedo Station. (Watts, 2008, p. 69–70)

As a result, the development of materiel, even that dependent on software, is unlikely to be produced by the government, limiting DOD's buying power.

A cursory analysis would likely conclude that DOD had significant buying power in the industry, especially since suppliers are limited in how much power they can exert. While DOD certainly has ultimate control over its suppliers because it can change the rules of the game at will, it cannot wield this power carelessly nor can it try to drive companies out of business, especially when there are only a few suppliers. The products the companies produce are the "sticks" with which the United States keeps in ready supply in case a "carrot" approach to diplomacy fails. Thinking of the United States without a reliable defense industrial base is to imagine a United States without F-35s, F-22s, M1A1 tanks, and nuclear-powered submarines. Though buyer power is not unlimited, it would still act as a deterrent to entry because of the potential for the buyer to re-write the rules arbitrarily. Buyer power can be decreased during periods of war or when DOD needs materiel to be fielded rapidly. In this scenario, the time-constraint would require DOD to offer more enticing contracts because of its total dependency on the supplier to fulfill a requirement needed to gain an advantage on the enemy.

5. Threat of Substitute Products

According to Porter, the threat of substitutes is high if there exist other goods capable of "improving the industry's price-performance tradeoff," or if the products, "are produced by industries earning high profits" (Porter, 1979, p. 142).

The price-performance tradeoff is examined first. As previously mentioned, Congress certainly believes there are improvements to be made in this space. The passage of the 1994 Federal Acquisition Streamlining Act and 1996 Clinger-Cohen Act both encouraged DOD to buy more commercial technology and improve DOD's information technology practices (Serbu, 2012). DOD, however, does not seem to have shared Congress' desire to improve this tradeoff because according to GAO, "contracts awarded using commercial item procedures have gradually declined in a narrow range from fiscal years 2007 to 2016" (GAO, 2017b, p. 1). The threat of substitute products for large materiel like ships and aircraft is extremely low due to many of the aforementioned barriers to entering those industries. However, there is certainly a case to be made for commercial products being integrated into these systems. The threat of substitutes therefore is highest one or two levels below the prime contractor space.

Currently, the defense industry is not a highly profitable one. "At the close of 2015, defense industry profits were again half of the S&P, and far less than profits for Dow 30 producers of hamburgers, diapers, and Coca-Cola, not to mention the truly prosperous producers of our iPhones and favorite apps" (Chandler, 2016, p. 1). Figure 7 shows defense firms' operating margins as compared to commercial capital goods firms. Considering only actuals and not estimates, no firm except Harris Corporation has earned more than 14%

operating margin and 12–14% would be considered a higher operating margin.[15] Harris is actually an interesting case study because its largest business segment by revenue, communications systems, made only 42% of its sales to U.S. government customers in fiscal 2017 and that business segment had the highest operating margin, 29.9% (Harris Corporation, 2017). This compares to 82% of electronic systems and 95% of space & intelligence systems revenue coming from U.S. government customers and associated operating margins of 20.6% and 16.4%, respectively (Harris Corporation, 2017). While this does not prove cause, it is interesting to note the correlation that as revenue sourced from the U.S. government increases, operating margin decreases.

[15] From Harris Corporation's 2017 Annual Report, the company is organized into three business segments: communications systems, electronic systems, and space & intelligence systems (Harris Corporation, 2017). Communications systems involve, "Tactical and airborne radios, night vision technology and defense and public safety networks" (Harris Corporation, 2017, p. 3). Electronic systems are, "Electronic warfare, avionics, robotics, advanced communications and maritime systems for the defense industry, as well as air traffic management solutions for the civil aviation industry" (Harris Corporation, 2017, p. 3). Space & intelligence systems are, "Advanced sensors and payloads, ground receiving and processing systems, products and analytics for global and space situational awareness and Earth observation missions" (Harris Corporation, 2017, p. 3).

Exhibit 1. U.S. Defense Operating Margins Compared to Industrials Firms

	2011	2012	2013	2014	2015E	2016E	2017E
Defense							
Boeing (BDS only)	10%	9%	9%	10%	10%	n.a.	n.a.
CACI	7%	8%	7%	7%	7%	8%	8%
Gen. Dynamics (ex. Aerospace)	12%	8%	10%	10%	11%	n.a.	n.a.
Harris	17%	18%	17%	18%	21%	16%	19%
Huntington Ingalls	2%	6%	7%	10%	10%	11%	10%
L-3 Communications	11%	10%	10%	9%	8%	10%	10%
Lockheed Martin	9%	9%	11%	13%	12%	13%	13%
Mantech	8%	7%	6%	5%	6%	6%	6%
Northrop Grumman	12%	11%	12%	13%	13%	13%	13%
Raytheon	11%	12%	12%	14%	13%	14%	15%
Capital Goods							
Caterpillar	12%	13%	9%	10%	8%	8%	9%
Cummins	15%	13%	13%	13%	14%	14%	15%
Danaher	16%	17%	17%	18%	18%	19%	20%
Dover	15%	15%	16%	16%	14%	14%	15%
Eaton	10%	12%	12%	11%	12%	13%	14%
Emerson Electric	16%	17%	16%	17%	16%	16%	17%
Flowserve	14%	14%	15%	16%	15%	15%	18%
Honeywell	15%	14%	15%	16%	18%	19%	19%
Illinois Tool Works	15%	16%	17%	20%	21%	22%	22%
Ingersoll-Rand	10%	11%	10%	11%	11%	12%	13%
Joy Global	21%	21%	19%	14%	12%	13%	13%
Lennox	4%	8%	9%	10%	11%	13%	13%
Parker Hannifin	12%	13%	11%	11%	13%	12%	13%
Rockwell Automation	15%	16%	17%	18%	20%	21%	21%

Figure 7. U.S. defense operating margins compared to industrials firms. Source: Callan (2015).

Figure 8 shows why it is improbable most technology firms would seek to enter the defense market. With the exception of Amazon, Palo Alto Networks, and FireEye, all of which are engaged in a massive capital spending, every firm on here earns operating margins that make DOD contractors' margins look paltry. Even the worst years for these firms, like Lam Research's 12% margins in 2012 and 2013, would be considered a high margin for defense contractors.

