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Internal Versus External for Small Weapons Systems

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INTERNAL VERSUS EXTERNAL ACQUISITION FOR SMALL WEAPONS SYSTEMS

THESIS

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Abstract

The acquisition method used to gain access to new technologies can heavily influence whether our war fighters have the required tools to fight increasing and constantly shifting global threats (Kessler and others, 2000). The purpose of this study was to investigate the process and results of internal laboratory development, testing and fielding of small weapons systems as compared to traditionally acquired systems which encourage customer pull and contractor development. This research provides insight into how Air Force Research Laboratory (AFRL) personnel choose an acquisition method, retain personnel capability, and maximize product capability. This study consolidates the opinions of subject matter experts and program managers through a wide range of interviewees within AFRL. Data analysis and extensive literature review led to conclusions such as: it is believed that there is no difference in war fighter capability and delivery between internally and externally developed systems; and internal efforts provide better personnel capability, but the current status quo is sufficient. It was also revealed that a majority of AFRL personnel feel pressure to always develop externally. Recommendations include that: AFRL foster an environment where the best acquisition method for the government is chosen; AFRL design an internal contract plan to keep internal efforts on target; and AFRL invest in further concurrent development efforts.

For my Mother and Father

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Scott Elkins

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INTERNAL VERSUS EXTERNAL ACQUISITION FOR SMALL WEAPONS SYSTEMS

I. Introduction

Introduction

Future military surveillance capability needs are laid out within the Joint War Fighting Science and Technology Plan (JWSTP) (2006). These needs are organized via defense technology objectives based on criticality. The services have not reached many of the JWSTP's objectives and, in the aftermath of Iraqi Freedom, some traditionally less important objectives are fast becoming requirements as services are conducting counterterrorism, training, and policing efforts rather than waging war. In such a fight, continuous surveillance ability over a large area would allow better pinpointing of terrorist activity and subsequent justice. For instance, after a roadside car bomb explosion, this surveillance video could be closely examined to identify and trace the individuals that planted the explosive device. Many different programs in the past few years have attempted to accomplish this goal and achieved varying degrees of success. Examples of these programs include the Pioneer (PEO, 2004) and Satellites (Monmonier, 2002),

Usually, a requirement like an advanced surveillance system will enter the Planning Programming and Budgeting Execution System (PPBS) process (DoD 7045.14, 2003) where, over a period of years, the requirement will be planned, funded, contracted, developed, produced, and sustained. However, in this case, over the past two years, a complete working system called project Angel Fire was developed internally by Air Force students in conjunction with the Air Force Research Laboratory (AFRL) to address surveillance needs in our current environment.

The Angel Fire effort did not start through requirements planning, nor does it have a program office ensuing its compatibility and supportability. In short, it is an anomaly within the DoD as a system that is likely needed, is already complete, and was internally developed. The concept of rapid internal development rather than traditional external development and a push rather than strictly pull acquisition system are the focus of this thesis. Projects like Angel Fire and a very few other recent DoD efforts demonstrate successful application of this methodology. Although internal development and push concepts are normal in basic business principles and application (Wheelwright and Clark, 1994), they are not prevalent in the DoD programs and systems.

Purpose

The basic purpose of this study is to investigate the process and results of internal laboratory development, testing and fielding of small weapons systems versus traditionally acquired systems which encourage customer pull and contractor development. The hypothesis is that these methods are equally effective in providing war fighter support. If this is true, a reallocation of funding should be accomplished to allow internal agencies to achieve greater participation in product development.

Assumptions

In order to investigate the purpose and test the hypothesis, several assumptions are necessary. Each assumption will be tested or investigated within this thesis.

Assumption 1: Current funding allocations (primarily in 6.2, 6.3 and 6.4) do not allow internal agencies to achieve full participation in product development.

Assumption 2: DoD has not taken full advantage of push opportunities.

Assumption 3: No one acquisition method has proven itself better than others.

Assumption 4: External development is the method of choice for decision makers

Research Question

With these assumptions in mind, the overall research question for this study is: *Is there a difference in war fighter capability and delivery between internally and externally developed small weapons systems and, if so, why?*

Component Questions

The overall research question was broken down into several investigative questions based on a literature review of concepts important to outsourcing.

- Which involves less cost?
  - Will concurrent efforts reduce cost?
- Which produces better capability?
  - Can internal be done?
  - Does one produce a better customer interface?
  - What defines personnel capability?
  - Does one produce better personnel capability?
- Which provides faster delivery?
  - Are there process problems in either acquisition method
- Are personnel given any guidance on the issue?

Definitions and Concepts

Before attempting to answer the research or component questions, some basic definitions and concepts are required to ensure the ideas presented can be fully understood. The most suitable method for presentation is via a table, as shown in Table 1.

Table 1 Definitions and Concepts

Term or Concept	Description
Internal Development	Any project which the DoD leads, directs, performs research on, and retains all rights to. This can include contractors who are part of the government's internal team.
External Development or Contractor Development	Projects which are completely or almost completely outsourced. The government may retain oversight and input, but the day to day activities are directed by the contractor and product rights normally remain with the contractor.
PPBS	Planning Programming and Budgeting Execution System. The process developed by former secretary of defense Robert McNamara whereby the defense department plans and allocates resources for systems through requirements planning years in advance of acquisition.
Small Weapon System	Mid-range dollar value acquisitions from approximately the UAV level down to software that is acquired via development
Traditional Acquisition	Development, production, and sustainment via a contract effort.
Concurrent Acquisition	An internal development effort being performed simultaneously as one (or more) external projects developing the same product. These can either be competitive, where internal and external teams do not typically share results until the product's completion, or collaborative, in which internal and external teams regularly share developments.
Requirements Pull System	An acquisition concept where the end user dictates specific requirements and the system fills the need.
Requirements Push System	An acquisition concept where research and development discovers a new product or capability and develops it for users (who may not realize the full extent of its abilities).
Development Funnel	A graphical description of the process of moving ideas from investigations though development to production. Figure 1 is a presentation of this.
Fuzzy Front End	A term to describe the investigations at the beginning of the development funnel. The process of conducting basic research and recognizing potential in a discovery to fill a customer need.

Continuation of Table 1 Definitions and Concepts

Term or Concept	Description
TRL	Technology Readiness Level. A measure of technology maturity used by DoD Program Managers (PMs) and laboratory employees to make determinations concerning the readiness of a technology for development or use in the field. Figure 2 provides a graphical depiction and definitions for each level.
Technology Designation or Funding Stream	Money is broken into numerical technology designations sometimes called "pots" or "funding streams" according to the level of technology the money is intended to support. The streams of primary interest in this thesis are 6.2 (applied research), 6.3 (advanced technology development), and 6.4 (demonstration and validation). These are covered more in-depth in later chapters, but should roughly correspond to TRL level as depicted in Figure 3.
War Fighter, User, or Customer	Those who request technologies or have needs that the acquisition system must fulfill.
AFOSR, VA, DE, HE, IF, ML, MN, PR, SN, VS	These are the office symbols for the ten AFRL directorates referenced in this research. They are: AFOSR – Air Force Office of Scientific Research, VA – Air Vehicles, DE – Directed Energy, HE – Human Effectiveness, IF – Information, ML – Materials and Manufacturing, MN – Munitions, PR – Propulsion, SN – Sensors, VS – Space Vehicles

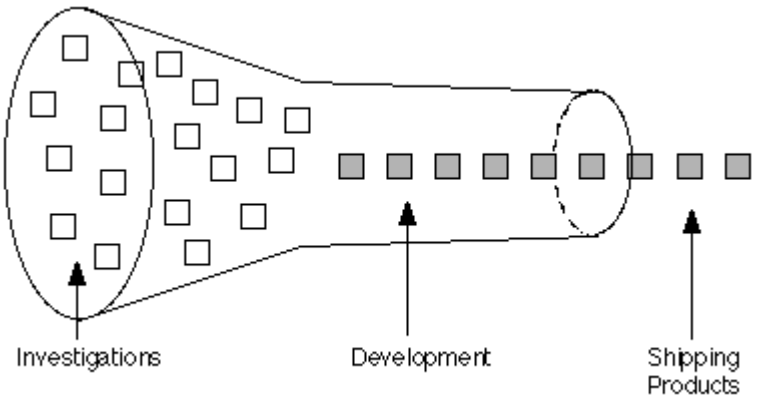

Figure 1 Wheelwight and Clark Technology Development Funnel

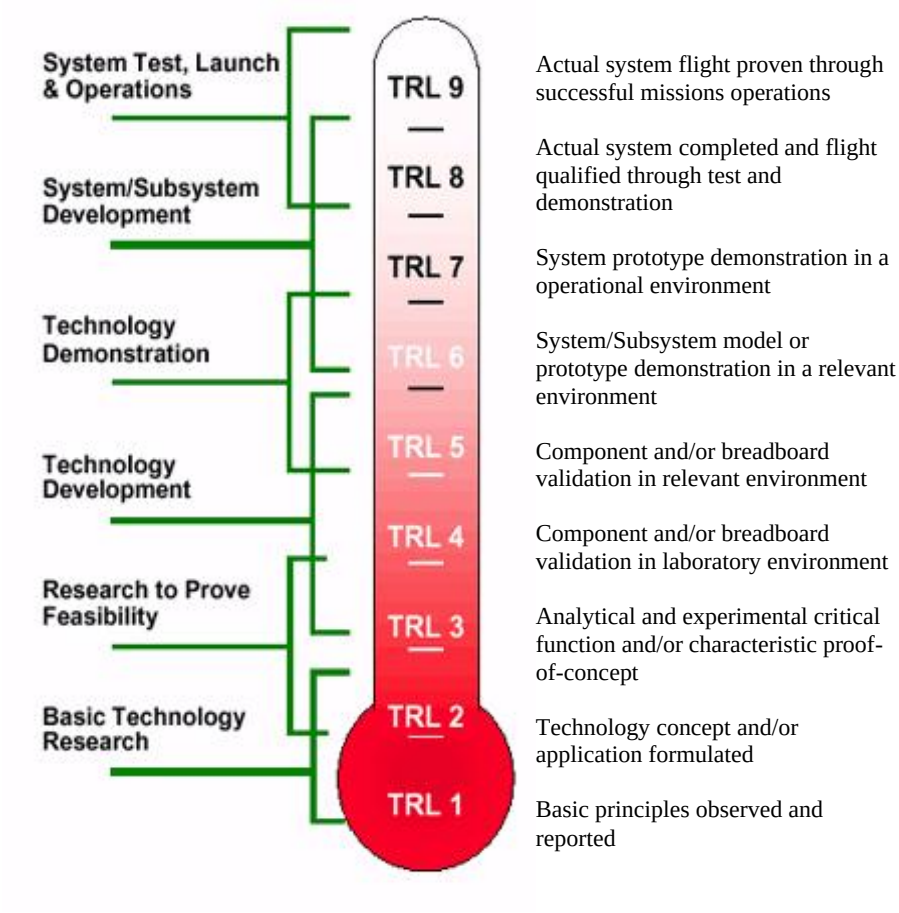

Figure 2 TRL Maturity Levels

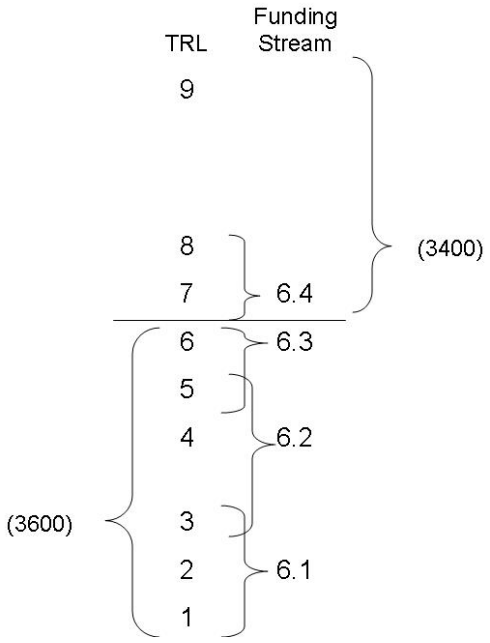

Figure 3 Relevant Funding Streams Mapped to TRLs

Background and Problem Importance

If there is no difference in war fighter capability and delivery between internally and externally developed systems then DoD should be taking advantage of internal product development or technology push. However, contractors are consistently selected to perform advanced research and prototype construction. Some experts believe an internally developed system would certainly have advantages over a contractor developed one. These include: patent rights which allows the DoD to build the weapon itself or contract to the lowest bidder thereby saving money, internal personnel development and knowledge which allows for rapid changes or modifications to the system should a need arise from the war fighter, direct links with the war fighter to develop and test exactly what they request, and a reduced time to field by removing the bidding, contract negotiation, and contractor protests which waste valuable time but are inherent to the contracting system (Allen, 1995). By diverting some 6.3 and 6.4 funds to the Air Force schools and research laboratories with the mandate to develop basic technologies into working weapons or develop a specific weapon, the government could save money and more quickly develop tools for the field. Of course, not all money will lead to productive weapon systems, but it is better to keep all options open.

Scope

Preliminary research revealed that internal development projects can be successful. This thesis does not imply that a large scale, highly technical and complex project (such as an F-22) could be developed through anything but a joint effort between industry and government, but rather that projects of smaller scope can easily be implemented and prototyped within DoD

laboratories. These include mid-range dollar value acquisitions from approximately the UAV level down to software that is acquired via development rather than commercial off the shelf (COTS). It does not include government impact card type purchases.

Examples range from software only products to larger projects like Angel Fire detailed above. Some other recent initiatives include the "friendly marking device" (a type of radar flare to mark friendly forces which was rapidly developed by an internal team), the "vehicle stopper program" (two internal efforts which produced four prototypes for a better vehicle barricade for security police) (Kleiman, 2006), and several software products.

Due to time and resources, this thesis will be only a pilot study and will involve only Air Force Research Laboratories (AFRL). The author will use case study methodology and an interview process to explore the issues related to in-house or contracting development efforts. This methodology provides easy access to interviewees and a research product that can be operationalized to the Air Force, and possibly to DoD laboratories. More importantly, it provides preliminary data for more in-depth research or a basis to incorporate new initiatives within the laboratories.

Summary

The basic purpose of this study is to explore the possibility of internal laboratory development, testing, and fielding versus the traditional system which encourages customer pull and contractor development. Assumptions were made based on literature reviews and preliminary discussions with laboratory personnel. Areas important to outsourcing were taken from commercial and government information sources and used to develop component research questions. The scope, importance, and definitions important to this study were also reviewed.

II. Literature Review

Introduction

Numerous methods for conducting acquisitions and contracting efforts exist for both the government and the civilian sector. This chapter will delve into that information to describe and, in one case, defend each of the four assumptions made in chapter one. It will also explore areas the literature ties to outsourcing decisions, which will become the basis for the interview instrument utilized to determine if a difference exists in war fighter capability and delivery between internally and externally developed small weapons systems.

