Practical Matters for Defense Contractors Converting DoD Technology to Commercial Markets

by

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Submitted to the System Design and Management Program
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Abstract

This thesis asks if and how the defense contractor can profitably transfer the technology and institutional learning obtained from DoD funded R&D to commercial markets. There are numerous examples of very successful defense conversion in U.S. history, such as the computer and internet. This phenomenon however, is not commonplace and the original developer of the military applied technology did not often profit from its commercialization. Faced with multiple disadvantages associated with having adapted to doing business with the DoD, this thesis hypothesizes that the one possible advantage that the DoD contractor has in competing in the commercial markets is access to advanced technological knowledge and personnel that have benefited from the learning associated from performing state of the art R&D for the DoD. This degree of advanced technology learning is not as accessible to the commercial firm because business pressures do not allow the degree of funding for cutting edge technology and less directly applicable research. This thesis examines the barriers for the DoD contractor attempting to move into the commercial market and examines cases studies of successful conversions and the recommendations from applicable prescriptive literature.

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1 Introduction

1.1 Motivation

1.1.1 Untapped Potential of Defense Research and Development

A great deal of money, time, and effort has been expended to develop science and technology for defense applications. Since 1976 the U.S. government has spent $2,358 trillion 2011 USD for defense research and development (AAAS, 2012). Most of this spending originates from the U.S. Department of Defense, or DoD. This is spending aside from the very high cost of actually operating the military in times of war and peace.

There is no question that the commercial sector and most of us as individuals living today have benefitted from the U.S.'s Department of Defense's funding for the development of technologies, such as the computer and the internet for example. On the one hand, given the high risk, high funding outlay and fundamental research that were necessary to develop these breakout technologies, it is hard to imagine anything but federal funding could have made these technologies possible. On the other hand, in terms of percentages, high impact technology transfers such as these are evaluated to be a very small fraction of the research and development activities funded by the U.S. Department of Defense (DoD)(Mowery, 2010).

Successes such as digital computing and the internet are termed "serendipitous" in that these projects were not originally developed for the reason of providing non-military benefit to society at large. A confluence of unplanned events led to these successes and the factors leading to these successes were only recognized in retrospect (White et al., 1996). This rarity of successful transfer to the civilian sector is not too surprising in that U.S. defense R&D is "mission-oriented," in that its purpose is not to provide technology for the commercial realm, but to provide technology that will support the long term military strategy of the United States (Kelley, 1999). Throughout most of the Defense Industry's history, there has been little incentive to transfer technology to the civilian sector. However, there have been periods of time, such as in the mid-1990's, when the defense industry faced a serious downturn after the end of the Cold War (see Figure 1-1 and Figure 1-2) and contractors were motivated to switch to commercial and other sources of income. Also, during the Clinton administration under the Technology Reinvestment Project (TRP) federal funding of DoD R&D switched to the concept of dual-use, or the intentional development of technologies and systems to have both civilian and defense applications. However, these efforts also did not show a high-level of success (Gansler, 2011; Kelley, 1997; White et al., 1996). This suggests that transferring military technology and knowledge to commercial applications is not a trivial matter and deserves study.

The commercial sector could benefit from not only the developed technology, but also from the expertise of those personnel that have generated the technology in the first place. In some sense this does happen to a small extent now in that engineers and scientists moving from defense to commercial companies do bring experience and skills developed from defense funded advanced technology development with them to their new commercially applied work (Alic, Carter, Branscomb, & Epstein, 1992). However, this benefit is quite indirect, and part of the value inherent in development of a technology or system is the existence of teams with complementary skills and knowledge, much of it tacit (Alic et al., 1992). It would be a much more direct and efficient means to utilize the knowledge and skills developed from DoD funded R&D if it were to be used in the same context and groups of people who originated the technology. The organization originating the technology may not be the same one that utilizes the technology at maturity, but it will be argued that the best way to bring a product or service to maturity will make use of the tacit knowledge available that would probably be missed or have to be rediscovered by a new team (Alic et al., 1992). It is the intent of this thesis to examine how an existing organization having originally developed technical expertise for the development of a military application can transfer these developed skills, develop related technologies for non-military applications and successfully sell them in new markets.

1.1.2 Instability of the U.S. Defense Contracting Market

There is a great deal of concern that the funding supporting the defense contracting industry will shrink in the future (Barnes, Entous, & Hodge, 2102). History shows that the U.S. Defense R&D budget is erratic and subject to political winds. Figure 1-1 shows the total U.S. Defense R&D spending normalized to the U.S. GDP from 1976 to 2012 and Figure 1-2 is the annual growth of the Defense R&D in terms of constant 2011 US Dollars and in terms of fraction of U.S. GDP that was obtained from data provided by the American Association for the Advancement of Science (AAAS, 2012). These curves show that there are multiple periods in the period spanning from 1976 to 2012 in which there is negative growth. The most mature and stagnant industry will be expected to at least grow with the overall economy. When the budget is normalized to the U.S. GDP, the defense spending growth is even less favorable because the overall growth of the U.S. economy is being taken into account.

Defense contracting companies and their employees are interested in diversifying their funding such that it does not solely consist of U.S. government and defense sources. Some U.S. defense contractors have moved into domestic state and local government and foreign military markets as a way of adapting to the instability of the U.S. military R&D funding (Jacobs & Shalal-Esa, 2012). The option considered in this thesis is the option of entering the commercial market. Any means to keep military contractors financially viable also has the benefit to the DoD in that when the world changes and their needs in a particular technology area become acute, the expertise that they previously funded and utilized will be available for them within a functioning business entity.

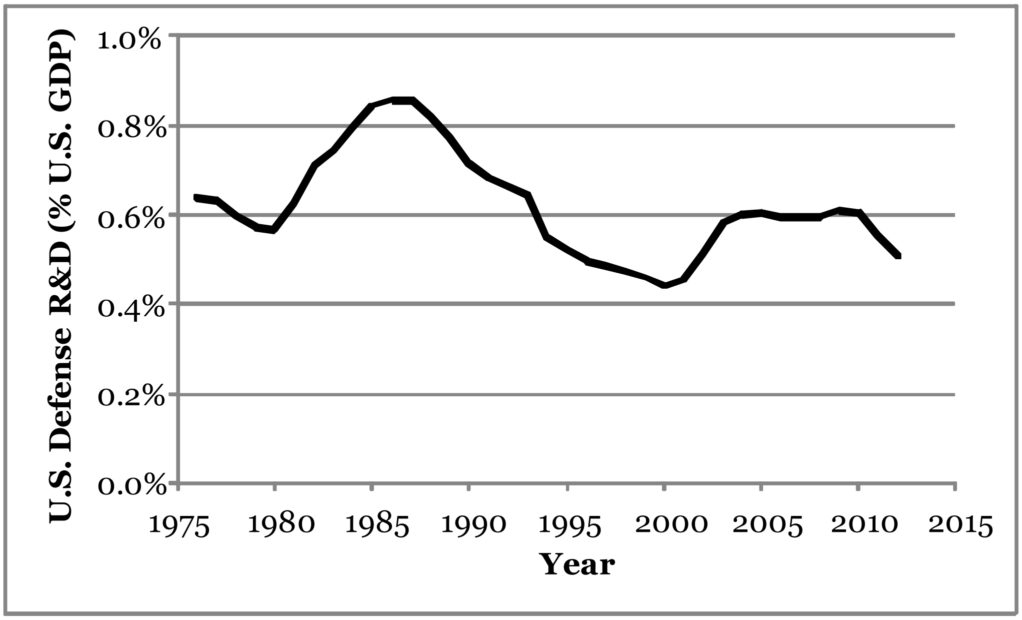

Figure 1-1. AAAS data on historical U.S. Spending for Defense Applications as a Fraction of U.S. GDP[1].

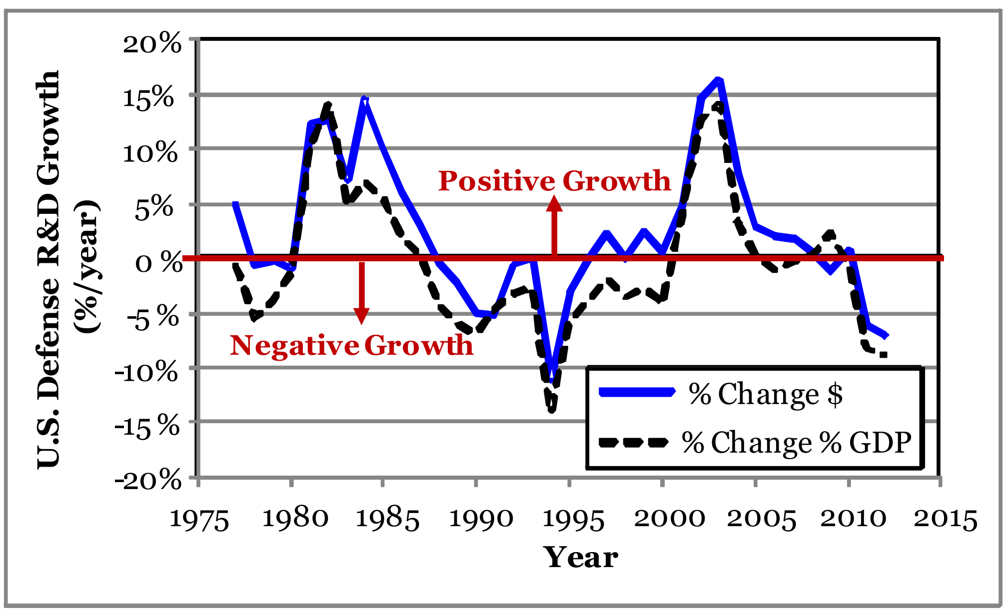

Figure 1-2. Year to year growth from AAAS historical U.S. spending for defense applications in 2011 USD[1].

[1] Source: data table from AAAS Research and Development series. FY 2012 data tables (AAAS, 2012)

1.2 Research Objectives and Approach

The most fundamental question that this thesis hopes to address is under what conditions defense contractors can adapt the technical skills within their organizations to successfully enter the commercial market. The objective of this thesis is to provide an overall system level view that would be helpful to a U.S. defense contractor that would like to adapt their existing skill set and technologies to the commercial market.

The following hypotheses will be tested:

- The internal organizational management and culture borne of the incentives of the defense marketplace are obstacles to the defense contractors' commercial success.
- Marketing to the commercial customer will be very challenging for the defense contractor.
- The defense contractor is the beneficiary of organizational learning obtained from the experience of performing research and development on advanced areas that would not be funded in the commercial realm.
- The defense contractor's learning derived from defense R&D experience can be turned into a competitive advantage in some cases.

These hypotheses will be evaluated by a study of the literature, some numerical and statistical data, and in the context of a real-world case study.

1.3 Scope of Thesis

In the most general sense, the topic of this thesis, "how can defense contractors move to the commercial realm", involves understanding the very large and very complex system in which the highly variable defense contractor and commercial market place resides. The fate of a defense contractor is tied to international events, politics and economics to some extent. Perhaps more directly the defense contractor is influenced by decisions and government policy that is a reaction to international events and national politics. Additionally there are many types of defense contractors that work in different technology areas, types of research, and scales of system development. The commercial market is likewise widely influenced in a global economy and spans a great variety of technologies. To be most congruent with the case study that is featured in this thesis, the scope will be narrowed to be most pertinent to the case of a U.S. defense contractor that fulfills engineering services to a new commercial customer within a particular subset of the commercial market. In this case it is a portion of a larger company that provides specialized services in design and evaluation of combat ship survivability that attempts to move software and expertise to the off shore drilling rig industry.

The term “technology” is a term without a unique definition (Wahab, Rose, & Wati Osman, 2012). The term “technology” and “knowledge” will be used somewhat interchangeably in the thesis. Technology and knowledge enable the creation of a product or service. In the context of this thesis, technology is embodied in the capability to predict survivability of specific designs of combat ships and offshore oil rigs. Technology underlies a particular product created for a particular application

Figure 1-3 is a conceptual sketch of subject areas that will be covered in this thesis as they are interrelated and areas upon more attention will be covered. U.S. politics undoubtedly has had a large influence on the history of federally funded research and development and U.S. Defense Policy. These are factors, along with the Defense Acquisition process have shaped the internal structures and incentives of the defense contractor dependent upon them. Much of the literature pertaining to defense technology transfer is centered on U.S. economic policy. All attempts will be made to resist the temptation to weigh in on what the federal government and policy makers *should* be doing and instead examine how the defense market has shaped the current state of most defense contractors.

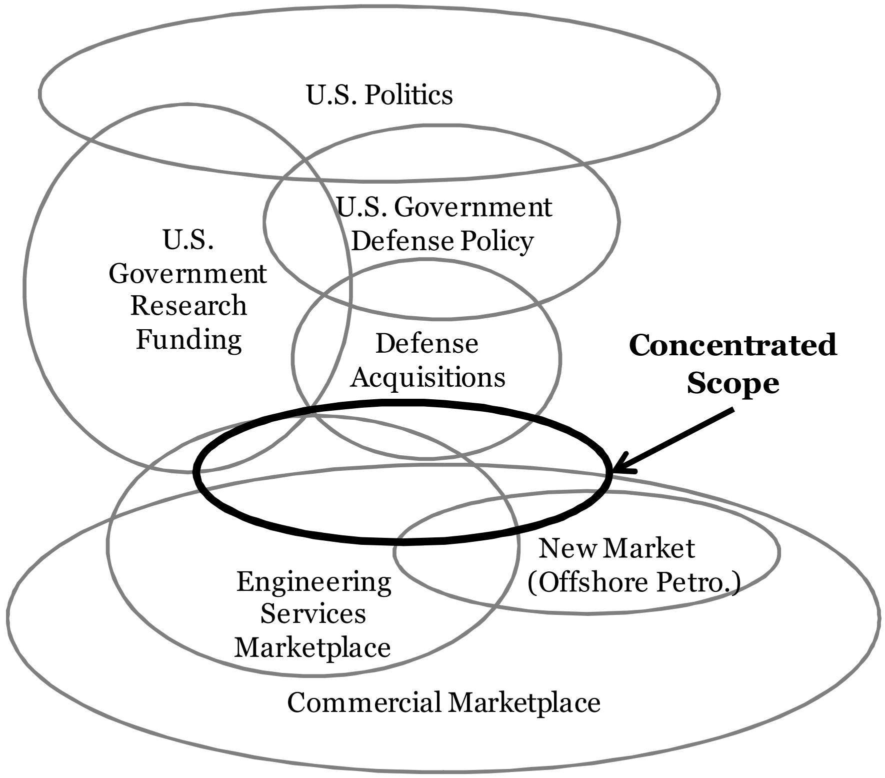

Figure 1-3. A graphical representation of the various areas of discussion and the concentrated scope of analysis of this thesis.