	2011	2012	2013	2014	2015E	2016E	2017E
Technology							
Amazon	2%	1%	1%	0%	2%	4%	5%
Apple	31%	35%	29%	29%	30%	29%	29%
Applied Material	23%	14%	14%	20%	19%	21%	22%
Cisco	26%	27%	28%	28%	29%	28%	29%
Facebook	-	44%	46%	57%	53%	54%	49%
FireEye	-	-	-85%	-70%	-40%	-20%	1%
Google	49%	34%	37%	40%	41%	39%	39%
IBM	20%	21%	22%	22%	22%	23%	24%
Intel	32%	28%	24%	28%	25%	27%	28%
Lam Research	25%	12%	12%	19%	20%	22%	23%
Microsoft	39%	38%	36%	32%	30%	29%	31%
Oracle	44%	46%	47%	47%	46%	44%	44%
Palo Alto Networks	0%	6%	7%	9%	13%	20%	24%
Qualcomm	37%	35%	36%	33%	32%	33%	35%
Symantec	25%	26%	25%	27%	28%	29%	32%
Texas Instruments	24%	19%	24%	31%	31%	33%	33%

Source: Capital Alpha Partners, Bloomberg

Figure 8. U.S. defense operating margins compared to industrials firms. Source: Callan (2015).

Overall, it seems that the threat of substitute products is low at the prime contractor level though there may be some openings at a subcontractor level where profit margins are higher and the government could improve the price-performance tradeoff. Capital Alpha Partners put it best in their August 2015 assessment of defense contractors.

> We don't see why more mature commercial technology firms would seek to do business with DOD when margins they could earn might be half of what they would see on commercial work, unless commercial contracts were used. This may be different, however, for smaller firms seeking rapid growth who would use DOD work to catapult their growth, particularly if DOD work can be applied to commercial markets. (Callan, 2015, p. 3)

B. USING THE PESTEL FRAMEWORK TO ASSESS SILICON VALLEY COMPANIES ENTERING DOD MARKET AS A LARGE PRIME CONTRACTOR

This section will discuss the defense business environment for large and Big 5 firms using the PESTEL framework. PESTEL will help identify the external factors affecting the market (M. Augier, class notes, April, 2017). It should be

noted that the legal factor in this analysis has been excluded because of the overlap between the political and legal elements with regard to the DIB. In commercial industries, there are political agendas on the federal, state, and local levels that can ultimately drive the legal risks and opportunities for a business. With the DIB, the regulator, in this case Congress, is the same as the customer (also Congress) because even though DOD *buys* materiel from DIB firms, Congress must first *approve* what DOD wants to buy. As a result, the risks that would be discussed in a separate legal section are largely the same as those in the political section.

1. Political

This thesis has already touched on the highly regulated environment in which defense contractors operate. There have been numerous think tank pieces, GAO reports, and professional publication articles detailing the effects of both enacted and proposed regulations. This thesis cannot offer as in-depth of an analysis of individual regulations but it can a high-level summary of a few instances in which politics has powerfully shaped the industry. It is important to point out that the defense industry is one leg of an iron triangle of competing interests that also includes Congress and the Department of Defense (which can at times be subdivided into administration appointees and career military officers) (J. Dillard, class notes, December, 2016). In a perfect world, these three stakeholders would have the same goals and formulate a strategy to achieve these goals even if there is disagreement about the process.

No assessment of the political aspect of the defense industry is complete without looking at an event that is now known “The Last Supper” as described by then-Martin Marietta CEO Norm Augustine (Augustine, 1997). Though spending had been declining since 1985 after the Reagan buildup, it only declined by about $40 billion (in FY2009 dollars) between 1985 and 1991 (Watts, 2008). After Operation Desert Storm concluded in early 1991, defense spending was cut by 10%, or $50 billion (in FY 2009 dollars) from 1991 to 1992 (Watts, 2008, p. 28).

The cuts from 1992 were followed in 1993 by Deputy Secretary of Defense William Perry stating, “I explicitly reject the idea of sustaining a defense company just to keep it in business. We’re not doing it to save jobs or help shareholders. We expect defense companies to go out of business, and we will stand by and let that happen” (Mintz, 1993, para. 6). Career military within DOD, industry, and some Congressmen pushed back heavily against these cuts and felt they were conducted in an irresponsible manner, done without analyzing which capabilities within the DIB were core to strategic advantage. As Augustine stated in 1997, “The companies that make up the defense industry have seen more than 50% of their market disappear” which shows just how powerful the political elements in the industry can be (Augustine, 1997, para. 2).

William Perry at least made the case that the budget cuts under President Clinton were strategic in nature and would only maintain the industrial base segments most important to warfighting (Mintz, 1993). Base realignment and closure (or BRAC for short) on the other hand is a purely political move by members of both branches of Congress to preserve military base-related jobs in their respective states. DOD has not conducted a BRAC-type exercise since 2005 and Congress has consistently prevented DOD from closing bases by including a provision in the National Defense Authorization Act (NDAA) most years (Mitchel, 2017) (Maucione, 2017). The effect of not closing unnecessary or underutilized bases is to force DOD to spend billions to keep these bases in a semi-operational status and to keep members of the community around the base employed. Congress’ resistance to BRAC is a perfect example of how politics affects the function of the defense economy, albeit on a more local scale.

Another example of political forces in the DIB is the U.S. Navy’s littoral combat ship (LCS). The Office of the Director, Operational Test and Evaluation concluded that, “The ship is not reliable,” yet it retains support in Congress, who has the ultimate responsibility of funding procurement (Department of Defense [DOD], 2015, p. 225). The ship is built in Alabama and Wisconsin and two large defense contractors, Austal and Lockheed Martin, have lobbied Congress heavily

to ensure the ships continue to get built (Chadwick and Smith, 2016). Additionally, the Navy, which was for a while in favor of continuing to build the LCS, but at a slower rate than Congress has pushed for, has changed course and decided it now does not want LCS-type capabilities and would rather have a frigate (Chadwick and Smith, 2016) (Freedberg, 2017). All of this goes to show that the politics involved in defense projects can have significant effects on the producing firms' financial and operational projections. Smaller firms and firms that depend on one or two large contracts with the U.S. government for large portions of their revenue would experience more severe negative impacts if programs are unexpectedly cancelled. Firms in the DIB have a very difficult time judging what the customer ultimately wants. Active duty warfighters could ask for and need a certain piece of equipment which could easily be denied by the civilian appointee heading DOD on the basis that the project would violate a presidential campaign promise. Even if both military and civilian leadership in DOD are in agreement, Congress could still refuse to fund it. This stands in stark contrast to a relatively more streamlined commercial process in which disagreements about strategy are settled once the CEO or senior executive makes a decision based on profit projections. Firms thinking about doing business with DOD would likely view this uncertainty as a negative. A supplier firm can do everything in its power to try to make the customer (military warfighter) happy with its product but still see its program cancelled for political reasons.

