Accelerating Government R&D with Private Financing

by

Andy R. Corzine
Bachelor of Science, Electrical Engineering, University of Oklahoma, 1993
Master of Science, Electrical Engineering, University of Oklahoma, 1995

Submitted to the MIT Sloan School of Management
in Partial Fulfillment of the Requirements for the Degree of

Master of Business Administration

at the

Massachusetts Institute of Technology

June 2009

Signature of Author: ____________________
MIT Sloan School of Management
May 8, 2009

Certified by: ____________________
John Van Maanen, Thesis Advisor
Erwin H. Schell Professor of Organization Studies

Certified by: ____________________
Admiral William J. Fallon (USN Retired), Thesis Reader
Wilhelm Fellow, MIT Center for International Studies

Accepted by: ____________________
Stephen J. Sacca, Director
MIT Sloan Fellows Program in Innovation and Global Leadership

Accelerating Government R&D with Private Financing

by

Andy R. Corzine

Submitted to the MIT Sloan School of Management
on May 8, 2009
in Partial Fulfillment of the Requirements for the Degree of

Master of Business Administration

ABSTRACT

In this thesis, I argue that accelerating government research and development (R&D) with private financing could simultaneously improve the nation's warfighting readiness and economy. I submit that better utilization of United States Department of Defense (DoD) laboratories through alternative acquisition and development strategies can address current inefficiencies. I also suggest that public-private partnerships (PPPs) provide an opportunity to improve the nation's "technological innovation system."

For-profit industries have much different business and funding models than the DoD. Entrepreneurial enterprises for bringing new technologies to the market abound. The questions addressed here are two-fold: (1) How can the business models and funding techniques from the private sector be effectively applied to a government organization such as the Naval Weapons and Armaments Center of Excellence (NWA CoE); and (2) Can a generalized and repeatable process in this domain be identified?

I present a case for alternative financing for government R&D and I suggest that the NWA CoE is poised to experiment in this realm. I list many benefits of PPPs, but note that motivating Venture Capitalists or other non-traditional investors in government technology development efforts is a critical but challenging factor. I outline specific recommendations that NWA CoE management could implement in the near-term. With respect to a more generalized and repeatable process in the broader government domain, I suggest some long term recommendations.

John Van Maanen, Thesis Advisor
Erwin H. Schell Professor of Organization Studies

Admiral William J. Fallon (USN Retired), Thesis Reader
Wilhelm Fellow, MIT Center for International Studies

ACKNOWLEDGEMENTS

I would like to thank all those who have helped shape this thesis as an important part of my Sloan Fellows experience. I learned a lot from everyone I interviewed, many distinguished professors, and countless classmates.

Thanks go to Scott O'Neil (SF '92) and Mike Chan for helping to develop the ideas for this thesis. And Scott's continuing mentorship is especially appreciated.

I owe a special thanks to my thesis advisor, John Van Maanen. His positive encouragement kept me motivated and his thoughtful guidance turned my work into a much better thesis.

I would like to thank my distinguished reader, Admiral William Fallon. It is truly an honor to have him associated with this work.

Finally, I would like to acknowledge my wife and daughters, Jeanine, Taylor, and Callie. Thank you for your love and support.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

In this thesis, I argue that accelerating government research and development (R&D) with private financing could simultaneously improve the nation's warfighting readiness and economy. I believe the United States Department of Defense (DoD) current acquisition system is inefficient in managing evolving technology. Specifically, when an operational need is identified, there is a multiple-year-long process for formally developing and funding the requirement. Moreover, funding levels for R&D and science and technology (S&T) efforts are diminishing and, at best, current R&D efforts attempt to pull specific technologies perceived to meet today's requirements rather than facilitate technology innovation that can be pushed forward to address needs in the future. Additionally, there are a number of government laboratories with strong in-house facilities and first-rate technical subject matter expertise that are sub-optimized, partly because of a long established reluctance to be active in business development and marketing. The Naval Weapons and Armaments Center of Excellence (NWA CoE) at China Lake, CA is one such example. I submit that better utilization of such laboratories through alternative acquisition and development strategies is one prospect for addressing these inefficiencies. Further, I suggest that public-private partnerships (PPPs) provide an opportunity to improve the nation's "technological innovation system."

Several current practices must change to realize a meaningful improvement. A fundamental shift in culture and behavior is required. Much faster delivery of effective systems must become the focus of the research, development, and acquisition process. And as such, solutions developed outside the traditional acquisition system need to become accepted alternatives. Also, failure tolerance is too low to adequately vet potential solutions in the early formal acquisition cycle. A new risk model is required to improve the DoD's efficiency in developing and fielding emerging technologies. To accomplish these things, a cooperative approach with businesses must be adopted.

Innovative strategies are needed to deal with these issues. For-profit industries, especially start-ups, have much different business and funding models than the DoD. Entrepreneurial enterprises for bringing new technologies to the market abound. The questions addressed here are two-fold: (1) How can the business models and funding techniques from the private sector be effectively applied to a government organization such as the NWA CoE; and (2) Can a generalized and repeatable process in this domain be identified?

1.1 Innovative Partnerships as a Path Forward

The DoD acknowledges (by way of the Defense Acquisition University (DAU) website in March, 2009) that, historically, developing and fielding technologies has taken too long and cost too much. The DAU goes on to say that "it is no longer acceptable or affordable to take from ten to fifteen years to develop a new Defense system. A 21st century acquisition process must encourage efficiency, flexibility, creativity, and innovation in order to provide modern technology to the warfighter in a timely manner."

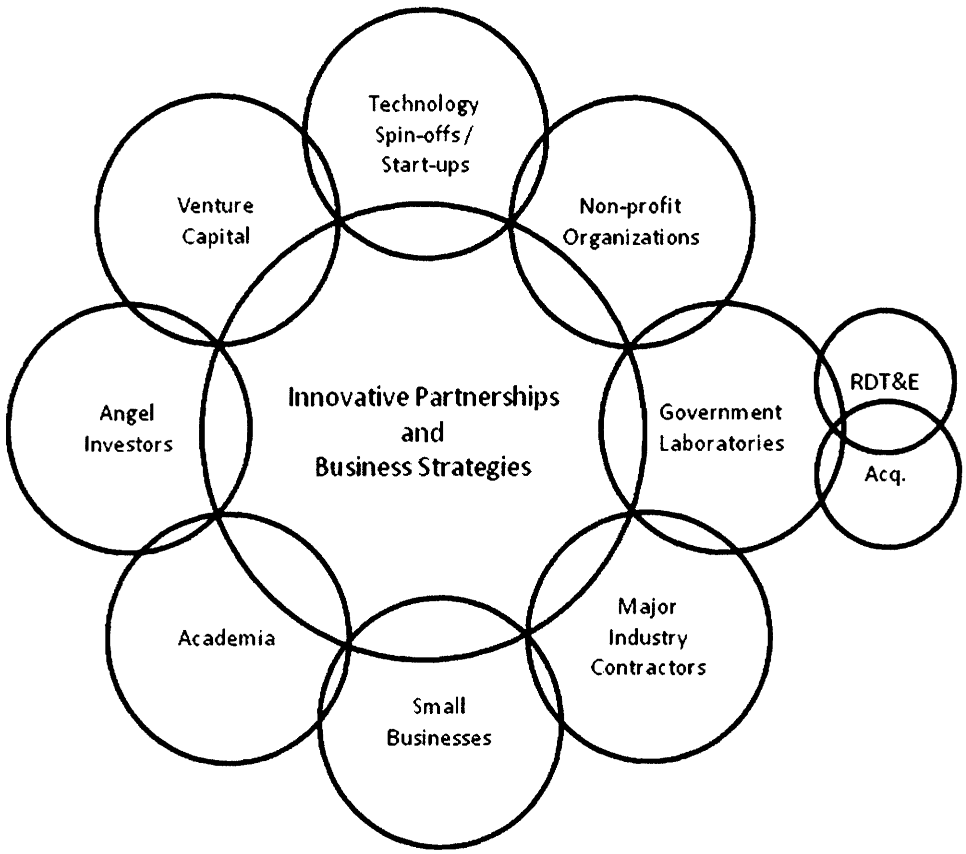
The DoD's response was to create the DoD 5000-based acquisition process (see https://akss.dau.mil/dapc/TUTORIAL/index.htm). The purpose of this process is given below:

> "The DoD 5000 series documents establish management policies with a simple and flexible approach for managing all DoD acquisition programs. They establish a flexible process that focuses on improved integration of requirements and acquisition processes, evolutionary acquisition strategies, disciplined technology development, interoperability, supportability, and affordability. The objective is to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price."

While well intentioned, delivering systems in something less than "ten to fifteen years" is hardly a stretch. It certainly will not result in anything remotely "modern" ending up in the hands of the warfighter. Contemporary DoD 5000 acquisition contracts are locked into "building to specifications" rather than a more modern and adaptive model of "building to market." It is worth noting that the DoD makes no mention of *cutting edge* technology or creative business arrangements to accelerate such development. It is in these areas that innovative partnerships can help.

Opportunities for technological alliances are plentiful (see Figure 1.1). The intent of Figure 1.1 is not to illustrate specific relationships among any particular set of organizations. Rather, the point is to show that a vast array of players with complementary resources have the opportunity to interact in a common technological space. Two or more organizations can be brought together through innovative partnerships and business strategies.

Figure 1.1. There exist a broad spectrum of potential technological alliances.



The traditional acquisition system allies the government with industry through a contractual relationship. Normally, a competitive bidding process results in a contract award to a major industry contractor with prime responsibility for a set of deliverables. The government laboratories are most often tapped for technical oversight of this work. As depicted in Figure 1.1, this description only represents a small fraction of the potential partners that could be leveraged for a more efficient total systems solution. Also, technical oversight primarily uses government laboratories in an acquisition (Acq.) role and neglects to exploit Research, Development, Test, and Evaluation (RDT&E) capabilities. Further, the current roles and incentives contracted and negotiated tend to put prime contractors and government laboratories at odds rather than fostering a partnership.

One of the principal motivations for participating in any technological alliance is the opportunity to realize efficiencies with respect to time and cost. That is, combining the right resources in the right fashion can help deliver products faster and cheaper. In addition, studies indicate that companies concentrating on R&D cooperation have significantly higher rates of profit (Hagedoorn and Schakenraad, 1994). That is, the use made of strategic technology alliances appears to improve corporate performance. I do not believe that PPPs in the defense industry are different in this regard.

Partnerships between DoD government laboratories and the private sector need not be predicated solely on a contractual relationship. These partnerships are more productive when they are rooted in trust and a common desire to work together. Some assumptions underlie this view. First, partners must be organizationally and politically compatible and hold complementary resources. A unique set of capabilities must be blended to meet an equally unique set of needs. Second, each organization must understand the mutual benefits of the partnership and the value each partner brings and receives. Third, a cooperative venture must be one in which risk and information are shared transparently. Each party must be motivated to use the partnership for the greater good. When these assumptions hold, the whole can be greater than the sum of its parts.