Assumption 1: Current funding allocations (primarily in 6.2, 6.3 and 6.4) do not allow internal agencies to achieve full participation in product development.

The highly formalized system in the DoD today may prevent performing all the developmental steps usually undertaken in the commercial world, thereby limiting options. For example, the "fuzzy front end" and developmental funnel has been replaced with regimented bureaucratic requirements in order to ensure meaningful use of taxpayer dollars (Khurana and Rosenthal, 1997). In commercial business, the fuzzy front end refers to the creative or basic engineering process. While the DoD funds this and even employs scientists, McNamara's PPBS system keeps the funding streams separate and divided into distinct codes (Department of Defense, 2003). These codes are 6.1 (basic research), 6.2 (applied research), 6.3 (advanced technology development), 6.4 (demonstration and validation), 6.5 (engineering and manufacturing), 6.6 (management support), and 6.7 (operational systems development). These are provided in Table 2 for ease of viewing.

Table 2 Technology Designations

Community	Numerical Designation	Category
Science and Technology (3600)	6.1	Basic Research
	6.2	Applied Research
	6.3	Advanced Technology Development
Acquisition (3400)	6.4	Demonstration and Validation
	6.5	Engineering and Manufacturing Development
	6.6	Management Support
	6.7	Operational Systems Development

At first glance, these codes seem to coincide with the lifecycle development of a product. In fact, Wheelwright and Clark developed a synopsis of the commercial industry development funnel and model that can be rather easily pictured side-by-side with DoD's model in Table 3 (1992).

Table 3 Commercial Funnel versus PPBS

Commercial Development Funnel	DoD Technology Designation ($$)
Knowledge Acquisition	(6.1) Basic Research
Concept Investigation	**(6.2) Applied Research**
Basic Design	**(6.3) Advanced Technology Development**
Prototype	**(6.4) Demonstration and Validation**
Pilot Production	(6.5) Engineering and Manufacturing Development
Manufacturing Ramp-Up	(6.6 and 6.7) Management Support and Operational Sciences Development

As Table 3 demonstrates, the DoD funding streams do, in fact, line up with Wheelwright and Clark's developmental funnel for Knowledge Acquisition, Concept Investigation, Basic Design, Prototype, Pilot Production, and Manufacturing Ramp-up. However, two main differences between the two processes exist. First, rather than being a continuous funnel, DoD separates funding according to 6.1, 6.2, 6.3, etc. This division of funding streams can cause issues when attempting to advance or transition technology from one level to the next. Second, unlike a commercial business which contracts out only as needed, DoD tends to contract out the majority of work in 6.2, 6.3 and 6.4 (indicated by bold in Table 3). In fact, Air Force laboratories are actively encourage to contract out eighty percent or more of the research they conduct (Masqulier, 2006). The acquisition system is inherently designed to start with a pull requirement, develop a program office, and hire a contractor to perform 6.2, 6.3, and 6.4 research, development and manufacturing (Guttman, 2003). Once the weapon system is brought on line, the system might transition to a depot for lifecycle management and support or these requirements may stay with the contractor.

Assumption 2: DoD has not taken full advantage of push opportunities.

In the commercial world, basic and applied research serves one of two purposes: it either facilitates a technology pull or is being performed with the goal of implementing a technology push (Khurana and Rosenthal, 1997). For the commercial world, a technology pull concept implies someone, possibly the customer or marketing, has requested that a product and technology development be engineered to support that product ("Defense Acquisition Handbook", 2005). In a technology push concept, a scientist performs basic research to develop

an item that might be useful to a product line or something that can be taken directly to market. These systems are illustrated in Figure 4 ("Defense Acquisition Handbook", 2005).

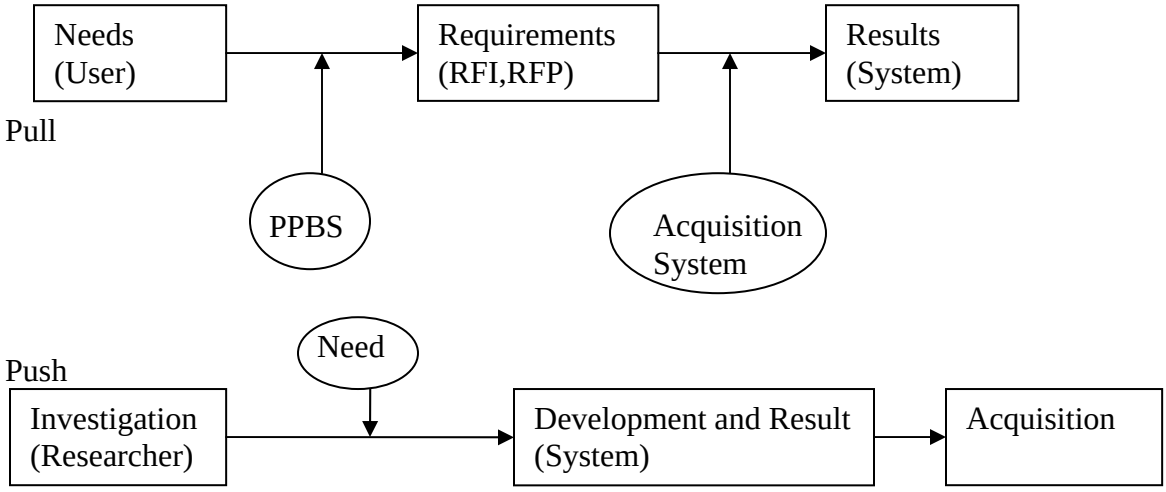

Figure 4 System Processes

Under the government's current financial and budgeting system, none of the linkages between product and research demonstrated in the commercial world exist. Universities and laboratories receive basic and applied research funding with the belief that research will lead to new technologies which can be utilized in the future (House Committee on Science, 1999). No end product drives the research. Recent ideas, such as Advanced Concept Technology Demonstrations (ACTDs), and plans, such as the Joint Warfighting Science and Technology Plan (2006), have attempted to bridge the gap between internal ideas and formal product development by providing dialogue between researcher and war fighter or providing general long-term capabilities requirements (Riley, 2003). ACTD provides the closest parallel to a normal push concept. In an ACTD, system prototypes are demonstrated to potential users who determine if the product is needed and, if it is, usually acquire it or fund it though the normal PPBS system ("Joint Capability," 2004; DoD, 2002). The difference in ACTD and the push system shown in

the above figure is that, even if further development is required, a prototype has already been developed; this effectively puts need after development. This process does not link the research to a specific product or negate the necessity to enter a pull process in order to actually fund a development project. Instead, where products (weapon systems) are concerned, the DoD operates on a PPBS driven technology pull concept that relies on proven technologies or proven contractors and requires planning acquisitions five years in advance (DoD, 2003). This implies that either the technology is proven before it enters the process for funding or it is supported by a contractor who has proven capability for advanced technology development.

Wheelwright and Clark developed a synopsis of the commercial industry development funnel and model that can be viewed side-by-side with DoD's model, as shown in Figure 5 (1992). The top and bold positions of the figure encompass Wheelwright and Clark's model while the lower portions are the DoD equivalent processes. Note that the DoD does not have a requirements push process, but relies almost exclusively on defined requirements rather than reviewing what technology can provide.

In a normal business, technology assessment and forecasting and market assessment and forecasting are reviewed together to plan the most likely products to succeed. This allows civilian industry to avoid mistakes often made by the government (reaching for technology that is not yet available) and to more easily transition technology to the end user (Wissler, 2006: 7).

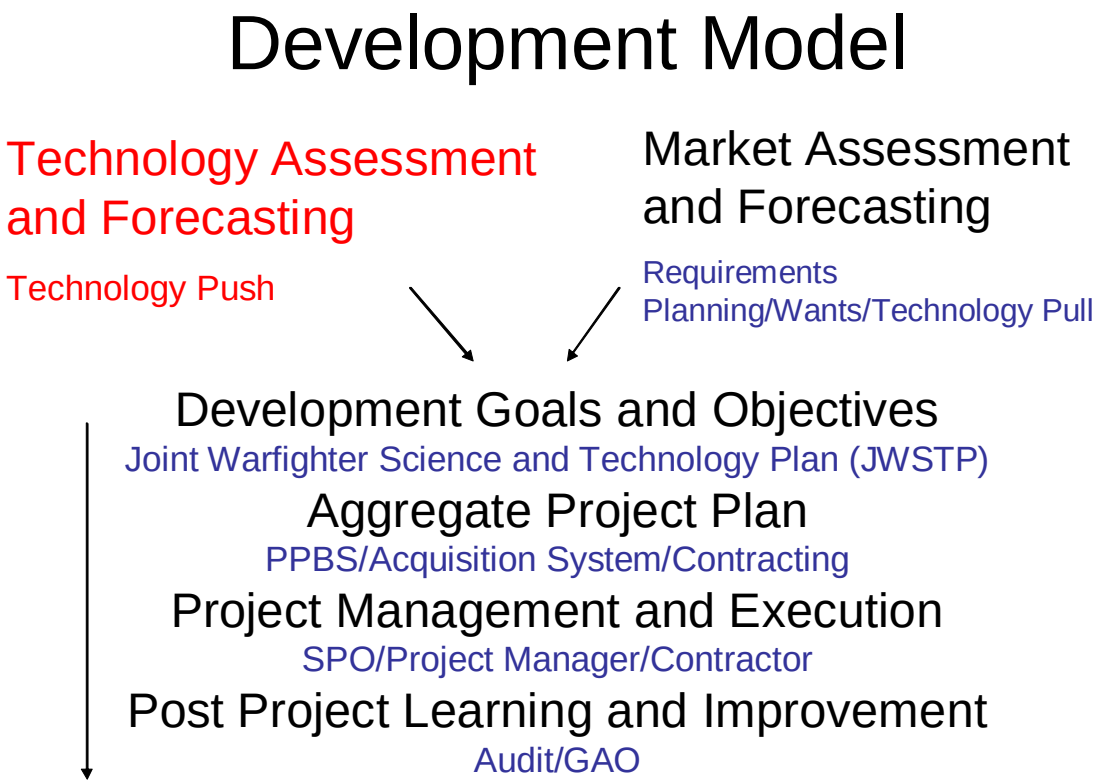

Figure 5 Development Models

Assumption 3: No one acquisition method has proven itself better than others.

Unlike previous assumptions which will be addressed in the results of this research effort, this assumption relies on historic fact so it must be proven or disproven within the literature review. This involves a review of the arguments, solutions, and problems the acquisition process has endured in the past to illustrate that all modern acquisition methods, including internal development, have been attempted in the past, but none have proven best. At the heart of this assumption is the ever-present movement from integration or vertical integration to disintegration or horizontal integration and back in a continuous loop or helix with no one method ever proving perfect (Fine, 1998). This helix is present both in industry and DoD. To

illustrate that no one acquisition method has proven better than another in DoD, this portion relies heavily on two authors, James Nagel and Wilbur Jones, who have written much on military acquisitions history. It is divided into two primary phases: a review of early acquisition history and then a comparison of these methods to modern thought.

Early United States Acquisition History (1775-1975)

James Nagel's A History of Government Contracting (1992) and Wilbur Jones' Arming the Eagle (1999) provide excellent overviews of contracting and acquisition roots in the US. An argument could be made that the basic issues they review apply to any country or entity performing a contracting process; however, for the purposes of this thesis and its scope, these two books form an adequate baseline without a need for international implications. Nagle attributes the issues in his two-hundred year history of government contracting and acquisition process changes to five recurring themes which, he argues, have plagued the US since the Revolutionary War. These include the military-industrial complex, profiteering, government vs. contractor sourcing, ethics, and competition.

Nagle states that the country's opinion of the military-industrial complex rotates in three phases each time a great emergency faces us: first, awe at the industrial strength and America's ability to conquer the task; second, complaints about the speed, efficiency, quality and cost; and finally, disgust at the final price and profits (Nagle, 1992: 4). This opinion rotation occurred in both great civilian undertakings, like the Hoover dam, and military undertakings, like the F-22 today. In particular, the American war machine has entered this cycle during each war, resulting in a quick demobilization after every war until the Korean War (Nagle, 2002:57). The result of this repeated demobilization was a difference in contracting and acquisition needs in peacetime and wartime. The led to contracting requirements that were sufficient during peace, but were too

slow for war (Nagle, 2002:58). In the 1800s, a practice was introduced which allowed small contracts for weapons and ammunition production to be granted to civilian industry in order to ensure their proficiency. By 1930, this became the standard procedure of maintaining industrial capability without maintaining the large industrial complex (Jones, 1999: 221). However, new aircraft technology contractors in the 1920s were given "shared risk and cost" rather than "fixed price" contracts. At times, these contractors were given full control of their projects (Jones, 1999:221). Although this close-knit relationship led to arguably excellent results, it fell under heavy congressional scrutiny during the depression. Arguments arose that the aircraft industry had made obscene profits at taxpayer expense; this led to very stringent cost and profit margin control for the next twenty years (Jones, 1999:222). Until these controls were loosened in the First War Powers Act of 1941, the modern military-industrial complex did not begin to arise (Jones, 1999: 262). With the Second War Powers Act, which included the government's ability to audit private contractor books and records, the modern acquisition relationship was realized (Jones, 1999: 265).

As early as 1777, "profiteering" began to occur in the US government acquisition process. In this timeframe, farmers, merchants, and those supplying the Army took advantage of the increased demand to increase price and profit (Nagle, 1992: 45). In an attempt to prevent this, the government shifted from buying goods on the open market to long term contracting with a single supplier to support all Army needs in a particular category for a given geographic region. This direct support shared sustainment style contracting system (much like the F-22 parts contract today) was put in place in 1781. To the detriment of the troops, contractors took advantage of the government almost immediately (Nagle, 1992: 54). As George Washington noted to Comfort Sands, who was supposed to be supplying the Army:

> "Why Sir are the Troops without Provisions? Why are the deposits which have so often, and so long ago been required by General Health, and pressed by myself, neglected? Why do you so pertinaciously adhere to all those parts of the Contracts as are promotive of your own Interest and convenience . . . and at the same time disregard the most essential claims of the public; thereby hazarding the dissolution of the Army and risking the loss of the most important Post in America?" (Nagle, 1992: 54)

In fact, profiteering was far worse than a few contractors bending the words of the contract to their benefit; merchants were colluding to increase prices and buying stock in each other to destroy any real competition (Nagle, 1992: 55). Between 1796 and 1798, six frigates were promised for $688,000, but cost overruns caused only three ships to be built at a final cost of over $1.2M. Again, rampant complaints of profiteering ensued, but the three ships built were the "most magnificent ships afloat" at that time (Nagle, 1992: 71). At times, the profiteering accusation was wholly unfounded; rather, it was due to increasing technology cost. For example, in the Navy, between 1930 and 1940, new technologies like sonar and radio swelled shipboard electronics costs from $17,000 to over $100,000 (Jones, 1999: 225). No solution to profiteering has been found, since congressional investigation and complaint usually come after project completion and very few sanctions have ever occurred.