2. Economic

The political aspect of the defense industry is closely related to its economics. The driving economic force behind a growing or contracting defense market is war which requires a political act, either by the President or Congress. Additionally, because Congress writes acquisition laws and controls the money spent on defense, the economic growth prospects of the industry are politically controlled. This can be best seen in Figure 2 and Figure 3 from chapter 3—defense spending increased in the mid-1960s as the United States became more

involved in Vietnam, again in the early to mid-1980s as President Reagan built defense capability during the Cold War, and once again in the years after 2001 as the country spent money for war in Afghanistan and Iraq (Watts, 2008). Because an uncontrollable external event is required to spark a war or conflict, defense firms' economic prospects can be exceptionally hard to analyze. Even if defense firms are doing everything right from a corporate governance and financial management standpoint, they can suffer incredible losses if a war ends—conversely they can do everything wrong during a conflict and see their prospects soar. In short, they have little ability to influence the size of the market they sell to.

That being said, more defense spending generally translates into higher revenues for defense contractors and vice versa. A particularly good example of this is shown in Figure 9. In 2012, every company except Boeing and Huntington Ingalls[16] saw either a revenue decline or growth of less than 1.5%. Similarly, in 2013, every firm except Boeing and Huntington Ingalls saw a decline in revenue. Contrast these decreases with 2016, when government spending on defense increased by 4.3% and every firm except Boeing and General Dynamics saw revenue increases.

[16] Note that Boeing and Huntington Ingalls are unique for different reasons. Boeing only gets about 31% of its revenue from defense contracts, making it less susceptible to changes in defense spending (Boeing, 2016). Huntington Ingalls, divested from Northrop Grumman in 2011, is one of only two military shipbuilders (the other being General Dynamics Electric Boat a subsidiary of General Dynamics). Huntington Ingalls' survival is critical to the DIB so that DOD has more than one firm capable of building military ships.

	2009	2010	2011	2012	2013	2014	2015	2016
Level 3 Communications	4.79%	-14.25%	-1.76%	-0.36%	-12.87%	-3.80%	-4.73%	0.43%
Lockheed Martin	6.03%	4.11%	1.81%	1.47%	-3.87%	-11.93%	1.48%	16.56%
Northrop Grumman	-14.44%	1.78%	-6.15%	-4.52%	-2.21%	-2.77%	-1.89%	4.17%
Boeing	12.10%	-5.82%	6.89%	18.86%	6.03%	4.78%	5.90%	-1.66%
General Dynamics	9.15%	1.52%	0.65%	-5.16%	-0.20%	-0.25%	2.00%	-0.37%
Raytheon	7.37%	1.08%	-1.43%	-1.52%	-2.90%	-3.71%	1.84%	3.54%
Harris Corporation	8.90%	-5.59%	14.67%	0.61%	-6.22%	-1.96%	1.42%	17.88%
Rockwell Collins	-7.15%	4.58%	3.78%	-5.72%	-1.26%	11.29%	5.32%	0.29%
Huntington Ingalls Industries	NA	NA	-2.20%	2.02%	1.67%	2.01%	0.91%	0.68%
Government Defense Spending	**0.19%**	**3.39%**	**-0.58%**	**-4.97%**	**-10.46%**	**1.99%**	**-3.84%**	**4.30%**

Figure 9. U.S. defense contractor year-over-year change in revenue. Adapted from Level 3 Communications, Lockheed Martin, Northrop Grumman, Boeing, General Dynamics, Raytheon, Harris Corporation, Rockwell Collins, Huntington Ingalls Industries, 2009–2016, and United States Government Publishing Office, 2017.

Another important takeaway from Figure 9 is that the portfolio of products in favor with DOD in any particular year and the timing of large contracts can have considerable effects on revenues. For example, DOD places high importance on the F-35 program and contracts related to the F-35 have helped the firm outperform Northrop Grumman, a fellow aircraft manufacturer, in terms of revenue growth over the past decade. Additionally, because the F-35 is such an important Lockheed revenue driver, procurement contracts from year to year will be a primary driver of revenue increases or decreases. An example of a firm that is more insulated from changes in defense spending is Huntington Ingalls as it is the only firm left capable of building aircraft carriers. Its revenue should be expected to fluctuate less than its peers where there is more competition or where there products are more likely to be affected by changes in defense strategy.[17]

[17] The aircraft carrier is central to America's ability to maintain a forward presence that is capable of rapidly responding on short notice anywhere in the world.

3. Social

There are two main social forces affecting the defense industry. The first is that firms will be facing a more competitive market in attracting talent with the current generation of college graduates than they have with past generations. There are multiple reasons why this might be the case. The second, which is related to the first but is its own issue, is the perceived or actual disconnect between the goals of defense firms and the goals of commercial firms in the technology industry. The difference in goals and values may make it more difficult for firms to attract the same high-caliber talent they have historically enjoyed.

In terms of sustaining DIB capabilities, an area of weak performance has been, "declining ability to compete against commercial industry in attracting best engineering talent" (Watts, 2008, p. 47). One reason for this could be the significant drop in research and development (R&D) spending in the defense industry combined with commercial industry R&D expanding.

> In 1954, the year after the Korean War ended, the federal government funded almost 54 percent of R&D compared with less than 44 percent by commercial industries; in 2006, the latest year for which the National Science Foundation has published data, federal government funding of R&D had dropped to less than 28 percent whereas industry's share had grown to over 65 percent. (Watts, 2008, p. 71)

Figure 10 provides more recent data which shows how federally funded R&D as a percentage of GDP has declined in absolute terms and also relatively to commercially funded R&D. All else equal, industries with higher growth offer more competitive compensation packages and prospective employees believe the industry and companies within it offer long-term stability. Though defense firms offer competitive compensation and the potential to work on challenging engineering problems, industry employment can change quickly if a new administration decides to cut defense spending. Additionally, defense firms are

spending much less on R&D, providing fewer opportunities for high-caliber talent to work on cutting-edge issues. In 2012:

> Boeing Defense, L-3 Communications, Lockheed Martin, Northrop Grumman and Raytheon — spent a total of $5.1 billion on R&D projects. During the same time period, the leading five technology companies – Microsoft, Intel, Google, Cisco and IBM — invested almost $38 billion on R&D. (Steinbock, 2014, p. 24)