It must be acknowledged that in any case, bringing a product or service to any market, especially a new one is can be difficult for all enterprises, not just defense contractors. The research in this thesis will discuss some of these factors as they are generally relevant and those that are especially relevant to the engineering service organization that is studied in the case study.

1.4 Organization of Thesis

Section 2 is an overview of work related to the concept of technology transfer for military technology and provides a historical overview of the history of dual-use technology and research and development. In the spirit of Russell Ackoff's "Design Thinking" (Ackoff, Magidson, & Addison, 2006) Sections 3 through 5 will cover in the context of defense conversions:

i. What the current state or "mess" is for the defense contractor
ii. Where the contractor wants to be in terms of commercialization

iii. What is required to meet the goal of commercialization

Section 3 will discuss the strengths and weaknesses that the DoD contractor has in bringing a product or service to the commercial market. Section 4 reviews past documented successes of similar activity that have been obtained from the literature and discusses common elements in these cases. Section 5 discusses prescriptive literature relevant to organizations that wish to move to new markets and how new markets for existing technologies can be developed.

Section 6 will cover a case study of an ongoing effort in which a group that specialized in combat ship survivability is working to transfer this expertise and associated software package to the application of offshore drill rigs survivability and safety. This section will consist of a description of the project and how the experience of the organization and individuals did or did not correlate well with the researcher's own hypotheses and what a study of the literature has suggested. Information is gathered from personal interviews and related internal reports. Section 7 will follow with overall conclusions and suggestions for areas of future work.

2 Background

2.1 Literature Survey

There is a wealth of literature concerned with the dichotomy of defense and commercial technology development. Much of this work concerns the high cost and inefficiency of defense R&D. The fact that commercial products are developed and manufactured for commercial markets at a fraction of the cost for similar products provided by defense contractors is studied in depth. In the academic literature, the contrast in commercial and defense oriented product and technology development is studied at a policy level, at the level of how the commercial practices can be adapted by the defense industry, and the history of how defense technology has been adapted to the commercial markets. Most of this work seems to at least weigh in on U.S. military acquisition and budgetary policy. Figure 2-1 is a conceptual sketch of the intersection and relationship of the subject matter that much of the literature discusses as important factors in the state of the typical defense contractor.

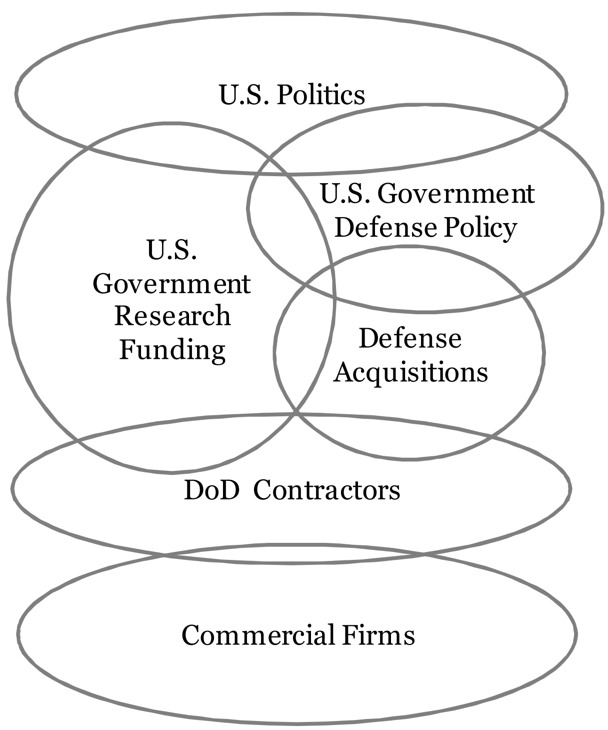

Figure 2-1. Conceptual sketch of subject matter found in literature and the relationships with each subject.

2.1.1 Investigations in Public Policy

A significant body of work examines how U.S. government policies have created the current state of inefficient government spending on defense R&D and acquisition for the wrong technologies for today's post-cold-war threats to the United States. These works analyze the interaction between the defense contractors, Congress, the government acquisition system and defense strategy and then discusses how government policy needs to be changed to adapt and create a better outcome (Ham & Mowery, 1995; Nanto, 2011; Schafer & Hyland, 1994; Trajtenberg, 2004) . While providing recommendations on public policy is outside the scope of this thesis, this work is relevant to this thesis in that it explains the system in which the defense contractor currently operates. This system has shaped the strengths and weaknesses that the military contractor has in pursuing the strategy of converting defense technology to that for the commercial market. Policy work also offers an important perspective because it offers alternative explanations for previous poor performance for efficient technology transfer by DoD contractors other than the intrinsic and incurable unsuitability of DoD contractors for efficiently bringing products to market.

Jacques Gansler is regarded as an authority on DoD acquisition and budget policy, having served as the Under Secretary of Defense for Acquisition, Technology and Logistics from 1997-2001, teaching at the University of Maryland's Center of Public Policy and Private Enterprise as well as being the author of numerous books on the subject ("Jacques S. Gansler," n.d.). Gansler's Democracy's Arsenal, published in 2011 is a recent and comprehensive treatment of many of the issues surrounding what Gansler judges to be a dysfunctional system of defense contractors, Congress, and the Department of Defense, that is failing to adapt to a changing global economy and changing threats to the U.S. He asserts that many of the problems facing the current system stem from a failure to change a system that was developed in the shadow of the cold war and the fact that the defense contractor is operating is economic environment created by a defense acquisition policy that is antithetical to the free-market and competition that would drive efficiency. The solution that Gansler offers is one of radically changing policy in defense acquisition and budgetary policy. This work is very useful because it is an exhaustive analysis of the inner workings of the defense industry and explains the practices and outcomes found in the commercial sector as a point of reference.

John Alic is another authority on defense economics and policy and served as a staff member in the Congressional Office of Technology Assessment in the years 1979-1995. Alic's 2007 book Trillions for Military Technology: How the Pentagon Innovates and Why It Costs So Much critically examines the system of military technology development of today.

2.1.2 Commercial Best Practices and Technology for Defense Applications

The best companies can develop products and processes for the commercial market at a fraction of the cost and time that defense contractors can. There has been a great deal of work in the policy and academic arenas related to determining how to transfer the best practices used by commercially oriented firms to defense applications. This work offers another perspective in analyzing the differences in the needs and practices for commercial and defense markets. In terms of top down policy studies and recommendations, the US GAO has issued number of reports to the U.S. Congress that discuss these issues (United States Government Accountability Office, 2006; United States Government Acountability Office, 2005). These reports describe the lack of commercial practices such as proper screening and stage gating of technologies for continued development for DoD projects. Another problem cited is the lack of accountability for products actually being transferred from the laboratory to the field by their developers, which is in contrast to that for the commercial organization. In terms of a more specific application of commercial best practices to defense applications Davis, (Davis, 2007) examines how to stage gate R&D using defense related metrics such as Technology Readiness Levels (TRL) and Manufacturing Readiness Levels (MRL) for "go/kill" decisions. This study determined that the business case evaluations were missing from the existing DoD evaluation metrics and needed to be enacted.

Other work considers the possibility of the U.S. military moving towards obtaining products and technology more directly from commercial industry as opposed to from traditional defense contractors. The advantages and disadvantages of Consumer off-the-shelf equipment for military applications is discussed in some practical literature (Barbarello, 2000). The barriers toward actually implementing this option is discussed in a survey regarding the attitudes of commercial firms have towards sharing their technology with the DoD (Crawford & Botwin, 2004). This survey indicates that commercial firms are hesitant to work with the military because of their perceptions of difficulties with intellectual property, acquisition and accounting requirements, and export control laws.

2.1.3 Defense Conversion to Commercial Applications

Of special interest is the body of work identified with the general subject identifier "defense conversion," which is a general term describing the conversion of defense technology to civilian applications. There is also work classified under "dual-use" technology development, defense "spinoffs", or defense technology "spillover" that addresses the defense conversion in a number of specific contexts. In the literature of interest to this thesis, the term "dual-use" refers to the situation in which products and processes are initially developed for both commercial and defense applications from the onset (White et al., 1996). A "spinoff" is the purposeful conversion of defense technology to the commercial realm after it has been developed for the defense market (Alic et al., 1992; White et al., 1996). "Spillover" is a term that also includes the less direct benefit of civilian technology from original development of defense applied technology. An example of a spillover effect is the ability of new technologies to be developed via the funding provided by the U.S. DoD in the role of acting as a paying customer. The DoD was willing to pay prices over what would be commercially viable while the technology developer's manufacturing processes were being developed so that the products could be competitively priced and sold at scale to the commercial markets.

An often cited work on the subject of defense conversion is Alic's book, Beyond Spinoff: military and commercial technologies in a changing world (Alic et al., 1992). This book compares and contrasts how technology is developed in commercial and defense contexts. In addition it offers many specific case studies of successful and unsuccessful conversions of defense technology to commercial applications. To distinguish the different modes of transition, the book (Alic et al., 1992) categorizes the modes of defense conversion as is indicated in Table 2-1. Alic also discusses public policy in the book as a possible cause and cure for the inefficiency of defense spending.

Table 2-1 Types of Defense Conversion and Spillover (Alic et al., 1992)

Term	Description	Example
Dual-Use	Purposeful development of products for both defense and commercial applications by contractors from outset	Artificial Intelligence, General Basic Research
Concurrent Development	Purposeful and planned development of products for both defense and commercial applications by contractors with bifurcation of development paths for each application	Jet Engine
Spinoff	Adaption of technology originally developed for defense applications for the commercial market.	Microwave Oven
Commercial Learning via Defense Procurement	Defense procurement of product allows the company to learn and work on improving the product and manufacturing processes as long as it needed to allow the product to be suitable for the commercial market. This is an example of spillover in the terminology of some authors.	Digital Computing
Reverse Spinoff or "Spin-on"	Defense uses product previously developed for commercial use; provides additional market for industry	Consumer off-the-shelf products (COTS), semi-conductor
Shared Infrastructure	Commercial and defense industries can pool resources for development of supporting infrastructure for products and industry	Launch Vehicles
Forced Diffusion	Purposeful diffusion instigated during the development of the product by defense transfer agencies	VHSIC chip development technology program

"Dual-Use" was a policy that peaked in the Clinton administration in the mid 1990's, however there have been numerous attempts before and since to that attempted to encourage the transfer of defense technology for civilian benefit. The Technology Reinvestment Program (TRP), enacted in the 1990's hoped to encourage the defense and commercial industry to develop technology suitable for both the commercial and defense needs. Part of the impetus of this was that the Cold War had ended and the defense needs for high technology had diminished, but needed to be maintained for future threats. Academic interest in this subject peaked in the mid 1990's as well assuming it is reflected in the number of references published at this time. Figure 2-2 is a plot of the frequency of publications from the Web of Science database with the term "dual-use" and "military" in the subject normalized by the total number of publications with the term "military" in the subject. This plot indicates special interest in "military dual-use" peaking around the year 1997. The database has publications dating back to 1929, but no mention of "military dual use" appears in the database before 1989. As a reference, Figure 2-3 is the graph of the number of publications with the term "military" in the subject field that was obtained from the Web of Science database, which is the normalizing factor for the plot in Figure 2-2.

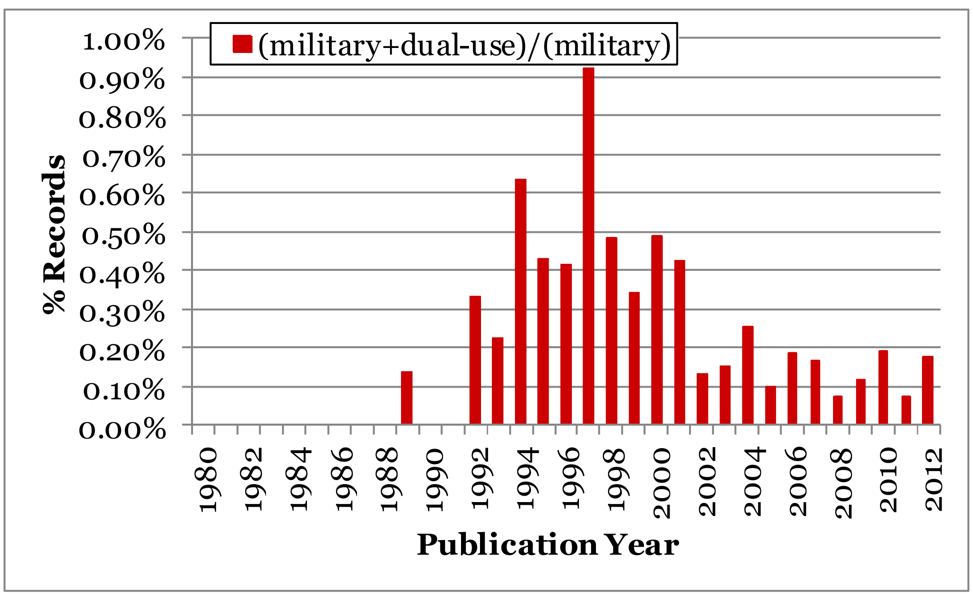

Figure 2-2. Number of Web of Science references with "dual use" and "military" in subject identifier normalized by the number of references with only "military" in the identifiers[2]

[2] Obtained from Web of Science, accessed 4/17/2012
http://thomsonreuters.com/products_services/science/science_products/a-z/web_of_science/

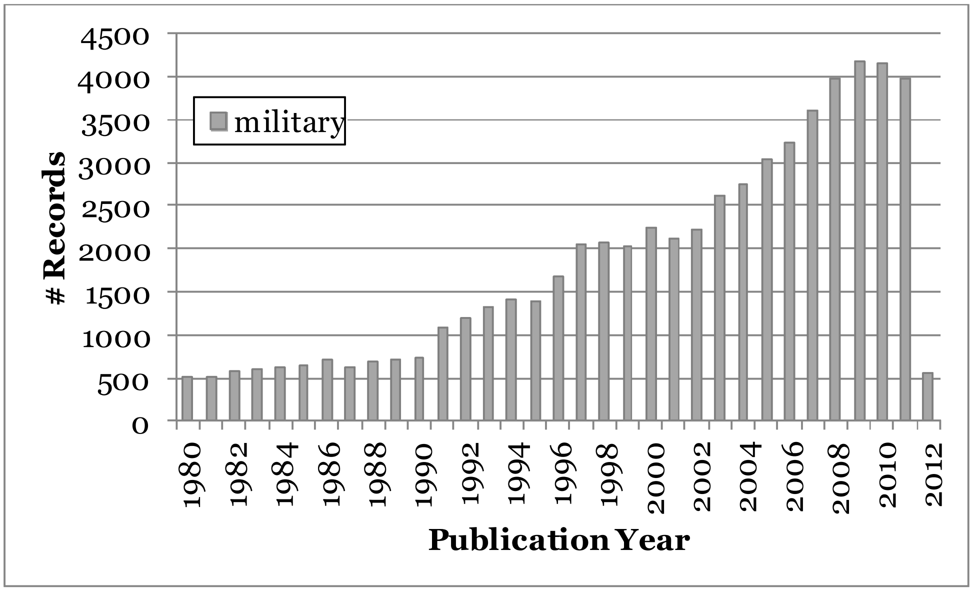

Figure 2-3. Number of Web of Science references with "military" in subject identifiers[2]

Some of the "dual-use" literature from the mid-1990's is either a pessimistic or an optimistic prediction of the for the potential for a dual-use technology development funding policy (Becker, 1994; Brandt, 1994; Clark, 1994; McAuliffe, 1995; U S Department of Defense, 1995). This policy and the outcomes associated with it will be further discussed in Section 2.2.2.