The arguments for government versus contractor sourcing have also been around since the early days of the country. In the first days of the Revolutionary War in 1775, congress established the Army contracting system relying entirely upon the government to procure, store and transport goods (Nagle, 1992: 24). By 1776, arguments arose that contractors could provide a better system at lower cost (Nagle, 1992: 32). In 1781, under Robert Morris and after numerous government provided supply failures, scandals, and fraud accusations, contracts were introduced for private companies to supply the Army (Nagle, 1992: 51). Unfortunately, by 1782, complaints arose about contractor profiteering (Nagle, 1992: 54). In response to this and numerous subcontracts, which confused who was responsible for low quality supplies, Morris

appointed an inspector of contracts and inserted contract clauses for inspection (Nagle, 1992: 54). Unfortunately, this did not meet its intended goal, and by the end of 1782 the contracting system had failed to provide as promised. As a result, many commanders contracted directly to supply their men (Nagle, 1992: 55). Fortunately, the Revolutionary War soon ended and these problems did not arise again until 1794. In his battles with Native Americans, Major General Wayne once again pointed out the "absolute necessity of some effectual & Certain mode of supplying the army than that of private contract." (Nagle, 1992) This led to additional attempts to refine the contracting process which resulted in varying degrees of success (Nagle, 1992: 69). By the early 1800's, a combination system of government and contractor production and supply of small arms existed that existed in the US through the War of 1812. However, sentiments continued to shift, first, in favor of national armories, and then, after the Mexican War, back to exclusive dependence on contract. In 1850, Jefferson Davis defeated an attempt by congress to completely privatize the industry arguing that both were needed for the best possible system (Nagle, 1992: 89). Davis argued that national armories were readily available, less expensive, and established a standard for price, while private manufacturers innovate in both materials to increase firepower and methods to lower production cost (Nagle, 1992: 89).

Ethical issues also caused problems within the acquisition process. At times throughout the early days, suppliers and commissary generals were paid via commission based on the amount of money that went through their hands; this followed traditional European practice. In fact, it was commonplace to commingle ones own money with the government money one was managing. Often, government money would be used for private ventures and vice versa; this led to numerous issues. For one, congress caught commissaries significantly increasing prices to make more commission profit (Nagle, 1992: 34). Congress attempted early on to go to a salary

based system; however, this failed because Congress could not pay an enticeable salary without raising the pay of others in similar ranked positions (Nagle, 1992: 40). Instead, congress attempted to combat fraud by regulation, which produced nearly disastrous results. Many capable managers left rather than deal with the requirements and the regulations which sacrificed efficiency at a time when swift contracting was desperately needed (Nagle, 1992: 38). In 1779, congress attempted to demand line item accounting for purchases, arguing that the money flowing through commissary and quartermaster hands was not producing equitable results. These calls were met with excuses and extensions or were just flatly ignored (Nagle, 1992: 41). In other cases, ethical people were falsely accused of defrauding the government. In 1798, Eli Whitney won a contract to deliver muskets to the Revolutionary Army within two years. It actually required over 11 years to deliver all of the muskets. Despite accusations of fraud and profiteering, the government continued to pay what would be considered incentive or award fees in full and advances on the final sum, and, in the end, Eli's technology of interchangeable parts proved invaluable. Several other contractor bids were accepted to get the total number of muskets required; many of these contractors were also granted extensions, received incentives and advances, and never produced anything, which is a much worse example of defrauding the government (Nagel, 1992: 84).

Finally, in the area of competition, Congress has always been partial to a competitive bid lowest-cost fixed-price contract. In Nagle's opinion, this is often the least efficient acquisition vehicle and typically leads to a last minute need to suspend the rules and rush to prepare for war. As early as 1781, congress approved sealed bid contracting. Shortly thereafter, sealed bid with negotiation with "responsibility" (prior proven ability to meet contract requirements), with cost-benefit calculations, and with other variations on the standard sealed bid/low price were

introduced (Nagle, 1992: 52). By 1799, every style of contracting vehicle currently in use had been attempted with varying degrees of success. These include cost plus (at the time called cost plus commission) in yet another attempt to keep the troops adequately fed by ensuring the contractor made a profit, and government furnished materials which attempted to keep the supply of uniforms uninterrupted by pre-buying the cloth and then furnishing it to contracted tailors (Nagle, 1992: 73). From 1805 to about 1840, the government even considered private armories, which were considered part of the public supply of arms and resulted in almost zero competition. In other words, long-term contracts were awarded that were continually renewed (Nagle, 1992: 87). This gradually evolved to re-bidding with renewal if performance was satisfactory and the price bid was as low as any other bid (Nagle, 1992: 88). Of particular note regarding contracts, is the recurring theme of buying or acquiring patent rights. For instance in 1816, a contract with Asa Waters for 5000 muskets at $14 each included the right of the United States to use his patented barrel welding technology in its armories as well as the right to extend this to any contractor making arms for the government (Nagle, 1992: 86). In 1917, a combined patent pool in the form of the Manufacturers' Aircraft Association served the same need (Jones, 1999: 202). By acquiring patent rights, the government could assure fair competition and generally lower bid prices. By 1918, acquisition regulations had been formalized partly due to the need to ensure competition. This five step process included specification preparation, advertising for bids, securing guarantee bonds, signing the contract, and executing it (Jones, 1999: 180). Except for securing guarantee bonds, the steps were similar to the methods used today (GSA, 2005) and have made the efforts to produce new weapons extremely slow. For example, it took 17 years to develop the M1 rifle (Jones, 1999: 220). By 1943, the steps had increased to 15; the need for

prior year planning became evident to proceed though the steps that were meant to ensure fair and equitable competition (Jones, 1999: 268).

Attempts at streamlining the system were made throughout the late 1940s and 1950s. This strengthened the Defense Secretary's position as well as consolidated some classifications and committees but did little to change the system until 1961 with the appointment of Robert McNamara (Jones, 1999:325). McNamara created the Office of Systems Analysis, Defense Contract Audit Agency, Defense Contact Administrative Service, and the Defense Supply Agency. McNamara also initiated several programs aimed to increase competition and incentivize contracting; some of these programs are still being used today while others have been abandoned (Jones, 1999: 329). Most notably, McNamara created the Planning, Programming, and Budgeting System which is still in use today and was originally meant to bridge the gap between the disjointed planning and programming (Jones, 1999: 328).

History (1775-1975) vs. Modern Thought (1975-present)

Modern government acquisition has been called a sea of paperwork (Nagle, 1992: 505) culminating from thousands of decisions made by thousands of people rooted in special interest, success, failure, and conflicting ideologies (Nagle, 1992: 519). The detailed, many volume manuals regulating modern acquisition includes the *Federal Acquisition Regulation* (FAR), DoD 7045.14 *Planning Programming, and Budgeting System* (2003), DoD 7045-H *Planning Programming, and Budgeting Handbook* (2004), as well as many others. In fact, due to the confusing nature of the numerous regulations, texts have been written in an effort to condense the information into an understandable and usable form. Some of the better resources in this area include Arnavas' Government Contracting Guidebook (2001), the Air Force Institute of

Technology Defense Acquisition Handbook (2005), and the Department of Defense Acquisition Strategy Guide (1994).

None of these vast regulations seem to have solved overarching problems or quieted the continuous debate about the proper acquisition methodology. In fact, the issues encountered in modern academic papers are surprisingly similar to the recurring issues of America's early years. Mark Holbrook, in his article tying acquisition reform initiatives to contract cost variance, attempts to ascertain which initiatives have had the most impact (2003). Holbrook demonstrates a few weak impact correlations, but more important is that, as seen in the previous section, the cycle of reform and analysis has been ongoing since the 1770's. Similarly, Christensen attempted to analyze cost overruns in defense contracting (1993). His research focused less on the cause than the inevitability that a contract more than fifteen percent complete will never recover from a cost overrun. Just like the frigates and muskets mentioned earlier as well as other examples cited by both Nagle (1992) and Jones (1999), cost overruns have plagued the system since the early 1800s.

Other examples of repeating history include *Lowering the Cost of Federal System Acquisition* (Kasser, 1996), *Spare Parts Horror Stories* ("Spare Parts", 1997), and *Back to Basics* (Dornheim, 2006). Kasser recommends moving system testing and inspection to an earlier phase of the development cycle in order to catch and repair anomalies before they impact the cost of the acquisition process. This is a simple adaptation of the theory of constraints idea of putting the inspectors before the bottleneck (Goldratt, 1984). Arguably this is a fine idea, but history demonstrates that inserting and extracting inspectors from the process has little long term effect (Nagle, 1992). *Spare Parts Horror Stories* chronicles yet another instance of procurement problems halting the mission. The article notes that the government waits longer and pays more

for Unmanned Aerial Vehicle parts from the contractor than from procuring the parts at a local engineering supply company. Again, this brings back the earlier arguments against profiteering. However, some may argue that the UAV technology justifies the premium on the common use parts (Nagle, 1992; Jones, 1999). Dorheim chronicles the Air Force's failed attempt to contract out all facets of the Evolved Expendable Launch Vehicle (EELV) Program (including management) (2006). After numerous setbacks, the program was returned to a cost-plus contract with full government technical oversights. This method has systemic historical problems, attributable to either profiteering or the government being the sole user (Nagle, 1992; Jones, 1999). The reason cited in the EELV case is the failure of a substantial commercial market to materialize. In other words, since the government is the sole user and more importantly sole funder of the technology, government oversight is required to ensure its interests are preeminent.

Even relatively "new" ideas such as spiral acquisition and cost as an independent variable (CAIV) are reflected in US acquisition history. Wayne Johnson argues that spiral acquisition has positive and negative implications. Among the positives are the ability to insert new technology, speed to the war fighter, continuous improvement, and knowledge retention. The drawbacks include an eighty percent initial solution, possible budget cuts, and multiple configurations in the field (Johnson, 2002). In a way, the 1800 and early 1900 government letting of small contracts to keep industry proficient while continuing internal development is a precursor to this concept. This strategy has proven slow in peacetime (reflecting years for weapons advancement – i.e. the 17 years for the M1 rifle), mostly due to congressional funding (Jones, 1999). Johnson even makes several arguments on the possibility that congressional and government financial interests could ruin the whole spiral development concept just as is seen in past attempts (2002). In Benjamin Rush's article on CAIV, a strong argument is made for including cost benefit tradeoffs

in acquisition decisions (1997). While this sounds like a new and great idea, the concept has existed in US acquisition since 1700. At that time, because the government was perpetually low on funds, everything involved a cost tradeoff. A particular similarity to today's concept is buying muskets. The level of technology was chosen based on need and cost (Nagle, 1992). This has been carried through the years to Truman's motto to get "more bang for the buck" in the late 1940s (Jones, 1999). Although Spiral Acquisition and CAIV are now formal concepts, the basic premise of development without production and cost as a variable have been around in the US acquisition process since the 1800s.

Summary

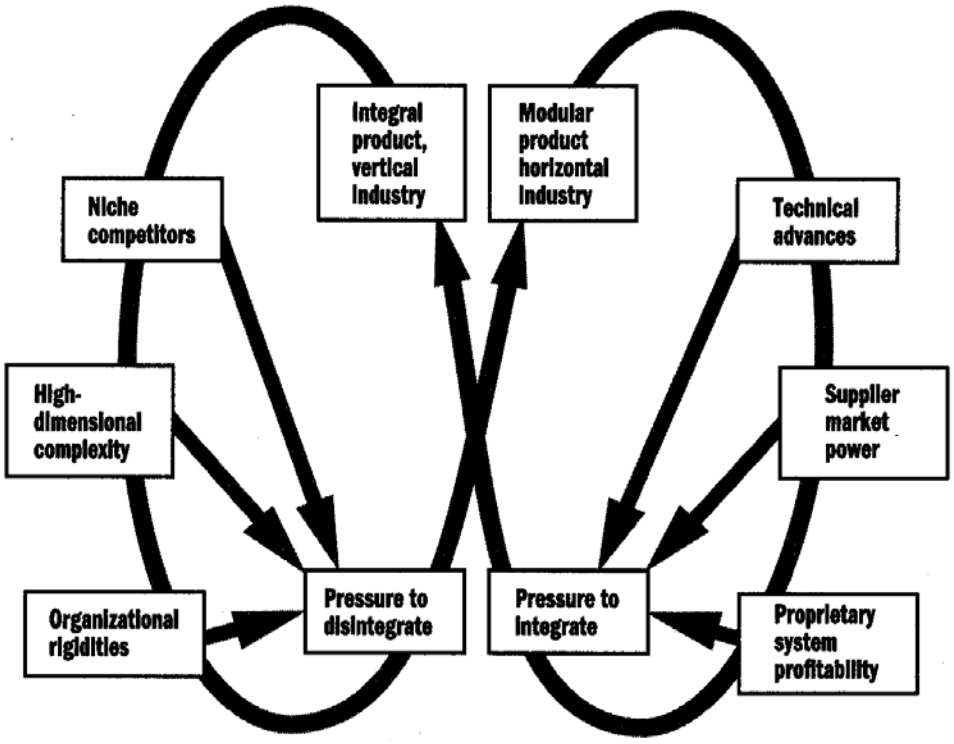

Figure 6 The Industry Double Helix

This section provided extensive support to prove that no one acquisition method has proven itself better than others. The section presented an in-depth look at historical success and failures of the acquisition process and methods. It demonstrates that all modern acquisition

methods have been attempted throughout the US's history and validates that no one method has proven best. In fact, history is ripe with successes and failures of each method. The process in use today is simply a more formalized system with no fundamentally new ideas or new acquisition vehicles. The process simply follows a continuous loop of integrating and outsourcing via various methods as illustrated in industry by Charles Fine in Figure 6 (1998). In order to increase the chance of developing a successful system, the DoD should keep options open by examining all reasonably available methods.

Assumption 4: External development is the method of choice for decision makers

Empirical evidence suggests this is true. Most DoD product development is conducted and completed externally. This indicates a propensity to choose external over internal development.

Several theories exist concerning the rationale for the extreme reliance on contractors in the acquisition process. One is that the government does not have the talent or resources to develop or transition weapon systems (White and Deutch, 2004). While this theory may be true for large complex weapons systems like the F-22, this thesis contends that it is not true for less complex, mostly off-the-shelf technology (i.e. the UAV previously mentioned). Government entities have designed working weapons systems and a specific recent accomplishment will be covered in the next section (Godbolt and Hawk, 2005).