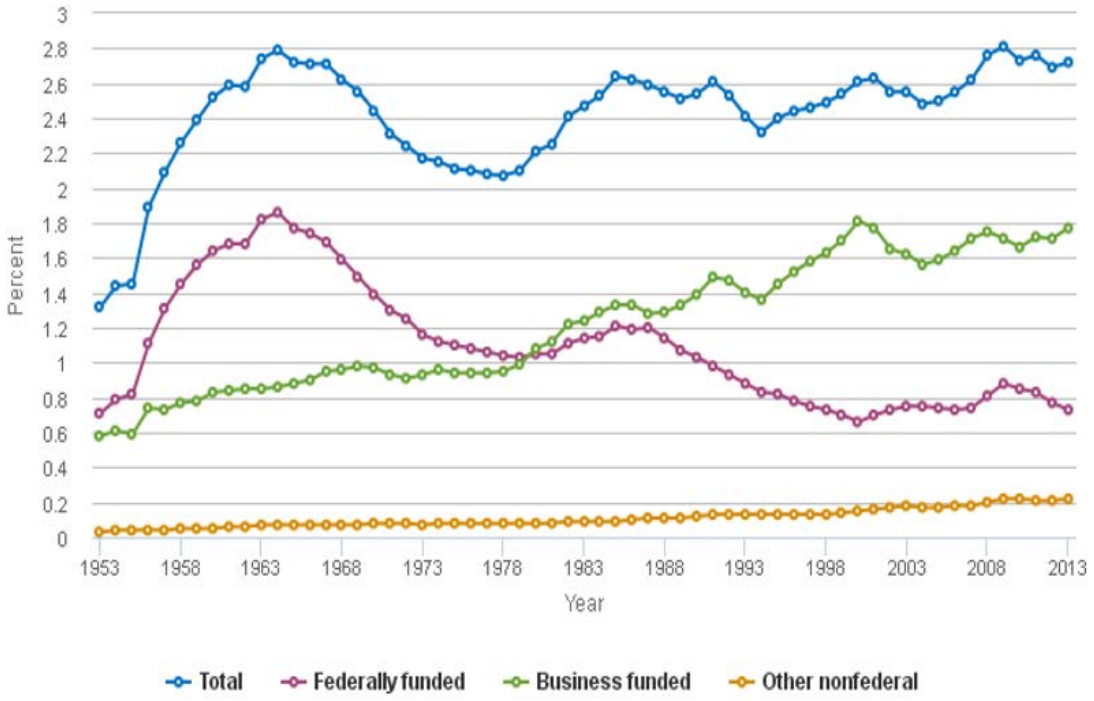

Figure 10. Ratio of U.S. R&D (total) to GDP, 1953–2013. Source: Bialos (2017, p. 12).

Another reason the talent market is so competitive is due to the shortage of science, technology, engineering, and math (STEM) personnel in some professions. The Bureau of Labor Statistics (BLS) has reported that there is a STEM shortage in petroleum engineering, process engineering, computer engineering, nuclear engineering, materials engineering, and thermohydraulic engineering (“STEM Crisis or STEM Surplus,” 2015) Defense and aerospace

companies understand that today's market is competitive. One recent headline from the Los Angeles Times read, "To compete with Silicon Valley for engineers, aerospace firms start recruitment in pre-kindergarten" (Masunaga, 2017). According to Jayathi Murthy, dean of UCLA's engineering school, "Students encounter Google and Amazon frequently on the Web… So in order for [defense companies] to be heard above that, they really need to engage on campus, and they do" (Masunaga, 2017, para. 13). Lockheed Martin's director for central talent acquisition was also quoted as saying, "One of the things we've been seeing is that this generation of students doesn't necessarily know or have grown up with Lockheed Martin, as their parents did" (Masunaga, 2017, para. 8).

The other social issue facing DOD is that there is, at the least, a perception that defense needs and commercial needs have little in common. This mind-set works against the DIB firms because of the rise of stakeholder theory and a higher social awareness amongst employees with regard to their employer's business. This can be seen in Google's first corporate code of conduct which used the motto, "Don't be evil" to emphasize the company's social responsibility (Google, 2009). Stakeholder theory takes into account aspects of a firm's operations like the environment, society, and government. As a result, firms whose primary mission is to support an organization meant to wage war could be viewed less favorably by a generation of employees more focused on the destructive implications of their firm's products.

Examples of recent negative social outcomes from the commercial sector suggest that the social consciences of technology firm employees may not preclude these firms from doing business with DOD. In the aftermath of the United States' 2016 Presidential election, Russia was found to have influenced voters via the social media sites Facebook and Twitter (White, 2017) (Guynn & Kelly, 2017). The public generally sees this as a honest mistake and has not held these firms accountable though Congress has held hearings where the firms were asked about their future commitment to preventing a repeat occurrence (Siemaszko, 2017). Similarly, many Silicon Valley firms, along with the venture

capital firms that support them, have come under fire for systemic sexual harassment and discrimination against women and minorities for promotion and pay (O'Brien and Segall, n.d.) (Guynn, 2017). The ultimate point is that Silicon Valley has its own social issues that may detract some from working there but there has not been a mass exodus of employees from these firms. Employees appreciate working on challenging tasks, even if some of the ultimate uses of their creations have negative side effects, a characteristic of both Silicon Valley and defense.

4. Technological

The Department of Defense and the firms in the DIB seem to be acutely aware of some of the technological challenges they will likely face going forward. The impetus for the Better Buying Power initiatives and Third Offset strategy is an expansion in the proliferation of advanced technologies. As then-Secretary of Defense Chuck Hagel stated in 2014:

> 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. So we will actively seek proposals from the private sector, including those firms, and from those firms and academic institutions outside DOD's traditional orbit. (Hagel, 2014, p. 6)

Based on these initiatives and the establishment of DOD entities such as the Strategic Capabilities Office (SCO) and Defense Innovation Unit Experimental (DIUx), DOD has sent a clear message to the DIB: programs that take decades to bring to production are not sustainable in an era of rapid technological change. This is not to say that the DIB is behind in technological capability, in fact as Watts states, a strength of the DIB is, "Creating entirely new technologies or systems such as satellite reconnaissance and stealth aircraft" (Watts, 2008, p. 46). Rather the issue is that a program that takes 15 to 20 years to develop can be obsolete by the time DOD is able to use it. Technological change then is an issue for DIB firms because of the time it takes to get products to market, not because the firms are not innovating.

DIB firms, while aware of this development, do not seem to know how to adjust to compete in a space that innovates more rapidly. The CEO of Northrop Grumman, Wes Bush, "said the types of commercial technologies that the Pentagon is eyeing, 'being inherently broadly available, offers no national security advantages by definition.'" (Munsil and Ewing, 2015, p. 2). This statement reflects a lack of understanding that while the United States' technological advantage is important, the ability to use the technology, even if widely available, in new ways and combine it with other innovations into a new system is the goal of DOD innovation initiatives. The mentality is not confined to just Northrop as Michael Daley, the chief technology officer for Raytheon Cybersecurity and Special Missions proved:

> When you're making technology in the defense market, you also have to address other aspects, including mission assurance, acquisition compliance — these things are important … there's an overhead to that. That can slow you down if you're not structured to deal with it. (Munsil and Ewing, 2015, p. 2)

Mr. Daley's statement, specifically as it pertains to acquisition compliance, shows a focus on playing by the established rules of the FAR. Commercial contracts move faster than DOD's structured and rigid FAR-based process. However, as DIUx's use of other transaction (OT) authority has shown, firms that are able to work with DOD using OT have the potential to bring military-useful products to market more rapidly than firms that do not.