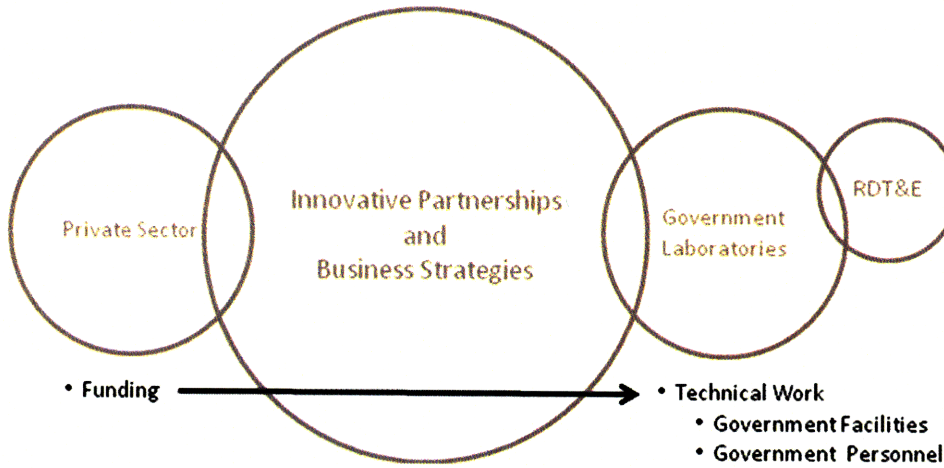
Alliances between government laboratories and defense industry contractors are normally interested in technologies driven by military missions and requirements. However, targeting "dual-use" technologies opens the door to other applications and business arrangements. By "dual-use," I mean that a given technology has application in two fields of use: the military and the commercial market. Any such partnership must also meet a minimum level of standards with respect to safety and security. Legality and ethics matter too in the sense that the interests of the country must always come first. It is important for these and other reasons to establish the right partnerships.

Studies have shown that certain combinations of technical roles enhance the effectiveness of public-private partnerships from the point of view of the organizations participating in them (Saavedra and Bozeman, 2004). Where companies and federal laboratory technical roles are similar, yet distinct, a positive effect on cooperative projects has been measured. There can be different mixes of technical roles, but the company's knowledge of the marketplace has proven to be essential to the enhanced effectiveness of the PPP. But, any partnership in the high-tech world of defense must keep in mind Colvard's (2008, p. 1) observation: "The first requisite of government is to be effective and secondly to be efficient. In the case of defense of the country, financial efficiency is important – but effectiveness – that is critical."

1.2 Possible Public-Private Partnerships for China Lake

Though a subset of the numerous possible alliances in the area of defense-related technologies, government-industry partnerships represent a very broad set of opportunities. I concentrate here on a particular category of partnerships relevant to the NWA CoE at China Lake, such that follow-on pilot studies can be reasonably performed. The NWA CoE at China Lake represents one of the increasingly rare government laboratories with significant in-house technical expertise. It also enjoys the benefit of leadership willing to experiment. The focus of this thesis is on innovative partnerships that involve funding from the private sector flowing in the direction of government laboratories for RDT&E technology work performed inside government facilities by government personnel (see Figure 1.2).

Figure 1.2. Possible Public-Private Partnerships.



Note that "Private Sector" in Figure 1.2 could be one or a combination of several of the entities represented in Figure 1.1. The notion illustrated in Figure 1.2 is an example of the type of public-private partnership I explore in this thesis. There is a range of possible partnerships with different combinations of resources. But the focus on technology development is what makes this effort somewhat unique. The idea is to proactively pursue such partnerships for the purpose of accelerating government R&D. A direct benefit to be discussed is the opportunity to use such a partnership to actively take advantage of the government's technical workforce.

It is fair to ask whether a government RDT&E lab can succeed in entrepreneurial ventures. It is also reasonable to consider the factors that have made the Massachusetts Institute of Technology (MIT) such a successful example of partnerships in the academic-business realm and evaluate whether such factors can translate into a broader environment such as a government lab. O'Shea, Allen, and Morse (2005) identified these key factors when accounting for MIT's success:

- Strong science and engineering resource base,

- Top technical experts,
- A culture that encourages entrepreneurship,
- Supporting organizational mechanisms and policies,
- Geographical context, and
- Flow of industry funds.

Of the factors on this MIT list, China Lake is well known for the first three elements. It will be shown that federal policies have changed and now facilitate entrepreneurial activities. Geographical context will always be a difficult hurdle for China Lake but will not be addressed here. Finally, the flow of industry funds is the critical feature of the ideas put forth in this thesis.

I explore the use of private funds in order to propose potential PPPs that could be established in a pilot program at the Naval Weapons and Armaments Center of Excellence at China Lake, CA. A variety of military customers come to this storied lab complex for R&D for needed technologies. Often, by the time Congress authorizes and appropriates funding, the requirement has become overcome by events.

As an alternative, consider a Venture Capital (VC) mechanism directly funding the government lab's R&D efforts. A Cooperative Research and Development Agreement (CRADA) or other formal collaboration agreement could be established with an entrepreneurial business in the private sector. The private business would focus on taking the technology developed by the government to market in the commercial sector. The process could flow in the following manner. A Not-for-Profit (NFP) organization is created to support the government's marketing of its technology to VCs. A VC would fund the government as an investment in technology through a Non-standard Agreement with the NFP. The NFP could also aggregate multiple VCs to reduce risk. China Lake scientists and engineers would develop a product. For instance, near-instantaneously-changing optics for soldiers transiting from a bright urban street into a dark hideout is a current effort. The military use would center on the application of these optics to standard issue goggles. A start-up entrepreneur could then develop sunglasses or even windshields in the commercial market in, for example, the trucking industry. This new market is the source of financial return on investment for the VC. This is a win-win-win scenario. The government lab benefits from having a new, faster, more flexible funding source. The technology that is developed by existing government infrastructure and expertise is a direct benefit to the new commercial business. When the new product is marketed and sold in the commercial sector, the VC firm benefits.

1.3 Making the Case for Accelerating Government R&D with Private Financing

The core idea in this thesis is to find a way to marry the entrepreneurial spirit and business knowledge in the area of funding technology programs (such as those at MIT) with government laboratories with high levels of technical expertise. This process is needed for three reasons: (1) The current acquisition process is too slow; (2) China Lake has the capacity and motivation to contribute to a more efficient system if an appropriate mechanism can be found; and (3) Private financing provides an alternate means for developing technologies that might well uncover an untapped business opportunity for investors. A specific pilot could be developed and implemented at China Lake in the near term as a gauge for broader government implementation.

The subsequent chapters will develop these ideas in the following way. Chapter 2 outlines how I went about this research. Chapter 3 provides an overview of general management strategies and how they relate to the partnership ideas in this thesis. Chapter 4 discusses PPPs in detail, including descriptions and consequences of their evolution, incentives for the partners, and recent experiments in this domain. Chapter 5 briefly outlines the history, organizational culture, and capabilities of the NWA CoE at China Lake. A collection of specific recommendations for testing PPPs at China Lake is provided in Chapter 6, followed by general conclusions.

CHAPTER 2: METHODOLOGY

This thesis was prompted by a desire to apply the academic frameworks and business perspectives discovered while I was a student in the MIT Sloan Fellows Program in Innovation and Global Leadership to a relevant problem drawn from my professional environment in government. This chapter provides a description of the process I followed to identify the specific problem to be studied, to gather supporting information, and to use various resources to help craft recommendations to my organization for follow-on actions.

2.1 Problem Identification

The idea of proposing an alternative approach to acquisition in the context of weapons systems RDT&E came from a general frustration working within the existing process. I have spent nearly 20 years working with and around talented scientists and engineers that have the potential to develop technologies in support of pressing military needs but are too often unable to adequately contribute to a solution due to limited funds and unnecessary bureaucracy. Spending a year at the MIT Sloan School of Management afforded the opportunity to look at the problem through a different lens. In order to stand a reasonable chance of implementing any new ideas that may come from further research, I decided it would be best to focus on a specific problem within the existing system. Therefore, I discussed the broad plan with senior leadership at the NWA CoE to identify some of the important issues at China Lake that could perhaps be addressed through research and a follow-on pilot study. The need to secure alternate funding sources for in-house technology development that could positively support urgent warfighter requirements was repeatedly discussed.

A burgeoning effort that quickly emerged from these conversations was the China Lake High-Tech Consortium (CLHTC). In discussions with Bill Hogan, he noted that the original mission conceived for this consortium was to "create opportunities for state-of-the-art, high technology products, solutions, programs and services for both the warfighter and the global marketplace, based on the timeline required by the customer and driven by the rapid pace of technology." This concept is quite broad in nature and would involve a collection of interested parties such as those illustrated in Figure 1.1. I wanted to further focus this thesis and decided to narrow the CLHTC concept down to a minimum set of players required to address the top issues at China Lake. The specific problem identified for further research was how to accelerate government R&D with non-traditional (i.e. outside the formal government acquisition process) financing.

2.2 Approaches for Gathering Information

Two approaches were used to gather information and postulate a path forward. The first approach was a literature review undertaken to identify relevant background material. The second approach was to conduct a series of informal interviews (n = 24) to get feedback on initial ideas and to gather inputs on how to shape them.

2.2.1 Literature Review

I wanted to review the general strategy literature to see if there were any useful frameworks that could be reasonably applied to the unique partnerships proposed in this thesis. This process drew heavily upon the materials presented in four courses in the MIT Sloan Fellows Program: (1) *Strategic Management*, taught by Arnoldo Hax; (2) *Managing Technological Innovation*, taught by Alan MacCormack; (3) *Managing New Ventures*, taught by Edward Roberts; and (4) *Creation and Exploitation of Innovation*, taught by James Utterback. Several of the ideas and references put forth in these courses were reviewed and are summarized in the following chapters. The material was examined for insights that might help with the design and implementation of entrepreneurial practices in a pilot program at the NWA CoE.

Searching for documentation on public-private partnerships was also a part of my literature review. I wanted to understand how PPPs have evolved and looked for practical applications and examples of PPPs. There is a good deal of published literature on the topic of public-private partnerships. Nearly all the books and articles reviewed focused on what could be considered "traditional" PPPs, those PPPs designed as a mechanism for the government to subsidize a particular activity in the private sector. This literature provides for few examples of PPPs utilized for bringing private funding together for technology development activities performed, in part or in whole, inside the government. At the same time, an examination of the incentives associated with traditional PPPs led to the question: "Why can't these same incentives apply if the complementary resources are turned around?" In fact, a deeper search into journals and online resources uncovered a number of activities similar to what I think could be accomplished in government R&D laboratories. These activities have been made possible by certain legislative changes occurring in the past few decades.

I expanded the literature search through a forward citation process starting with these documented activities. Much of the literature dealing with R&D in the government deals with traditional acquisition programs and was viewed therefore as not pertinent to the thesis. Traditional acquisition programs are those concerning government procurement of a complete weapon system from a defense contractor. Little R&D is actually performed within the government in traditional acquisition programs. I wanted to examine non-traditional, innovative approaches to science and technology development in government labs and my literature search was oriented toward discovering examples of such approaches.

2.2.2 Informal Interviews

I considered the opportunity to conduct informal interviews essential for providing direction for this research. I wanted to talk with people that had relevant experience with the ideas and new practices associated with the topic of this thesis. In particular, I wished to interview people from a wide variety of organizations that could offer diverse perspectives on bringing entrepreneurial strategies to the government. (See Appendix A for a list of interviewees). Those interviewed represent Navy, Air Force, Army, DoD and Joint-Service civilians, partnership intermediaries (PIs), academics, small businesses, business consultants, and retired military officers. Seventeen interviews were conducted in person; seven were conducted over the phone. The data gathered in these sessions were used to refine my ideas and test possible recommendations.

Interview data from government laboratories was helpful because it reveals what has been done to date and where potential opportunities lie with respect to innovative strategies and programs to accelerate R&D in the government. As I will show, there are mechanisms in place at DoD laboratories that facilitate such moves. Discussions at China Lake were particularly important for establishing the NWA CoE's readiness for implementing change in the form of a follow-on pilot study.

2.3 Forming the Core Proposal

As mentioned, the general strategy and innovation literature was examined to help formulate general recommendations for moving my ideas forward at China Lake. Interview data suggested specific actions that could be taken. Additionally, I drew on my personal experience within the government and at China Lake. The methodology was largely iterative. For example, interviews provided anecdotal contributions on many related topics and also pointed me to additional literature resources. New information in turn led to new ideas for interview sources. I compiled notes throughout the process and used this information to adapt my concepts and incorporate them in subsequent discussions. Reviewing the information in total and blending ideas into a cohesive concept that I felt could be practically implemented at China Lake led to final recommendations.