Others argue that the government has long used the procurement process to further social and economic objectives (Nagle, 1992: 1). Guttman makes the case that the current political climate favors a small government, but no individual or organization wants to give up current government benefits provided specifically to them. Therefore, the only way to reduce government employees, and thereby government size, without a change in benefits is to privatize

and contract. This method does reduce the number of people on the government payroll, but it does not necessarily reduce government or the cost of government (Guttman, 2003). If this argument has merit, then a contracted or privatized system, even if more expensive, would be preferable to government development regardless of cost. However, one would hope this argument does not extend to cost of life. If not, then speed to the war fighter would be important and still be a valid argument for internal development over external development.

Another argument for the existence of a large contractor presence in the acquisition process is that outsourcing is cheaper. Numerous articles tout the benefits of outsourcing and demonstrate initial savings, but very few give any quantifiable evidence that outsourcing is cheaper in the long term (Poole, 1980; Kotabe, 1989; Bettis and others, 1992; Quinn, 1992; D'Aveni and Ravenscraft, 1994). In fact numerous US Government Accountability Office (GAO) reports point to weapons system cost overruns, lack of cost savings, and general overpricing of goods, such as a $10 washer sold to the government for $127 ("Spare Parts", 1997).

In short, general arguments against government development of weapons systems do not seem to have merit except when concerning the most complex and expensive systems. However, other arguments detail specific problems with the way the government currently acquires systems that do have merit, but can be remedied through a simple change in mindset. For instance, critics point to the fact that government scientists have taken on a managerial role. The true technical work has been given to contractors; government personnel have been relegated to contract managers (Suddarth, 2004). Suddarth views this as a two prong problem. He addresses and suggests remedies to both the reduction in the number of and current role of government engineers. The reduction in engineers reduces the feasibility in building strong internal

capability, while the current usage of engineer is typically to monitor contracts (2004). Obviously, if government scientists are no longer available for technical work, then internal development is not possible. In meetings with Air Force Research Laboratory (AFRL) personnel, this is the second most referenced problem in undertaking internal development efforts (interviews). However, personnel levels and career paths are issues that are under governmental control and can be rectified (Suddarth, 2004).

Critics also point to the lack of funding for research and development. Suddarth notes that most adjustments decrease the science and technology budget and that the long term trend to the Science and Technology budget is not promising (Suddarth, 2005). Suddarth points out two issues: first, that the development budget is generally shrinking, and second, that the budget is tightly controlled and rigid, leaving no room for spontaneous internal breakthrough programs. In other words, the internally developed, technology push, working directly with the war fighter program may not be possible due to rigid budget and bureaucratic requirements. In fact, during the interviews with AFRL personnel, this was the most referenced problem with undertaking internal development efforts. Suddarth presents several reasons for this problem, including pressures from Congress to reduce duplication of effort and long-term strategic planning; both of these issues stifle creativity (2005). Funding constraints, however, are another issue which can be remedied.

Personnel training and budgetary issues are both issues that have merit concerning the internal versus external development debate, however the core of this thesis is to compare final results of internally and externally developed programs rather than explore remedies to the system's bureaucratic issues. It is possible that internal development could be faster, cheaper, and more capable, but require major guideline and constraint revisions to implement.

Concepts Important to this Research

The purpose of this thesis is to show that not only has exclusively utilizing one development method proven impossible throughout history, but it also continues to be problematic today. The AFRL Strategic Plan under General Paul stated that 80% of research efforts should be outsourced; however, there is no factual or empirical rational included. Other government documents, such as OMB Circular A-76, indicate that outsourcing will reduce cost, and that same idea, discussed below, is prevalent throughout industry. As with other industry fads (i.e. Total Quality Management, Lean, and Six Sigma), the DoD and Air Force undoubtedly assumed all claims were true and therefore planned to save money through outsourcing efforts. The concepts used in this research draw upon all the concepts included in the theory, goals, and perils surrounding outsourcing in the literature. To aid in explanation and later in formulating questions, these concepts are categorized into sub-areas for this research. These areas are cost, feasibility, capability, training, speed, customer relation, concurrency, and guidance.

Cost

In preliminary questioning of subject matter experts, cost was one of the most cited reasons for making a contracting decision. This is not surprising since government is usually focused on cost. Recent articles and reports touting the savings involved in contracting out what was once organic capability have been growing throughout the 1980s and 1990s (Poole, 1980; Kotabe, 1989; Bettis and others, 1992; Quinn, 1992; D'Aveni and Ravenscraft, 1994; Lei and Hitt, 1995; Rasheed, 2000; Grasso, 2003). Many believe that, especially in the bureaucratic case like the government, cost will certainly be reduced by outsourcing (D'Aveni and Ravenscraft, 1994). This may have been demonstrated in initial competition through Most Efficient Organization (MEO) efforts in which many base functions were replaced by cheaper contractor

efforts throughout the 1990s (GAO, 2000). However, this is usually a one time effort so any potential savings might be offset by future contract cost increase. The competition method for these efforts may also be skewed. For example, a military Airman's cost per hour is calculated based on all future earnings *to include retirement*. This creates a cost target that is easy to beat. Since many Airmen separate prior to retirement, this cost estimate seems skewed toward outsourcing. Other examples involve not including the price of the cost analysis and contracting process in the total cost to contract an effort as well as failure to include ad-hoc services typically performed by government employees that will require additional pay for a contractor. One final example that can skew the cost estimate toward the government is not including tax advantages in hiring private providers (Carver, 1989; McEntee, 1985; O'Looney, 1998). Unfortunately, both sides of the argument include bias.

In all this, initial cost savings is considered the central issue. Long-term profitability, or in the case of government, lowest cost, cannot be found in short term-cost savings (Rasheed, 2000; Fine, 1998). Some form of return on investment calculation would be more appropriate.

Feasibility

Another central theme in outsourcing is best business practice or strategic outsourcing. This could be described as concentrating on areas of proficiency while outsourcing the remaining areas (Quinn, 1992). DoD laboratories encompass a large area of expertise. Even within AFRL, areas from sensors, to software, to human effectiveness, to propulsion are encountered. While a central authority could direct all laboratories to concentrate only on a certain area while outsourcing the rest (which, in essence, forces them to be identical), it is more logical to the author to assume that they are not all alike. Therefore, rather than concentrating on the area in which each laboratory excels; this thesis concentrates on internal feasibility. In other words, this

thesis seeks a methodology to present and produce ideas internal to the laboratory rather than assume that all work be contracted.

Capability

A third area, capability, might, at first, seem similar to best business practice or the laboratory's area of expertise, but it is meant to gauge what Charles Fine in *Clock Speed* refers to as a companies "core competencies" (1998). Some authors, like Fine, think it is possible for industry to swing too far into outsourcing while pursuing lower costs. They loose their internal capability and competencies and become completely reliant on others (Bettis and others, 1992; Fine, 1998). In the business world this can mean the end of a company, but in a laboratory environment it could mean the inability to do in-house work.

Training

Some authors counter that training is enough to keep personnel sufficiently technically proficient to maintain their core competencies while enjoying the cost benefits of outsourcing (Bettis and others, 1992). This leads to the question concerning what training is required within DoD laboratories to maintain proficiency and competency. Guidance, at least within AFRL, mandates 80 hours of training every two years. These hours can be satisfied in a number of ways ranging from mandatory Air Force recurring training to doctoral degree classes.

Some authors take this argument one step further stating that technical proficiency in all areas may no longer be required. The company is paying the contractor for that proficiency so personnel only need to be good contract monitors. In fact, some feel that too much technical training may lead to undue project bias (Sahlin, 1998; O'Looney, 1998). In this argument, it would not be an issue for a DoD laboratory to loose the ability to do in-house work or to loose technical expertise.

Speed

Another issue often brought up in relation to outsourcing is speed. In the case of DoD developments, this involves the time required to get a product to the war fighter. Usually, this topic is related to best business practice such that if everyone concentrates on their core competencies, then products can be brought to market faster (Bettis and others, 1992; Kessler and others, 2000). This means that, in theory, contracting efforts actually decrease product development time. However, other authors disagree with this premise and provide data to dispute it (Kessler and others, 2000). The rationale is that streamlining the effort internally and avoiding the contracting process can speed production.

Customer Relations

Customer Relationship is another area sometimes cited in reference to outsourcing. Some arguments claim that outsourcing puts a strain on customer relations since customers must go through an intermediary to reach the product developers. Others argue that outsourcing allows a company to focus on customer needs rather than product development (Rasheed, 2000; Hagel and Singer, 1999). In industry, the later premise leads some firms to concentrate on product development while outsourcing customer relations. In DoD, the process typically occurs through contracting design and build while a government employed program manager continues customer relations.

Concurrency

Although initial MEO efforts have always included the initial government team (those currently doing the work), future re-competition efforts do not. Similarly, competitive bids for laboratory contracts are usually between contractors only. However, some recent cases have shown better long term results when public sector providers are included in the mix of potential

competitors whenever possible (Flanagan and Perkins, 1995; O'Looney, 1998). This increases competitors and can guard against low-balling and price escalation. In the laboratory environment, this means at least maintaining the capability for an internal development effort so that these benefits remain possible. The actual process of internally competing has been dubbed concurrency for the purpose of this thesis and the surveys contained therein.

Guidance

As stated earlier, a laboratory can be forced through direction to always choose a certain path. While this area is not a part of the reviewed literature dealing with outsourcing, company guidance can play a very important role in the direction of the company (Hall, 1984; Peters, 1987). This area will be very important if the employees understand and adhere to any requirements imposed by higher level agencies. This area may also be problematic if employees completely ignore any guidance.

Summary

The literature surrounding or supporting each assumption was briefly reviewed to either prepare the assumption for testing or prove it valid. The concepts important to outsourcing in the literature were reviewed one by one and compared to historical occurrences.

The goal of this thesis is not to prove that government development is the optimal solution, but rather to investigate if one method is actually superior to the other if they are both equal. In other words, to ensure the greatest chance of product development success by showing, as Jefferson Davis said, that "both are needed" (Nagle, 1992: 89).

III. Methodology

Introduction

This chapter covers the methodology chosen to conduct this research and the tools and techniques used for data collection. Although extensive literature exists surrounding the topic, there is no official Air Force guidance regarding when to develop internally versus externally. Additionally, a few recent publications have argued the wisdom of contracting out to save cost (Fine, 1998). This coupled with the reported propensity for DoD laboratories to choose external development led to the thesis purpose. Data availability as well as time and resource limitations led to the determination that an exploratory case study was the best approach.

Qualitative Research Method

The design chosen is an exploratory case study approach. This does not detract from the relevancy or contributions of this thesis. A common misconception is that various research strategies are hierarchically arranged, when in fact they are all equal (Yin, 2003). Depending on the type of research question, extent of researcher control, and amount of contemporary versus historical focus, one method may be more applicable than another. In this case, the objective of comparing the results of internal laboratory development, testing, and fielding of small weapons systems was accomplished though the capture of the everyday circumstances and conditions that were present (Yin, 2003). The recognized experts in qualitative design are Robert Yin and John Creswell (Espy, 2006; Suarez, 2006), and, as a result, their methods are relied upon heavily in this case study design and analysis. Both agree that a case study is ideally suited for the study of a real life phenomenon without clearly defined boundaries (Yin, 2003; Creswell, 2003). This

methodology essentially describes the situation of internal weapons development presented in this study.

The Exploratory Case Study

Yin defines a *case study* as a historical account with the added benefit of direct observation and interviews (2003). As applied to this thesis, an exploratory case study is most applicable; the value of the knowledge and exact questions requiring answers are not yet known (Creswell, 1994). Although great effort has been made to base the questions and assumptions in grounded theory, results of the interviews could prove insightful in contributing to or modifying the interview questions for a larger study. In order to perform the research, study questions must be developed, a unit of analysis defined, a method of gathering data chosen, and a criteria for interpreting data selected (Yin, 2003). Yin defines this as the *study blueprint.*

The overall research question for this study is: *Is there a quantifiable difference in war fighter capability and delivery between internally and externally developed small weapons systems and, if so, why?* The decision to internally develop a system or contract it out has a long history. The decision often is not made by one person or even by one department. Current DoD guidance on whether to develop internally or externally is near non-existent beyond basic contract cost comparison requirements. These realizations led to several investigative questions:

- Which involves less cost?
  - Will concurrent efforts reduce cost?
- Which produces better capability?
  - Can internal be done?
  - Does one produce a better customer interface?
  - What defines personnel capability?

- Does one produce better personnel capability?

– Which provides faster delivery?

- Are there process problems in either acquisition method

– Are personnel given any guidance on the issue?

Since an exploratory or pilot study typically consists of a sample of data (in the case of this thesis those will be individual interviews), the unit of analysis is the individual being questioned (Creswell, 2003). The analysis will be summarized at the AFRL level.

Although many methods of data collection for a case study exist, an interview process is most applicable for an exploratory situation. Interviews reveal more than history and are more fluid than surveys. Interviews also provide more information to a researcher because the researcher can ask insightful follow-up questions to any initial questions on the survey instrument. Analysis proves more difficult since varied verbal responses must be quantified into units usable in research comparisons.

In this case, the criteria for interpreting the data follow directly from the method of data collection. Since an interview process is used, the only option is qualitative data analysis. For qualitative data analysis, three methods are most applicable. These are pattern matching, in which several pieces of information across the interviews can be related; theme development, in which recurring themes are magnified through repetition; and explanation building, in which each interviewee connects a piece of the puzzle (Yin, 2003; Campbell, 1975; Trochim, 1989).

Data Gathering

The interview process for this exploratory study was limited to employees within AFRL. The time consuming nature of an interview process and Creswell's optimal number of 20 to 30 per pilot study required additional restrictions on the scope of the process (2003). By having all

units of analysis in AFRL, the data could be more concentrated, the timetable more compressed, and the results more applicable and transferable to a particular unit.

After selecting AFRL as the primary test case, a Subject Matter Expert (SME) within AFRL provided a list of potential interviewees ensuring a cross section of directorate, age, position, and years of service. The only requirement for inclusion in the interview process was at least three years in a government research related position. This requirement was included to ensure units of analysis were qualified and knowledgeable enough to provide responses to the interview questions. The proposed questions were also reviewed and tested by a small group of SMEs to ensure accurate and non-repetitive questions as well as proper word selection. The questions were left open-ended to allow further elaboration (Creswell, 1994).

The perspective interviewees were then contacted by phone and e-mail to schedule face-to-face individual interviews. Usually these interviews were conducted within the office of the interviewee, but, on occasion, were accomplished in a substitute setting (such as a conference room). A few interviews had to be conducted by phone due to the geographic separation of some AFRL directorates from Wright-Patterson AFB. Each interviewee was advised of the purpose, sponsors, and disposition of the research and assured that participants would not be personally identifiable. Only the researcher was aware of the actual names of interviewees and only the thesis committee had access to the interview raw data to ensure privacy. They were also presented a privacy act statement as required by the AFRL Internal Review Board which granted permission to conduct the interviews.