2.2 The Modern Defense Industry

This section briefly describes the history of the modern defense industry to provide background and context for subsequent discussions of the current state of the typical defense contractor. Observations and lessons learned from experiments in policies directed at dual use technology are also discussed in the context of the recent history of the defense industry in the United States.

2.2.1 The Military Industrial Complex

The U.S. "military industrial complex" as we know it today originated at the end of World War II. This is a time in which defense R&D and procurement exploded and an entrenched industry that specialized in military research and development and the manufacture of armaments began to develop. In 1940 military R&D consisted of $29.6

million (1930 USD) which was a *minority share* of 35% of the total federal R&D budget. By 1945 military R&D budget was $1.3 billion 1930 USD, (Mowery, 2010). This spending reflects the costs of World War II (WWII) and the costs incurred by the Manhattan Project to develop the atomic bomb. This period was an initial spike in the growth of defense spending that inaugurated an era that never returned to pre-WWII levels. Figure 2-4 is plot of the total federal government defense spending (as opposed to only R&D spending which is indicated in Figure 1-1) on as a fraction of U.S. GDP. This plot shows the surge in spending and continued high levels ("Defense Spending In 20th Century United States 1902-2015 - Federal State Local Data," 2012). Also superimposed on the plot in Figure 2-4 is the total spending in constant 2005 USD, obtained by multiplying fractional GDP data by the data obtained for the US GDP from the US Department Commerce (US Department of Commerce, 2012). Looking at the total cost of defense spending in terms of the percentage of GDP in recent years does not provide as alarming a picture of runaway growth and oscillations of defense spending that looking at the data in terms of actual dollars does.

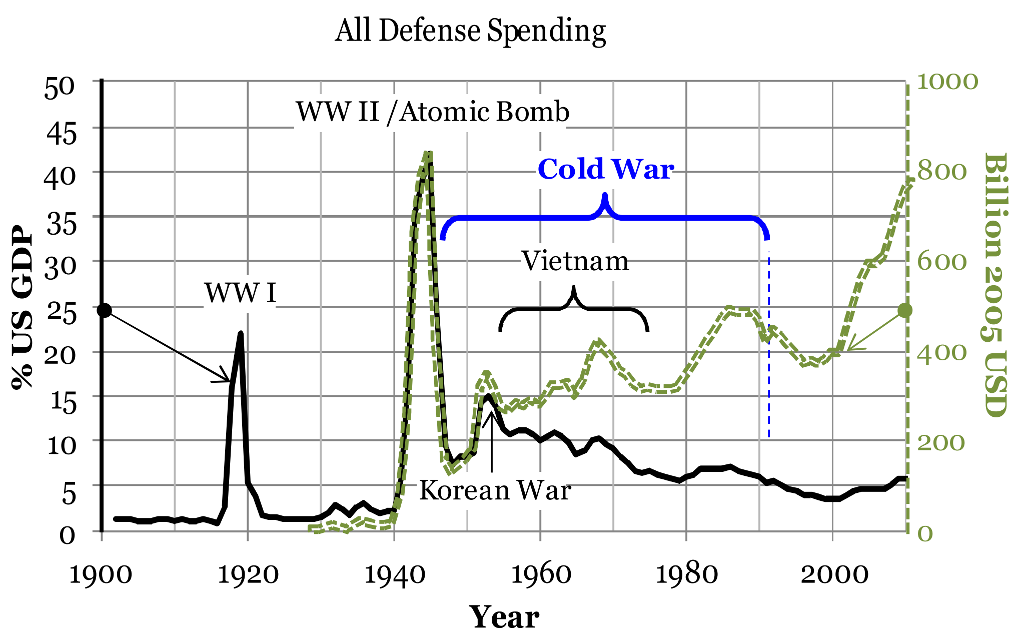

Figure 2-4. Total US Defense Spending as % of US GDP and in 2005 USD[3]

[3] Data obtained from usgovernmentpending.com ("Defense Spending In 20th Century United States 1902-2015 - Federal State Local Data," 2012) and bea.gov (US Department of Commerce, 2012)

The Department of Defense was created by the passage of the National Security Act of 1947 ("Milestones: 1945-1952, National Security Act of 1947," n.d.). Defense spending since has accounted for between 50% and 70% of all U.S. government R&D spending (Mowery, 2010). This spending has supported commercial enterprises outside of the government in times of war *and* peace. The growth of this defense contracting industry started to pick up again during the Korean war (1950-1953) so did the divergence of the requirements of technology for commercial and military applications as the cold war continued and even after it ended (Alic, 2007; Nanto, 2011).

The term "military industrial complex" was coined by Dwight Eisenhower in 1961 during his presidential farewell speech to express his concern that a system consisting of a political Congress that controlled defense spending, military contractors with strong financial interests and the military itself could exert undue influence on the nation and politics. In this same speech Eisenhower stated (Nanto, 2011):

> *Until the latest of our world conflicts, the United States had no armaments industry. American makers of plowshares could, with time and as required, make swords as well. But now we can no longer risk emergency improvisation of national defense; we have been compelled to create a permanent armaments industry of vast proportions. Added to this, three and a half million men and women are directly engaged in the defense establishment. We annually spend on military security more than the net income of all United States corporations.*

This quote reflects the enormity of the system in which the defense contractor works. It doesn't seem things have changed all that much except the share of the economy controlled by the industrial defense complex isn't quite as large since the U.S. economy has grown. There have been great economic and political interests driving the behavior of this system for a very long time.

The Cold War that was the apparent stimulus for the policy of large outlays in defense spending ended in late 1991 ("The End of the Cold War," 2000). The next section takes the history of the U.S. defense industry to the 1990's and the attempts to promote dual use of defense technology now that the cold-war had ended and it was difficult to justify high levels of defense spending.

2.2.2 Dual-Use, Spill-over and Spin-offs in the 1990's

The 1990's time period was when defense funding precipitously dropped (as shown in both Figure 1-2 and Figure 2-4). As is the case today, this is a situation that should have inspired defense contractors to pursue other avenues of business, including intentional spinning-off of defense technology or technical knowledge to other markets. The "dual-use" policy enacted in the TRP program between 1993 and 1996 also spurred interest in defense conversion in general by starting to fund technology with both commercial and defense applications (*Investing in Innovation: Creating a Research and Innovation Policy That Works*, 1999). The results of this experiment are an interesting point of reference to answer the most fundamental question of: "Can purposeful development of commercial technology by defense contractor organizations be successful?"

From the contractors' and DoD's points of view, the idea of dual-use technology development and spillover is a very appealing way to justify continued funding of the military-industrial complex. The claim is made that with conventional defense spending that it is benefitting the civilian standard of living and overall economy of the United States, so defense spending is worth it, even in times of peace, given a the natural "spillover" effect. However, studies to measure the extent of this spillover are somewhat ambiguous of the efficiency of research spending (Stowsky, 2004). Admittedly, this would be somewhat difficult to measure objectively. Stowsky points out that part of the problem with DoD technology transfer is that the DoD has a long held instinct to keep technological developments secret in order to protect the military's tactical advantage (Stowsky, 2004) and are not practiced at disseminating technology.

The aims of the TRP program and dual-use defense spending were manifold. Proponents of the policy predicted that the policy would drive positive trends in U.S. commercial and defense industry (Stowsky, 1996) such as:

- Advancement in commercial technologies assuring a technology base for the military in times of need
- An increase in commercial innovation in general
- An increase in the competitive edge of U.S. industry in the global economy

- A means to help wean the defense industry off of the higher level of funding to which it has become accustomed
- Help with transitioning the over-built defense industry to commercial markets

Politically, the TRP policy was controversial and was fiercely opposed by factions of the Republican Party, rival to the Democratic Administration enacting the policy (McAuliffe, 1995). Conservative think tank, the Cato Institute, did not like the policy because it smacked of corporate welfare (Moore & Stansel, 1995).

Others predicted the failure of the policy for more objective reasons.

- The policy tried to accomplish too many things at once (Stowsky, 1996)
- Military requirements are too different from commercial ones (Clark, 1994).
- The DoD and the military contractors are the wrong people making decisions about which technology to pursue for commercial interests (Clark, 1994) since they clearly have no experience in the area.
- Commercial industry will not want to work with the DoD because of the onerous business requirements (Berkowitz, 1994).

In the end the TRP was ended after only 3 years and no particular explosion of dual use products came to the market. The most likely explanation for the failure of the TRP dual-use policies to enact any of the goals was the fact that the branches of the armed services were continuing dictate the types of technologies that were being developed (Kelley, 1997; Stowsky, 1996). They continued to fund programs to meet their pressing needs as they had done previously as opposed to funding research that was more aligned with overall benefit of the civilian and commercial sector. So, in some sense, the ability of the defense contractor to create products and services for the commercial market was not truly tested by this policy and disappointingly the study of this period does not yield a silver bullet in terms of understanding the process of defense conversion.

3 The Typical Defense Contractor's Readiness

Referring to the literature such as that discussed in the previous section, Sections 3.1 and 3.2 will discuss the characteristics of the typical contractor that can be advantageous and disadvantageous for engaging in the commercial marketplace. The differences between the typical operations and innovation practices of defense and commercial enterprises will be discussed Section 3.3. The implications of the material presented in Sections 3.1 through 3.3 will be summarized in Section 3.4.

3.1 Drivers for Defense Contractor Innovation: High Performance Technology and Institutional Learning

This thesis argues that the main advantage that the defense contractor has for competing in the commercial marketplace is the institutional technical learning obtained from working on state of the art technology funded by the Department of Defense. The commercial firm has had to invest it own money in research and development activities. Learning has occurred, but so has spending of resources to obtain that learning. Likewise, the research in which the commercial firm has invested is not as likely to be as ambitious.

One of the main assumptions underlying the value of the defense firm's advantage is the hypothesis that being able to develop state of the art technology requires a fundamental understanding of the underlying physical processes of the technology. It is proposed that the military contractor is more likely to have special learning in reach technologies and basic research than the average commercial enterprise (Alic et al., 1992). The associated organizational knowledge attained will provide the ability to provide superior performance in products and services and possible breakout technologies.

In terms of funding activities, the Department of Defense categorizes research and development from the most basic research to the most applied system development on a scale from 1 to 7 (or alternatively 6.1-6.6 as indicated by Alic (Alic et al., 1992)) as shown in Table 3-1 ("DoD Financial Management Regulation 7000.14-R," 2011). Related to this is the DoD designation of Technology Readiness Level (TRL) between 1 and 9 that describes how mature a technology is, which is indicated in Table 3-2.

Table 3-1. Department of Defense Research, Development, Test, and Evaluation Budget Activities[4]

Budget Activity #	Description
1 (6.1)	Basic Research: no specific application
2 (6.2)	Applied Research: understand the means to meet a specific need
3 (6.3a)	Advanced Technology Development: development of subsystems and components; at Technology Readiness Levels of 4, 5, or 6
4 (6.3b)	Advanced Component Development and Prototypes: evaluate integrated technologies; completion of Technology Readiness Levels 6 and 7
5 (6.4)	System Development and Demonstration: mature system development, integration and demonstration
6 (6.5)	Management Support
7 (6.6)	Operational Systems Development

[4] Obtained from ("DoD Financial Management Regulation 7000.14-R," 2011) and (Alic et al., 1992).

Table 3-2. DoD designations of Technology Readiness Levels (TRL)[5]

TRL #	Criterion	Example Representation
1	Basic principles observed and reported.	Paper studies of a technology's basic properties
2	Technology concept and/or application formulated.	Analytic studies
3	Analytical and experimental critical function and/or characteristic proof of concept.	Components that are not yet integrated or representative
4	Component and/or breadboard validation in laboratory environment.	Integration of hardware in the laboratory
5	Component and/or breadboard validation in relevant environment.	High fidelity laboratory integration of components
6	System/subsystem model or prototype demonstration in a relevant environment.	Testing of prototype in a high-fidelity laboratory environment
7	System prototype demonstration in an operational environment.	Testing of prototype in test-bed
8	Actual system completed and qualified through test and demonstration.	Developmental test and evaluation of the system in its intended system
9	Actual system proven through successful mission operations.	System in the field

In 2012, it is reported that the DoD spends 12% of its budget on R&D (Klein, 2012). Presumably R&D is comprised of Budget Activities 1 through 7, as indicated in Table 3-1. Budget activities 1 through 4 are referred to as "Science and Technology" development, and have much more flexibility in the types of applications than more system-specific development as is indicated by activities 5-7 ("DoD Financial Management Regulation 7000.14-R," 2011). "Science and Technology" development accounts for an estimated 16.5% of the DoD R&D budget in 2012 (AAAS, 2012).