CHAPTER 3: GENERAL STRATEGY REVIEW

This chapter provides a short synopsis of frameworks and strategies that are employed in entrepreneurial enterprises in private industry. The purpose of this review is to examine the applicability of several strategic approaches and concepts to the core ideas of this thesis. This review was prompted by observations made by business consultants I interviewed on the strategic challenges faced in China Lake. Identifying opportunities to bring technological and business innovation to China Lake's partnership efforts in the near term is the immediate concern. Government adaptation of private industry "best practices" is the broad goal.

Innovative business approaches within government are needed to both finance the development of cutting edge technologies and bring them to the market. Some classical frameworks can be applied to a government establishment like the NWA CoE at China Lake to help guide the organization. I identify them below and also review several strategies employed by entrepreneurial ventures that might also be applied in the government environment.

3.1 Framework Review to Support Business Case

Business innovation has been discussed by managerial and organizational scholars at length and new ideas and strategies continue to emerge. Porter's "Five Forces" have long been the standard for evaluating the attractiveness of an industry and Porter's "Value Chain" is commonly used by organizational strategists to further assess the firm's competitive position within that industry (Porter, 1985). A popular alternative approach is Peteraf's (1993) "Resource-Based View." More recently, the "Delta Model" has suggested focusing on customers rather than competition and has established a framework for doing so (Hax and Wilde, 2001). I look at these four strategic frameworks to see if a business case can be made for my PPP concepts.

3.1.1 Porter's Five Forces

Porter's Five Forces of a competitive industry are: (1) the threat of new entrants; (2) the threat of substitutes; (3) the bargaining power of suppliers; (4) the bargaining power of customers; and (5) the competitive rivalry in the industry. With respect to developing technologies with commercial potential, government labs face a very high threat of new entrants. The vast majority of technological innovations come from outside the government. On the other hand, the threat of substitutes is relatively low, considering the fact that targeted technologies are driven by military requirements. The bargaining power of suppliers is somewhat ambiguous in this context since new technologies are often being invented and developed on site in government labs. This may be an issue for commercialization but not for invention and development. The bargaining power of customers is high, particularly if venture capital firms are looked on as customers for the government. Investors demand a high return on risky ventures. The competitive rivalry in the VC industry is intense. The number of competitors is large and the competition for funding, particularly in times of financial hard times, is high. The Five Forces, in sum, suggest that technology development in the government is not an attractive proposition. However, niche opportunities may look more attractive, particularly if some of the risks can be mitigated through innovative partnerships.

3.1.2 Porter's Value Chain

Porter's Value Chain can be broken into primary activities (logistics, operations/production, marketing, and sales) and support activities (infrastructure, human resource management, technology development, and procurement). A cursory value chain analysis shows that the government is typically weak in all the primary activities, with the possible exception of logistics which, in the technology cases of interest here, is not a critical matter. The government is better at the support activities, particularly with respect to infrastructure and technology development. As a complement, successful businesses in the private sector excel at the primary activities and can leverage government infrastructure and technologies for further efficiencies. This simplified breakdown strengthens the case for partnership.

3.1.3 The Resource-Based View

The Resource-Based View of the firm looks to four factors for determining competitive advantage through a unique competency: (1) the ability to create value; (2) the ability to sustain value; (3) the ability to appropriate value; and (4) the ability to do so at a cost less than the value produced. The government has a relatively long list of patents and can certainly make a claim to a unique competency. Targeting those technologies that appear to have potential for dual-use applications (i.e. military and commercial use) can help create value. Value can be sustained (at least for some period) through licensing and other intellectual property (IP) agreements. Appropriability is more problematic. For starters, creating value through partnerships will inevitably (and rightly) split any realized returns. And, in some circumstances, returns to the government may be in the form of in-kind contributions as opposed to cash payments. Finally, cost will be a challenge. Overhead and bureaucracy must be minimized in order to make a practical business case.

3.1.4 The Delta Model

The strategic dimensions of the Delta Model are customer segmentation, existing and desired competencies, the organization's mission, the strategic agenda, and monitoring the strategy with metrics. The Delta Model's focus is on "customer bonding" and stresses measuring performance. These aspects of the Delta Model approach seemed to be well received by the individuals I interviewed. For this reason, I look at the components of the Delta Model in somewhat more detail than I did for the previous strategic models.

Customer segmentation can be performed along many dimensions. For a DoD laboratory, I suggest that it is appropriate to recognize traditional acquisition program customers and attempt to identify additional customers through customer segmentation according to different degrees of value added. This strategy emphasizes the addition of collaborators and investors to the government's customer base. This is desirable not only because it fits the structure of my partnership model but also opens the possibility of "total solution seeking" customers. This is a description Hax uses to describe customers who are "locked-in" to a particularly valuable capability offered by an organization or alliance.

The next step in applying the Delta Model is to perform an assessment of the current competencies of the organization and evaluate what opportunities there are for increasing competencies in desired areas. The Delta Model considers eight strategic options for government organizations: (1) channels of delivery; (2) system support; (3) intellectual value; (4) administrative efficiency; (5) differentiation; (6) attraction and development of the customer; (7) knowledge transfer; and (8) total breadth of the offering.

"Channels of delivery" looks for significant barriers that make it difficult for other organizations to take away customers. A government lab may have such a barrier for traditional acquisition customers (e.g. Center of Excellence designation) but can only make that claim in an open market if it maintains distinctive expertise or infrastructure.

The "system support" option requires an organization to own an exclusive network for connecting with customers. This option is not actually helpful if an organization is trying to make it easier to do business and share technologies.

"Intellectual value" is technical expertise and is quite high in some government labs. The many patents coming out of government labs are tangible examples.

"Administrative efficiency" is self-explanatory. The government is typically weak in this area, but can look to partners to fill this role.

"Differentiation" refers to providing a unique product or service. Government labs have unique competencies, ranges, facilities, and equipment.

The intent of "attraction and development of the customer" is for an organization to provide exceptional customer satisfaction and retention. This capability was of interest to many of those I interviewed. Several people suggested that China Lake (and the government in general) is not adequately responsive to customers. Perhaps the government can leverage partnership intermediaries' relationships to develop new customers.

The "knowledge transfer" aspect of the Delta Model refers to the *transfer* of knowledge – across the segments of an organization and, more importantly, from the organization to customers. Dombrowski and Gholz (2006, p. 121) observed: "Real questions persist about how much proprietary data the for-profit contractors are willing to share with one another." It is perhaps easier to share information between the government and one or more industry partners than it is for multiple partners from the private sector to share information.

Finally, "total breadth of the offering" refers to the ability of an organization to anticipate and satisfy all relevant customer requirements. Technology development efforts in small businesses and government labs are typically focused on specific technologies. Once again, it is advisable to find partners with complementary skills.

The point of defining an organization's mission in terms of the Delta Model is to highlight the differences between the current and future scope of products / services, customers, end users, distribution channels, complementors, and geography. Given these differences, an organization can identify the unique competencies it must develop or acquire. In the case of bringing a product or technology to market, the government must change scope with respect to customers, complementors, and distribution. Unless the military is the primary target for the commercialized product, the end users will change as well. It is difficult to make a judgment on geographical scope. With such a drastic change in overall scope, the government will need to "acquire" several competencies. One way to accomplish that is via partnerships.

The last two dimensions of the Delta Model, the strategic agenda and monitoring the strategy with metrics, are part of a continuous adjustment cycle an organization must follow as it tries to implement its strategy based on past results. This feedback loop includes specific details regarding organizational structure, business processes, performance, and culture and all must adjust over time since strategy is continually shifting. I submit that the government should follow standard industry procedures in these areas. Those interviewed suggested the possible use of the Balanced Scorecard for measuring and comparing government labs with "best practices" in industry. The Balanced Scorecard suggests looking at four areas as a measurement tool for gauging performance: financial performance, organizational learning, business processes, and customer perspective. These criteria are consistent with the Delta Model approach.

3.2 Strategies Employed by Entrepreneurial Ventures

Much work has been done in the area of managing technological innovation. Important differences emerge across several dimensions: Is the technology an incremental improvement or a radical innovation? How mature is the technology? Is this a new venture or a well-established organization? Do the firm's structure and processes support technological innovation? To be sure, many elements must be evaluated to determine an appropriate technological strategy.

Managing technological innovation is a complex proposition, perhaps even more difficult within the confines of the federal government. A quick look at some of the practices associated with successful innovative firms is in order. Four practices were highlighted in MacCormack's *Managing Technological Innovation* course: (1) Design and follow a development process; (2) Involve senior leaders early; (3) Balance experience with experimentation and learning; and (4) Actively network and identify opportunities for collaboration. I am especially interested in those practices that could carry over to public-private partnerships.

Cusumano (2004) suggests eight essential elements for a successful software startup. I believe these elements are applicable to ventures across sectors:

1. A strong management team,
2. An attractive market,

3. A compelling new product, service, or hybrid solution,
4. Strong evidence of customer interest,
5. A plan to overcome the "credibility gap,"
6. A business model showing early growth and profit potential,
7. Flexibility in strategy and product offerings, and
8. The potential for a large payoff to investors.

The final issue to be considered in this strategy review chapter is how a large, established organization (like a government lab) can leverage its own resources and also behave more like a smaller, entrepreneurial business. The ability of a company to use its internal R&D to gain access to resources that are normally outside its reach is an element Roberts (2004) found vital for successful technology management. For example, the government could look to private investors as a funding source normally beyond its reach. Roberts and Berry (1985) propose that entry strategy is another success factor when starting a venture. I believe this factor can be applied in a government laboratory setting. They suggest that business strategy can follow a "familiarity matrix" based on the familiarity the organization has with the technology and with the market. Further, they comment that using a VC-backed Joint Venture is appropriate for new technologies in new markets due to the ability to exploit synergies and distribute risk across partners while opening the door to untapped markets. Roberts and Liu (2001) propose that an important factor is the "technology life cycle." They follow Utterback's (1994) model which includes a Fluid Phase, Transitional Phase, and Mature Phase, but add a Discontinuities Phase. Roberts' and Liu's (2001, p. 34) point is to "use partnerships that are targeted to a particular technology life cycle stage." And, while the need to ally may be greatest during the Mature Phase, I believe that unique PPP concepts may require partnerships at much earlier phases with non-traditional partners. This may be particularly true when trying to develop radical jumps in technology, rather than incremental changes.

CHAPTER 4: PUBLIC-PRIVATE PARTNERSHIPS

> "R&D leads to innovation and innovation to technological change. Technological change, in turn, is the primary driver of economic growth. Public-private partnerships leverage the efficiency of R&D and are thus a critical aspect of a nation's innovation system."
>
> (Link, 2006, p. 1)

This chapter provides a sketch of the existing R&D system in the DoD and how public-private partnerships have evolved. Some of my discoveries via the interview process were how R&D and the acquisition process in the government has changed over the years and the consequences that have come from the decreased level of in-house scientific expertise in government labs. The need to redevelop and maintain the government's technical workforce thus becomes a complement to my primary goal of accelerating government R&D through alternate financing. Examples of successful public-private partnerships for other purposes provide the motivation to use PPPs to meet these goals.

The acquisition process and the role of government R&D has been a subject of much discussion for at least several decades (Peck, 1962; Fox, 1974; Burt, 1975). As noted, the DoD 5000 process was instituted in an attempt to improve the acquisition system. This process attempts to deliver capability improvements faster, reduce total ownership costs, and address interoperability, supportability, and affordability. As this emerges, there is a continuing need to bring work in-house, identify external sponsors, and accelerate the process. The Secretary of Defense (SECDEF), Robert Gates, was quoted in *The New York Times* (September 30, 2008) as saying "I have expressed frustration over the defense bureaucracy's priorities and lack of urgency. When it comes to procurement, for the better part of five decades, the trend has gone towards lower numbers as technology gains made each system more capable. In recent years these platforms have grown ever more baroque, ever more costly, are taking longer to build and are being fielded in ever dwindling quantities."