The interview, itself, was a focused interview (Merton and others, 1990) revolving around the basic areas presented in chapter 2 and some additional general question areas. This is summarized in Table 4. Notes were taken during each interview and recordings were made

when allowed by the interviewee. Before beginning the main line of questioning, each interviewee was advised of the study's scope and the definitions of in-house, external, concurrent, and system as they applied to the line of questioning. The focus areas and initial interview questions asked are presented in Table 4. Follow-up questions were asked as needed to completely understand interviewee responses; additional questions concerning funding streams and transition were only asked to individuals who commented upon issues with transition.

Table 4 Interview Instrument

AREA	QUESTIONS
Feasibility	Are you aware of any avenue to present and produce internally developed ideas? Is it possible for AFRL to create a working prototype of a system? What would AFRL need to accomplish this? What stumbling blocks currently stand in your way? Have you been involved in an internal development effort?
Concurrency	Are you encouraged to promote competition? Is this ever done though direct competition via multiple efforts? Could laboratory development provide direct competition? Have you been involved in a concurrent effort?
Customer Relation	How often must you translate customer requests to industry? Do your industry contractors interface directly with the customers? Would it be easier to implement customer needs if the project were internal?
Capability	Are your government employed personnel technically proficient? Do they spend their time developing systems or providing oversight to industry developed systems? Would they be more technically proficient if directly involved in system development?

Continuation of Table 4 Interview Instrument

Training	How do you ensure your engineers remain technically proficient? Is training centered on engineering or contract management? In your opinion, what can be done to improve the situation? Do government personnel really need engineering experience in today's environment?
Cost	Would it cost more to develop internally? How would concurrent development apply to or affect your area? If your product was internally developed, would it be cheaper to produce or sustain?
Speed to War Fighter	Could an internally developed system be fielded faster than an externally developed one? Can the government perform tests that are required for fielding faster than industry? What roadblocks do internally developed systems or industry developed systems have an advantage in surmounting to reach IOC?
Guidance	What guidance do you follow when deciding what to develop internally and what to contract to industry? Do you have any unwritten rules on the subject?
General	In your opinion, what would be the single most important issue in a debate between internally developing and externally developing systems?

Data Analysis

After the data collection, analysis was conducted involving techniques for case studies recommended by Creswell and Yin (1994, 2003, 2003) beginning with Creswell's spiral which prescribes organization, perusal, classification and synthesis as depicted in Figure 6. The data is broken up into phrases which can be stored in a database. It is then reviewed repeatedly to understand overarching concepts and meanings so that the data could be classified into common categories and summarized. Finally, it is used to form propositions and hypotheses concerning

relationships. This combined with the pattern matching, theme development and explanation building mentioned earlier provided results for this exploratory study and possibilities for future study (Trochim, 1989; Yin, 2003).

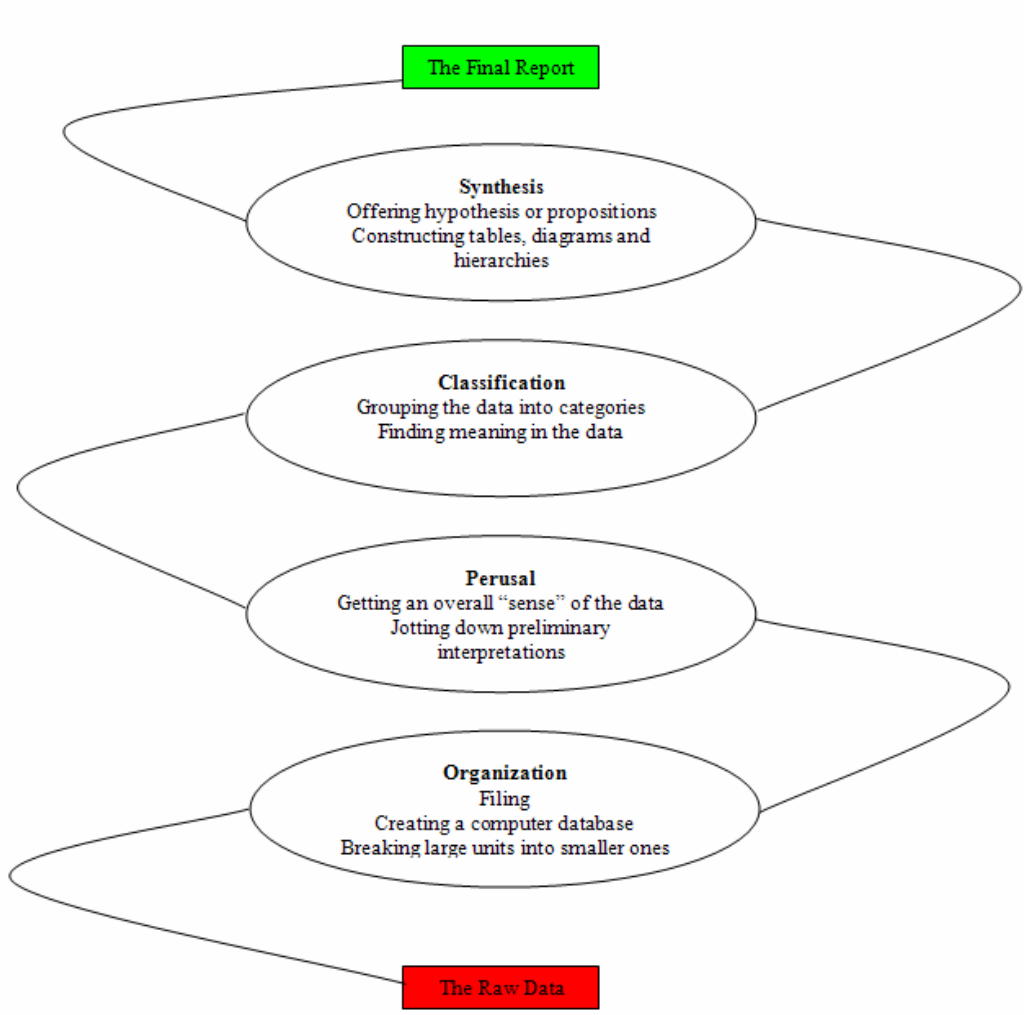

Figure 7 Data Analysis Spiral (based on Creswell, 1998)

Reliability and Validity

Several preventative measures were incorporated to ensure validity and reliability in the study. First, the presence and input of SMEs during the overall process and third party review of

data ensured construct validity and provided internal feedback (Yin, 2003). Second, to validate data synthesis, an external audit by colleagues not associated with the study was performed to determine if they reached conclusions similar to the researcher. Third, to prevent any inadvertent researcher bias, participants were randomly selected. Finally, the case study skills and procedures used were based on texts and books by experts in research which are well documented to ensure reliability (Yin, 2003, Creswell, 1994).

Overall, the researcher attempted to gain an understanding of what could feasibly be done to modify or change current practices and the rationale or perceptions that guided the malleability of the status quo. The researcher remained adaptive and flexible during questioning to ensure opportunities for new insight were not overlooked and refrained from any personal bias from past experience. This analysis allowed the researcher to better understand internal and external capabilities of DoD laboratories in general and AFRL in particular.

IV. Analysis

Introduction

The focus of this effort is to evaluate the extent to which DoD laboratories are capable of implementing and delivering internally developed small weapons systems versus those externally developed. The review of the literature became the baseline for the interview instrument questions. Interviews were then conducted with a wide range of laboratory personnel. Certain initial responses required follow-up questions to further explore each topic to get a full understanding of the interviewee's views on the subject. The typical interview consisted of approximately 70 minutes of discussion. Only two were less than 45 minutes and one continued for over 120 minutes. Based on Yin and Creswell exploratory case study methodology, the goal for completed interviews was between twenty to thirty. For this study, twenty-nine subjects were interviewed (not including the subject matter expert who was discussed in chapter three).

This chapter discusses the data captured from those twenty-nine subjects and patterns and themes that were uncovered in the subsequent analysis. The following sections will cover analysis of the data, note any themes that occurred for each question, and include some individual comments that were significant.

Interview Question Analysis

In addition to the questions within each interview focus area, each individual was asked for information on distinguishing factors including where they worked, how many total years of DoD laboratory experience they had completed, types of money with which they dealt (61, 62, etc), what TRL range they managed (if any), and whether they were on a management or scientific track. This information was used for several purposes. First, it was used to ensure an

adequate cross section of laboratory personnel was included in the sample. The sample includes a wide range of all distinguishing factors, including representatives from all but one of the ten AFRL directorates. Second, any correlations between these statistics and the answers given to the questions might indicate influence on that response from another source. For instance, if everyone in one directorate provides similar responses, but their responses are different from other directorates, this could indicate something evident in only that directorate's culture or directives. Lastly, the absence of any evident correlations to specific categories enables easier generalization of individual responses to the overall group rather than a specific portion of the group.

When it was evident that responses were similar based on a distinguishing factor, relevant information was noted in that questions analysis. For some questions, general comments by individuals are included as additional information. In general, specific comments are attributable to a single individual. Where two or more individuals presented similar ideas, this is noted in the analysis.

Area One: Feasibility

Q1-1) Are you aware of any avenue to present and produce internally developed ideas?

The goal of this question was to delve into the first connection in the push question. Was there a way for personnel to push internal ideas into the funding stream at least for initial research? Without a way to push an idea to funding, the likelihood of any internal project is unlikely. Some follow-up questions included: *Is the funding available immediately or must you wait on the two year PPBS cycle*, and *Is this specific to your directorate?*

Almost everyone had access to funding for their internally developed ideas. However, only about half of those could get access to money for a good idea without waiting for at least a two year PPBS cycle. The overall results are presented in Table 5.

Table 5 Push Metrics

Themes	# of responses	% of participants	# of participants
Yes; There is a process to get money immediately for good ideas.	12	41%	29
Yes; There is a process to get money for good ideas by waiting 2 years on the PPBS cycle.	12	41%	29
No; There is no process to get a good idea funded.	5	17%	29

The process most referenced gaining access to money was briefing the individual's chain of command on their idea. This was mentioned by twenty of the twenty-nine subjects. Of those, nine described a formal recurring, quarterly, or semi-annual process to present research ideas for funding and the others described a more ac-hoc process. Six of the twenty-nine cited some form of management reserve to allow immediate funding of projects within their directorate. Programs specifically mentioned were the innovation research fund, the innovation idea fund, and the high impact technology program. Other processes described for immediate internal idea funding were moving funds from a lower priority project or reallocating unspent quarterly funds from other projects.

Six of the twenty-two cited bringing in external funds as a way to immediately fund an internal idea. Although most of those noted any idea that brought in extra funds was worth research, one of the individuals interviewed claimed that this only worked when researching something sanctioned by their directorate.

The nature of respondent answers were generally tied to their directorate. All PR respondents noted that external funding was always welcome. SN and VA respondents repeatedly cited formal processes to fund ideas. However, at least one individual in both SN and VA was not aware of their directorate's push options.

Q1-2) Is it possible for AFRL to create a working prototype of a system?

The goal of this question was to get the interviewee's basic opinion of AFRL's overall internal capability. A typical follow-up question included: *Would this system be on par with a contractor developed system?* Twenty-eight of twenty-nine respondents thought AFRL could create a good prototype. Of these, twenty-four individuals said this could always be done, two said it could be done for software but not hardware, one said portions of systems could be done, and one said prototyping through simulation was possible and adequate for a basic prototype. One individual from SN went further to describe standing up a laboratory rapid product development center in collaboration with AFIT to design and fabricate internal ideas.

The one individual who thought AFRL could not create a good prototype commented that AFRL is only an integrator, not a developer of technology. This response was specific to this individual as others from the individual's directorate thought AFRL could create a quality prototype.

Q1-3) What would AFRL need to accomplish this?

This question was a standard follow-up to Q1-2. If Q1-2 was a yes, this question was typically re-phrased: *Could you accomplish this with what you currently have available?* About half the respondents thought they had everything required to create a prototype. Those who responded no generally lacked equipment, facilities, people, skills, or funding. Table 6 summarizes the results.

Table 6 Internal Prototype Feasibility

Themes	# of responses	% of participants	# of participants
We have everything we need.	15	52%	29
We need additional equipment and/or facilities.	8	28%	29
We need additional people/skills.	6	21%	29
We need additional funding	5	17%	29

Five of twenty-nine cited fabrication or machining as the primary skill lacking. Two cited a lack of software or modeling skills. One individual thought systems engineering and transition skills were needed.

In equipment, three of twenty-nine thought that the government lacked machine and fabrication shops. Two others indicated that better access to wind tunnels was required. All five of these individuals were in agreement that the facilities were once available, but had been downsized, cutback our outsourced. One interviewee discussed the early to mid-1990s move toward divesting capability considered non-core competencies and its impact on the lack of fabrication capability.

Within the six of twenty-nine respondents that required additional people with skills, one respondent also added that one government employee was often handling five to eight different projects.

The responses to this question seemed tied to directorates. Except for two funding requests, PR, HE, and IF personnel generally replied they needed nothing additional. All VA and DE interviewees indicated that additional resources were required.

Q1-4) What stumbling blocks currently stand in your way?

This question was meant to explore deeper issues than Q1-3. It typically needed clarification with the phrase: *This can include personnel, skills, equipment, political, and any other issues. Not just physical, but environment and culture.* Almost seventy percent of personnel interviewed noted political issues which caused stumbling blocks to internal development. This was, by far, the largest cause of road blocks. Table 7 summarizes the general themes.

Table 7 Stumbling Blocks

Themes	# of responses	% of participants	# of participants
Political	20	69%	29
Budget	10	34%	29
Skills/personnel./time	4	14%	29
Equipment	2	7%	29

For political road-blocks two main themes existed. Ten of the twenty respondents discussed their directorate's paradigm that the laboratory exists to do basic research, not to develop products and that a large majority of research should be done through contracts. When asked why, the most often cited reason was personal choice of the directorate chief. The other main theme was teaming. Six of the twenty responded that a good internal effort took teaming across directorates and internal politics made that difficult even when the people with the required expertise were known. When asked why teaming efforts were difficult, squabbles over budget, manpower, and credit for results were cited as reasons. One individual commented that it was easier to move money from the Army to his directorate for research than it was to move money from one directorate to another.

For budget, the central theme was lack of funding in general. However, three individuals commented on congressional earmarks. The comments for this question seemed to be very specific to the individual and their experience rather than any particular directorate or track.

Q1-5) Have you been involved in an internal development effort?

This question was not the main emphasis for this area, but a leading question for the follow up questions. If the interviewee answered yes, the following questions were asked: *Can you tell me about the effort and product?* and *How did it turn out?* The real goal of this question was to compare the results of internal and external projects. Twenty-five of twenty-nine participants had experience with an internal development effort. Six of those twenty-six drew upon experience from the 1980s. Almost all of the comments about the programs these individuals were involved with as well as the results from these programs were positive. No one thought a contractor could have done a better job for a cheaper price. Two individuals thought their government effort should have included a better transition/production plan.