Activity 1 (6.1) is basic research and has the widest possible applications, and is the most "dual-use" almost by definition, but in terms of Technology Readiness, it is at best at the

[5] Obtained from ("DoD 5000.2-R: Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs," 2002)

lowest level. Basic Research accounts for only 2.8% of all 2012 DoD R&D funding, and the vast majority of this funding is awarded to universities and government laboratories (AAAS, 2012). Activity 2 (6.2) is Applied Research, which is research that involves performing studies in order to find a solution to a specific problem which also will be associated with the lower levels of Technology Readiness. This spending consists of 6.4% of the total DoD R&D budget in 2012 (AAAS, 2012). Activity 3, (6.3a) is Advanced Technology Development, which is expected to have a TRL of between 4 and 6, indicating that a prototype of a component exists at least at the breadboard level. Activity 4 (6.3b) is called Advanced Component Development and Prototypes, which includes the prototype of the component being tested in the system and is required to have a TRL attained of 6 or 7 or demonstration that the component will work within the system of which it is a part. According to the AAAS, “6.3” spending (assumed to be activities 3 and 4) will account for 7.3% of all R&D spending in 2012.

Activities 5 through 7 (6.4 - 6.6) involve the development of a specific product or system. In the researcher’s assessment, development activities 4 through 6 are probably that most like the typical “product development” that is engaged in by commercial firms using proven technology (Ulrich & Eppinger, 2007). It is reported that only the largest global companies actually invest in any basic research whatsoever. Common wisdom indicates that the commercial firm will not have the incentive or ability to fund risky technology that is not likely to payoff in the near term (Alic et al., 1992). Presumably, in terms of technical readiness, there is greater use of the highest readiness technology levels in Table 3-2. Thus this type of investment is only likely to achieve incremental improvements.

To grossly simplify the evaluation of the complex and variable outcomes of technology research and development, it is proposed that the contractor who has had the experience of working in 6.3 funded research activities that are at a moderate technology readiness could be in the best position for transferring the technology to commercial applications. Basic and even applied research is most likely very far away from any tangible product. On the other hand, the development stages (6.4 to 6.6) of the system have probably already involved incorporating the specific needs and stringent requirements of the military application into design decisions. Also, the more highly specific and developed system is also more likely to be classified or described as "sensitive," which would limit the ability to distribute the technology. The contractor that has the experience of taking the technology through the 6.3 stages has developed the technology into at least a proof of concept, but have not committed to specific military missions and requirements.

Hard data on commercial firm R&D spending specifically in terms of the classification system in Table 3-1 are not readily available. Also, it is difficult to determine how to compare the spending of DoD R&D and commercial market oriented R&D. U.S. companies serving the commercial and consumer markets report that they spent more money on R&D in absolute terms than does the DoD by about three-fold in 2009 (National Science Foundation, 2012). However, companies that serve the commercial markets are a much larger part of the economy than is the defense industry. It must also be noted that the degree of R&D investment as well as the type of investment varies by industry. In a report on global corporate R&D it was proposed that a better metric of the degree of R&D investment in corporate firms is the fraction of R&D spending per total revenues of that company (Upbin, 2011). In this same article, it is reported that the top ranked companies in R&D spending in the world were chip and pharmaceutical companies that can spend over 30% of their revenue on R&D; however, at the 50th globally ranked company was indicated to spend only 0.2% of its revenue on research and development. The conclusion to be drawn is that if the DoD spends 12% of its total budget on R&D and a more typical company spends less than 0.2% of its revenue on R&D of any kind, the DoD is a much more R&D oriented organization, and the defense contractor that works with the DoD in this manner will have a much stronger exposure to R&D activities, especially the less applied ones.

3.2 Barriers for Defense Contractors' Move to the Commercial Markets

3.2.1 Regulations and their Legacy

Doing business with the DoD comes with onerous accounting and reporting requirements that increase the overhead costs for running a defense contracting company. The negotiations involved in contracting to provide goods or services for the DoD are complex. The DoD Federal Acquisition Rules (FAR) are thousands of pages long not including supporting documents ("Federal Acquisition Regulation (FAR) Home Page," n.d.) DoD contractors are required to have a staff proficient in DoD contracting and accounting requirements. Accounting and reporting for DoD companies is estimated to cost about 15% to 25% above that for commercial enterprises (Gansler, 2011; Shenhar, Hougui, Dvir, Tishler, & Sharan, 1998) , adding substantially to the overhead in the defense contracting organizations. Because the accounting methods are so different, when a single corporation has both commercial and defense markets the two business entities are almost always separated (Gansler, 2011). Although the a commercial business can be spun off from the originating organization as the product becomes mature, the development of the product up until that point may be "taxed" unfairly under the original organization (M. H. Meyer, 2007) and make the development costs seem higher than they really are.

Another complication that comes with doing business with the DoD is that any product or technology that has been provided to the DoD is subject to the scrutiny of export controls. All discussions of course assume that the technology in question is not subject to military classification. Export of technologically advanced products that may provide a foreign military any advantage is regulated under the International Traffic in Arms Regulations (ITAR) by the U.S. Department of State and Export Administration Regulations (EAR) by the Department of Commerce. The penalties for violating import restrictions are dire. Penalties consist of fines of millions of dollars and the possibility of serving prison time (McHale, 2011). The act of providing a technology or source code that is subject to Export Administration Regulation to a foreign national in the United States is considered to be the same as exporting the technology to country of the foreign national ("U.S. bureau of industry and security - export control basics (exporting 101)," 2010) . This essentially makes the free distribution of certain technology in the U.S. subject to export regulation. Added to that the export regulations are extraordinarily complex (Calvaresi-Barr, 2006) and it is difficult for exporter to know under what regulating agency his product falls. This is also a problems with many commercial firms that wish to export advanced technology that hasn't necessarily been in use by the

DoD. One strategy is to obtain evaluation of the product by pro-actively contacting all conceivably relevant agencies. Problems are less likely if the component or technology involved is not specifically involved in any militarily classified system.

Intellectual property rights are another potential roadblock for the defense contractor hoping to profit from the commercial exploitation of a technology whose ownership is in question. The Bayh-Dole act allows small businesses and non-profits to develop federally funded research and obtain patents. This is extended to federal contractors, but they must pay royalties to the Federal Government. In some instances having done business with the DoD precludes the ability of a firm to have any intellectual property rights on technology. The government can have unlimited rights to the work or a government purpose license allowing disclosure to 3rd parties for alternate sourcing (Alic et al., 1992).

3.2.2 Culture and Practices

Some of the potential barriers to the DoD contractor moving into the commercial marketplace spring from the danger of a persistent corporate culture that has come into being in order to best adapt to the DoD business model. Many of the practices and values that are compatible with doing business with the DoD are not compatible with the commercial marketplace. One area of concern is the legacy of the DoD financial incentives. In the commercial market, a product is ideally produced at the lowest cost possible, from which the commercial seller is able to maximize profits from its sale at a competitive price. However, DoD acquisition practices often involve contractual agreements that only allow a small percentage of profit to the DoD contractor, but allow essentially unlimited costs in R&D (Gansler, 2011). This is the polar opposite of what constitutes good business in the commercial arena. As a result, the DoD contractor has no financial incentive to invest in labor saving equipment or software or to improve in processes or manufacturing for greater economy in the delivery of its products and services. It has been shown that defense contractors are more likely to engage in labor intensive processes because of the contracting arrangement makes this more profitable, but certainly not more cost-effective (Rogerson, 1992). The defense contractor is more likely to be in a state in which it has a very inefficient enterprise that is not commercially competitive. Potentially worse, the defense contracting organization may have an ingrained culture that does not have the values and drive to make the organization efficient in the future.

A cultural characteristic common in many defense contractors is how technical performance is highly valued. Along with this attitude, work that is more technically advanced and state of the art is more respected and desirable. Best value or the tradeoffs between performance and price for a product or the development of efficient processes and manufacturing is required for a product to be commercially viable. These not valued or sought in this atmosphere (Alic et al., 1992).

In a related vein, the DoD has a poor track record for bringing technology to the field and practice (United States Government Accountability Office, 2006). This is thought to be for a number of reasons. One possibility is that the DoD has a history of funding overly risky technology that has a poor chance of success to start with (White et al., 1996). Proper stage-gating of programs is not practiced with enough diligence and objectivity and programs that have a poor prognosis are not killed early enough. Another potential cause is the fact that there is not a formal stage in the development process to assess the readiness of technology to leave the laboratory and there is no process in place to actually transition the technology from the laboratory to manufacturing or production (United States Government Accountability Office, 2006). The DoD devotes few resources to technology transfer in general; in contrast, the U.S. Department of Agriculture spends as much money disseminating knowledge as it does doing the original research that created the knowledge (Alic et al., 1992).

Furthermore, in contrast to commercial practice, the developers of DoD technology are not responsible for transferring to the technology out of the laboratory to practical application. This stage is typically completed by another defense contractor (Alic et al., 1992). This leads to no accountability for the developers of the technology to create a technology that is usable and manufacturable. Another theory about why the DoD and the DoD contractors have such poor outcomes with successful technology transfer is that DoD technology development is often classified, and complete sharing of information is often not allowed, let alone encouraged. Secrecy in is antithetical to diffusing technology.(Stowsky, 2004).

The implications of the DoD and its contractors not having a good record of technology transfer is that defense contractors are not as likely to have experience in bringing a product to its final stages of development and to market. They are less likely to choose technologies at the appropriate readiness levels for commercial development and they are less likely to have strong processes that enable an R&D development project to be killed once data show that the product is not likely to be viable for the current market. DoD contractors are not likely to have as strong competencies in process development and cost-effective manufacturing and distribution as their successful commercial counterparts.

3.2.3 Marketing Competency

This thesis hypothesizes that DoD contractors will have the most difficulty in the task of marketing commercial products or services. One reason that this would likely be difficult is that in the defense acquisition process, product requirements are dictated from separate organizations from the supplying organization. Or in other cases, the product requirements are conveyed directly in terms of specific technical terms. For example, it has been the researcher's experience that when working with U.S. Navy laboratories, the "customer" is often engineer or scientist with a graduate degree and marketing to this customer often involves another engineer or scientist with an advanced degree from the defense contracting organization having highly specific and technical conversations with this customer to determine not only what, but how the given work is to be done. This is in stark contrast to many commercial customers who are only interested in how a product or service is going to solve his or her problems, not the specific technology that is used to solve a problem, as many engineers want to communicate.

In many commercial markets, a large part of successful product development is the producer is able to understand what the user really needs and doesn't need (M. H. Meyer, 2007). In many cases, the contractor, especially those in sub-contracting roles will not have a strong existing competency in need-finding and mapping technical requirements to the needs of the user (Alic et al., 1992). This would be especially acute in the consumer market as opposed to the industrial market because the process of determining needs would be so different from the established DoD requirements process.

Also defense products will typically have very stringent survivability and ruggedness requirements. What is important to a military customer is usually the polar opposite of what is important to a commercial customer. As was mentioned previously, in the commercial markets the correct combination of price and performance leads to success in the market, while in the defense market, the needs of excellent performance in harsh environments almost always trumps price.

The successful defense contractor has invested in building competencies for marketing to the DoD that are not applicable to the commercial market. For example, many resources are dedicated to DoD proposal writing, which is quite complex process with many regulations and content and formatting requirements. Skills in DoD proposal writing are an important skill for top employees in defense contracting firms. There is also an existing overhead structure that supports an administrative staff that specialized in DoD proposal writing requirements that have skills in processes that are not necessary for commercial proposals to industrial customers.

Also, the defense contractor is likely to have invested in "strategic hiring" of personnel that are former high ranking military officers or have had influential positions in defense research laboratories and contracting agencies (Bender, 2010). This hire, very valuable for the defense contracting organization for building defense business, is typically given a high rank and salary within the contractor's organization. This type of hire will have most likely spent a career in the defense organization and be steeped in its culture and values. He will also most likely wield influence within his new organization and encourage the values of the military organization within the contractor's organization. As was discussed earlier, these are values that are not necessarily compatible with commercial success. The specific aspect of having contacts and in depth knowledge of the defense agencies is not especially helpful for developing commercial markets, though this is not to say that this type of person is in capable of adapting to new needs in the future and may have good organizational and leadership skill in general.

3.3 Commercial vs. Defense Product Development

Table 3-3 lists comparisons of the commercial and military innovation and product development process obtained from similar tables by Alic and Shenhar (Alic et al., 1992; Shenhar et al., 1998).

Table 3-3. Table summarizing main differences between product development in commercial and defense markets

Factor	Commercial	Military
Impetus for Design	Market driven, opportunistic	Dictated by military requirements
Types of Products / Services	Simple, reliable, moderate performance	Complex, stringent requirements
Funding for R&D	Financed by company itself	Government financed
Types of R&D	More applied and short term	More basic and long term
Nature of Response	Rapid incremental change, punctuated by fundamental redesign	Slow, large improvements
Product Cycle	Months or Years	Years or Decades
Priorities	Process technology for low cost manufacturing, high quality and flexibility	Product technology for functional performance and long shelf life
Linkage of R&D and production	Integrated management of R&D, production and customer service	R&D and production separately contracted
Basis of Competition	Competition of free market; overall value, price and quality is basis of competition	Few competing contracting firms. Often required to partner with competing contractors by DoD
Technology sharing	Success based on proprietary advantage	Often technology sharing with competitors imposed by DoD

Table 3-4 compares the organizational and operational characteristics of the typical commercial and defense contractor enterprise (Alic et al., 1992; Shenhar et al., 1998).