4.1 Evolution of PPPs

Standard contracts promoting fair and open competition remain the primary mechanism through which private industry interacts with the federal government. Contractual procedures are heavily regulated by the Federal Acquisition Regulation (FAR) and the Defense Federal Acquisition Regulation Supplement (DFARS). As mentioned previously, government-industry partnerships need not only be predicated upon a contractual relationship. Since 1980, legislation has slowly but continuously been enacted to promote alternative partnerships. The primary motivation for most of this legislation has been to achieve benefits associated with technology transfer. This progression has been well documented (http://www.acq.osd.mil/ott/techtransit/laws.htm; Chang et al, 1999; Apen et al, 1994). A few of the changes with direct implications for this thesis are highlighted below.

> *Stevenson-Wydler Technology Innovation Act of 1980* (Public Law (PL) 96-480) [Title 15 United States Code (USC) Sections 3701-3714]. This act requires federal labs to take an active role in technical cooperation with industry through information dissemination and the creation of Offices of Research and Technology Application (ORTA) in the major laboratories.
>
> *Bayh-Dole Act of 1980* (PL 96-517). This act provides intellectual property rights protection for invention descriptions from public dissemination and

the Freedom of Information Act. The act also allows government owned and operated laboratories to grant exclusive licenses to patents.

Federal Technology Transfer Act of 1986 (PL 99-502). This act creates a charter for the Federal Laboratory Consortium (FLC) for technology transfer and provides a funding mechanism for that organization to carry out its work. It also provides local authority for labs to enter into CRADAs and negotiate licensing. This allows laboratories to make advance agreements with large and small companies on title and license to inventions resulting from CRADAs with government laboratories. The legislation also provides for exchanging government laboratory personnel, services, and equipment with their research partners and allows current and former federal employees to participate in commercial development, given there is no conflict of interest.

Defense Authorization Act for Fiscal Year (FY) 1991 (PL 101-510). This act establishes model programs for national defense laboratories to demonstrate successful relationships between federal government, state and local governments, and small businesses. It also provides for a federal laboratory to enter into a contract or memorandum of understanding with a partnership intermediary to perform services related to cooperative or joint activities with small businesses. [Title 15 USC Section 3715].

Cooperative Agreements – 1991 [Title 10 USC Section 2358]. This is an extension to the authority provided to the Defense Advanced Research Projects Agency (DARPA) in 1989 that allows DoD laboratories to use Cooperative Agreements (CAs) for basic, advanced, and applied research and development projects of interest to the DoD. This mechanism allows cost sharing.

Other Transactions – 1991 [Title 10 USC Section 2371]. This is an extension to the authority provided to DARPA in 1989 that allows DoD laboratories to negotiate provisions for transactions other than contracts and cooperative agreements that are mutually agreeable to the government and other parties. Other Transactions (OT) are not governed by the FAR or DFARS and allow cost sharing, with guidance that the government share not exceed the sum of all other contributions whenever practical.

Defense Authorization Act for FY 1993 (PL 102-484). This act establishes the DoD Office of Technology Transition (OTT).

National Technology Transfer and Advancement Act of 1995 (PL 104-113). This act is an attempt to accelerate commercialization of inventions developed through collaborative agreements between the federal government and industry. Further, it provides incentives to encourage creativity in developing new technologies with dual use potential.

Defense Authorization Act for FY 1997 (PL 104-201). This act extends section 845, which had been added to Title 10 USC Section 2371 in 1993 allowing DARPA to use OTs for prototype projects even in cases where standard contracts could be used. This legislation provides further flexibility to DoD laboratories by broadly defining prototyping to include subsystems, components, and technologies. This facilitates innovative business arrangements among the government, prime defense contractors, and non-traditional industry players.

Defense Authorization Act for FY 2002 (PL 107-107). This act allows the government's commercial customers to make claims for damages caused by the government's poor contract performance, just as with other commercial vendors of goods and services. This act puts the governmental sales of goods and services on equal ground with commercial firms by holding government agencies accountable for cost, schedule, and performance.

4.2 Impact of Legislative Changes to the DoD

In a report to the Office of Technology Policy (2002), the DoD notes that its three service branches maintain laboratories with a wide range of state-of-the-art human and physical resources, including expertise in a number of technical areas, as well as unique, world-class facilities and equipment. Also, the DoD differs from all of the other federal agencies in that its mission-related responsibilities are particularly extensive, such as: space missions, medical research, land management, health care, telecommunications, weaponry, national security, transportation, environmental management, and training. While the primary purpose of DoD laboratory R&D is to meet military requirements, technology transfer has been mandated by Congress to be a goal as well. In this light, it is instructive to examine some of the metrics used to assess laboratory performance in the 2002 report to the Office of Technology Policy. DoD labs are assessed annually whether or not:

- One or more technologies transferred under a CRADA became available for consumer / commercial use
- One or more industry partnerships yielded technologies that strengthen the lab's capabilities
- One or more licensed technologies became available for consumer / commercial use
- One or more licensees produced a licensed product / process that strengthen the lab's capabilities

- They have income from invention licenses
- They have income from running royalties

The metrics show some of the potential benefits of public-private partnerships. Not only do PPPs benefit government labs, they may also benefit the industry partners and the greater commercial marketplace. So while the government is not specifically set up to efficiently support global R&D, a basic framework is in place to facilitate some contributions in that respect.

4.3 The Need for In-house Technical Competence

Since the end of the Cold War, government downsizing and contracting out technical work has resulted in a reduced public technical workforce. This has, in turn, led to a smaller amount of technological innovation coming out of DoD labs. The downsizing and outsourcing has raised a host of additional concerns. Colvard (2008, p. 1) summarizes these concerns as follows:

> "In the technically complex world of defense, the inherently governmental functions are not simply the policy decisions of force structure and missions. They include three key elements. Government employees must be able to understand the military problems in technical terms, know someone potentially capable of solving them, and be able to recognize valid technical solutions when they are achieved. To do these three things, government employees must be technically capable. Technical capability is achieved through an experiential – not abstract process. This requires that the government support the conduct of research and development in its internal laboratories and centers sufficient for the employees to achieve a level of first principles understanding of the technology, which may be used to solve military

problems. The Service program managers who leverage it to deal with the private sector for engineering development capacity can then use this technical capability to support acquisition decisions. The intellectual residuals that accrue from the internal technical work remain with the government. Thus, the government should sustain internal technical effort, sufficient to retain capability, and go to industry for capacity."

The need to redevelop in-house technical capabilities has the attention of senior leaders in the DoD. On April 4, 2008, the Deputy Secretary of Defense (DEPSECDEF) issued a memorandum in reference to the recently passed PL 110-181 which added section 2463 to Title 10 USC. This memorandum focused on using DoD civilian employees to perform new functions or functions that are performed by contractors. Acknowledging that the legislation would come under scrutiny, the memo (p. 2) advises that PL 110-181 must be "used to reduce workforce costs, realign inherently governmental and exempt functions for government performance, and manage more efficiently and effectively." On October 10, 2008, the Secretary of the Navy (SECNAV) followed suit with a memorandum (p. 1) that clearly spelled out the need to take advantage of the new legislation. It reads in part:

"In order to acquire the Department of the Navy's (DON) platforms and weapons systems in a responsible manner, it is imperative the DON maintain technical domain expertise at all levels of the acquisition infrastructure. The foundation of in-house expertise is the source of independent technical judgment in the acquisition process. A strong technical infrastructure is also critical to the Navy being its own Lead Systems Integrator (LSI).

> The Systems Commands (SYSCOMs), Office of Naval Research (ONR), Warfare Centers, and Naval Research Lab (NRL) are the principal sources of in-house technical support. Their technical population, however, was significantly reduced in recent years, as well as the fraction of their workload that is Research, Development, Test and Evaluation (RDT&E). This combination of personnel reductions and reduced RDT&E has seriously eroded the Department's domain knowledge and produced an over-reliance on contractors to perform core in-house technical functions. This environment has led to outsourcing of "hands-on" work that is needed in-house, to acquire the Nation's best science and engineering talent and to equip them to meet the challenges of the future Navy. In short, it interferes with the Department's ability to control its own technical destiny."

In his December 2008 memorandum "Strategy to Balance Acquisition In-House and Contractor Support Capabilities," SECNAV's Principle Civilian Deputy referred to the October memo in describing the way forward. This "way forward" (p. 1) includes building up critical technical functions at Navy Working Capital Fund sites such as China Lake.

> "Emphasis should be on the acquisition workforce career fields that are stressing the execution of your programs: most likely in...Systems Planning, Research, Development, and Engineering (SPRDE). [DON Fiscal Policy, Acquisition Program Management / Program Support, July 7, 2008] should be considered when determining the appropriate resources for...technical / engineering support functions from Navy Working Capital Fund."

4.4 Incentives for Participating in a PPP

As with any partnerships, adequate incentives must exist for each partner to participate. A careful examination of incentives for participating in a PPP is warranted to assess the feasibility of a privately-financed, government technology development effort. I highlight incentives for the government, partnership intermediaries, small businesses, and investors. These lists and descriptions of incentives are the result of my personal analysis of the literature I reviewed and the interviews I conducted.

4.4.1 Government Incentives

The government could engage in a privately-financed technology partnership for many reasons. Consider the following:

- Deliver effective products to the warfighter faster
- Maintain military advantage through technological superiority
- Decrease programmatic risk through increasing technology readiness level
- Decrease reputation risk by not failing alone (this translates into a more acceptable failure model for advancing technology)
- Align requirements and capabilities
- Access to funding outside the normal acquisition model
- Develop in-house technical competence
- Aids in retention and hiring of cross-generational scientific workforce
- Improve visibility and reputation in global community
- Gain insights into commercial advances of cutting-edge and disruptive technologies
- Increase value of existing assets

- Leverage private sector management expertise and business / market connections and awareness
- Learn from entrepreneurial approaches, e.g. innovation processes
- Leverage external capabilities to improve the breath, depth, and flexibility of technical knowledge for creating more challenging solutions without overburdening the internal workforce
- Fulfill mission to transfer technology to the commercial sector
- Stimulate the economy through job creation and market development

4.4.2 Partnership Intermediary Incentives

The Partnership Intermediary's motivation is straightforward. The PI is under contract or has signed an MOU specifically to perform these functions as an honest broker. That is, they are being paid to identify opportunities and facilitate successful partnerships. It is in their best interest as a business (even if it is a not-for-profit organization) to establish and maintain an active network of firms and agencies that understand the business of the government lab and related industries. This network includes both potential collaborators and investors. The intermediary should have knowledge of state-of-the-art technology endeavors in the labs, have relationships with suitable VC firms and other potential investors, and have the business acumen to pull it all together. The PI can be further encouraged to perform well if their long-term viability is contingent upon becoming financially self-sustaining through funds generated via partnership agreements they broker.

4.4.3 Small Business Incentives

Small, resource-limited businesses may have much to gain through partnerships with government laboratories. Some of the incentives from the small business perspective are the same as those of the government (e.g. alignment of requirements and capabilities) and others are more complementary in nature (e.g. access to VC funding). Small business benefits include:

- Reduce financial exposure through access to proven technologies
- Adapt / create technologies for commercial market
- Align requirements and capabilities
- Expand marketability through government validation
- Access to VC and other investor (e.g. Angel) funding
- Leverage government assets: cost avoidance and reduced development time
  - Property, facilities, and equipment
  - Restricted land / airspace
  - Communications bandwidth
- Augment expertise through personnel exchange
- Improve visibility and legitimacy in military and global network
- Gain insights into commercial advances in cutting-edge technology
- Technology transfer from the government
- Identification of Small Business Innovation Research (SBIR) opportunities

4.4.4 Investor Incentives

Perhaps the most difficult piece to fit into the puzzle is the financing. Non-traditional funding sources such as VCs do not commonly invest in government related technology efforts, particularly those with development required inside the government for military customers. To enable such an opportunity, a VC would have to be presented with a compelling argument with sufficient incentives. I believe this is possible. Consider the following incentives and motivating factors for VC investment:

- High potential return on investment based on lower initial investment threshold compared to non-government derived IP
- Likelihood of product success
- Established markets and well financed potential customers
- Fast turnaround
- Gain insights into commercial advances in cutting-edge technology
- Ties to firms that are licensing emerging technology from the government
- Expansion of technical and business consultant network
- Attracting additional investors and strategic partners
- Control of spin-off companies

The constraints of a PPP must also be addressed. The PIs I interviewed noted that VCs are often not willing to fund government projects directly for lack of trust, perception of low technical competence, and unwillingness to accept costs and delays associated with government bureaucracy. It has also been the experience of PIs that most VCs would rather invest in proven technologies than fund development efforts. Further, since there is no guarantee of a government contract following technology maturation, VCs do not want to bet on a product focused on only military customers. Recommendations for overcoming these challenges are provided in Chapter 6.