The impact of federal R&D decreasing as a percentage of GDP and of total national R&D was discussed in the last section, but a related issue, the globalization of R&D funding, also poses its own set of challenges to the DIB. Today, the United States accounts for only about one-fourth of global R&D, a figure that has declined from 34% in 2009 (Bialos, 2017, p. 20). This makes the United States less able to guarantee that it will be the driver behind incremental innovations that could result in a game-changing technology. As Bialos states, the inability of DIB firms to access foreign innovation is a challenge:

> 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. (Bialos, 2017, p. 30)

For commercial firms who currently collaborate freely with foreign firms, this is a potential source of advantage because they are not as restricted as DIB firms in international business.

The final aspect of technological change in the defense environment are the technologies that are in development or that exist and DOD and traditional defense contractors are unaware of them. One CSIS report addresses the issue of technologies existing outside of DOD's purview: "It is the innovation coming out of the global innovation ecosystem that is untethered from DOD that provides the biggest challenges and opportunities for the Department today" (Hunter et al., 2015, p. 22). These innovations are referred to as "outside-direct" and "outside-indirect" innovation where direct refers to commercial firms seeking to do business with DOD and indirect refers to commercial firms that do not want to do business with DOD (Hunter et al., 2015, p. 23).

Outside-direct innovators have the potential to force technological change in the DIB. The firms themselves are likely knowledgeable about the competitive environment of the specific defense market into which their product falls (for example aerospace, ground vehicles, or cyber). There are, however, hurdles that these firms must clear in order to impact the defense technological environment. Firms must ensure that their personnel have appropriate security clearances, conform (in most cases) to government accounting standards, and understand that their margins are likely not going to be as high as they would be if their products have a commercial market which could be a tough sell to shareholders. Yet another is that if there is not a requirement or funding for a product industry is seeking to market to DOD, the firm and its product may be turned away. Another hurdle, likely the highest, is the attitude within DOD and traditional DOD

contractors that, “there is a belief in many places in the Department that military and Departmental needs are so unique that only purpose-built approaches are appropriate” (Hunter et al., 2015, p. 23). These challenges are not insurmountable but they could delay technological change in the defense industry.

The other source of innovation, outside-indirect, is the, “most challenging center of innovation… as well as the one that may offer the greatest possible rewards if DOD better optimizes its process to harness it” (Hunter et al., 2015, p. 23). Here, the barriers of the outside-direct market remain, with a few added challenges. One is that some firms in this space do not want DOD for customer. For example, Boston Dynamics, creator of some of the most advanced robots in the world was purchased by Google in 2013 (Hunter et al., 2015, p. 25). At the time DOD had contracts with Boston Dynamics but Google did not intend to renew them once they expired (Hunter et al., 2015, p. 25). To make matters even more complicated, Alphabet (Google’s parent company) sold Boston Dynamics to the Japanese firm Softbank Group in 2017 (Macfarlane, 2017).

In addition to firms actively avoiding DOD and DIB contractors, the Department and vendors may not be aware of some of the outside innovation taking place (Hunter et al., 2015, p. 25). Career bureaucrats without private industry contacts or experience and DIB employees with a “not created here” mentality may stunt the incorporation of these innovations into the defense ecosystem. This presents its own set of challenges because similar to the limited ability to access foreign innovation, the defense ecosystem could be caught entirely off guard by a new innovation or waste resources developing a product that is already available commercially.

5. Environmental

The final aspect of the PESTEL analysis is whether or not environmental concerns will impact the defense industry. DOD first issued an operational energy strategy in 2011, recognizing the role energy concerns play in national

defense (Department of Defense [DOD], 2016). DOD's overall strategy is focused around three objectives, all of which center on improving operations and lethality:

- Increase future warfighting capability by including energy throughout future force development.
- Identify and reduce logistics and operational risks from operational energy vulnerabilities.
- Enhance mission effectiveness of the current force through updated equipment and improvements in training, exercises, and operations (DOD, 2016, p. 6)

These objectives influence the DIB in that energy risks, challenges, and opportunities are now an official consideration in the acquisition process. Firms must find new ways to reduce energy consumption while simultaneously maintaining or improving the operational performance of its products.

Two recent examples from the Navy and one from the Air Force show DOD's commitment to reducing fuel consumption. The Navy is starting to modify its fleet of destroyers with hybrid electric drives that use less fuel at lower speeds but can still go as fast as their predecessors (Department of the Navy [DON], 2014). Similarly, the Navy upgraded the USS Makin Island, an amphibious assault ship with a hybrid electric drive that also saves power at lower speed (DON, 2010). According to the Navy, it expects to save about $250 million in fuel costs over the ship's life cycle (DON, 2010). The USAF's KC-46A Pegasus, a refueling aircraft, is also touted by its maker, Boeing, as being, "based on the most fuel-efficient commercial airplane in its widebody class" (Boeing, 2017, advanced capabilities section). While these innovations help the services reduce costs, it also helps reduce the logistical burden of more frequent refueling, which also reduces the operational risk to forces (DOD, 2016). The longer an asset can operate without having to make a port call, conduct

aerial refueling, or be forced to cease forward movement on the ground, the less concerned the military has to be with securing energy sources in austere operating environments.

These innovations show that environmental concerns, albeit through an operational and strategic lens, are having an effect on the DIB and DOD. They are likely to continue and intensify as DOD looks to mitigate risk further by making its machines of war more autonomous and self-sustaining. Even more telling is that traditional defense contractors like Boeing, Huntington Ingalls, and General Dynamics can provide DOD requested innovation.

V. CONCLUSION AND AREAS FOR FURTHER STUDY

The qualitative analysis of chapter 4 must be simplified into a more easily digested form. In the case of Porter's Five Forces, this task can be accomplished using a simple rating system that explains a force's impact in one word. For this analysis, each of Porter's Forces will be assessed as high, medium, or low. To reach a conclusion about one of the Five Forces, the considerations that affect each force will be evaluated and rated on a high, medium, or low scale as well. The overall determination for a force will take into account each consideration but the considerations will subjectively be given different levels of importance. If a consideration that drives one of the Five Forces is dominant, an explanation detailing why that force is dominant will follow.

The PESTEL framework on the other hand, does not specify what sub-considerations drive each of its elements. As a macro-framework that takes a much broader view of the forces that can affect an industry, this makes sense because the same political or economic trends can affect industries differently. As a result of the considerations that affect each aspect of PESTEL not being specified, this analysis will look at each factor and classify its relative importance as high, medium or low and then address whether the factor is favorable, neutral, or unfavorable based on the trends analyzed in chapter 4.