Table 3-4. Differences between Commercial and Defense Organizations and Operations

Factor	Commercial	Military
Accounting Reporting	SEC, Stockholder, IRS	Extensive Reporting to DoD in addition to SEC, Stockholders, and IRS
Standards and Regulation	Detailed Military Specifications	May be regulated, i.e. FDA, etc.
Marketing	Varies between advertisement to non-specific customers and relationship based selling	Long term relationships with few customers, RFP's, government lobbying, hiring of ex-military for marketing
Decision Making	In best instances fast, and timely	Slower timing, bureaucratic, following that of main customer, the U.S. government
Culture and Values	Business driven, practical engineering	State of the art technology and engineering

This comparison is indicative of how the defense innovates in order to meet the needs of the military mission and the commercial organization must innovate to meet the changing needs of the free market. The commercial enterprise is required to be agile to meet the constantly changing needs of the market while competing with other companies, while the military contractor moves slowly, as does its main customer the federal government. These tables, though vastly oversimplified, could be a good way for DoD contractors benchmark their processes and priorities with the typical commercial firm that they may now be competing against.

3.4 Discussion

The evaluation of the advantages and disadvantages that the defense company for entering the commercial marketplace in Sections 3.1 and 3.2 do show that there are many reasons for the defense contractor to be disadvantaged. The only real advantage that the defense contractor can have is in terms of learning and access to state of the art technology, the applicability of which to the commercial markets at any particular time or world situation is highly variable.

This quote from David Walker from the General Accountability Office (GAO) that is reproduced by Gansler (Gansler, 2011) epitomizes the common attitude towards the DoD' spending and operational efficiency in much of the literature:

> *DoD is number one in the world at fighting and winning armed conflicts – it's an A+. But in my opinion DoD is a D (rated on a curve and given the benefit of the doubt) on economy, efficiency, transparency and accountability*

In one sense, the DoD contractor cannot be equated with the DoD. One cannot expect an efficient, commercially competitive result when a contractor must work within a defense acquisition system that makes commercially competitive results impossible to accomplish. It may not be the contractor's fault that it has not developed commercially competitive products and services, and the fact that it hasn't in one system is not indicative that it cannot in another system. On the other hand, working in a system completely at odds with the free market does allow the organization partake in behaviors and attitudes that are also at odds with the free market and encourage a culture incompatible with success in a competitive marketplace. The skill set and competencies that are valuable investments for DoD contracting are not valuable investments for most commercial business

It is the technical skills and knowledge in a DoD contracting firm are the most transferrable to the commercial marketplace, since basic physics and engineering practices are the same whether applied in either a military or defense context (Alic et al., 1992). The least transferrable skills are that of management and a staff required to fulfill the onerous requirements for reporting and contracting required by the Department of Defense.

4 Historical Case Studies of Successful Defense Conversions

The case studies included here are those that are available and deemed most relevant to the focus of the study. The case studies included in this section are not directly relevant to the focus of this thesis on engineering services and supporting software; they are concerned with technologies and manufactured goods. There is no identical match of well documented success stories to precisely the same situation as the case study here. However, the historical case studies included here are relevant in other important aspects. The cases of the Amana Radar Range and the Galileo Electro-Optics are examples of commercial success of companies that have developed a technology for a military use and profitably transferred it to commercial markets as spinoffs.

There are other examples in the literature relevant to successful government and military conversions of research and development to civilian applications that are not included here because they are not as relevant to the base case for a number of reasons. For example, NASTRAN is a success story for the government agency NASA's development of general finite element software in the 1960's that is the origin of many existing commercial software available today (Alic et al., 1992). The case study in Section 6 is concerned with development of software; however, the story of NASTRAN's government conversion is not as relevant as other stories are. NASTRAN's transition to the commercial market originates from the government's decision to release the source code to the public domain, and the ability of commercial enterprises, including McNeal-Schwindler to capitalize on it. The government contractor that had a part in developing NASTRAN, Computer Sciences Corporation did not convert the product and did not profit from the conversion("Finite Element Analysis Resources: A Brief Review of NASTRAN Versions," 2010).

4.1 The Raytheon and the Microwave Oven

Percy Spencer, a developer of radar system technology at Raytheon is credited with being the inventor of the microwave oven in 1945. The key technological component of both the radar systems and the microwave oven is based on the magnetron, a device designed to emit microwaves. Presumably, the development of the magnetron device would fall under a DoD "6.3" research activity or "Budget Type 3 or 4" activity as classified in Table 3-1.

According to the popular mythology, Spencer noticed that a chocolate bar in his pocket had melted after he had been standing near an operational magnetron, with which he had been working ("Inventor of the Week: Percy L. Spencer," 1996). From this observation, work was begun to apply the magnetron device to cooking food, developing eventually what was known as the "Amana Radar-Range" or now more commonly known "microwave oven." The oven was first marketed to commercial customers, as it was initially a very large and bulky device. It took about 20 years for the oven to be developed to a point in which it was compact and affordable enough to be suitable for the commercial market.

The following factors are thought to be significant in the success of the venture (Alic et al., 1992):

- Percy Spencer, the inventor of the magnetron central to the microwave oven was personally involved in the development of the Radar-Range product
- The CEO of Raytheon took a special interest in the project, which may have something to do with the fact that Raytheon had just had faced budget cuts after the end of World War II that threatened the health of their business.
- Raytheon first marketed the product to industrial customers, who would value what it could do for them enough to pay an initially high price.
- Raytheon corporate interest in investing in the further development of the device persisted in spite of a slow development process bringing it to the commercial market (20 years).
- Raytheon had acquired the company Amana for another reason, but Amana had experience in commercial marketing that Raytheon did not themselves possess.

4.2 Galileo Electro-Optics / NetOptix Corp.

Shenhar offers the example of Galileo Electro-Optics as an example of a company that was eventually able to successfully transition its defense applied technology to the commercial markets (Shenhar et al., 1998). Galileo, based in Sturbridge, Massachusetts at the time, produced optical devices used for remote sensing, night vision devices and other applications for the defense market. These were devices, components of other systems, so the technology development in this area would be classified a DoD "6.3" research activity or "Budget Type 3 or 4" activity as classified in Table 3-1.

In the 1980's Galileo took the approach of keeping the same basic technology base and the same technical personnel, but looked for new markets and applications of their technology. It found the applications in office products and medical products. Later events indicate that Galileo moved into fiber-optic technology and was enormously successful; Corning acquired Galileo after it was newly named NetOptix for $2.1 billion in 2000 (Howe, 2000).

To summarize, the following points are important in understanding the success of Galileo (Shenhar et al., 1998) :

- Galileo had tried multiple times to leave the defense market, suggesting that the company was not satisfied being a defense contractor and was very motivated to change.
- Galileo kept the same the same technical personnel when it adapted its core technology for other applications.
- The company ended up having to lay-off 50% of its workforce, so the transition was not painless.

Allowing some speculation, another important point in this story could be that a little luck and a changing market and eco-system made their technology more valuable to other industries. They were able to offer the right technology at the right time for their transition, and move into a growing market.

4.3 Discussion

The small sample of brief case studies has some common threads with the case study in Section 6. These companies had a high motivation to expand away from the defense contracting. Raytheon had just experienced a massive downturn in federal funding after the end of World War II. No doubt due in part to that fact, the CEO of Raytheon at the time was an ardent supporter of the project. The fact that Galileo had tried a number of times to leave the defense market indicates that management was strongly motivated to change their business. In both cases the core technical personnel and expertise were used in the development work required to adapt the existing technology to the new applications.

It is also worth noting that both ventures were not immediately successful. Galileo had to lose half of its workforce before its new markets started to take off and Raytheon's road to the large scale sale of microwave ovens took over 20 years.

5 Strategies for Entering New Markets

There are internal and external challenges for any business moving to a new market. The internal challenges that are specific to defense contractors due to the legacy of DoD business practices were discussed in Section 3.2. This section will address interaction with the general market, and draw from prescriptive literature including that aimed at general industry.

5.1 Adjacent Markets

Entering a new market is a way for any company to grow, but it is also a way to risk losing invested money and damaging the original business by diverting resources away from it, and even hurt the reputation of the company. Many authors that write about corporate growth blame the failure of new corporate ventures on the failure of companies to carefully choose their new ventures to be closely adjacent to their core businesses. The farther away a company ventures away from its core business and competencies the higher the risk of failure (Zook, 2004). In the best case, an adjacency can actually improve the strength of the original core business.

5.1.1 Assessing Adjacency and Core Competencies

A company's core businesses are driven by its core competencies. A successful company's core competencies are the specific skills and knowledge from which a company is able to provide the products and services that its customers value and are willing to purchase at a price that provides a profitable business for that company. The core competencies maintain a business's competitive advantages over its rivals in the marketplace. Some examples of core competencies are General Electric's "human resources" and "learning culture" or Proctor & Gamble's "innovation" and "customer understanding" (Takaoka, 2011).

An adjacency is new ways of doing business that expands on the existing market or business model in which the company currently engages. Zook classifies the types of adjacency moves into 6 types (Zook, 2004):

1. Product
2. Geographic
3. Value Chain
4. Channel
5. Customer
6. New Business

"Product adjacencies" consist of selling new products to existing core customers. This is considered to be the adjacency with the least risk and the biggest payoff. In the military contractor context this would involve selling a new product to the U.S. military. This type of adjacency is probably a viable strategy for DoD contractors and has no doubt been used before. However, given shrinking defense budgets of today, the option of selling a new product to the DoD is probably not as viable during these times, hence the subject of this thesis.

"Geographic adjacencies" are pursued by selling the same product to a new geographical area. Zook opines that the difficulty successfully executing this adjacency is often underestimated, since it can involve cultural and supply chain difficulties, especially in international markets. The military contractor pursuing foreign military sales would be pursuing a geographic adjacency.

"Value chain adjacencies" involve adding products and services up and/or down the value chain. An example of this would be a distributor of consumer products opening up its own retail stores, which is a difficult expansion, since it involves very different activities than those that have been learned during the commission of the original business activity.

"Channel adjacencies" involve selling products and services through a new channel. For example, Amazon selling its Kindle e-readers in retail stores such as Walmart versus solely through amazon.com is a channel adjacency. This seems to be most relevant to the consumer product and service realm. Channel adjacencies, given the rigid acquisition process of the DoD and government does not seem like a valid option for the DoD contractor.

“Customer adjacencies” involve changing an existing successful product to adapt it to a new customer segment. This is the adjacency strategy that is most consistent with the concept of a defense contractor moving into commercial markets, although defense products are very rarely unmodified for the civilian market (Mowery, 2010).

“New business adjacencies” are created when a new business is built around an internal tool or competency that was originally developed to support the original business. Amazon selling its cloud based platform that was developed to run its e-commerce site as a service for other businesses to run their sites on is an example of this.

5.1.2 Adjacency for Military Contractors

The major core competence that can be advantageous for the defense contractor is the ability to develop state of the art technology, as is discussed in Section 3.1. For a defense contractor, many of its core competencies, which enables it to engage in business with the DoD, as were discussed in part in Section 3.2, are not valuable in the context of the commercial markets.

As was discussed in the previous section, certain adjacencies are less relevant to the military contractor. Shenhar et al. has created a framework relevant to Zook’s “customer adjacency” distance from the core business that is specialized for the military contractor. Shenhar has created a scale of market and customer types that indicates the degree of difference of a customer type from the original military customer. The most similar customer to the military customer is a para-military organization such as a police force or other U.S. government agencies, the moderately different customer is the industrial customer, and the least similar customer is the consumer. Also, a scale to the degree of change required in the product is proposed starting from the smallest change consisting of from a modified product, to a moderate change consisting of a product based on the same base technology to the greatest change consisting of a completely new technology. The possibility of a completely unmodified military product being sold to any market besides the defense market is not considered. The dimensions of customer and market type and change in product are combined to create a risk matrix as is indicated in Figure 5-1 (Shenhar et al., 1998).

Change in Market → +

Consumer		High risk	Very high risk	Very high risk
Industrial		Moderate risk	High risk	Very high risk
Para-military/ Government		Lowest risk	Moderate risk	High risk
Military	Current State			
	Same Products	Modified Products	Same Technology, Different Products	Same People Different Technology

Change in Product → +

Figure 5-1. Shenhar (1996) Product-market risk matrix for defense conversion[6]

The use of this matrix in Figure 5-1 provides a sense of the distance from the core business for each adjacency move. This risk matrix provides the lowest risk for business activity of the military contractor selling a slightly modified product to a Para-military or government customer, which amounts to an adjacency very close to the core at a very low risk. The very farthest business from the core business and highest risk adjacency would consist of having the same staff develop a new technology for the consumer market.

In the case of the microwave oven case study discussed in Section 4.1, the adaption of the radar magnetron for microwave cooking would be classified as "same technology, different products" under Shenhar's scale of product similarity. Initially Raytheon/Amana sold this product to the Industrial Market, and created a venture that would be classified as "High Risk" under the risk matrix in Figure 5-1. If they had

[6] Figure 5-1. Shenhar (1996) Product-market risk matrix for defense conversion is adapted from Figure 1 in Shenhar (Shenhar et al., 1998)

chosen the consumer market initially, it would have been classified as “Very High Risk,” and very unadvisable. Galileo Electro-Optics , described in Section 4.2, also moved to industrial customers, and in this case would be classified under “Moderate Risk” or “High Risk” depending on the degree to which it needed to modify its products, with either “modified products” or “same technology, different products.”

5.2 Partnering Decisions

Shenhar et al. also discusses the strategy of partnering with other companies that are in the new market to which the defense contractor is moving. This work recommends that the higher the risk of the adjacency the more a partnership should be considered (Shenhar et al., 1998). Andrew and Sirken exhort any company hoping to expand its business by creating new products to explicitly consider all of the options available to market them because beyond just ensuring viability of the new product, choices in commercialization can dictate the profitability of the product in the years to come (Andrew & Sirkin, 2003). Their nomenclature describing the commercialization options are:

- Integrators (sole ownership): complete development including manufacturing and marketing
- Orchestrators (outsourcing, partnership, joint venture): contribute in only some of the steps required to take a new product to market and use one or more partners
- Licensors: license the technology

Developing the new product or service completely in house (integrating) will require the greatest risk and investment. This option is only viable if the company has the product design, manufacturing process and technical talent that is necessary. Andrew and Sirken state that most organizations do not appreciate the degree of investment and time required for this option, even though it may seem like the safest route with the most control. These authors recommend this option in the cases in which the time to market is not important, when the market needs remain stable, and when the new product is using proven technology.

Partnering (orchestrating) reduces the risk and investment. But on the other hand, entering into a partnership also requires the skills of being able to collaborate with as many partners as necessary and to be able to make decisions quickly. The project management competency requirements in a multi-organizational project are high. The corporate culture has to be compatible with giving up some control. Partnering is recommended when there is a mature supplier and partner base, the market for the product is very competitive and the technology is not completely mature.