4.5 Partnership Examples

Many efforts to exploit parts or all of the elements of the legislative changes covered earlier in this chapter have been attempted. According to the Government Accountability Office (GAO), Department of Energy (DoE) laboratories established numerous CRADAs and Work-For-Other agreements (analogous to Work-For-Private-Party agreements in the DoD). However, since Congress started phasing out dedicated funding for such activities in FY 1996, the number of DoE partnerships has dropped

(GAO-01-568, 2001). The GAO reports that while the use of research funds instead of dedicated funds helps ensure that a CRADA will have primary benefits to the lab's research mission, the GAO also noted that without dedicated funds the laboratories may be less likely to support technology development partnerships.

What the report suggests is that DoE labs will not take direct funding away from core research projects in order to support technology development. GAO report GAO-01-568 goes on to say that the DoE has decreased the use of government funding for technology development efforts and is entering more agreements fully funded by private partners. The report also notes that the DoE has increased work-for-other and technology licensing activities funded by private businesses. The implication is that these activities provide funding but may not support the lab's primary mission. Most other reviews of how technology transfer laws have been used look at efforts made by government agencies seeking innovative technologies from sources in the private sector rather than that of the government laboratories seeking to accelerate their own technology development.

The use of partnership intermediary agreements (PIAs) is now common for supporting hands-on technical work performed by firms in the private sector. A PIA is a formal contract or Memorandum of Understanding (MOU) between a federal laboratory and a PI. The PIA serves as a means for a PI to provide services to the federal lab focused on establishing joint ventures. The Department of Defense has established a number of mechanisms to accomplish this end.

The Defense Venture Catalyst Initiative (DeVenCI) is an effort managed by the Office of the Secretary of Defense (OSD) Defense Research and Engineering. According to http://devenci.dtic.mil/index.html (2009), this initiative focuses on increasing DoD awareness of emerging commercial technologies developed by non-traditional sources. The initiative also seeks to increase the awareness of private firms of DoD needs and requirements. Rather than seeking or providing funding, The DeVenCI strategy is to solicit active participation of the venture capital community to gain knowledge of and access to small, innovative companies with emerging technologies useful to the DoD and to broker interactions between the two groups. In addition to searching for commercially driven technologies that may be able to meet an established military requirement, it seems reasonable to consider the opposite proposition: identify military driven technologies that might have commercial applications.

The Office of Technology Transfer is also aligned under OSD Defense Research and Engineering. Sources in this office indicate that a number of partnership intermediaries and resources have been established at the national level. For instance: TechLink (http://www.techlinkcenter.org/cgi-bin/techlink/index.html), TechMatch (http://www.dodtechmatch.com/DOD/INDEX.ASPX), FirstLink (http://www.dodfirstlink.com/), and T2Bridge (http://www.t2bridge.org/). TechLink is apparently OTT's only directly sponsored PI, while others have often been started with Congressional earmarks. Some of these partnerships may become self-sustaining. Again, the typical case is to match innovative solutions from industry to DoD needs. An interviewee from OTT notes that another PI function at this level is to provide two-way education (of laws, of processes, etc.) to the partners doing the work.

Similar organizations have been established at the Service and Agency level. According to http://www.onpoint.us/ (2009), "OnPoint Technologies is a strategic private equity investor with a mission to discover, invest in and support companies at the intersection of Army and commercial marketing needs." OnPoint was created in response to an Army Broad Area Announcement on Army Venture Capital. The purpose of OnPoint is to meet Army requirements through investment in small growth-oriented firms developing innovative technologies of interest to the Army. For example, OnPoint has invested in A123 Systems, a developer of advanced Lithium-Ion based cells for rechargeable battery packs, and IFCT, a developer of next generation fuel cell systems. In a similar effort, an independent panel (2001) reports that In-Q-Tel (http://www.iqt.org/) was established in 1999 to accelerate the acquisition and implementation of new technologies for the Central Intelligence Agency.

For these PI organizations to work, several conditions must be met:

- Access to people in many communities;
- Shared performance metrics;
- Streamlined processes and an entrepreneurial orientation guide activities;
- Objectives that are clear and aligned; and
- Ideas and technologies are shared.

Partnership Intermediaries can also be established at state and local levels. For instance, SpringBoard (http://www.gospringboard.org/) is a statewide program in Alaska to help transfer and commercialize DoD technologies.

In Maryland, the Maryland Technology Development Corporation (TEDCO) brings "innovations from...federal labs into the State's economy by facilitating the transfer of technology to the private sector and by providing emerging technology companies and university researchers with vital seed funding and specialized technical assistance."

(http://www.marylandtedco.org/, 2008) An official at the Naval Surface Warfare Center (NSWC) in Indian Head, MD told me about his experience with TEDCO. Indian Head engineers developed a technology called the Joint Modular Intermodal Container (JMIC). A patent application was filed and provided to a university (Johns Hopkins University Applied Physics Laboratory, JHU APL). The university did a commercial assessment to determine the viability of the product for establishing a business. They then wrote a business plan. A recent group of JHU graduates formed a small company, Baltimore Shipping Technologies (BST), and submitted the business plan along with an application for license to NSWC. Indian Head set up the license agreement and a CRADA. BST applied for financing and got TEDCO to fund the company. TEDCO has a VC component that runs a state supported equity fund. BST subsequently paid Indian Head for license fees and funded engineering development to commercialize the product through the CRADA. BST then sold the product back to the government for use by the Army and Marine Corps. The product is also sold commercially for transporting medical supplies and energetic materials. Challenges associated with controlling rights exclusivity (i.e. different fields of use) have been managed through careful wording in all agreements. In this case, primary technology development was already complete and government engineers were tapped for commercialization activities.

Another example is worth describing as well. The Army's Armaments Research, Development, and Engineering Center (ARDEC) at Picatinny Arsenal has established a partnership with InSitech, Inc. (a 501(c)3 NFP organization). ARDEC awarded a five-year OT contract to InSitech to speed the development of dual-use technologies coming out of ARDEC's labs for supporting the warfighter. This award is also intended to provide a positive economic impact to communities in the local New Jersey area.

Interviewees from InSitech suggested a comprehensive approach frames this partnership. Five key points are made in summary here. First, InSitech was created as a *customized* PI. Many PIs exist (some of which are already externally funded such as TechLink); however, each has its own focus and scope. InSitech tailors its efforts to the needs of ARDEC and the surrounding region. Second, the establishment of a five-year exclusive contract serves to dedicate services and align incentives. Third, InSitech collaborated with Chart Group, L.P. to form Chart Venture Partners, L.P. Chart Venture Partners raised a large (>$100M) venture fund for investing in small companies that can commercialize proven technologies funded and developed in ARDEC's labs or small companies that can develop technologies that can be used by ARDEC. In practice, InSitech looks primarily at commercially developed technologies that may have military application in a "requirements-pull" fashion and funds entrepreneurs to spin-off new businesses. Several businesses have been created in the area and most of them have the government as their principle customer. Fourth, interviewees from InSitech noted that they normally find funding for taking existing solutions to market rather than for technology development. They have set up a Prototype Development Accelerator (PDA) to finance prototype and development efforts in small companies, but this is currently funded through earmarks. The fifth point I gathered from interviews at InSitech is that they are building a local / regional consortium of parties from all sectors. The Picatinny Applied Research Campus (PARC) attracts companies to the local area to develop technologies in support of short-term goals, but also facilitates collaborative solutions to long-term objectives.

One final example is provided to illustrate that it is possible for the government to accelerate its technology development process by proactively looking to the private sector for commercialization and funding. Consider the case of the BomBot, a remote-controlled counter-improvised explosive device (CIED) system (Morrison, 2007). The BomBot began as an Air Force technology, was improved by the West Virginia High Technology Consortium (WVHTC) Foundation, became the base technology for a start-up manufacturing company, made the transition into a program and was sold back to the DoD to support its warfighters. The BomBot successfully became a military and commercial product – all in a span of less than two years. Recalling that the ultimate goal of DoD technology transfer is to help the warfighter and technologies developed in government labs are all aimed at this purpose, Morrison (2007, p. 21) uses the BomBot example to make the point that "to have a small business take the technology and turn it into a product that, in the end, can be sold back to the Defense Department to benefit the warfighter, helps everyone." Funds are brought into the labs to develop technology (with the added benefit of keeping its personnel sharp), production costs are lowered through licensing arrangements, the establishment of a new business boosts the local economy, and a large contract provides a financial return on investment to the sources of funding.

CHAPTER 5: OVERVIEW OF CHINA LAKE

This chapter provides a brief history of the Naval Weapons and Armaments Center of Excellence at China Lake, some relevant examples of technology development and transfer at China Lake, and a description of the current situation of the Center. It is useful to review this information before building a case for China Lake's readiness to implement a pilot study of the PPPs central to this thesis.

5.1 Brief History

The Naval Weapons and Armaments Center of Excellence at China Lake is an important asset within the government with a rich history that has been well documented (see http://www.navair.navy.mil/nawcwd/clmf/hist.html). It has changed over the years from a weapons testing facility to a full-spectrum Research, Development, Acquisition, Test, and Evaluation (RDAT&E) organization. The organization began as the Naval Ordnance Test Station (NOTS), established in 1943 to test aviation ordnance as part of the war efforts. Rocket testing quickly expanded to include weapons research, development, test, and evaluation (RDT&E) and training. By the time the organization was restructured as the Naval Weapons Center (NWC) in 1967, it was a full-spectrum weapon *systems* RDT&E facility. The next major organizational restructuring in 1992 saw NWC aligned under the Naval Aviation Systems Command (NAVAIR) as the Naval Air Warfare Center Weapons Division. Most recently, the 2005 Base Realignment and Closure (BRAC) Commission recommended the establishment of the Naval Weapons and Armaments Center of Excellence at China Lake through the consolidation of several Naval facilities.

Interviewees noted that the NWA CoE at China Lake has a reputation as a highly innovative organization with a creative ability to solve technical challenges. The ability of military-civilian teams at China Lake to meet challenging problems largely depends on the combination of research and development laboratories and test and evaluation ranges. This unique, highly capable combination of in-house technical talent backed up by operational expertise with available facilities for all aspects of RDAT&E has now supported the military for more than 60 years.