The comments for this question seemed to be very specific to the individual and their particular experience rather than any particular directorate or track. Not even years of laboratory experience seemed to impact whether an individual had been involved in an internal effort.

Area Two: Concurrency

Q2-1) Are you encouraged to promote competition?

Like the previous area, the first question was meant to gauge the overall climate. Even though competition is generally encouraged in contracting efforts, there was some preliminary evidence that fund shortages and GAO accusations of duplication of research were overriding factors. Twenty of twenty-nine interviewees reported that they were encouraged to promote competition. Eight of those twenty also noted that, for them, competition only included the process of getting

three bids. Of the nine that were not encouraged to promote competition, almost all cited budget as the primary reason. However, two individuals noted that duplication of research accusations (basically accusation that resources are being wasted) kept the competition down. No distinguishing factors effected this question.

Q2-2) Is this ever done though direct competition via multiple efforts?

This question was meant to delve further into question 2-1. Its purpose was to gauge how much competition is encouraged and at what level. It is also a lead-in to question 2-3. Ideally, by getting respondents thinking about the benefits of letting multiple contracts to provide more opportunities for success, interviewees without experience in concurrent projects would think about, rather than immediately dismiss, question 2.3. Follow-ups for this question addressed why multiple contracts were or were not done.

Almost two-thirds of the twenty-nine subjects indicated that multiple contracts were not used. The basic themes of why are broken out in Table 8.

Table 8 Multiple Contracts

Themes	# of responses	% of participants	# of participants
Yes; Multiple contracts.	10	34%	29
Usually no; Multiple contracts are not let due to budget constraints.	8	28%	29
Usually no; Multiple contracts are not let due to duplication of research/audit fears.	11	38%	29

Of those that did let multiple contracts, all but one restricted them to Phase I, or idea generation, type contracts. The remaining person indicated that they occasionally let competing phase II, proof of concept, type contracts. All ten of the individuals who responded yes indicated

that budget was the primary reason for not continuing with competing contracts even when it might prove valuable.

All twenty-nine respondents did agree that funding multiple contracts and multiple avenues did provide the best chance for a quick success and the best success. This question was definitely directorate dependent. For SN, VA, and PR, almost all respondents replied yes. In the other directorates, the responses were the opposite.

Q2-3) Could laboratory development provide direct competition?

This is the first question aimed at the concept of concurrency. Ideally, those without direct experience would provide an opinion based on theory they discussed in question 2-2 and at least begin thinking about the issue to answer later questions. Those with concurrent effort experience would begin descriptions here and continue into the next question. A typical follow-up question included: *Would this be beneficial?*

In this case, two-thirds of respondents believed the laboratory could provide direct competition. A basic breakdown of the themes is included in Table 9.

Table 9 Direct Competition by Internal Effort

Themes	# of responses	% of participants	# of participants
Yes; Internal efforts can provide direct competition.	19	66%	29
It might work	4	14%	29
No; Internal efforts cannot provide direct competition.	6	20%	29

Seven of twenty-nine respondents, or approximately one quarter of the total respondents, believed that concurrent competitive development produced better, faster products and more capable government employees. Five believed that collaborative concurrent development

produced the best results. All five described this as a mix of collaboration and competition where internal and external development proceeded independently, but included meeting points where information was shared.

Of the six no's, three responded that their directorate contracting office did not allow direct competition with external contractors and two cited fear of research duplication accusations. The fear of accusations of duplication of research was also cited by three respondents answering that internal development could provide direct competition. In all cases this fear was described as an audit concluding that money had been wasted on duplicate efforts regardless of the success of the efforts, but that a failed effort in particular would be targeted as an example of bad decision making.

Again in this question, the respondent's directorate influenced some responses. In particular, individuals from PR cited their contracting office disallowing a concurrent arrangement.

Q2-4) Have you been involved in a concurrent effort?

A yes answer to this question was immediately followed with requests for a full explanation of the project, products, and lessons learned. Specific questions included: *Is this method a good idea?*

Thirteen of the twenty-nine subjects had direct experience with concurrent development. Twelve of the thirteen thought this was a better way to go than simply contracting out product development. Comments included "no contractor wants to get beat by the government" and "our personnel knew more about the research and were able to ask tougher questions to the contractor." Others pointed out that the government was in a position to more easily try avenues that were higher risk, but might reap a bigger reward. Seven of the twelve pointed out that at

least part of their internally developed systems became a part of the final product and one individual was certain that the parallel internal effort was essential to getting a working product at all. Five of the twelve individuals indicated that collaborative concurrent efforts where ideas were shared throughout the process was a better way to go. All twelve indicated that taking the best ideas from both efforts before proceeding to production was the best way to physically show the benefits of collaborative efforts, but that the intangible benefits of training were just as important.

The one interviewee who thought the effort did not work well commented that the lack of a transition plan stifled a good effort. This individual recommended the involvement of the program office early to ensure transition planning occurred.

Specific answers to this question did not seem to be dependent on individual distinguishing characteristics. However, it is worth noting that only one individual with less than ten years DoD laboratory experience (out of 6 included in the sample) had experience with a concurrent effort.

Area Three: Customer Relation

Q3-1) How often must you translate customer requests to industry?

This question was meant to provide an overall metric of how well industry understood or attempted to understand the requirements of the war fighter. It is also intended to lay the framework for question 3-3. Depending on the initial response, example follow-up questions might be: *Do you have problems getting customers to keep requirements stable?* and *Why do you think you have to translate performance parameters?*

About half the respondents found that they often had to translate customer requests to industry. A breakdown of the general response themes is detailed Table 10.

Table 10 Translation Periodicity

Themes	# of responses	% of participants	# of participants
Often	14	48%	29
Rarely	6	21%	29
Never	3	10%	29
Depends on the customer/Caused by the customer	6	21%	29

For those that indicated they had to translate requests often, two noted that the contractor's interest in cost and shareholder profit can be an issue. They may be more interested in developing something that can be modified for another market than what the government actually needs.

For those that indicated they rarely had to translate requests, 3 mentioned enabling agreements and software. For example, an Expectation Management Agreement (EMA) drawn up at a meeting between customer, System Project Office (SPO), and AFRL is beneficial to place all requirements in perspective for easier translation to a contractor. Another example is an internal software product called Work Center Support which allows contract managers and contractors to communicate and collaborate electronically, consistently track milestone progress rather than only discussing progress at meetings, and specify performance parameters to required detail.

For those that said never, one commented that with an adequate budget and a project linked to on-going efforts, communication was usually not an issue. Another pointed out that a close relationship helps tremendously, but getting around contracting rules can be an issue when attempting to keep trusted partners.

Six individuals cited that the customer could be the source of communication problems. Specific comments included the customer was too short-sighted or not sure of the real requirement. Constant changes in AF policy were also blamed for communication breakdowns. None of the distinguishing factors of individual respondents seemed to influence responses to this question.

Q3-2) Do your industry contractors interface directly with the customers?

This question was meant to gauge contractor trust. Disallowing customer-contractor interface implies distrust of the contractor. It was typically followed up with: *Do you always provide an intermediary?* The results for this question were almost evenly split between yes and no. They are categorized Table 11.

Table 11 Direct Interface

Themes	# of responses	% of participants	# of participants
Yes; Direct, sometimes unsupervised, interface is frequent.	11	38%	29
Sometimes direct interface is allowed	5	17%	29
No; An intermediary is always provided	11	38%	29
Depends on the customer/contractor	2	7%	29

Comments associated with each category were very varied and seemed to be tied to the individual's past experience more than anything else. Even though only two of twenty-nine respondents cited that it depended on the customer or contractor, all gave anecdotal evidence of their view based on past experience with customers and contractors. The central issue in the evidence was trust. This included trust that a customer would not break contracting rules by directing the contractor to perform tasks outside the contract scope, trust between contractor and

government customer to completely share all relevant information, trust that the contractor will not try to take advantage of direct access to a customer, and trust that the contract manager will be informed of any important contractor-customer discussions.

Even though the tabled results suggest almost 40% always trust the contractor and almost 40% never do, the results of the anecdotal evidence suggest that it depends upon the customer and contractor. Again in this question, individual distinguishing factors were of little to no influence.

Q3-3) Would it be easier to implement customer needs if the project were internal?

This final question in the customer relation area is direct. The question was typically followed up with: *Why?* Table 12 details the basic responses to question 3-3.

Table 12 Is Internal Implementation Easier?

Themes	# of responses	% of participants	# of participants
Yes; Customer needs are easier to implement on internal projects	13	45%	29
No; Customer needs are actually easier to implement on external projects	4	14%	29
Does not matter	8	27%	29
Depends	4	14%	29

The reasons given by the thirteen of twenty-nine responders who indicated yes included themes of better control, more latitude for interpretation, greater flexibility to implement customer requests, and more trust that government employees will keep the interests of the war fighter in mind. Two noted that external efforts tend to focus more on what industry needs while internal efforts tend to focus more on what the government needs.

Two of those who said external implementation was easier noted that internal efforts were not generally held to a plan or statement of work. This led to indefinite efforts and lack of accountability. Two others noted internal communication channels are difficult to navigate across directorates; this can make it difficult to provide a customer's need. One individual brought up the issue of requirements creep being more prevalent for an internal project since internal work is considered "free" by some.

Within the eight interviewees that responded it does not matter, one claimed that up-front involvement of the program office made the difference in meeting customer needs. Another claimed that meeting customer needs is personally driven so either internal or external efforts could be better.

For the four who claimed it depends, three maintained it depended on the customer's need. For COTS, large projects (large in scope or large in production run), and add-ons to existing contracted systems, external efforts could more easily meet customer needs. For smaller short run projects or truly innovative projects, internal efforts were better suited. One maintained that it depended on the responsiveness of the contractor. Distinguishing factors for individuals did not seem to influence their response to this question.

Area Four: Capability

Q4-1) Are your government employed personnel technically proficient?

This question addressed the fear that, in recent years, government engineers are becoming contract monitors and are loosing their skills to really manage a contract or perform any required internal engineering and development. Other questions in the capability and training areas cover whether those skills are really needed to manage a contract (i.e. question 5-4). The typical follow-up question was: *What percentage do you think are proficient?*

Contrary to this fear, most interviewees considered the majority of their peers technically proficient in their field. Table 13 breaks down the percentage of peers in each interviewee's branch whom the interviewee assessed as technically proficient.

Table 13 Percentage of Subject's Peers that are Technically Proficient

Themes	# of responses	% of participants	# of participants
Less than 25% are technically proficient	1	3%	29
Between 35% and 50% are technically proficient	3	10%	29
Between 50% and 75% are technically proficient	5	17%	29
Between 75% and 100% are technically proficient	12	41%	29
100% of peers are technically proficient	8	28%	29

Almost 70% of interviewees rated 75% or more of their peers technically proficient. However, two noted that many of the most capable individuals were at or close to retirement age and many of the younger employees were not as proficient. This could cause a decline in the numbers over the next few years. One individual claimed that all personnel came into the job 100% proficient, but that their skills atrophied over time. This argument is the exact opposite of the others, but still indicates a lack of capability maintenance which is explored in the next seven questions.

Distinguishing factors among the individuals did seem to be an issue in this question. Of the four that rated 50% or less of their peers as not technically proficient, three of the four were on the general management track versus the technical track and three of the four had less than ten years of DoD laboratory experience. The second fact is more important since the interviews only

included six individuals with less than ten years of DoD laboratory service. More than half of the new engineers in the laboratory deemed individuals in their branch not technically proficient.

Q4-2) Do they spend their time developing systems or providing oversight to industry developed systems?

This question builds upon question 4-1 and was intended to address the fear that government employees are loosing their proficiency at engineering while becoming "paper pushers." Typically, follow-up questioning involved asking the interviewee to express the ratios by percentage. A breakout of responses is given Table 14.

Table 14 Percentage of Work that is Industry Oversight

Themes	# of responses	% of participants	# of participants
Less than 50% of the time is spent on oversight of contracts vs. internal research	0	0%	29
Between 50% and 70% of time is spent on oversight of contracts vs. internal research	9	31%	29
Between 70% and 90% of time is spent on oversight of contracts vs. internal research	13	45%	29
More than 90% of the time is spent on oversight of contracts vs. internal research	7	24%	29

As the table shows, two thirds of respondents thought personnel in their branch spent more than 70% of their time managing contracts rather than doing actual research and a full quarter of respondents believed that over 90% of the time was spent on paperwork efforts.

Oddly, no distinguishing factors seemed to affect the response. The areas of higher levels of internal work (51% to 70%) seem to be branch specific and spread across the laboratory directorates.

Q4-3) Would they be more technically proficient if directly involved in system development?

This question is a follow-up to Q4-2. It was meant to ascertain if hands-on projects are really required for proficiency and if a hands-on level of proficiency is really required. Typical follow-up questions include: *Is training enough?* and *Do they need a hands-on level of proficiency?* This question also serves as a control for Q5-3 concerning the importance of experience.

Twenty-eight of the twenty-nine subjects believed that hands-on experience would heighten technical proficiency and that training could never substitute for the lessons of hands-on development. Four of these twenty-eight noted that mistakes made while performing hands-on research are invaluable learning tools that cannot be experienced any other way. Three noted that working directly on the project gave an individual a vested interest in the outcome; this is much different than someone simply managing a contract. The vested interest in the outcome forced more in-depth learning and expertise.

Only one individual of twenty-nine argued direct involvement was not needed to increase technical proficiency. This individual proposed that good, in-depth, contractor management, oversight and collaboration could reap the same benefits as direct involvement on an internal project.

Twenty-six of the twenty-eight interviewees who indicated that in-depth experience increased proficiency also thought that at least some in-depth experience was important for everyone, even the program manager, in order to effectively do their jobs. The other two thought that some administrative positions may not require a hands-on level of proficiency. The interviewees were in overwhelming agreement on this question so distinguishing factors made little difference.

Q4-4) Would you have to have "different" people to develop a project internally?

This final question in this category again addresses the capability of government employees. The purpose of this question was to provide a check against Q4-1 where "technically proficient" may not mean capable of internal development to some individuals. Follow-up questions include: *What percentage would need replaced?, What percentage would need refreshers or additional skills training?,* and *What percentage are capable as-is?*

This question involved several tiers of response. Fifteen of twenty-nine interviewees believed that at least some portion of their branch workforce would need to be replaced in order to accomplish internal projects. A breakdown of the suggested percentages is listed in Table 15.

Table 15 Percentage of Workforce to Replace

Themes	#	%	# of yes's
10% to 24%	3	20%	15
25% to 49%	7	47%	15
50% to 70%	4	27%	15
80%	1	6%	15

These numbers roughly match those from question 4-1. Only five individuals believed that more than 50% of their branch personnel would require replacement in order to accomplish internal development. Three individuals included the caveat in their response that they were only talking about civilian employees. They thought that a higher percentage of military personnel would require replacement with more proficient individuals. Two individuals also noted that the numbers may change in the near future due to the retirement of capable individuals. In addition to replacement, some individuals thought engineering "refresher

training" would be required for a percentage of those not replaced. This is summarized in Table 16.