A. PORTER'S FIVE FORCES

As Table 3 shows, competition amongst the existing large and Big 5 firms in the market is high with a couple caveats. The driving forces of competition in this market are the high exit barriers which keep firms in the market, high fixed costs, and the number and size of the competitors in the market. As discussed in chapter 4, high exit barriers include the government potentially preventing an exit, the highly specialized nature of some of the equipment the firms make produce for DOD, and the need to keep the workforce employed even if overcapacity exists in the industry (Watts, 2008, p. 47). The highly specialized

nature of the machines and tools needed to make custom equipment for DOD for which there is little or no commercial overlap also leads to high fixed costs. This issue is even more prominent in shipbuilding, airplanes, and large ground combat systems.

Table 3. Assessment of competition within the industry

Consideration	Suggest High, Medium, or Low Competition
Number and size of competitors	Medium
Rate of industry growth	High
Product differentiation and switching cost	Low
Fixed costs and perishability of the products	High
Capacity augmentation	High
Exit barriers	High
Rivals strategies and personalities	Medium
OVERALL	**HIGH**

The only caveat to the competition among firms in the industry is the tiered level of competition between large and Big 5 firms. Even in 2015, the Big 5 accounted for over 28% (down from 30% in 2013) of total obligations while the next 15 largest firms accounted for about 16.7% of obligations (CSIS, 2017, p. 73). Furthermore, the 2013 report by CSIS showed that, “contracts obligating $500 million or more has increased fairly steadily, from 11 percent in 2000 to 24 percent in 2013” (Berteau et al., 2014, p. 28). Because the Big 5 mainly produce the products under contracts of $500 million or more and because those contracts are typically for materiel DOD considers critical to warfighting, they have enjoyed insulation from competition with other firms in those critical areas. However, when discussing competition among the Big 5 and among large contractors independently, the market does appear to be highly competitive.

There are six considerations for the potential of new entrants, which is really a discussion of the barriers that exist for firms seeking to enter the market

(Porter, 1979). As shown in Table 4, all six suggest that the potential of new entrants is low. Firms in the DIB enjoy brand recognition which is bolstered by a "not invented here" syndrome that discounts technology and solutions that do not derive directly from DOD needs" (Hunter et al., 2015, p. 23). In addition to these intangible qualities, companies that already operate in the DIB enjoy economies of scale as a result of years of experience operating in the DIB. Finally, government policy, discussed in detail as part of PESTEL, is a significant deterrent to entry, as Bialos and Hunter showed.

Table 4. Assessment of potential for new entrants into the DIB

Consideration	Suggest High, Medium, or Low Entry Potential
Economies of scale	Low
Product differentiation	Low
Capital requirements	Low
Cost disadvantages independent of size	Low
Access to distribution channels	Low
Government policy	Low
OVERALL	**LOW**

Next, the power of suppliers in the DIB is moderate to low, as shown in Table 5. Out of the five factors affecting supplier power, only two give the suppliers a moderate amount of power while the other three erode supplier power. It is also important to point out that there are two considerations that dominate this force. Though there are relatively few suppliers (ie: the Big 5 for certain types of materiel), these firms sell to one customer which means that even the most concentrated sectors of the defense industry are not more concentrated than their customers (Watts, 2008). Secondly, the industry's importance to the supplier group is extremely high. The Big 5, with the exception of Boeing who has a considerable commercial business, earned between 60 and 84% of their revenues from the U.S. government in 2016 (Boeing, Raytheon, General Dynamics, Northrop Grumman, Lockheed Martin, 2016). Foreign military

sales which are approved or disapproved by the U.S. government add even more risk that for the government to affect these firms' revenues.

Table 5. Assessment of supplier power in the DIB

Consideration	Suggest High, Medium, or Low Supplier Power
Supplier concentration	Low
Switching costs	Medium
Do suppliers have to compete	Medium
Can the supplier integrate forward	Low
Industry importance to supplier group	Low
OVERALL	**MEDIUM/LOW**

Although supplier power in the DIB was assessed as low, the power of the customer, DOD, must still be evaluated. There are three considerations that suggest high buyer power, two that suggest a moderate amount, and two that suggest low buyer power, as summarized in Table 6. The most important factors here are that DIB products account for a substantial amount of DOD's costs, product quality, and the inability for backward integration. Because DIB products account for a large portion of DOD costs (as discussed in chapter 4), DOD is extremely price sensitive. One needs to look no further than the Department's Better Buying Power initiatives to understand DOD's price sensitivity. Furthermore, the importance of the quality of the products DOD buys diminishes its buying power. The products DOD buys from the DIB are highly customized, push the state of the art, and if poorly designed, can kill service members. Finally, the inability of DOD to integrate backwards (produce the products the DIB produces) also limits its buying power. Though the government has the ability to change the rules for its suppliers, it is not in the government's best interest to wield its buying power as if it were a monopsony buyer with many competitors in the commercial market. So while buyer power is high, DOD is forced to check that power in some circumstances.

Table 6. Assessment of buyer power in the DIB

Consideration	Suggest High, Medium, or Low Buyer Power
Power concentration / volume purchases	High
Purchased products standardization	Medium
Do purchased products account for substantial costs	High
Profit margin	Medium
Importance of product quality	Low
Does product save buyer money	High
Can buyer integrate backwards	Low
OVERALL	**HIGH**

The final aspect of Porter's Five Forces is the threat of substitute products, and both considerations suggest a low threat of substitutes as shown in Table 7. The main reason the threat is so low is because, as detailed in chapter 4, defense industrial base Big 5 and large firms' profit margins are low compared to their commercial counterparts. Price reductions are difficult to achieve when multiple technologies in a single project are cutting-edge and the vendors already earn relatively low margins. The analysis of these firms' profit margins and the implications for the threat of substitutes may well be the most important of the five forces.

Table 7. Assessment of the threat of substitutes in the DIB

Consideration	Suggest High, Medium, or Low Threat
Improves industry price-performance tradeoff	Low
Produced by industries earning high profits	Low
OVERALL	**LOW**

Figure 11 summarizes the evaluation of the power dynamics at work in the DIB. Taken together, they suggest that entering the DIB as a large or Big 5 supplier would be quite difficult and likely less profitable for the following reasons:

- Jockeying for position amongst DIB firms has made competition destructive so that firms are better off spending time and resources protesting contract awards in an attempt to win that award instead of seeking other business opportunities (Watts, 2008, p. 59)
- There are also considerable barriers to entry—this is positive once a firm is in the industry but the lack of profit reward for entering the industry does not provide an incentive to overcome the barriers
- Even if firms did want to overcome the barriers to entry, the power dynamics work against the sellers
- A low threat of substitutes is appealing once a firm is in the market. However, the main force behind the low threat of substitutes is low profit margins which would deter potential entrants.