5.2 Capabilities

China Lake has represented and delivered innovation from its earliest days. It has been a model for an integrated military-civilian team working together. The Center is known for its entrepreneurial spirit and has been widely acclaimed by the DoD for its advancements in managerial and business processes. China Lake was, for example, an early adopter of the Demonstration Project personnel system, a pre-cursor to the National Security Personnel System now widespread across the government. It is most famous, however, for its technological innovations. Representative examples of China Lake innovations are listed below:

- First aircraft rockets in the United States inventory
- Developed free fall weapons technologies such as launchers, dispensers, submunitions, and fuzes
- First air-to-air guided missile ever used in combat – Sidewinder
- First anti-radar missile – Shrike
- First precision guided air-to-surface weapon – Walleye
- Designed and built non-nuclear components for the Manhattan Project
- First to develop plastic bonded explosives
- First to develop and test the concept for the Polaris missile

- First real-time night display of targets
- First to demonstrate an anti-satellite weapon
- Developed concepts, techniques, and hardware that were successfully used in hurricane abatement, fog control, and drought relief
- Technology to photograph the back side of the moon

A number of technical disciplines are required to support these achievements. China Lake continues to be recognized for its technical expertise in complex weapon systems and software integration, energetic materials and subsystems, advanced weapons and guided missiles, interoperability of warfare systems, and fuzing components and devices, among other areas. China Lake scientists are internationally renowned for expertise in laser and optical components and are experts in the areas of modeling and simulation and sensor systems such as synthetic aperture radar (SAR). All of these technological innovations and supporting disciplines are to support the warfighter. But, as I note below, in the past, such work has also led to broader applications.

5.3 Technology Transfer Examples

The NWA CoE at China Lake has a long and decorated history of successful technology transfer (see http://www.navair.navy.mil/techTrans/index.cfm?map=local.ccms.view.aB&doc=awards.2). Perhaps the most famous product is the "glow stick." In 1962, researchers at China Lake began to develop a series of non-fire-producing chemical compounds with the properties of long-lasting luminous intensity and efficiency in extreme temperature conditions. An improved technology was patented in 1986 and 1987 and licensed commercially. The chemiluminescent system resulting from these efforts consisted of two liquids that are stored separately and luminesce instantly when mixed. Intensity and duration of the light emission can be varied by catalysis, and the color of emitted radiation can be varied by dye selection from a family of fluorescent compounds. Primary uses with the Navy include emergency lights, underway ship-to-ship replenishment, man-overboard float lights, target marking, helicopter landing zone marking, night parachute and paradrop operations, and (with a near-infrared dye) as a covert night-vision radiation source. The devices were widely used during Desert Storm for covert marking and signaling (light sticks were standard issue for every person in the Gulf War). Current usage within the DoD is about 15 million units per year. The commercial products that grew out of licensing this technology now play a part in a vast number of commercial areas (representing a huge market) including: safety, law enforcement, recreational novelties, amusement parks, emergency safety lights, and deep-sea fishing.

Another successful technology transfer story from China Lake centers on partnering with industry to develop a security system for local area computer networks. This effort is documented in a Department of Commerce report (2002). A computer network security system based on Market Central Inc.'s SecureSwitch™ Information Security System (SSISS) and Radionics Inc.'s Readykey® Information Security System for Computers™ (RISSC) was developed for local area computer network security. It was superior to existing techniques. The combined SSISS/RISSC system provided a maximally secure computer network for processing highly sensitive data. China Lake employees invented and patented a basic shielded computer network switch for safely isolating and connecting local networks to external networks in 1996. The technology was further refined and moved toward commercialization through a CRADA with Market Central

Inc., to produce the switches and, with Radionics Inc., to access its control technology and market distribution system. This became the only network switch to be approved by the DoD as meeting the National Communication Security Memorandum (NACSIM) 5203 security requirements. The National Security Agency tested, validated, and accepted the original system for its own use. The Navy's secure switch technology was transferred and licensed to Market Central, which sold the switches as a commercial product in the ever-increasing computer security systems market.

5.4 Readiness for PPP Pilot Study

I have suggested that the Department of Defense should make better use of some of its labs to develop and prototype technologies that provide innovative solutions to pressing needs. In my talks with Admiral William Fallon, he suggested that the warfighters need smaller, faster, simpler, lighter, cheaper ways to do things. The key is to be *innovative*, not necessarily advanced. Applying basic technologies in new ways can lead to surprising results. Large companies in the defense industry tend to spend more time pursuing cutting edge technologies (which are also needed). But technology innovation is also an area that DoD labs can undertake. The Naval Weapons and Armaments Center of Excellence at China Lake, CA is one of the DoD's unique laboratory assets which has a history of innovation and can continue this tradition by taking advantage of certain mechanisms afforded through the legislative updates reviewed earlier in Chapter 4.

The core mission of the NWA CoE at China Lake is to provide effective, affordable, integrated, interoperable warfare systems to the warfighter and to support those systems for life. However, as evidenced by the examples provided, China Lake supports not only technology transition but also technology transfer. Public-private partnerships afford the opportunity to serve both interests. All those I interviewed at China Lake support the idea of a pilot study in this domain. This is not surprising, since the desire to find ways to privately finance government R&D is rooted in problems identified by NWA CoE senior leadership.

Practically speaking, the NWA CoE is ready to support this effort as an organization. If anything, China Lake engineers may take on too much of an ownership mentality; enthusiasm at China Lake may need to be focused to facilitate cooperative partnerships. Technology development efforts are ongoing in a number of arenas at China Lake and critical infrastructure is in place to support the technical work. Technology transfer and legal offices are established. Administrative efficiency, admittedly lacking in the past, is improving and senior leadership is committed to further improvements. A thorough, independent study of capability gaps and opportunities to improve the organization has recently been conducted. A pilot study to develop a PPP that links China Lake technologies with private sector business acumen, funding, and market experience is a timely venture. Those interviewed are also very interested in the prospect of using this process as a means to develop technical talent.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

I believe that the business models I have described and the funding techniques I outlined that are associated with the private sector provide a realistic framework for initiating a pilot study at the Naval Weapons and Armaments Center of Excellence at China Lake. Resources are limited at the Center – and elsewhere – such that blending government expertise and facilities with complementary resources from the private sector makes sense.

I have presented a case for alternative financing for government R&D and I have suggested that China Lake is poised to experiment in this realm. I have listed many benefits of public-private partnerships, but recognize that motivating Venture Capitalists or other non-traditional investors in government technology development efforts is a critical but challenging factor. A pilot study at China Lake can test the ability to execute the ideas of this thesis at a local level. More importantly, demonstrating the ability to attract VCs to such PPPs is an important step in establishing a long-term mechanism for meeting the needs of the NWA CoE and improving the technological innovation system across the nation.

In this chapter, I outline specific recommendations that China Lake management could implement in the near-term. With respect to a more generalized and repeatable process in the broader government domain, I suggest some long term recommendations.

6.1 Near-term Pilot Study

Several steps must be taken to implement the non-traditional technology development scheme discussed in this thesis at China Lake. These steps represent the culmination of my analysis of the literature and interview notes and are listed and elaborated on below.

1. *Establish a dedicated in-house team for the pilot study.*

    A streamlined process is essential for success. Hand-pick a small group of individuals (n < 7) from the research and engineering department, technology transfer office, business development office, and legal team to execute a study and give them ready access to technologists and decision makers.

2. *Identify an appropriate partnership intermediary.*

    The critical component to a successful government / VC relationship is likely to be the quality and effectiveness of the PI. The PI must have strong ties to the VC community. The PI should also have a keen awareness of the marketplace. Make sure the PI understands or has the interest and capacity to learn the business of the lab. The PI must have a physical presence at China Lake. Set up a tailored Other Transactions Agreement (OTA) with the PI. Choosing InSitech may be appropriate since they have relevant experience and can avoid the pitfalls associated with starting with a new organization.

3. *Incentivize the PI for the long term.*

    a. *Funding.*

        Fund a contract to support a series of projects coming out of the lab. True benefit is more likely to be realized through an integrated program rather than a one-off effort. After a 2-year initial period, public funding should be phased out as the partnership becomes self sufficient and continues to grow and fund the development efforts.

b. *Intellectual Property rights.*

Maintain government purpose rights. Allow the PI to own the IP for commercial applications. This agreement enables the PI to license the technologies. This could become a self-sustaining mechanism.

c. *Long-term viability.*

Stipulate that follow-on contracts are contingent upon successful partnerships with private sector funding sources. Provide affordable facilities to locate personnel on-site and tie lease payments to the value of the financial contribution coming to the government.

4. *Identify a prioritized list of specific technologies to target with commercialization / dual-use potential.*

Provide briefings and demonstrations of existing intellectual property and ongoing technology work to the PI. The PI should facilitate an independent assessment of the technologies and associated markets by partnering with industry analysts. Picking dual-use technologies for which the primary customer is not the military is a logical starting point (although a military application should not be ruled out). This is not meant to imply a change in military technology strategy or change in lab focus. Rather, it is meant to prioritize technologies that now support the existing strategy and also have commercial potential. These technologies should be considered first for non-traditional funding opportunities. Identifying unsatisfied market needs in areas such as renewable energy and software enhancement will likely gain the most traction in the investment community.

5. *Establish a formal relationship with a complementary small business partner.*

I recommend that the NWA CoE follow the successful model demonstrated at MIT. Namely, bring technical experts from China Lake together with business savvy firms in the private sector. Using expertise where it exists is efficient and keeps the experts happy. The PI should use their relationships within and knowledge of the market to develop a list of potential partners with strong marketing, contracting, and services experience. Establish a CRADA between the government lab and a selected small business that has the entrepreneurial interest (and "spirit") for commercializing the technology but otherwise lacks the resources to pursue the effort on its own. The CRADA should broadly allow for shared facilities, information, data rights, funding, and technology development.

6. *Develop a comprehensive business plan and a strong marketing strategy.*

This step should draw on strengths of the small business partner and PI. I suggest carefully segmenting customers based on the degree of value added and focusing initially on VCs as the customer. This plan should emphasize traditional motivating factors for VCs such as potential market size, financial return on investment, and control in the commercial activities.

7. *Cooperatively sell the concept to multiple investors.*

Exploit the PI's ties to the VC community to target investors willing to consider non-traditional investment opportunities. Representatives from the PI should be located in close proximity to the VCs to facilitate frequent personal interactions. The PPP team can build trust through demonstrated proficiency in technical and business matters. In addition to building a sound business case, the PPP team must clearly communicate the additional benefits of the PPP model, such as a large potential payoff from multiple markets and diverse expertise across a team.

The VC must bet on commercial market opportunities but may also be further motivated by the prospect of a second, potentially huge, opportunity in the form of a government contract. Funds can flow to the government for assistance in developing the core technologies. This arrangement could be particularly attractive when the government already has the unique, capital-intensive infrastructure in place and has the expertise to exploit it. The VC firm benefits from a close partnership with the government lab and the business by leveraging the strengths of each. And, while government supported research may conventionally lower expected returns, the government often takes on more risk by pursuing technologies that would not be funded elsewhere. If successful, the rewards are substantial.

Another cooperative scenario could involve using government subject matter experts as part of a due diligence process since these experts uniquely understand the military requirements. There would not be contract guarantees. The government's efforts could, however, provide the VCs with reassurance that a given product / technology will meet the requirements of a potential military program.

Another benefit of PPPs to private investors and businesses is the size and diversity of the government laboratory complex. VCs and businesses can draw on a large range of technological development programs in the government that are unavailable through partnerships with a single firm in the defense industry.

Ultimately, private investors must come to understand that working with the government can be similar to working with private organizations. PIs interviewed pointed out that with respect to intellectual property, government purpose rights do not mean private firms cannot make a profit.

They can make a profit – although the government usually has a negotiated discount for applications in their field of use. In the scenario presented here, the government is motivated to help their private partners make profits in order to build a sustainable alliance.

The effectiveness of an initial pilot study should be measured by three principle factors. First and foremost, the ability to secure VC financing is of critical importance. This factor is the fundamental premise of the thesis. Second, successfully spinning off a commercial business should be a result of the pilot. A successful commercial business provides the financial return on investment and is therefore critical for earning the trust of the VC community. Third, the technology readiness level for military applications should be advanced. Technology acceleration is the NWA CoE's primary objective.

6.2 Long-term Recommendations

The above recommendations should not be considered in isolation. There are additional activities that need to be undertaken if a repeatable, general PPP R&D process is to develop and spread. Two areas that I believe important to the long term success of PPPs are: (1) Establishing a formal government role; and (2) Developing a comprehensive strategy.