Table 16 Percentage of Workforce Requiring Refresher Training

Themes	# of responses
30% to 49%	5
50% to 99%	2
100%	1

Fourteen of twenty-nine interviewees indicated that no replacement was required. They believed assigned personnel were capable of internally developing a project. Three of the fourteen thought that the branch only needed a target or goal and the personnel would gain the required knowledge (if necessary) to achieve it. Two of the fourteen commented that moving or teaming personnel was the only requirement for success. However, six of these fourteen thought that even though no replacement was required, at least some engineering refresher courses would be required.

Eleven of twenty-nine interviewees stated that additional personnel would be required for internal development regardless of the percentage of people requiring replacement. The directorate of the interviewee seemed to be a distinguishing factor in this question. A large portion of the negative responses came from HE and SN, while a large portion of the high replacement or refresher training requirements came from VA, IF, and PR.

Area Five: Training

Q5-1) How do you ensure your engineers/technicians remain technically proficient?

The first question of this set is meant to address any other ways technical people can remain capable without direct hands-on research projects. Twenty-seven of twenty-nine interviewees indicated that the primary means of remaining technically proficient is self-initiative. There is a requirement to maintain a level of APDP certification and eighty hours of credits every two years, but the variety of training that counts for credit allows an individual to set their own development path. One individual stated that this was not significant and insisted that if the laboratories provide interesting (hands-on) work, the employees will ensure that their skills current. Eleven individuals noted that training (including advanced degrees, conferences, and paper publication) is encouraged. Four individuals indicated that Individual Development Plans (IDPs) were supposed to be discussed between employee and supervisor to ensure adequate training, but twenty-five of twenty-nine interviewees did not mention them. Despite question 4-3, only three individuals indicated that rotating hands-on projects and field work around the office was part of their training program. One noted that they were going to add hands-on projects.

Two of the twenty-nine interviewees indicated that their directorate had a formal mentorship or formal on-the-job training (OJT) plan. Employees in these areas were managed based on their track to ensure at least minimum proficiencies were retained as needed. These individuals were from two separate directorates. No other interviewee from either directorate mentioned the programs which implies that none of the individual distinguishing factors are correlated with responses.

Q5-2) Is training centered on engineering or contract management?

Typically, this question is followed-up with: *Is required training centered on engineering or contract management?* This question is intended to determine the relative importance of

engineering vs. contract management. In other words, are the laboratories deliberately training contract managers rather than engineers or vice versa?

The answers to this question were also varied and multi-tiered, but for the root question twenty-one of twenty-nine interviewees indicated that required training was centered on contract management. This training includes Acquisition Professional Development Program (APDP) up to level three. Three people thought that this APDP training was designed for program managers at SPOs and virtually useless in the AFRL environment. Eight of those twenty-one who said required training was centered on contract management also said that most people choose engineering training for their voluntary portion to fulfill the eighty hours every two years requirement. One individual noted how fast technology was advancing and commented that required training should be centered on engineering.

Six of the twenty-nine interviewees indicated that both engineering and contract management were equally stressed. Two commented that individuals were encouraged to get smart in the areas they were lacking.

Two of the twenty-nine interviewees stated that the answer to the question is job dependent. Personnel in administrative and contract management jobs are encouraged to take more contracting classes and those in technical and hands-on jobs are encouraged to take more engineering classes.

In most cases, individual distinguishing factors were not significant. However, all the respondents from PR indicated that both contract management and engineering were equally stressed. One comment, that personnel were encourage to gain knowledge in their deficient areas, came from an interviewee from PR. In addition, one PR response noted that employees

were also encouraged to take business courses where appropriate to ensure basic business knowledge.

Q5-3) In your opinion, what can be done to improve the situation?

This question was included to see if any individuals recommended hands-on training or internal development as a training method to ensure capable employees. Three out of twenty-nine interviewees actually indicated that this is the case. The remaining responses were also very informative. All responses are presented in Table 17.

Based on questions 4-3 and 5-1, more recommendations for hands-on training were expected. Interviewees obviously felt more strongly about these other proposals. There were no obvious links between any distinguishing factors and individual responses to this question.

Table 17 Training Improvement Responses

Theme	# respondents
Develop an AFRL specific acquisition/system engineering/DAU training program.	7
Mandate that a portion of 80hrs/2yrs be used for technical proficiency refresher courses.	5
Need an all-in-one training management system	5
Keep the content local, focused and/or short (a one day class or seminar for example in neural nets or a briefing on war fighter lessons learned). Engineers want efficient training, not trips.	4
Reduce non-technical "mandatory" training.	4
Need to be with the customer or have access to the customer's training to help understand what they need (we are blocked from some insightful classes due to career field requirements).	3
VA's mentoring program and checklist or similar formalized system should be used across the laboratory; management and leadership should be heavily involved.	3

Continuation of Table 17 Training Improvement Responses

Theme	# respondents
Allow more time for training.	2
Training points of contact and supervisors need to do a better job advertising available training courses and recommending alternative courses.	1
Need a course on how to apply an appropriate level of systems engineering depending on the projects (not all projects need the full blown 300,000K effort); this needs to be consistent throughout the laboratory and for program reviews.	1
Put off the acquisition courses for later (unless a very specific one can be developed for laboratory personnel); concentrate on technical training, design of experiments, testing, and statistical analysis for the first couple of years at least.	1
Talk to people to see what they need; make the reasons for any mandatory training clear to the trainee.	1
Provide branch chiefs and directorate heads with management and administration skills training.	1

Q5-4) Do government personnel really need engineering experience or engineering degrees in today's environment?

This final training question was intended to gauge the importance of engineering experience to laboratory personnel capability. Results pointing to the requirement of a technical degree were of secondary importance. Typical follow-up questions included: *Would a business or other degree work just as well with experience?* and *Which is more important – the degree or the experience?*

Twenty-six of twenty-nine interviewees stated that an engineering degree was essential in today's environment. Of those twenty-six, seventeen thought the degree was more important than experience. Eight of the twenty-six thought both were equally important, especially at higher levels in the chain. One of the twenty-six thought, even though the degree was a must,

experience was more important, especially for someone on a technical track. Reasons for the degree requirement fell under four basic categories and are detailed Table 18.

Some individuals had very strong feelings and comments like “it can’t be done without an engineering degree” and “it is too easy to let a contractor make bad decisions without an engineering degree” were typical. Four individuals clearly indicated that not only was an engineering degree required to effectively manage a contract, but due to fast moving technology, an engineering degree specific to the type of research being contracted was essential. One individual commented that “if the contact is general enough that a non-technical person can handle it, then it doesn’t belong in the laboratory” and another commented “there is a difference between a contract monitor and a contract manager and a person without an engineering degree is almost always just a monitor.”

Table 18 Reasons for an Engineering Degree

Themes	# of responses
Accuracy/Ability to Manage rather than just Monitor contracts	11
Keep the contractor honest	6
Credibility/Communication	3
Accountability	2

Three of twenty-nine interviewees stated that it does not require an engineering degree to adequately manage a laboratory contract in today’s environment. All three of these individuals believed experience was more important than the degree. In addition, some specific comments were “sometimes a business background is important” and “we need other points of view.”

Oddly, comments referring to business skills were also given as caveats by three individuals that thought a degree was required. The comments indicated that higher level managers need basic business skills or training in addition to their engineering degree. Again, individual distinguishing factors did not seem to influence responses to this question.

Area Six: Cost

Q6-1) Would it cost more to develop internally?

This first question delves into the issue of cost. Typical follow-up questions included *Why?* and *Would it be cheaper?* As stated in the literature review and as one interviewee put it "Just the act of letting a contract is expensive." The general consensus among the seven interviewees, who discussed the actual cost of a contracting effort, was that letting a single contract contained total costs of around $300,000 (time, personnel, paperwork, etc).

Only five of twenty-nine interviewees thought it would cost more to develop internally. Reasons given included lack of a timeline and loose requirements which caused long production schedules and requirements creep, loss of capability which increases costs over time, and internal mistakes which the contractor charges more to fix. One individual also noted that "assuming the project is long enough to make back the initial investment in time to contract, we are buying time to spend on other projects which saves overall costs." Four of the twenty-nine interviewees claimed that it depends on such matters as scope, required integration, laboratory equipment upgrade requirements, and how the money is counted.

Twenty of twenty-nine respondents stated that it actually costs less to develop internally. Four individuals stated that for small efforts, the cost to let a contract can often cost more than the contract is worth. Five individuals stated that external overhead and rates have grown to match or exceed any internal overhead and that even efficient, large companies sometimes

squander contract money with little results. One individual stated that it might cost more initially, but over the long term internal development would drive competition, eliminate excess profit, and provide a risk reducer for bigger initiatives. Two individuals did note that an internal schedule was important and transition costs could be an issue if transition is not adequately planned during the effort. Again, in this question, individual distinguishing factors did not seem to influence responses.

Q6-2) What tradeoffs would be required to develop internally?

This question was targeted at activities that might fall through the cracks if the laboratory shifted to a high percentage of internal development. Despite the question testing with SMEs mentioned in methodology, this question still produced considerable confusion. Many individuals began giving responses similar to those in the feasibility area concerning what they required. Although these responses were considered and recorded to see if any new information could be gained for area one questions, they are not included here. Instead, when confusion occurred, the following follow-up question was asked: *Is there anything you would no longer be able to do?* The results were extremely varied; however, the main themes are detailed in Table 19.

Within the fourteen responses for better prioritization, comments included the ability to quickly cut projects that were not producing results and included risk reduction within prioritization. Seven of these fourteen individuals indicated that even when useless and very high risk programs were cut after prioritization, some worthwhile programs would still need to be eliminated due to lack of resources.

Those that thought that flexibility would need to be reduced were generally concerned that the advantages provided though internal flexibility in meeting customer requirements caused the typical internal effort to proceed very slowly and be highly vulnerable to requirements creep.

This was seen as different from typical contract theory in which the product quality is proportional to the amount of funding contributed and the contractor is held accountable for production. Recommended solutions to this problem were ensuring the internal effort included a timeline, a set of goals, and measures of efficiency and then holding members of the effort accountable for meeting those goals.

Table 19 Tradeoffs Required for Internal Development

Themes	# of responses
No tradeoffs are required.	5
We would need to better prioritize and possibly cut the number and/or reduce the scope of programs under development.	14
We would need to reduce internal flexibility in order to ensure projects were complete by managing internal efforts like a contract.	8
Management and regulatory control of budget, manpower, and workforce must be reduced.	8
Assign a greater emphasis to short term payoffs rather than long term research.	3
Reduce the level of detail required in internal acquisition plans.	1

Those that stated management control reduction was essential argued that to successfully compete with a contractor, the ability to transfer, hire, fire, and team personnel needed to reside with those leading the projects. This would ensure that the personnel possess the skills required to complete the effort. If the personnel do not have the required skills, more time and effort will be devoted to training personnel in the skills required than to simply contract out the effort. Communication was also noted as an issue. Management control of cross chain of command

communication required reduction so that project leaders could easily reach experts needed to complete efforts. One individual even suggested further laboratory consolidation to allow for easier teaming and communication. Finally, two individuals noted that Congressional earmarks often required certain contracts. While this is included as a management control that must be reduced, it is outside the scope of the laboratories.

The only individual distinguishing factor of note was that all five individuals who believed no tradeoffs were required were from the general management versus technical track. However, this only accounts for about one-third of the individuals interviewed in this track.

Q6-3) How would concurrent development apply to or affect your area?

Unlike earlier questions about concurrent development, this question was specifically directed at cost. Ideally, individuals would build on earlier concurrent questions and describe any cost savings gained via better or more quickly developed products which might offset the price of dual efforts. Follow-up questions included: *Would a competitive internal program force down contract costs?* and *Specifically, how would it affect cost?* Table 20 summarizes the major themes from respondents.

Table 20 Concurrent Development

Themes	# of responses
It provides better products and a more skilled internal workforce which offsets any duplication of effort costs.	15
It reduces cost.	13
It is not allowed or cannot be done.	8

Seven of twenty-nine interviewees commented that concurrent efforts could both reduce both cost and improve products. Another interesting fact was that five of the twenty-one

individuals who thought concurrent efforts were beneficial, believed collaborative concurrent efforts (where knowledge was shared between the teams at points during development) was superior to competitive concurrent efforts. Two general comments from the twenty-one individuals were "a good management process is required to ensure we reap the benefits of trying something different, getting the experience, and managing the contract well all at once" and "solid requirements are a must for both internal and external efforts for this to work."

Within the thirteen respondents who thought that concurrent efforts reduced costs, five noted that contract mangers gained a better understanding of the costs by being involved in a concurrent effort which could lead to better decision about contract costs. Four of the thirteen noted that internal efforts have a better understanding of what is specifically needed and are designing to that need, while contractors are often trying to sell either commercially viable solutions or all-inclusive (extra "bells and whistles") solutions which usually cost and include more than the government needs. Two of the thirteen thought that by exploring higher risk/higher payoff solutions via internal efforts, the laboratory saved money on contractor costs (that generally charge more for high risk endeavors) and potentially reduced cost by finding a higher payoff solution. Two individuals noted that a contract manager who participates in a concurrent effort has a better understanding of the research and more credible grounds to threaten a work stoppage if the contractor is wasting money or not adequately progressing. Finally, two individuals claimed that internal effort successes helped sell AFRL as a "brand" and provided the grounds for cost reduction by allowing negotiations with the terms "if you [the contractor] won't do it for less than that, we [AFRL] will do it ourselves."

The fifteen who thought that concurrent efforts led to better products noted that increases in laboratory personnel skills and understanding allowed better questions and more focused

management of the contractor, that internal research on higher risk alternatives allowed bigger payoffs, and that internal solutions can be the better product. Seven of the fifteen claimed concurrent development was a great way to increase internal personnel skill levels. Most agreed that the best of both internal and external efforts should be used for final production to ensure a better overall product.

Of the eight individuals who claimed concurrent efforts were not possible, three claimed their budget or allegations of research duplication made a concurrent effort impossible, three claimed that their contracting section prohibited concurrent efforts, and two claimed that internal politics made teaming the required skills and people to manage a concurrent effort impossible. No one claimed that concurrent efforts would not reduce cost or produce better products.

The only individual distinguishing factor that was significant was if an interviewee was from PR. All three responses indicating contracting could not allow an internal effort came from PR.

Q6-4) If your product was internally developed, would it be cheaper to produce or sustain?