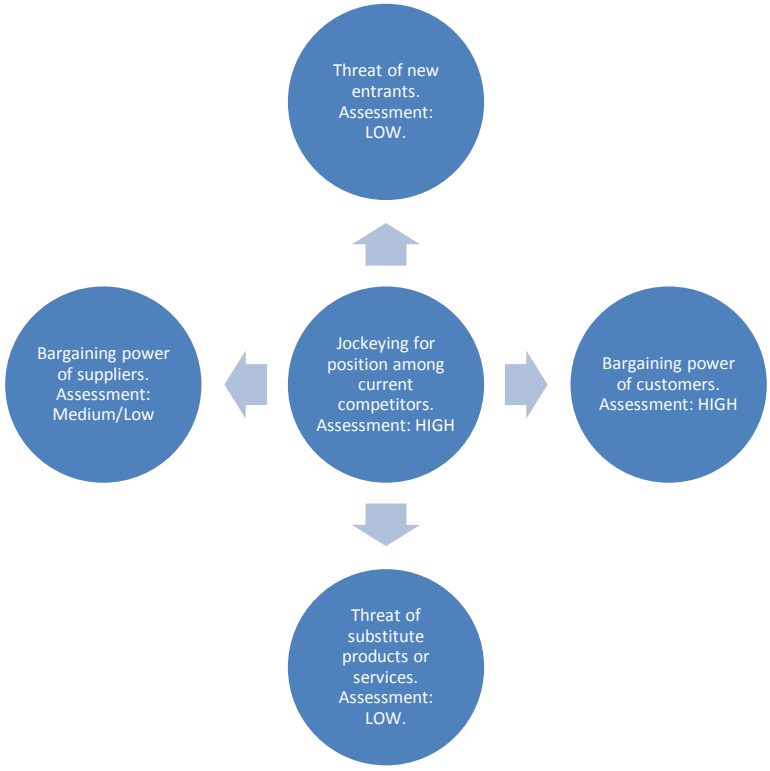

Figure 11. Assessment of competitive forces shaping defense industrial base.

B. PESTEL

With respect to the defense industry, the political factor is highly important and unfavorable. A quick glance at the Big 5's annual reports show that with the exception of Boeing, under "Item 1A. Risk Factors," the other four firms state something to the effect of, "changes in government defense spending and priorities could have consequences on our financial position, results of operations, and business" (Raytheon, 2016, p. 13). The reason this factor is unfavorable is because it represents an unknown and uncontrollable risk. The risk is that voters elect politicians who want to re-prioritize funds to non-defense domestic programs as seen during the late 1980s and the 1990s (Augustine, 1997). This can happen in spite of stellar performance. As Norm Augustine stated in 1997:

> It [the defense industry] helped create the global village by inventing jetliner travel and space-based telecommunications, it spurred the development of digital computers, and it revolutionized access to space with the space shuttle and scientific probes to other planets. (Augustine, 1997, introduction, para. 1)

Despite the success of the industry, as of 1997, "defense procurement has declined by more than 60% in constant dollars since 1989" (Augustine, 1997, introduction, para. 3). With the exception of a recession or depression, if an industry is meeting or exceeding its stakeholders' demands, it will not endure the same plight the defense industry was subject to in the 1990s.

The economics surrounding the industry are also highly important but they are neutral with a slight lean towards unfavorable. As mentioned in chapter 4, wars and perceived threats drive the economics of the defense industry because the more war and threat that exists, the more DOD needs to procure to engage in these conflicts. It is no coincidence that the highest number of troops on the ground in Iraq and Afghanistan were from 2008 to 2010 and that coincided with the highest nominal amounts for defense contract obligations in history which also coincided with annual revenues for the Big 5 vendors that, as of 2017, have

never been higher[18] (*Reuters*, 2011) (*Associated Press*, 2016) (Boeing, Raytheon, General Dynamics, Northrop Grumman, Lockheed Martin, 2016). The reason the economic aspect is neutral is because it can drive profits to record levels as the Big 5's annual reports show from 2008 to 2010. However, a lack of conflict can also depress revenue levels as the same reports circa 2013 and 2014 show.

The social aspect of the analysis ranks medium in terms of relative importance and neutral with regard to impact. The reason for the medium rating is that the political or economic factor has the potential to dominate. The two main concerns were that DIB firms were facing a competitive employment market and that there may be a disconnect between the goals of defense firms and the goals of commercial firms. For example, if a president were to state a national goal to put an astronaut on Mars by 2030, many defense firms would find themselves swarmed with talent, similar to when President Kennedy challenged America to put a man on the moon (Watts, 2008, p. 82). Second, if a larger scale war were to start, the economic rationale of working for a DIB firm would be national survival, the precedent for which is the mobilization during World War II. While the shorter-term social impacts on the DIB may be negative, the trend can be reversed quickly if there are changes made in the political or economic realm.

The technological trends affecting the industry are also highly important and the effects are likely to be unfavorable to firms currently in the industry. DOD has recognized the importance of the United States' declining share of global R&D, the privatization of R&D, and the more rapid development of technologies capable of offsetting some of DOD's methods for employing its forces. At the

[18] Note that Boeing and Lockheed Martin are an exception here as they have had annual revenues that are higher since the 2008–2010 time period. Boeing gets two thirds of its revenues from commercial sources so while conflict is a driver of their profits, it is not as important as the commercial airplane market. Lockheed Martin's 2016 revenue was $47.238 billion while its 2010 revenue was $45.671, just $1.5 billion more (Lockheed Martin, 2010 & 2016). The F-35, which in 2016 accounted for 23% of the firm's revenue accounted for only 12% of revenue in 2010 (Lockheed Martin, 2010 & 2016). Because the F-35 is driven by a requirement dating to the mid-1990s when the United States was not at war, we can, for illustrative purposes, see what revenues would have been in 2016 if the F-35 had only accounted for 12% of sales. Doing so would reduce Lockheed's 2016 sales to just $42.051 billion, substantially less than 2010 sales.

very least, DOD has released policies meant to address these issues. Unfortunately, it does not seem that firms in the DIB are eager to adapt by shortening their two-decade product development process which leaves them exposed to firms that can innovate and produce faster. While this may be an unfavorable trend for firms currently in the DIB, firms outside the DIB may see this as an opportunity to take market share from slower-moving, older companies.[19]

The last part of PESTEL considered in this analysis is the environmental aspect which has medium importance though the trend is favorable. The DOD documents pertaining to the environment address it from the standpoint of operational risk, specifically that the current model of energy consumption slows the operational tempo of our forces and demands that we secure vast sources of energy when we go to war (DOD, 2016). Thus, far, as the examples from chapter 4 show, traditional DIB firms have been receptive to DOD's desire to reduce energy consumption. The ability to incorporate fuel-efficient engines on the scale required for ships, airplanes, and ground vehicles is a skill unique to most DIB firms. Furthermore, other government agencies such as the National Aeronautics and Space Administration (NASA) and the Department of Energy (DOE) contract with these firms for research into this area. As a result, firms already in the DIB have multiple government agencies seeking solutions from them in this area.