Licensing is another option that should be considered. This is a low risk and low investment option. However, it requires that the firm has the ability to manage intellectual property and the ability to perform the basic research that goes along with patentable technology. This is recommended when the innovation has very strong intellectual property protection, the market is immature and risky, and the innovating company does not care to build its brand.

Given the hypothesized lack of marketing competencies and inexperience in doing business in the commercial market in general, this framework for partnering decisions would point towards the defense contractor finding at least one partner. Most military contractors are experienced with either partnering, contracting, or subcontracting with other military contractors, including their own competition because of the nature of military acquisition (Alic et al., 1992) . Project management skills have been developed in this atmosphere to enable effective multi-organizational project management. In other cases, licensing may also be a good option for the defense contractor, provided they have good intellectual property management skills.

5.3 Changing and Innovating within Corporate Organizations

Meyer and Poza document a case study in which Raytheon was able to adapt their defense sensor system technology and market it to the U.S. Department of Homeland Security (M. Meyer & Poza, 2009). The Department of Homeland Security is a U.S. governmental agency. The case on which this work is based, differs from the type of defense conversion that is of the most interest for this thesis, the case in which an existing military technology or knowledge is adapted to a commercial market. However, from Raytheon's point of view, this was a new customer, with different needs and attitudes from the DoD customer to which they were accustomed. This case study is also interesting because it also explores the process of innovating within the corporate environment. It is especially relevant because it is an example of defense conversion within the corporate environment of a defense contractor.

Meyer and Poza take Raytheon's experience as a reference point about which to generalize about the characteristics of good defense conversion candidates and the business practices that will increase the likelihood of success for the conversion. These authors propose that it is first important ensure that the candidate market is growing, a market for which the company has a well defined products, and is closely adjacent to their core business. Corporate support and commitment to fund the venture for some prescribed period of time even in the face of initial failures is also required. A team must be formed to execute the new project and must contain team-members that have an internal record of creating growth in the original core business. These authors also specify that the team members must be willing to work closely with some of the new customers to fully understand what they need, what their new customers' operating constraints are, and how and in which channels they prefer to purchase the products or services. The team must acquire an understanding of the full "eco-system" in which the new market resides and the implications of this eco-system on the company's business model.

The authors Roberts and Fusfield discuss team-member roles that are desirable for effective teams for innovative activities within a corporate organization (Roberts & Fusfield, 2002). These roles are:

- Idea Generating: learning and synthesizing ideas about markets, technologies, and new approaches and procedures
- Entrepreneuring or Championing: pushing and demonstrating the value of the new ideas, especially to management
- Project Leading: planning and coordinating the new effort
- Gate-keeping: collecting and dispersing information about important developments inside and outside of the organization
- Sponsoring or Coaching: protecting and advocating for the new effort outside of the team

These are not formal roles, and more than one role can be played by a single person, or a single role can be played by multiple people over the lifetime of the project.

5.4 Conclusions

This section has touched on some of the factors that concern any company entering a new market: evaluating the market relative to company capabilities, evaluating the best partnering choices, and building teams and policy structures within the corporation to execute the project of entering the new market. In particular the defense contractor entering a new commercial market has characteristics that narrow the options somewhat. Moving into the consumer market as the first step is very high risk for military contractor according to the analysis set forth by Shenhar et al. Assuming that the military contractor does not have good competencies in marketing and understanding commercial markets, the framework Andrew and Sirken would recommend the defense contractor either partner with a company more experienced in the new market or even consider licensing if its intellectual property is strong. Finally, as is the case for any type of organization, the internal corporate structure must be in alignment with the new venture, and provide a framework under which the venture can succeed.

6 Case Study: Combat Ship to Oil Platform Survivability

This section will look at a case study in which there is an ongoing effort in a medium size company to commercialize software and expertise developed for combat ship survivability for the application to offshore oil rig safety and survivability.

Note that the name of the companies, company divisions and other specific titles and names involved have been changed in order to protect the identities and confidentiality of the entities involved.

6.1 Background

6.1.1 Overall Organizational Background

6.1.1.1 Organizational Structure

The parent company, MID-SIZED[7] Science and Technology is primarily a professional services provider with the U.S. Department of Defense making up 90% of its business ("MID-SIZED Science and Technology, Hoover's Company Records - In - Depth Records.," 2011). The parent company consists of approximately 3000 employees in total at over 40 major offices in the U.S. with smaller satellite offices both in the U.S. and worldwide ("Company Website: MID-SIZED Science and Technology," 2012). This is a matrix organization that is split into 2 major strategic business units or "sectors." Each of these sectors is comprised of 3 "groups." This portion of the organization chart is shown in Figure 6-1. The business activity that will be discussed in this case study occurs within the arbitrarily named Sector 2[8] and Group 2.2. The support organizations are also indicated at each level in the hierarchy shown in Figure 6-1. At the corporate level (referred to as level 0) there are organizations devoted to legal services and strategic initiatives, and marketing is not indicated in the Figure 6-1 is an organization that resides under the Chief Administration Officer (CAO). At the sector level (level 1) there is a Business Development organization and a Chief Technical Officer (CTO).

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[7] MID-SIZED is a pseudonym for the actual company name, which is being withheld to preserve confidentiality

[8] The business divisions are also disguised here.

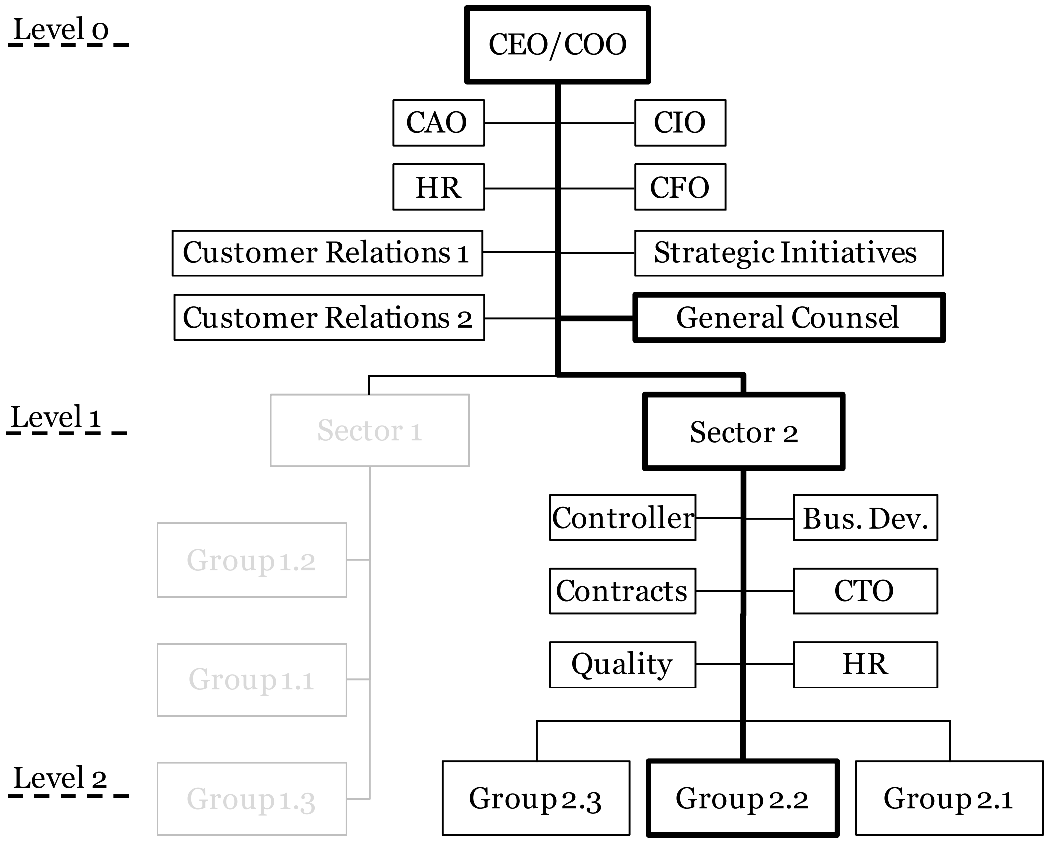

Figure 6-1. Highest levels of organization of studied business and engineering activities[9]

A total of 5 tiers or levels exist in the parent company. The activity that is discussed here originated within an arbitrarily named Division 2 (level 4 in the hierarchy) that is within an arbitrarily named Operation 2 (level 3) within Group 2.2 (level 2) as is indicated in Figure 6-2. In summary, the division manager that this business development effort is centered upon is 4 levels away from the corporate organization and is competing with a large number of competing organizations within the various levels.

[9] Disguised data obtained from ("Company Website: MID-SIZED Science and Technology," 2012) The bold lines indicate the flow to the areas in which the new business development studied took place in the hierarchy.

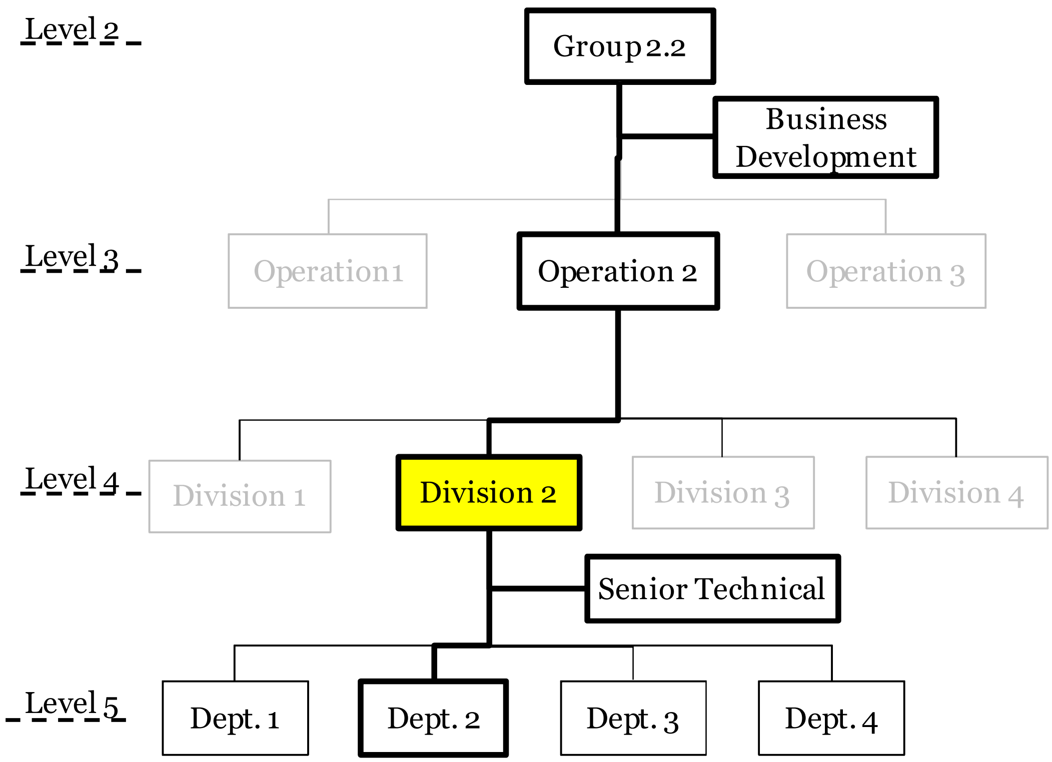

Figure 6-2. Partial organization chart indicating the Division 2 in which the business development activity originated within the company[9].

6.1.1.2 Organizational History and Current State

MID-SIZED was founded 10 years ago in 2002 and consists mainly of 15 acquisitions of other defense contractors and consulting companies. One of these acquisitions is NAV-ARCH[10]. NAV-ARCH is a provider of Naval Architecture, Marine Engineering and Program Management support. NAV-ARCH was acquired 8 years ago by MID-SIZED, but has existed as a functioning business entity for 48 years before the acquisition ("Company Website: MID-SIZED Science and Technology," 2012). It is worth noting that given this history of acquisitions and its short life as an organization; the parent company MID-SIZED does not have a single entrenched corporate culture throughout; however each acquisition in many cases, including NAV-ARCH, has its own culture and way of doing things. Figure 6-3 shows a partial organization chart starting with Group 2.2, the organization in which the studied engineering and business activities occurred

[10] NAV-ARCH is a pseudonym of the acquired company used for the purpose of confidentiality.

that indicates the partitioning of separate operations consisting of employees from 2 different acquisitions: Acquisition A (NAV-ARCH) and Acquisition B, another engineering services company with some overlapping competencies. Figure 6-2 indicates the rest of the organization chart below "Group 2.2" including the location of the division from which the business development that is studied here originated.

The main expertise and customer base of Operations 1 and 2, originating from the NAV-ARCH acquisition is the design and engineering of surface ships. Operation 2 was dependent on contracts from the U.S. Navy for the development of new surface ships. A very large portion of this work disappeared when the recent plans to develop the next generation cruiser, CG(X) were cancelled in 2010 ("Draft Shipbuilding Report Reveals Navy Is Killing CG(X) Cruiser Program," 2009). No other programs of comparable size replaced it or were foreseen to replace it (Fabey, 2012). This operation had moved to providing services to international military customers, but an overall downturn in the global economy made these business opportunities much rarer. These factors resulted in a poor prognosis for the operation's financial viability.