6.2.1 Government Role

When considering a non-traditional technology development process, federal government labs and their counterparts in the private sector must perform outside conventional roles. It is instructive then to consider the role that government RDT&E laboratories can and should perform in this domain. A given lab has its particular strengths and competencies. However, there are distinctive activities that government can perform with respect to technology development. Four such areas are described below.

A. Systems Integration and Engineering

With the evolution of diverse technologies in the defense industry and the ever-increasing need to "fight smarter" using methods such as network-centric warfare (NCW), systems integration and engineering are now crucial. Dombrowski and Gholz (2006) made a number of observations with regard to systems integration and public-private partnerships. They cite NCW as a motivating driver for both. Dombrowski and Gholz (2006, p. 112) summarize their thoughts on systems integration and PPPs in the following way:

> "Many organizations including laboratories owned by the military services have long helped the military integrate systems at the weapons, platform, and system-of-systems levels. By contrast, successful niche systems integration providers can provide technical advice and management assistance that minimizes the appearance of conflicts of interest, the overhead cost of managing complex systems development, and the military's vulnerability to unrealistic technological proposals. With respect to systems integration, the transformation calls for sustaining innovation. The implication is that established organizations are prepared with the right sort of public-private partnership among the military, technical advisers, and manufacturers to pursue military innovation."

This logic helps make the case for a strong systems integration and engineering role within the government in an organization such as the NWA CoE at China Lake. China Lake supports the military in integrating systems at the weapons, platform, and system-of-systems (SOS) levels. China Lake also maintains the acumen to provide technical advice with respect to technology possibilities. In order to sustain innovation, the NWA CoE could partner with complementary organizations. Dombrowski and Gholz go on to acknowledge that, historically, SOS integration has been accomplished by laboratories within the systems commands and that NCW forces the acquisition community to rely more on SOS integrators in the oversight role. This further reinforces the need to remain technically proficient throughout the acquisition process.

China Lake is specifically listed as a SOS organization that can provide analysis, scientific research, technical support, and testing and fleet support. SYSCOMs and non-traditional sponsors of technology development can draw upon expertise from such laboratories, which maintain important niche capabilities, research expertise, and capital-intensive physical assets required to develop and test new designs. The NWA CoE cannot perform all SOS integration efforts. These efforts could be done in cooperation with private for-profit and not-for-profit organizations. With respect to the potential conflict of interest (or the appearance thereof), some separation between integration and production is need. Again, a partnership makes sense. Integration can be performed in government labs and production can take place in the private sector.

Dombrowski and Gholz (2006) present three additional factors as key considerations when determining who should perform the SOS integration role. First, measurable performance matters. The NWA CoE measures up. For example, China Lake's F/A-18 Advanced Weapons Laboratory (AWL) is a Software Engineering Institute (SEI) Capabilities Maturity Model (CMM) maturity level 3 (ML3) organization and anticipates achieving maturity level 5 (ML5) within the next three years. ML5 is a designation representing roughly the top 5% - 10% of software development organizations worldwide. Second, perceived independence is important. Dombrowski and Gholz (2006, p. 126) note: "The key role of a system-of-systems integrator…requires that it be able to make tradeoffs in the interest of system performance rather than in the interest of the organizations that design or make the system." The government and private industry have fundamentally different business models. While government labs are chartered to effectively support the warfighter, private sector businesses are in business to sell their products and services to provide a financial return. Third, a keen understanding of the customer is critical. DoD labs clearly have insights into relevant military requirements. Dombrowski and Gholz (2006, p. 132) summarize these arguments in the following way:

> "Military innovation cannot be implemented without a renewed public-private partnership based on mutual understanding and trust between the military's warfighters and doctrine-writers and the technical specialists in system-of-systems integration, who manage the interface with for-profit defense manufacturers. Given the predominance of sustaining innovations in systems integration, the key step in preparing the defense industrial base for network-centric warfare is not to try to change the cast of characters but to update and focus the technical emphasis of the military's own acquisition community."

In an interview, Colvard added a cautionary note: 'Systems integration is reflective but systems engineering is prospective. While the government can learn from the past it is more important to look to the future.'

B. Standardization

Considering the two different business models of government and industry, standardization is another natural role for the government to play. It makes sound business sense from the government's perspective to establish standards to minimize acquisition costs over the long term. Further, the government can act as an objective party in developing standards. The government is less likely to be skewed by self-interest to support one particular solution over another. And, having a trusted agent play an integral role in this arena is critical for coming up with long-term solutions for the warfighter and consumer alike.

Another reason that standardization is an activity the government can and should perform is that standardization is a critical component of the system-of-systems approach. Standardizing interfaces and processes enables multiple pieces all to work together in an integrated fashion. Government labs are logical places to contribute to the development of many of the technologies associated with standardization. Demonstrating prototypes of interface hardware and software is a critical step in linking multiple products manufactured by different vendors, for instance. .

C. Prototyping

Prototyping can also be an important activity for government labs to undertake. But more than just supporting standardization, prototyping is a key part of the learning process that develops and maintains technical competence. In general, the government does not and should not take products to market. Production capacity is for private industry. But a government lab, like the NWA CoE, does have enough capacity to produce working prototypes. Prototyping could then act as a bridge between urgent requirements and formal procurement.

D. National Security

The final area in which government labs can play an important role in technology development is national security. The federal government has the lead role in this area. Federal government laboratories must play a significant role in the development of technologies in support of national security concerns. Government subject matter experts are intimately familiar with the threats and the requirements to neutralize them. The government also certifies security equipment to certain standards. Federal lab involvement ensures standards are being met in the development of the underlying technologies.

6.2.2 Developing a Comprehensive Strategy

While this thesis concentrates on linking government R&D with private financing through innovative partnerships, in practice, this objective should be part of a comprehensive approach to achieve a broader set of goals. Partnerships should not be established just as an opportunity for government labs to spend someone else's money. It was noted that historically most partnerships have been financially driven. But it was also suggested that they could also be motivated by what I will call "leadership creativity." Innovative partnerships might help the government in this regard.

There are certain business practices that can be applied to enhance government R&D. First, emphasis must be placed on hiring the top talent available. The benefits of government service, particularly in times of economic crisis and high unemployment, can be emphasized when aggressively pursuing excellent science and engineering job candidates. Second, discretionary programs must be put in place to make sure government laboratory personnel have challenging technical problems to solve to keep their work relevant and skills sharp. Third, fostering innovation through a willingness to accept risk – and failure – is important. Fourth, close engagement with current and potential customers could develop new technologies that meet an unsatisfied warfighter need and/or market opportunity. Once a research and development area has been identified and established, efforts should be made to run the area in an entrepreneurial way that stresses marketing. Fifth, government leadership must not be focused on any particular technology or partnership, but maintain a system-wide view with long-term benefits in mind. Sixth and finally, government labs must not cultivate an "ownership mentality." That is not to say that engineers should not take pride in their work. But it is incumbent upon them to be willing to work collaboratively with large and small companies from private industry for their common gain.

As part of a comprehensive R&D strategy, the NWA CoE should also take advantage of existing programs and mechanisms such as SBIRs, Test Service Agreements (TSAs), Commercial Services Agreements (CSAs), CRADAs, and Enhanced Uses Leases (EULs). These programs and mechanisms can develop technologies through alternate sources, leverage existing facilities, share information, and fund technical work in support of its mission. SBIRs provide a mechanism to seek funding for small businesses to further mission relevant technologies (but do little to develop in-house technical competence). Testing and Range Services and Sales of Goods and Services offer some advantage in being able to tap local government resources. However, they are hampered by competition restrictions. CRADAs can avoid such restrictions, facilitate the sharing of costs and other resources, and provide flexibility to negotiate data rights. EULs are potential sources of revenue or in-kind contributions such as infrastructure improvement projects. These leases use one government-owned asset (property) to fund a different government need (technology development). More importantly, EULs offer an opportunity to bring industry players in close physical proximity to the government labs for workshops and short-term service agreements. They might also provide for permanent industry presence further facilitating collaboration on joint programs.

The NWA CoE should also look internally for creative ways to move forward. In his October 10, 2008 memo on DON acquisition, the Secretary of the Navy, Donald Winter (p. 2), said: "Laboratories should provide promising technical personnel with academic opportunities and work assignments that allow growth to become senior systems engineers and chief scientists." In one of my interview discussions, Bill Hogan put forth the "McLean Challenge" as a way for China Lake to make progress in this regard. (Dr. William B. McLean is a former China Lake Technical Director and is generally considered the father of the Sidewinder missile.) The "Challenge" encourages technical teams and senior leadership at China Lake to:

1. Suggest how their specific technology could be used commercially or differently than today;
2. Build a basic business model;
3. Hold a competition for "best of class;"
4. Fund the winning idea(s); and
5. Provide an entrepreneurial leave of absence.

All of these ideas can be brought together in the China Lake High-Tech Consortium. A consortium would help develop close ties between local and regional players from government and industry. However, efforts should not be limited to just a local or regional focus. Efforts to exploit state and national resources should continue in parallel. As mentioned, TechLink is a federally funded PI. The NWA CoE should take advantage of this asset to broaden its partnership opportunities. Similarly, TechMatch is an online technology transfer resource that can be tapped at no additional cost.

Another forum that could prove beneficial is the "World's Best Technology (WBT) Showcase". The WBT showcase (http://www.wbtshowcase.com/, 2009) is "the nation's premier event showcasing the largest collection of vetted and mentored companies and technologies emanating from top universities, labs, research institutions, and the private sector from across the country and around the globe." There is already some limited participation by government laboratories in this community event and the NWA CoE should consider participating.

This type of interaction might even lead to establishing partnerships with foreign firms. Policies are in place for multi-national collaborations involving government laboratories. Foreign financing for bringing military related technology to market would certainly challenge existing processes and would of course require careful consideration.

In a few cases, where the existing system prevents the acceleration of technology transfer to the warfighter or marketplace, process innovation should be considered. Perhaps the government can revert to the OSD level or other special funding for development and/or tailored PI support or consider new legislative proposals to extend the scope of partnership opportunities.

Changing the relationship between defense laboratories and traditional sponsors across the federal government – potentially through updated legislation – may also offer new opportunities. A case can be made that the government should invest more in R&D and S&T efforts than is currently provided or planned. And, given the desire to enhance the technical competence of the government's laboratories, it is appropriate to direct any additional resources to those labs. Standout facilities like the NWA CoE should be prime targets for these technology development efforts. China Lake has been consistently ranked very high in military value through several BRAC rounds. In one of my interviews, an experienced government official suggested that the federal government should recognize that China Lake is a "unique national resource" that may need additional seed money if more traditional funding processes are not enhanced. Perhaps it is time for the federal government to directly include technology development in certain labs as a budgeted item.

The federal government should also make concerted efforts at funding organizations like the FLC to promote coordination across labs. For example, ONR has started a pilot program across the Naval Enterprise to see what technologies go together. This kind of effort could be done at the FLC level. Such coordination activities might well promote macro efficiencies and might encourage innovative public-private partnerships as well.

System-wide, there is a need to shift from a government-centric to a cooperation-centric model. Shifting the lab culture to accept public-private collaborations is just a start at addressing this broader issue. But it is an important start. In our discussions, Jim Colvard pointed out that there is another consideration that must be addressed when dealing with a military organization. There are, in his view, three distinct cultures in military organizations: The culture of (1) political appointees, (2) military personnel, and (3) civilian employees. There are differences in systems, power and control, loyalties, development processes, and skills across the three. As Dombrowski and Gholz (2006, p. 117) put it: "The relationship between science-oriented military laboratories and regulation-oriented systems commands is often tense. [There are lots of reasons for this and] the difficulty is magnified within the military chain of command." Special care must be taken to openly communicate with all parties to clearly articulate the benefits to all involved and not to appease one party at the expense of another.