Figure 12 is a visual depiction of the five PESTEL forces used when evaluating the industry environment. Taken in sum, it seems that the firms currently operating in the DIB face an uphill battle, mainly due to the political, economic, and technological aspects:

- The political risk for DIB firms is unparalleled when compared to any other industry. The customer, ultimately Congress, has the

[19] This analysis does not conclude the DIB firms are not innovative, in fact many of the examples throughout this thesis are a result of DIB innovation. However, the amount of time it takes to complete these cutting edge projects may no longer be a valid model because of the rapid pace of technological change. Firms may need to alter their models to fielding incremental changes and using technologies that are at a more mature state.

power to shape economic events that ultimately benefit or hurt these firms' financial performance. The customer also has the ultimate power to change laws regulating the industry that can meaningfully impact their performance.

- While the economic aspect is neutral, it is certainly not favorable. The event needed to produce economic gains, war, is generally unwanted in the United States which is akin to facing a market that reluctantly buys a product
- The technological aspect, if not addressed by DIB firms has the potential to leave the door open for a new firm that thinks differently.

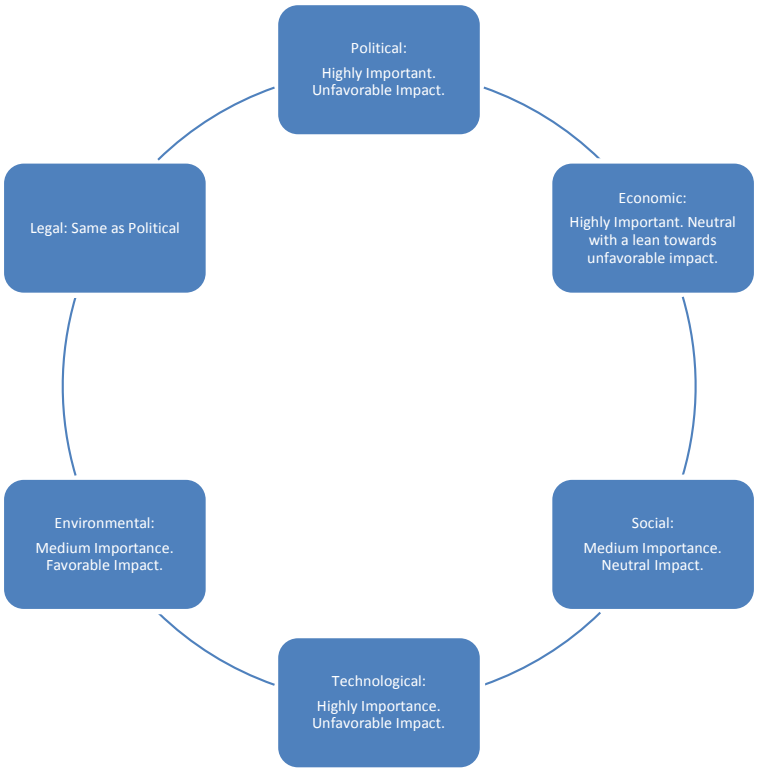

Figure 12. Assessment of the political, economic, social, technological, environmental, and legal forces affecting entry into the defense industrial base.

C. SUMMARY OF THESIS CONTRIBUTION AND AREAS FOR FURTHER STUDY

This thesis has aimed to contribute to the reader's understanding of the defense industrial base business ecosystem in the following ways:

- Utilization of Porter's 5 Forces to assess the power dynamics between existing competitors and then drawing conclusions about whether or not those dynamics are favorable for potential new entrants
- An analysis of the external forces affecting the defense industrial base using the PESTEL framework and using that assessment to draw conclusions about whether or not those forces are favorable for potential new entrants
- An overall conclusion that both Porter's 5 Forces and PESTEL identify numerous challenges that would deter firms from entering the defense industrial base as a large or top-tier (Big-5) firm

In this assessment of civilian companies playing a role in the defense industrial base going forward, there were multiple areas of potential further research. There were times when the literature discussed interesting and related points that would result in a complimentary analyses to the ones in this thesis. Though there were more than three, the list has been narrowed down to include: corporate culture, internal strategy, and mapping DIB firms' supply chains.

The first area for further research was the corporate culture of DIB firms. As pointed out in a discussion with Mr. Barry Watts, there is likely a difference in corporate culture between corporations that make submarines versus corporations that primarily make aircraft (Barry D. Watts, interview with author, November 8, 2017). The reason a cultural assessment is important is because regardless of these firms' strategies, "culture eats strategy for lunch" (M. Augier, class notes, April, 2017). What this is saying is that regardless of a firms' strategy

to compete, if the culture of the firm does not support that strategy, then the strategy will fail. This paper has discussed a few of DOD's plans to spur innovation in the DIB; however, these DOD initiatives have seemingly been undertaken without first asking whether or not the existing suppliers, the top 20 of whom account for nearly 50% of DOD contracts, have the corporate culture to achieve what DOD wants from them. Furthermore, these initiatives imply that the DIB has not been innovative (thus also implying that innovative thinking is not part of the culture) in the past even though these firms' track records for delivering state-of-the-art technology is exceptional.

Another potential area for analysis is shift away from models that analyze external forces to ones that look at internal strategy. An analysis of the core competencies of these firms or using the resource-based view of the firm would yield valuable insight into how these corporations see themselves competing in the DIB. One of the shortcomings of Porter's 5 Forces and PESTEL is that they only analyze power dynamics amongst firms and external forces affecting them; they do not explain whether or not individual firms have identified sources of advantage to complete within the environment the other models outline. A key piece of this analysis could be to do core competency or resource based view of the firm for the firms DOD's innovation initiatives seek to attract. Comparing and contrasting what a traditional DIB firm views as its key resources and what a non-traditional (but potential) DIB firm views as its key resources would make an interesting case study of the perception that DIB firms are not as innovative as their commercial counterparts.

The final potential area for study (certainly there are more but for the sake of brevity, three is the limit) is a mapping of DIB firms' logistics chains. In reading a few DOD documents that ultimately were not used as references for this paper, it became apparent that DOD has been trying to compel DIB firms to voluntarily provide supply chain data. There is a high likelihood that the major prime contractors do not know where the subcontractors two or three levels removed procure raw materials or subcomponents from. This leaves DIB firms open to

supply chain risk that is not quantifiable because the sources of risk have not been identified. Even more importantly, it leaves DOD open to operational and possibly strategic risk, especially if key components of materiel deemed critical to national military strategy are sourced from a high-risk location. Research into this area would most likely be of a classified nature and there could be substantial hurdles to getting data from prime and subprime contractors. Nonetheless, mapping a supply chain and understanding the risk associated with it, is key to understanding where an adversary may seek to exploit a weakness.

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