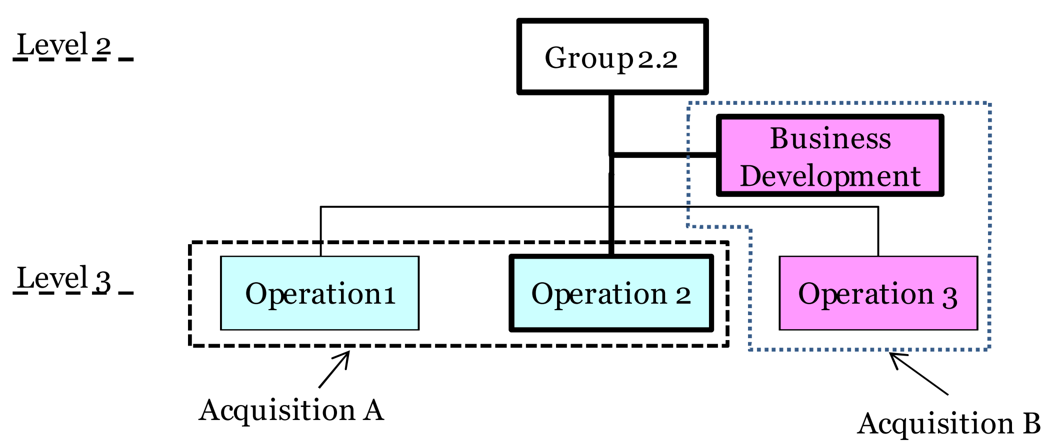

Figure 6-3. Partial organizational chart indicating the composition of previous acquisitions

6.1.1.3 Existing Marketing Approach

The marketing approach of MID-SIZED has a high dependency on face to face meetings with current or prospective customers as well as responding to requests for proposals and included work with international military customers. It is common in the defense sector as well as in many commercial engineering services to have “strategic hires” that have previous employment at key customers’ organizations (Culbert, 2011). In the case of MID-SIZED this constituted a number of personnel that were former U.S. Navy officers or were employed within Navy research laboratories that were charged with business development as a major work activity.

But also, like many similar companies in engineering services and involved in science and technology development, MID-SIZED, does utilize the technical staff in its business development, since they are closest to the customer and best understand their technically complex needs, as is expressed in the MID-SIZED Form 10K:

> *Our technical staff is an integral part of our promotional efforts. The customer relationships they develop through their work often lead to additional business and new research opportunities* (MID-SIZED Science and Technology Corporation, 2011).

6.2 The Catalyzing Event: Deepwater Horizon Disaster

On April 20, 2010 there was a devastating explosion on the Deepwater Horizon oil rig in the Gulf of Mexico that attracted world-wide attention and put the offshore drilling industry’s operations and safety practices under the spotlight (Birknes, 2010; Freudenburg & Gramling, 2011; Graham et al., 2011; Konrad & Shroder, 2011) . As the images of the aftermath of this disaster in Figure 6-4 and Figure 6-5 connote, this disaster had a very negative effect on world-wide public opinion about offshore oil drilling, led to a moratorium on drilling in the Gulf of Mexico and was in many ways very bad news for the offshore oil drilling industry as a whole.

Figure 6-4. Coast Guard Photograph of Deepwater Horizon Fire[11]

Figure 6-5. NOAA veterinarian examining oil-covered sea turtle in the Gulf of Mexico[12]

Much of the news coverage about the Deepwater Horizon Disaster concentrated on the environmental impact to the Gulf Coast area and the managerial and corporate culture that allowed priorities for safety to be sacrificed for the sake of budget and schedule. What were talked about less were the events that immediately followed the blowout. Shortly after the driller reported that the well blew out, explosive gas from the well had

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[11] Credit: U.S. Coast Guard; Source: http://en.wikipedia.org/wiki/File:Deepwater_Horizon_offshore_drilling_unit_on_fire_2010.jpg, downloaded on 3/28/2012

[12] Credit: NOAA/GADNR; Source: http://www.nmfs.noaa.gov/pr/images/oilspill/kempsridleyturtle_brianstacy_noaa_gadnr.jpg, downloaded on 3/28/2012

moved up through the drill pipe and collected on the rig deck. Two explosions followed. Apparently these explosions caused devastating structural damage which in turn injured and trapped personnel, prevented the crew from manning emergency stations and destroyed emergency backup systems and power generation (Birknes & et al, 2010; Transocean, 2011). No doubt the explosions had some part in taking the lives of the 11 missing crew-men and made controlling the rig and fighting the fire difficult.

In the best of situations, offshore drilling is extraordinarily dangerous as these statistics from the Report from the Presidential Commission on the Deepwater Horizon Disaster cites:

> *Drilling for oil had always been hard, dirty, dangerous work, combining heavy machinery and volatile hydrocarbons extracted at high pressures. Since 2001, the Gulf of Mexico workforce—35,000 people, working on 90 big drilling rigs and 3,500 production platforms—had suffered 1,550 injuries, 60 deaths, and 948 fires and explosions*.(Graham et al., 2011)

Aside from falls and mishaps with machinery, an ever present danger is the risk of fires and explosions on the offshore drilling rig. The worst tragedy on an offshore oil rig in history involved the Piper Alpha explosion and fire in 1988 in the North Sea that killed 167 men (Konrad, 2011).

Some of the media coverage related to this incident included information about the impressive technology comprising the dynamically positioned drillships such as the Deepwater Horizon. It was the fact a drillship is essentially similar in many of its primary functions to a surface ship that prompted a division manager within Operation 2 within MID-SIZED (formerly of NAV-ARCH) to speculate if skills and knowledge that he knew that his organization used for surface ship analysis and design for the U.S. Navy could be applied to some of the problems highlighted by the Deepwater Horizon disaster, most notably their combat ship survivability design and analysis expertise.

6.2.1 The Existing Product and Related Expertise

Division 2 within operation 2 specialized in the evaluation of and design for surface ship survivability. Survivability in the context of a combat surface ship is described according to regulations in the DoD 5000.2-R as:

> *AP3.2.4. Survivability. The capability of a system and crew to avoid or withstand a man-made hostile environment without suffering an abortive impairment of its ability to accomplish its designated mission. Survivability consists of susceptibility, vulnerability, and recoverability.* ("DoD 5000.2-R: Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs," 2002)

Susceptibility in the context of a naval surface ship refers to the how easily a system (or ship) is discovered (via infrared signatures, etc.) and therefore is open to attack. MID-SIZED interpreted susceptibility to be related to the design features of the rig that may be the cause of a hazardous event ("Offshore Oil Industry Marketing Assessment – Foreign and Domestic Targets and Strategy," 2010). (Given the accounts of the Deepwater Horizon Disaster, susceptibility could also be described in terms of management practices, economic factors and human behavior.) Vulnerability refers to the how well a system is able to withstand an attack and continue to function. Recoverability is defined as the ability of a system after sustaining damage in the attack to take emergency actions to prevent the loss of the system and minimize loss of personnel ("DoD 5000.2-R: Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs," 2002).

Associated with this expertise was a software package that was developed and continued to be developed by personnel within the organization, dubbed SYS-SURV[13] that was primarily used and continually improved and developed for combat ship survivability prediction and design, although it had been used for buildings in a few instances. This software offered root-cause failure determination, structural and network analysis and

[13] SYS-SURV is a fictitious name for the software package

the integration of vulnerability and recoverability evaluations of system designs. Also more specific to the combat ship and potentially offshore oil-rigs, it provides fire and flooding simulations and ballistic and fragment damage predictions ("Company Website: MID-SIZED Science and Technology," 2012). It made use of first order physics and empirical data and Monte Carlo simulation to provide probabilistic predictions. A major advantage of this software package was that it integrated many different types of analyses into a single package.

The software was developed and continued to be developed as company proprietary since the company had a strategy of pursuing international military sales in the initial face of the declining U.S. defense budgetary allocation to surface ship development ("Tool Development for the International Naval Market," 2009).

6.2.2 Summary

The following background factors contributed to the inception of the transfer of naval combat ship survivability software and knowledge to commercial deepwater drilling applications:

- Drilling rigs are very similar to combat ships in many ways in terms of their structure and function and supporting systems including safety systems
- There is an ever present risk of fires and explosions from the gases associated with petroleum drilling
- A horrific incident on the Deepwater Horizon highlights the danger of explosions and fire and the highlights the inadequacy of current survivability designs.
- The organization had a very technically advanced product and a special expertise in combat ship survivability that was pertinent to the explosion and fire survivability of marine structures.
- The fact that U.S. Navy surface ship design services are not in demand in the current political and economic environment for an organization that depends on this business is a strong motivation for change and new business development.
- Business development is encouraged and expected from all levels of the organization hierarchy.

6.3 What Happened: Moving the Product and Expertise to a New Market

6.3.1 Internal Inquiry and Initial Market Research

In April 2010, around the time of the Deepwater Horizon event was heavily covered in the news, the aforementioned interested division manager had a number of conversations with various people within the organization about the concept of using an internally developed software package for oil rig survivability analysis or other capabilities Serendipitously, one of the employees in the MID-SIZED / NAV-ARCH organization had a personal and professional acquaintance who was currently working for an offshore drilling contractor based in Norway. This employee then contacted his acquaintance working in the offshore drilling industry. The Norwegian offshore drilling engineer expressed great interest in the possibility of improving survivability and safety analyses for offshore rigs ("Platform Survivability Assessments for the Offshore Oil Industry: Marketing Assessment," 2010). Having such immediate access to precisely this sort of contact was very fortunate.   The offshore drilling contracting industry is in fact a central part of the offshore drilling industry and has the most direct interest in survivability design and assessment, since these companies design and lease the drill-ships. Transocean, a prominent member of the offshore drilling contracting industry was at the center of the Deepwater Horizon incident and faces multiple lawsuits because of the disaster off of the Gulf Coast (Lubin, 2011).

Even though it was not evident at the time, the fact that this offshore drilling contact was associated with an organization based in Norway was also very opportune because of the level of concern that the Deepwater Horizon disaster caused the Norwegian people and government. Independently, and after the fact, the researcher used Google Trends ("Google Trends," 2012) to monitor the relative interest in the search term "Deepwater Horizon" in different geographical areas. The results of this indicate the surprising result that Norway had the greatest relative interest in this search term as is indicated in Figure 6-6. The data are normalized to all of the traffic originating from a particular country that visits the Google search site. Figure 6-7 is a plot of breakdown of this data by individual city that shows that New Orleans, Houston, and Washington DC are performing the most Google searches on “Deepwater Horizon” relative to their total traffic level. This is compatible with the predicted degree of impact that this event had on these regions. The fourth ranked city for interest in “Deepwater Horizon” indicated in Figure 6-7 is Oslo, Norway, which would indicate special interest in this subject in Norway as well. Further investigation about the current state of Norway shows that this interest most likely coincides with the fact that a massive oil spill in the North Sea could be potentially devastating to Norway and its economy. Fishing in the North Sea is an important part of the Norwegian economy. The petroleum sector is controlled by the Norwegian government and this industry makes a substantial contribution to funding its socialist economy (“CIA - The World Factbook: Norway,” 2012). Publications originating from the Norwegian oil industry interests also reflect a deep concern about the deepwater horizon incident and a commitment to safety regulation and mention in particular precisely the same sorts of engineering assessments for safety that the tool that MID-SIZED would provide (Birknes, 2010; Haug et al., 2010).

Other personnel proactively contacted other stakeholders and potential customers including Transocean and BP Oil, in which interest was expressed, but not to the degree apparently of the Norwegian contacts. Apparently the US offshore industry contacts were not prepared to act in the near future, presumably in part because they were in the shadow of the legal problems that were ongoing with the Deepwater Horizon incident (“Platform Survivability Assessments for the Offshore Oil Industry: Marketing Assessment,” 2010).

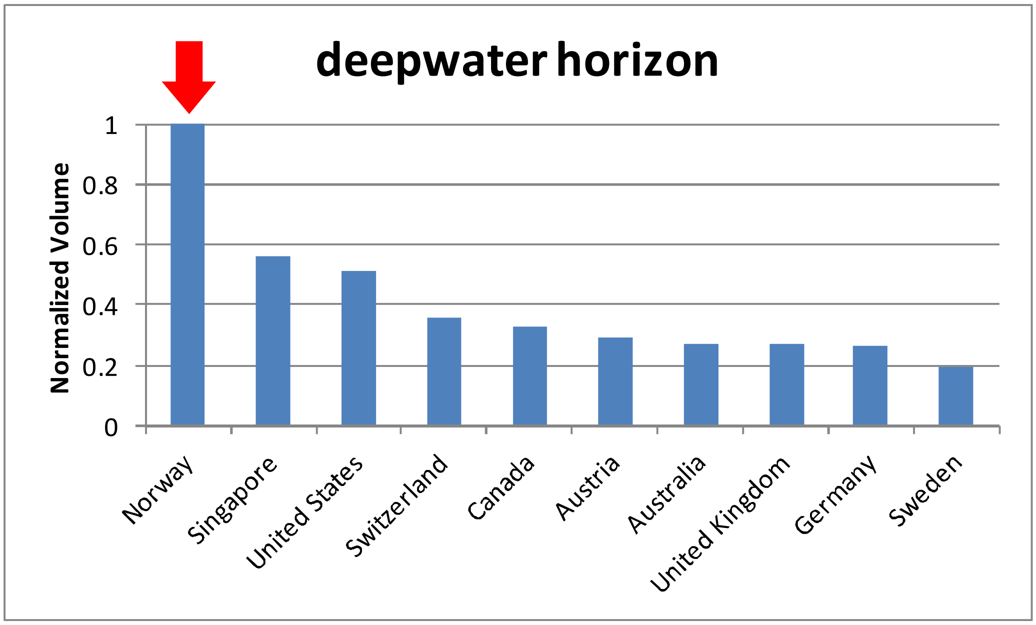

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Figure 6-6. Geographical Information for increased density of the search term worldwide obtained from Google Search Trend[14]

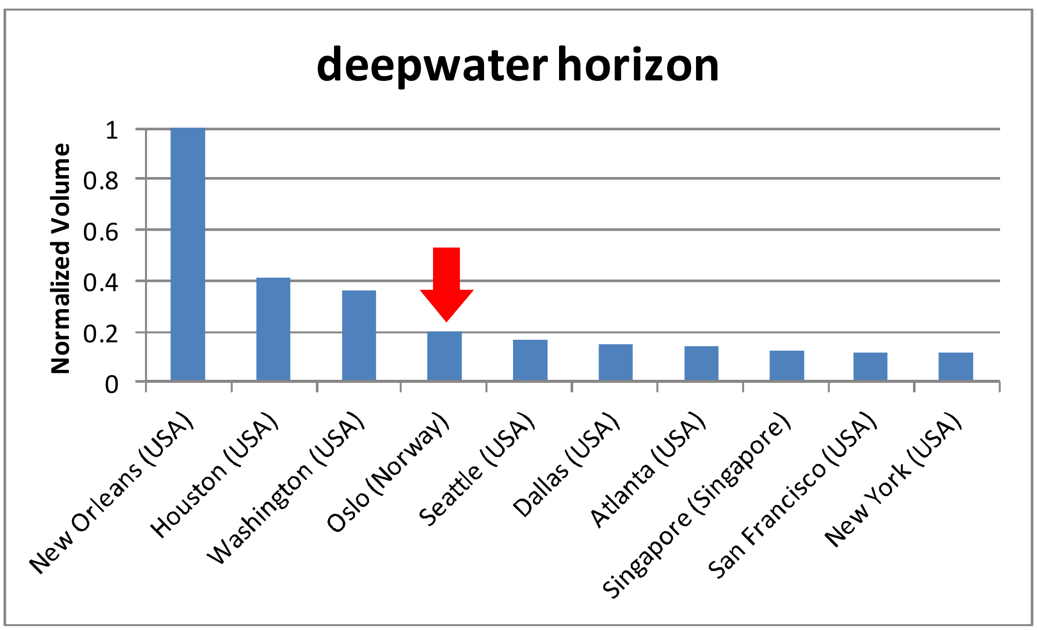

Figure 6-7. Google search trend density by city worldwide[14]

[14] Data obtained from Google Trends of search term "Deepwater Horizon" ("Google Trends," 2012)

6.3.2 Upper Management Briefings and Market Research

In the beginning August 2010, a briefing advocating pursuing the offshore oil industry survivability market was made to MID-SIZED upper management. This included a prediction of the likely impact that the Deepwater Horizon incident would have on the offshore industry including an anticipated renewed commitment to safety and accident prevention. The impact on regulations and engineering best practices resulting from the Exxon Valdez oil spill was used as a point of reference. The briefing provided an assessment of the market size and the MID-SIZED capabilities that would be relevant in this market. Next steps consisting in part of a pilot study on an actual oil rig was proposed along with other marketing investigations and ("Platform Survivability Assessments for the Offshore Oil Industry: Marketing Assessment," 2010). The presentation was well received at the CEO level and resources were provided to continue the effort.