Updating legislation so that under special circumstances a technology development effort backed by VC (or similar) funding could lead to a non-competitive contract would encourage non-traditional funding sources to participate in partnerships. A move in this direction would mean that VCs might be as motivated to finance a technology targeted primarily for military customers as it would be to finance a technology targeted for products destined for the commercial marketplace. "Special circumstances" might include urgency of need, limited capacity of the defense industrial base, restricted production quantity, discrete contract duration, or opt-out clauses.

There are also a range of potential financing schemes closely aligned with the public sector itself. The notion of a government / military controlled equity fund has many positive features. A Rand study (Chang et al, 1999) highlighted a number of these with respect to an Army equity fund that would also be applicable to other Services and Agencies at both state and local levels. The fund would operate as follows: A government/military organization would invest a small portion of its R&D funds as a cornerstone limited partner in an equity fund chartered to develop the organization's dual-use products and services. The organization then attracts other limited partners who provide the majority of the fund's capital. This helps the government avoid conflict of interest issues by being a limited partner. The organization's return is multiplied by the amount provided by the other parties to fund the development of needed products. In addition, the government might buy dual-use products at a lower cost because production costs are lowered by the economies of scale that result from the larger commercial production. Returns on its investment would be deposited in a revolving account and used to research and develop other products of interest, reinvested in further R&D equity funds, or accepted as in-kind contributions.

The Rand study points out that a government laboratory complex can take advantage of its research funds by using a highly focused investment strategy. The government is isolated from direct investment decisions in any individual company and conflict-of-interest issues can be minimized by the governmental sale of interest if a commercial market is established or before production contracts are awarded. This scheme is applicable to most industry niches and can enhance innovation and competition in second- and third-tier industry players. This concept might also be attractive to firms with unique capabilities that would not normally compete for defense contracts.

When I started work on this thesis, my goal was to apply some of the lessons I have learned from my time in the MIT Sloan Fellows program in order to suggest some new and promising ways United States Department of Defense laboratories might operate. While there were many directions possible, I decided to examine where, why, and how public-private partnerships might be encouraged in government labs and, in particular, encouraged in my own lab at China Lake. I believe that the public-private partnership model developed in this thesis is a challenging yet worthwhile pursuit. I realize I may have presented an overly optimistic perspective on how these public-private partnerships can be developed and perhaps underestimated the problems such partnerships would face. I think the key is to move forward and learn over time what works and what does not work.

Surely a PPP pilot study is a low-risk next step that would help determine whether or not the ideas presented in this thesis are viable in a government lab environment. I realize that there are difficulties I have not fully considered here and practice is always more complicated than theory. I am hopeful, however, a pilot study will be undertaken as a crucial learning experiment and perhaps, if successful, will represent a step towards the long-term improvement of the government R&D process.

BIBLIOGRAPHY

"Accelerating the Acquisition and Implementation of New Technologies for Intelligence: The Report of the Independent Panel on the Central Intelligence Agency In-Q-Tel Venture." http://www.findlaw.com, June 2001.

Apen, Paul G., Brian C. Benicewicz, and Joseph R Laia. "A New Model for Public-Private Partnerships," *Technology in Society*, Vol. 16, Iss. 4 (1994), pp. 389-402.

Burt, Lieutenant Colonel David N. "The 'How To' of Weapon Buying," *Air University Review*, January-February 1975.

Chang, Ike Y., Steven Glaing, Carolyn Wong, Howell Yee, Elliot I. Axelband, Mark O'Nesi, and Kenneth P. Horn. "Use of Public-Private Partnerships to Meet Future Army Needs." Arroyo Center, RAND Corp., 1999.

Colvard, Dr. James. "The Inherent Governmental Functions in the High Tech World of Defense." Received via personal communication, 2008.

Cusumano, Michael A. *The Business of Software: What Every Manager, Programmer, and Entrepreneur Must Know to Thrive and Survive in Good Times and Bad*. New York, Free Press, 2004.

Defense Acquisition University. *Defense Acquisition Process Tutorial.* https://akss.dau.mil/dapc/TUTORIAL/index.htm.

Defense Venture Catalyst Initiative (DeVenCI). U.S. Department of Defense, Defense Research and Engineering, http://devenci.dtic.mil/index.html.

Deputy Secretary of Defense Memorandum. "Implementation of Section 324 of the National Defense Authorization Act for Fiscal Year 2008 – Guidelines and Procedures on In-sourcing New and Contracted Out Functions," 4 April 2008.

Dombrowski, Peter J. and Eugene Gholz. *Buying Military Transformation: Technological Innovation and the Defense Industry*. New York, Columbia University Press, 2006.

Fox, J. Ronald. *Arming America; How the U. S. Buys*. Division of Research, Graduate School of Business Administration, Harvard University Press, Cambridge, Massachusetts, 1974.

Hagedoorn, John and Jos Schakenraad. "The Effect of Strategic Technology Alliances on Company Performance," *Strategic Management Journal*, Vol. 15, Iss. 4 (1994), pp. 291-309.

Hax, Arnoldo C. and Dean L. Wilde II. *The Delta Project: Discovering New Sources of Profitability in a Networked Economy.* New York, Palgrave, 2001.

Link, Albert N. *Public/Private Partnerships: Innovation Strategies and Policy Alternatives.* New York, Springer, 2006.

Morrison, Joshua. "Partnership Intermediaries and DoD Technology Transfer," *Defense AT&L*, Vol. 36, Iss. 3 (May 2007), pp. 21-23.

Naval Air Warfare Center Weapons Division. "From the Desert to the Sea. A Brief Overview of the History of China Lake," *The Rocketeer*, NAWCWD, China Lake, California, 4 November 1993. http://www.navair.navy.mil/nawcwd/clmf/hist.html

Naval Air Warfare Center Weapons Division. "NAWCWD China Lake Technology Transfer Awards," NAWCWD T2 Technology Transfer, A NAVAIR Laboratory With Full-Spectrum RDT&E Capabilities, NAWCWD, China Lake, California. http://www.navair.navy.mil/techTrans/index.cfm?map=local.ccms.view.aB&doc=awards.2

O'Shea, R., T. Allen, and K. Morse. "Creating the Entrepreneurial University: The Case of MIT." Presented at Academy of Management Conference, Hawaii, 2005.

Peck, Merton J and Frederic M. Scherer. *The Weapons Acquisition Process; an Economic Analysis*. Boston, Division of Research, Graduate School of Business Administration, Harvard University, 1962.

Peteraf, Margaret A. "The Cornerstones of Competitive Advantage: A Resource-Based View," *Strategic Management Journal*, Vol. 14, No. 3 (1993), pp. 179-191.

Porter, Michael E. *Competitive Advantage: Creating and Sustaining Superior Performance*. New York, Free Press, London, Collier Macmillan, 1985.

Roberts, Edward B. "Linkage, Leverage and Leadership Drive Successful Technological Innovation." *Research Technology Management*, Vol. 47, Iss. 3 (May 2004), pp. 9-11.

Roberts, Edward B. and Charles A Berry. "Entering New Businesses: Selecting Strategies for Success," *Sloan Management Review*, Vol. 26, Iss. 3 (1985), p. 3.

Roberts, Edward B. and Wenyun Kathy Liu. "Ally or Acquire?" *MIT Sloan Management Review*, Vol. 43, Iss. 1 (2001), pp. 26-34.

Saavedra, Pablo, and Barry Bozeman. "The "Gradient Effect" in Federal Laboratory-Industry Technology Transfer Partnerships." *Policy Studies Journal*, Vol. 32, Iss. 2 (May 2004), pp. 235-252.

Secretary of the Navy Memorandum. "Department of the Navy Acquisition," 10 October 2008.

Secretary of the Navy Principle Civilian Deputy Memorandum. "Strategy to Balance Acquisition In-House and Contractor Support Capabilities," December 2008.

Shanker, Thom. "Defense Chief Criticizes Bureaucracy at the Pentagon," *The New York Times*, September 30, 2008.

Stiglitz, Joseph E. and Scott J Wallsten. "Public-Private Technology Partnerships: Promises and Pitfalls." *The American Behavioral Scientist*, Vol. 43, Iss. 1 (1999), pp. 52-73.

TechTRANSIT. U.S Department of Defense, Deputy Undersecretary of Defense (Advanced Systems & Concepts), Office of Technology Transition, http://www.acq.osd.mil/ott/techtransit/laws.htm.

U.S. Department of Commerce. "Recent Trends in Federal Lab Technology Transfer: FY 1999–2000 Biennial Report: Report to the President and the Congress Under the Stevenson-Wydler Act," Office of Technology Policy, Technology Administration, U.S. Department of Commerce, May 2002.

Under Secretary of Defense (Acquisition, Technology, and Logistics) Memorandum. "Guidance on Public-Private Business Arrangements Per 10 USC 2563," 30 December 2002.

United States General Accounting Office (GAO). *Technology Transfer: DOE Has Fewer Partnerships, and They Rely More on Private Funding* (GAO-01-568). Washington, D.C., 6 July 2001, p. 1.

Utterback, James M. *Mastering the Dynamics of Innovation: How Companies Can Seize Opportunities in the Face of Technological Change*. Boston, Massachusetts, Harvard Business School Press, 1994.

APPENDIX A: INTERVIEW SOURCES

Date	Name	Title	Organization	Method	Category
15-Oct-08	Admiral William J. Fallon (USN Retired)	Wilhelm Fellow	MIT Center for International Studies	In Person	MIT, Navy
20-Nov-08	Greg Zacharias, PhD	Senior Principal Scientist	Charles River Analytics	In Person	Small Biz
26-Nov-08	Daniel Serfaty	Chairman and CEO	Aptima	In Person	Small Biz
5-Jan-09	Scott O'Neil, SES	Executive Director	NAWCWD	In Person	Navy
6-Jan-09	Michael Seltzer, PhD	Head, Technology Transfer Program	NAWCWD	In Person	Navy
6-Jan-09	J. David Janiec, SES	Director, Weapons & Energetics Department	NAWCWD	In Person	Navy
8-Jan-09	Joan Johnson, SES	Director, NAVAIR Software Engineering	NAWCWD	In Person	Navy
14-Jan-09	Michael Chan	Analyst, Research & Engineering	NAWCWD	In Person	Navy
14-Jan-09	William Hogan, PhD	Managing Director	Impact Advisors, LLC	In Person	Consultant
3-Feb-09	Kristen Schario	Technology Transfer Manager	AFRL	Phone	Air Force
5-Feb-09	Stephen Roemerman	Chairman and CEO	Lone Star Aerospace	Phone	Consultant
6-Feb-09	Scott Deiter, PhD	Chair, FLC Executive Board	NSWC Indian Head	Phone	Navy
6-Feb-09	Brian Kiviat	Director, Technology Dev. and Transition	ASN (RDA)	Phone	Navy
9-Feb-09	David Appler	Contractor, Office of Technology Transition	OSD-ATL	Phone	DoD
9-Feb-09	Theresa Baus, PhD	Head, Technology Partnerships Enterprise Office	NUWC Newport	Phone	Navy
11-Feb-09	Alan Trager	Adjunct Lecturer in Public Policy	Harvard Kennedy School	In Person	Harvard
13-Feb-09	Terrence Clark, SES	Director, NAVAIR Ranges	NAWCWD	In Person	Navy
13-Feb-09	Dr. Ronald Smiley, SES	Director, Avionics Department	NAWCWD	In Person	Navy
19-Feb-09	James Colvard, PhD	SECNAV Consultant	SECNAV	In Person	Navy, DoD
20-Feb-09	Dr. Robin Keesee, SES	Deputy Director	JIEDDO	In Person	Joint
20-Feb-09	Dr. John Fischer, SES	Director, Systems Engineering	NAVAIR	Phone	Navy
5-Mar-09	Timothy Teen	President and CEO	InSitech	In Person	PI, Army
5-Mar-09	Michael Devine (SES Retired)	CTO	InSitech	In Person	PI, Army
5-Mar-09	Joseph Moran	Managing Director & CFO	InSitech	In Person	PI, Army