In the middle of September 2010, a follow-up briefing was presented to MID-SIZED upper management. This briefing discussed the specific contacts and marketing messages made. This presentation made more specific estimates about the timing and costs involved for the previously proposed pilot study, which was felt to be required for successful marketing efforts.

Discussions with various stakeholders in the offshore oil rig industry were continued over time, including oil industry regulators in the US and Norway.

6.3.3 Pilot Study and Continued Marketing

In the middle of August 2011 a pilot study was initiated with a Norwegian offshore drilling company mentioned previously to perform an analysis using the modified SYS-SURV tool of an existing offshore rig owned by the Norwegian drilling company ("DEEPSEA ______ Integrated Barrier Analysis Pilot Study - Lessons Learned Report," 2011)[15] . The study was a complex modeling effort. The modelers in fact visited the actual rig in the North Sea to assess the as-built configuration of the rig and to fully understand the very complex structure. The main challenge, besides the complexity of

[15] The author and precise title of this referenced internal memorandum is omitted to preserve anonymity

the system, was the difference between terminology used by the offshore oil rig industry and that by the naval surface ship community that the modelers used. The results of the problems uncovered by the SYS-SURV tool were then compared to that obtained by existing tools that were used for the original design of the rig. The SYS-SURV tool was deemed to have superior performance because it uncovered a super-set of hazards identified by the original analyses. The fact that multiple analysis types were included in a single tool was seen as an advantage because it could save substantial time.

At the time of this writing the adapted SYS-SURV tool is being marketed to the offshore oil rig industry. The value proposition that is offered is that it offers superior accuracy and savings in time and money because it integrates several analyses that would normally need to be done separately. It is worth noting that in term of the time from the original idea of offering an initial product to the market is about 2 years.

6.4 Organizational Study

The literature studies discussed in Sections 2 through 5 suggest that there are certain factors that will increase the likelihood for success for a market expansion effort. Analysis of the system in which the defense contractor must work when doing business would also suggest certain institutional barriers would also exist. Aside from obtaining volunteered information about the history of the venture, some specific questions about the venture were posed[16]:

- What was management commitment?
- What was the team composition for the initial venture? Specifically did it include those who had developed the original technology?
- What were the challenges in your marketing and market research?
- How significant were the following specific issues and how did you deal with them?
    - Export Restrictions
    - Intellectual Property
    - Industrial Culture and Communication
    - Overhead Costs

[16] A single respondent was available to answer the questions: the "Division Manager" that played as central role in this story ("Communication with MID-SIZED Division Manager: March 13, 2012," 2012).

This section will present the answers to these questions and discuss the background research that prompted the question.

6.4.1 Management Interest and Commitment

The respondent indicated that enthusiastic management interest and approval went all the way up to the CEO level since the first briefing to corporate in the summer of 2010.

This is congruent with successful corporate ventures described in the literature as was discussed in Sections 4 and 5. Alic posited that in the case of development of the microwave oven this was a major factor for success (Alic et al., 1992). Meyer and Poza also stated their belief that corporate championing is an important factor for success and played an important role in Raytheon's successful move to the homeland security industry (M. Meyer & Poza, 2009).

6.4.2 Team Composition

Senior personnel including experts in marine survivability and related areas were involved in the market research, which consisted on numerous interviews and contacts. The main architect of the software package SYS-SURV was also involved with the venture. A small team was formed for a pilot study to develop a benchmark model for an actual oil rig included experienced users of the original software.

Alic stated that the fact that the originator of the original base technology was heavily involved microwave oven application was an important part of the success (Alic et al., 1992). This is consistent with the theory of the great importance of tacit knowledge in technology transfer.

6.4.3 Marketing and Research

The respondent admitted that it was a very fortunate that initial contacts included Norwegian offshore oil industry. U.S. partners were much less willing to commit to any clear path because of the wake of the Deepwater Horizon legal issues. Continued investigation indicated how favorable the Norwegian market was. However, they continue to pursue US based offshore drilling industry.

Although it was not explicitly stated, it goes without saying that this marketing was difficult, but it was expected. The actions of the involved team members show considerable effort was invested over almost two years to get to the point at which they feel that they are ready to begin offering a product to the market.

6.4.4 Barriers

Export Regulations

Because of its long time experience in the defense industry, including the providing engineering services to foreign militaries, MID-SIZED was accustomed to carefully navigating export regulations and had the necessary licenses and approval. This was not the problem that one might anticipate based on the literature describing the complexity of export regulations that was described in Section 3.2.

Intellectual Property

MID-SIZED had a policy of maintaining intellectual property rights on all of their software. The development of the software was funded internally, and so there was no question about intellectual property rights. This apparently was not a significant barrier in this case as was speculated in Section 3.2 but indicates that the policy of maintaining intellectual property could pay off. However, in some instances, maintaining intellectual property in the form of patents can be quite costly and complicate contract negotiations for DoD business (*Intellectual Property: Navigating Through Commercial Waters*, 2001).

Industrial Culture and Communication

The main barrier was really the vocabulary and terminology used by two different industries. The fact that the company was a defense contractor was not the reason that this problem existed. This would be a problem for any cross-industry collaboration.

Overhead

Misplaced overhead was not perceived to be a significant factor in this instance. It was hypothesized that because the defense contractor's overhead is spent on services such as accounting and reporting that are not valuable to the commercial venture, that the development work would look like it was more expensive than it really was, as was discussed in Section 3.2.

6.5 Discussion

The market adjacency location in Shenhar's scale Figure 5-1 is a "Modified Product for an Industrial market" categorizing it as a "Moderate Risk venture." MID-SIZED found partnering with an established player in the industry invaluable. The venture was able to obtain enthusiastic corporate support and had the cooperation of experts in the technology and knowledge base in which they were working.

Unforeseen events and a little luck played an important part of the successes of this venture to date. Ironically, the fact that US based offshore companies were so affected by the Deepwater Horizon disaster made them hesitant to commit to partnering or switching tools. Fortunately, they had the luck to begin their marketing inquiry in the especially receptive Norwegian offshore industry.

Certain policies and experience made some of the expected DoD industry barriers to be less of a problem. They were careful to maintain intellectual property rights on all of their commercial software, so there was no question about the ownership of the technology.

The due diligence in investing the time and money to perform a pilot study on a real oil rig structure using tool provides an important proof for marketing. The effort in market research and learning about the industry over time as well as being careful to have conversations with regulators was no doubt also an important part of their success to date.

7 Conclusions

7.1 Evaluating the Thesis Statements

Four hypotheses were posed in this thesis. This section will evaluate the accuracy and level of support for each of them in this work.

7.1.1 Hypothesis 1: Legacy of DoD Business Processes and Culture

> ***The internal organizational management and culture borne of the incentives of the defense marketplace are obstacles to the defense contractors' commercial success.***

The literature is unequivocal in reporting that the incentives for the DoD contractor are often at complete odds with the free market. DoD contractors' core competencies such as negotiating DoD contracts, fulfilling DoD accounting and reporting requirements, and possessing marketing intelligence and personal relationships for DoD customers have no value for commercial business. It was proposed that sustaining the peculiar needs of the DoD customer would be a burden for an enterprise that had no need for them.

However, the defense contractor queried about his experience in pursuing a commercial market in Section 6 was not particularly discouraged by these barriers. Problems associated with export controls and intellectual property were not a problem because the organization had pro-actively dealt with these potential problems by a policy and experience in complying with these regulations. He believed that overhead "taxes" were a "secondary or tertiary" effect.

7.1.2 Hypothesis 2: Commercial Marketing Especially Difficult

> ***Marketing to the commercial customer will be very challenging for the defense contractor.***

Marketing to any new customer is difficult for any business. In terms of the engineering services industry, the barriers for entry are very high, no matter who is trying to enter the new area (Culbert, 2011). In relationship based businesses, including much of the defense business this requires a great deal of time and energy and face to face interactions with potential customers. In fact, the team pursuing the offshore market seemed quite willing to reach out to many different stakeholders in the offshore industry.

Relationship based business marketing may play into the experience and competencies of the defense contractor. However, consumer marketing is completely different, and Shenhar et al. discourages this move for the defense contractor (Shenhar et al., 1998).

An off-hand comment by the source used for this study indicates that the problems in marketing might spring from the fact that engineers are not effective at communicating the benefits of a product to their customer and tend to emphasize the features and techniques used, in which the customer is much less interested.

7.1.3 Hypothesis 3: DoD Sponsored Learning

> ***The defense contractor is the beneficiary of organizational learning obtained from the experience of performing research and development on advanced areas that would not be funded in the commercial realm.***

Certainly the DoD funds things that would never be funded by commercial firms. However, it is also in question how valuable the learning is for application to the commercial market. This is a highly variable factor.

The case study described in Section 6 did indicate a developed expertise in marine survivability was obtained from extensive work in combat ship survivability as well as having the benefit of validation data for their modeling tools.

7.1.4 Hypothesis 4: DoD Learning as a Competitive Advantage

> ***The defense contractor's learning derived from defense R&D experience can be turned into a competitive advantage in some cases.***

There is ample evidence that defense R&D has had enormous impact on the commercial markets. It is important to note that often the benefit of the commercial activity spurred by defense funded learning has not necessarily been conferred on the original developer of the technology for the DoD. However, in certain instances, such as the case studies mentioned in Section 4, and potentially the case study in Section 6, this is the case.

7.2 Preliminary Recommendations

The literature does yield some common recommendations for any company hoping to enter a new market. Analyzing this literature in conjunction with the documented DoD system and associated characteristics of the DoD contractor does provide a set of recommendations that are most relevant to the DoD contractor that wants to profitably convert defense technology.

7.2.1 Choosing Technology

Aside from the most important consideration of how competitive and appropriate the technology or component is for the market, "6.3" funding could be a good place to look initially for candidate technologies or components. The descriptions of R&D funding indicating the degree of specialization and technology readiness suggests that "6.3" funded technology may have the best balance of generality and technology readiness for non-military applications as was discussed in Section 3.1. Component level, technology that is part of a larger system may be also a good candidate. Other factors to consider are the sensitivity and classification level that of the systems with which the technology is associated, in terms of likely problems with "sensitivity" and being subject to export controls.

7.2.2 Choosing Markets

As was discussed in Section 5, consumer markets are the most challenging markets for the defense contractor and the Shenhar framework illustrated in Figure 5-1 or other market adjacency frameworks should be considered to ensure the market is similar enough minimize risk. Meyer and Poza also suggest that a new market should be a growing market (M. Meyer & Poza, 2009).

7.2.3 Forming Teams

In terms of corporate venturing, it is a common recommendation that there is an enthusiastic champion of the venture and that the upper management makes it clear that they support the venture (Alic et al., 1992; M. Meyer & Poza, 2009).

It is also recommended that for complex technologies, at least some of the key personnel involved in developing the technology or products in the original context are included in the new development project; they have tacit knowledge that will likely be indispensible (Alic et al., 1992).

7.2.4 Organizational and Cultural Factors

It is clear that many of the practices that are appropriate for working with a DoD customer are antithetical to the free market (Gansler, 2011). Old assumptions need to be questioned as much as possible to combat the tendencies to do things in the way one is accustomed with the DoD customer.

7.2.5 Marketing Approach

In any case, marketing is very difficult for new players in an industry and careful research and understanding of the market and the systems that influence it are essential (M. Meyer & Poza, 2009). It is probably good advice for any new player to devote special resources and time understanding the new market. Partnering with an existing player in the target industry should be seriously considered (Shenhar et al., 1998).

7.3 Future Work

As was mentioned in the discussion about the scope of this in Section 1, the true scope of defense conversion is an enormous one. The case study and main concern of this thesis represents a very small subset of all of the possible technologies and company types that are part of the defense industry and have potentially transferrable technologies or knowledge. In this study, defense conversion was limited to U.S. defense agencies and U.S. companies. Defense conversion in different countries with potentially different economies and societies may also be worth studying.

Certain recommendations, such as “6.3” type funded projects may provide the best mix of technological maturity and generality for defense conversion have no empirical proof. Conceivably this could be studied in a more systematic and empirical fashion via patent data and other publically available information. Also other specific characteristics of the technology and company types such as the target industry or the armed service branch that was originally served by the technology could be correlated to the rates of successful conversion.

Other efforts that are associated with defense conversion efforts such as the SBIR program could also be studied with perhaps more insight than the brief study of the Clinton TRP program yielded.

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