This question was designed to explore patent rights and proprietary technology generally associated with contractor versus government developed programs. If interviewees initiated this topic in response to earlier questions, the responses were transposed to here. A typical follow-up question included: *If your product was originally contractor developed, would it be cheaper to produce or sustain?* The goal was to compare long-term sustainment costs based upon the original design source of the product. Even with the SME question validation discussed in methodology, the phrasing of this question confused several individuals who attempted to address government versus contractor sustainment. Thus, for some subjects the qualifier,

regardless of whether government or a contractor performs the sustainment, was included and the question repeated to illicit a meaningful answer. The responses are detailed Table 21.

Table 21 Internal vs. External Development Concerning Sustainment

Themes	# of responses	% of participants	# of participants
External development leads to cheaper sustainment costs.	11	38%	29
Internal development leads to cheaper sustainment costs.	5	17%	29
Does not matter	5	17%	29
Depends	8	28%	29

For those eleven who thought that external development led to cheaper sustainment costs, two insisted that industry would either charge more to produce or block an internal effort from production in order to ensure they received their development cut. Four of the eleven claimed that contractors would be producing and sustaining products in the long run and that the cost of transitioning products from internal development to external production outweighed any cost gains of internal development. One individual noted that this flaw could be overcome by including a contractor associated with the eventual production contract on the in-house development team. Finally, four of the eleven pointed out that internal efforts typically forget to design with production and sustainment in mind, so contractors are still required to rework the product. However, one interviewee commented that the laboratories are considering the addition of a Manufacturing Readiness Level (MRL) requirement to force development efforts to consider manufacturing in design.

Of the five that indicated internal development efforts could produce cheaper long-run sustainment costs, two interviewees noted that the internal development process must consider sustainment during the design for this to work. One also noted that to gain these benefits a stable design team is required until the project is finished.

The eight individuals who stated that it depends were split into three categories. Two stated it depends on the product. Specific and small projects were better suited for an internal team while large or on-going projects were better suited for an external team. Two stated that it depends on who will sustain the product. If the government plans to sustain the product, then development should be internal. If the product will be contractor sustained, then development should be external. Three cited that it depends on the contractor. If the contractor is willing to use our designs, then an internal effort can produce lower sustainment cost products.

Of the five that thought it did not matter, two individuals noted that regardless the product designer, sustainment costs may be influenced by SPOs whose guidance is often to concentrate on the best performance characteristics for the initial buy rather than an attempt to decrease long term sustainment cost. In this question, individual distinguishing factors did not seem to influence responses.

Area Seven: Speed to War Fighter

Q7-1) Could an internally developed system be fielded faster than an externally developed one?

The first question of this series was directed at overall time to field. Conceivably, faster work implies faster development spirals and better products to the war fighter faster. Responses were generally consistent with this category and did not require follow up questions.

Responses to this question were approximately evenly split. Nine of twenty-nine interviewees responded that internally developed systems could be fielded faster than externally developed ones. Two people noted flexibility as the key to internal efforts. One noted that the time it takes to let a contract can cause significant delay in product development. Finally, one noted that rapid field testing was more easily available to internal efforts.

Nine of the twenty-nine interviewees believed externally developed systems could be fielded faster than internally developed ones. Five individuals cited integration with existing systems as the primary reason. They claimed that most laboratory development efforts would be integrated into something already contracted so that contractor should perform the development of the new system. Two individuals claimed that contractors are able to assign one person to one technology while internal design often has one person assigned to multiple development efforts. Two interviewees believed contractors had better networks with SPOs and war fighters pulling the system to get it fielded faster. One person commented that the internal metal gap (not the physical division of funding streams) between individuals concentrating on 6.2 research and individuals concentrating on 6.3 development hindered internal efforts to develop products.

Eight of twenty-nine subjects thought that both methods were equally expeditious. Two of these indicated that internal development was actually faster, but transition would require additional time. However, another individual stated that the DoD has a problem transitioning both internal and external development efforts.

Three of twenty-nine interviewees thought that the response depended. Two cited the sustainment effort as the differentiating factor with internal favoring small sustainment efforts and external favoring large ones. One claimed it depended upon who owned the process experts.

If the expert was a laboratory employee then the laboratory would be faster. If the expert was in industry, then industry would be faster.

Again, individual distinguishing factors did not seem to influence responses to the question. However, some interviewees went more in-depth on the issues associated with transition. None thought the actual division of money within the PPBS system presented an issue if transition was planned correctly. Issues with transition other than funding are outside the scope of this thesis, but will be briefly addressed in chapter five.

Q7-2) Can the government perform tests that are required for fielding faster than industry?

This question is specifically directed at testing—whether it can be performed faster internally or externally. This question was originally intended to help determine if processes, paperwork, or PPBS funding constraints were causing fielding issues. However, responses to question 7-1 essentially eliminated funding stream divisions as an issue for internal development. Responses to this question usually did not require subsequent questions.

Nineteen of twenty-nine interviewees believed that nether internal or external efforts had a conclusive advantage in systems testing. Twelve of twenty-nine respondents concluded that neither selection was better, although two of those commented that internal testing might be cheaper. Four of twenty-nine respondents claimed the response depends upon who employs the expert and owns the test facilities. Three of twenty-nine respondents believe that testing is always a joint effort.

The other ten of twenty-nine respondents were almost evenly divided. Four of twenty-nine interviewees claimed that internal efforts had the advantage in testing. Two claimed that access to military personnel, who must take a testing risk made the process faster and cheaper

than a contracted test. Six of twenty-nine interviewees claimed that external efforts had the advantage in testing. Comments indicated the belief that the contractor may have more experience and a better network for conducting tests or the government no longer has the capability to conduct tests. Of the respondents that believed the government or industry had a conclusive advantage, individual distinguishing factors did not seem to influence responses to the question.

Q7-3) What roadblocks do internally developed systems or industry developed systems have an advantage in surmounting to reach IOC?

The final question in this area was intended to exhaust the list of items differentially affecting internal and external development fielding. Follow-up questions were not generally required. Responses were widely varied and are presented in Table 22.

Table 22 Roadblocks

	Government Effort	Contractor Effort
Advantages	Risk (3) Cost Funding or requirements changes are easier	Integration with the contractor's existing system is easier (7) Network/Political Expectations (3) Ease of sub-contracting/Can quickly spend end of year money (2) Certification
Disadvantages	Problems with Transition/Supportability (10) Requirements Creep Accountability	Stakeholder and outside sales requirements/ Requirement to make a commercially viable system and make money (3)

All ten individuals citing transition as an issue were asked if the division of funding streams created the problem. Two individuals noted that the division aggravated the situation and direct access to 6.3b and 6.4 funds within the laboratory would help, but all ten stated that if planned correctly, funding stream divisions would not affect transition. One individual noted that the key to avoiding transition roadblocks for internal and external development efforts was a well managed experienced team.

The seven that stated industry efforts had an advantage when integrating a new development with an existing contracted system all included the caveat that this is only an advantage when the contractor developing the new capability is the same contractor that owns the current system. Any other contractor would usually not hold an advantage over the government.

Five of the twenty-nine interviewees stated there were no roadblocks to Initial Operational Capability (IOC) that either the government or industry had an advantage in surmounting. Two interviewees stated that specific expert individuals might give one or the other an advantage on some projects and one interviewee stated that a well managed expert team was the key either way. Once again, no individual distinguishing factors seemed to influence responses to the question.

Area Eight: Guidance

Q8-1) What guidance do you follow when deciding what to develop internally and what to contract to industry?

Area eight is the first area not directly related to outsourcing. However, as discussed in the literature review, company guidance can affect actions and, therefore, responses to most of the other questions. Logic dictates that this would be even more true in a military organization built

on precisely following orders and chain of command. This question was directed at physical regulations or memorandums to discover if laboratory personnel were being actively pressured to contact out most projects. As was presented in Chapter 2, Preliminary evidence and past commander statements indicate this is true. When the question was asked, many individuals immediately began reciting rules of thumb. In this case, the responses were considered and recorded under question 8-2. The question was then further explained and restated.

The lack of instruction awareness revealed here is of importance. Twenty-six of twenty-nine respondents were not aware of any guidance. One individual noted that they used the contracting rule to acquire COTS products whenever possible, two individuals noted Congressional earmarks on funds required some funding to be spent on specific contracts, and one individual mentioned contracting decisions would be reviewed by a supervisor. Although the 80%/20% contract versus internal development rule from AFRL's past commander, General Paul, was quoted a number of times by individuals during their interview, only one individual mentioned it here. Responses to this question effectively show that the decision to contract out or not is left to the individual.

Q8-2) Do you have any unwritten rules on the subject?

This is the only follow-up question to Q8-1. In addition to discovering the basis for each person's decision, this question, like question 8-1, was intended to highlight any non-written pressure to contract out most projects. As stated above, many individuals began responses to Q8-1 which had to be moved to this question.

Although responses were varied and often included multiple themes, they generally did not include always contracting out or even trying to make 80% of the programs contract efforts. In fact, the opposite was true. Eleven of twenty-nine respondents stated that if the resources

were available, the project was accomplished internally. Four of the eleven added the caveat that they would contract if they had a significant amount of money to spend, but two of those said they would try to do a concurrent effort.

Table 23 Unwritten Contracting Decision Making Rules

Theme	# of responses
Do it in-house if resources are available and will continue to be available until project completion (unless we need to spend money quickly).	11
Do an analysis to pick the best ROI.	9
Begin high risk projects internally.	7
Do what the directorate says.	5
Be sure to spend any contracting money.	5
Who is the expert?/Does someone already produce something similar?	4
If it is needed quickly and can't slip, do it internally.	3
Can the potential contractor be trusted?	2
Can the product be easily transitioned?	1
Do we need to develop the skill? (if so, do the project internally, but hire an expert in-house contractor)	1
The 80% contrats/20% internal research rule.	1

The next highest response with nine individuals was to perform an analysis (cost/benefit, Return on Investment (ROI), make/buy study) to see which method is more cost effective. Seven of twenty-nine interviewees stated that it depends upon the risk or level of maturity of a technology. New and risky technology is at least begun internally to reduce cost. Five of twenty-nine individuals claimed they would follow the dictates of the directorate, but only three

of those claimed it was usually a mandate to contract out. The responses are presented in Table 23.

It can be seen that except for two excepts (being sure to spend money and following the 80%/20% guidance), most interviewees did not concern themselves with being sure to contract out a percentage of the work. In fact, performing an external effort typically seems to be the secondary choice.

Oddly, the five responses concerning following the directorate were spread across three directorates so this seems to be an individual or possibly branch opinion. As such, no individual distinguishing factors seemed to influence responses to the question.

Area Nine: General

Q9-1) In your opinion, what would be the single most important issue in a debate between internally developing and externally developing systems?

This question was simply included to produce a level of importance on the issues associated with internal and external development by tallying up the total number of each response theme. Ideally, all themes presented would already be covered in this thesis. If one is missing, then it would make a good candidate to include in any follow-up research. The responses are presented in Table 24.

The major themes listed in the table were explored in this thesis. Again, business case and resource availability made the top of the list. All six interviewees who cited sustained, accountable resource availability commented that if this was available internal, then internal was better. Only three individuals cited themes that presented possible influence to contract out. One of those concerned culture and the other two concerned mission and goals. None of the responses seemed to be influenced by individual distinguishing factors.

Table 24 Important Themes

Theme	# Respondents
Business case (Cost/Benefit, ROI) – note: this involves keeping internal options open via some internal projects/training.	8
Sustained resource availability and accountability for results (this includes a long term team where the best people do not get randomly pulled for other efforts)	6
Expertise/capability/integration	4
Risk/Innovation requirement (evolutionary = contractor; revolutionary = government effort)	3
Transition/Sustainment	2
Mission/Goal (if ARFL rule is 80/20, then we should do 80/20; if AFRL wants to increase in-house expertise, then that should be the rule)	2
Avoiding a one-size-fits-all approach/balance (the proper amount of both internal and external to get the best product)	2
Functionality required (does it need the full acquisition cycle or is it a focused quick-turn need)	1
Culture (current culture dictates external is better)	1
Good, competent program managers (if they really know and understand the system, they can make the right decisions)	1

Q9-2) Do you have any other comments on the topic?

This final question was included to capture any missed topics and inquiries. Again, all responses should already be covered in this thesis. If one is missing, it would make a good candidate to include in any follow-up research.

First, three individuals claimed that everybody thinks it is cheaper to contract and that many large decisions are based on this premise. Before completing this interview process, the author would have agreed with this sentiment. However, considering the responses from

interviewees to questions throughout the interview process, it seems that most individuals (at least those within the AFRL laboratories) understand that external development does not always save money.

Three individuals also discussed extremes, which was a major concern of this thesis. One commented that "statements like 'We will outsource all our spares' are nearsighted." Another claimed that extremes on either side are ridiculous. Basically, the themes agreed with assumption number three of this thesis: there is no one best acquisition method so all options should be considered.

Two individuals discussed speed related to customer requirements and spiral acquisition. One claimed that: "The user always wants the perfect 100% solution immediately and if they can't get it, they don't want to wait. They need to accept a partial solution ASAP. For instance, basic military tactics should dictate that the possibility of loosing three people in the plane to save 200 on the ground should be worth accepting the 80% solution until something better can be developed." The process was also described as waterfall acquisition rather than spiral acquisition. Although this scenario was not directly covered in the thesis, it does affect speed, and, according to respondents, internal products can be developed rapidly but have difficulty transitioning. Perhaps war fighters should accept prototypes until full production is initiated to increase speed to the field.

Two individuals addressed transition. Neither of these statements involved separation of funding streams or lack of a push process as an issue so they are outside the scope of this thesis, but are included here for information. They are: "Transition planning doesn't take place because nobody wants to hand off their program. Everybody wants to be the hero rather than do what they are good at." and "Transition would work better if the laboratories were part of the SPOs so

that a plan for product use is in place at the beginning." This second statement could be stretched to conclude that internal developments could be more easily pushed if laboratories were a part of SPOs or it could be used to conclude that all development efforts should be based on a pull from the SPOs.

Two interviewees addressed group dynamics, training, rewards, and teaming efforts as barriers to internal development. One claimed that the laboratory needed to include more teaming efforts. New initiatives like Focused Long Term Challenges were helping, but most innovation and development requires a team of individuals. Some people are led to be team manager while others like to be more involved; training should reflect this fact. Forcing the same training on everyone is also unproductive. Some personnel require extra business training, some program management training, and others more in-depth engineering training. The type of training should be based upon the needs of the team rather than a random assessment or coded position. Another interviewee addressed rewards. The individual pointed out that the available award system provides high incentives for individuals and individual efforts, but nothing for groups. Since research generally occurs in groups, a way is needed to provide incentives to groups. Training is addressed in this thesis, but not to this detail. However, both ideas appear to be credible methods to increase internal development success.

One individual discussed the concept of Congressional earmarking and following the wishes of Congress. The basic point was that Congress wants the money to flow through the laboratory and be spent on contracts providing jobs for their constituents. The basic 80% contracts/20% internal development rule was designed to ensure that this happens, while enough internal development is continued to maintain capability. Since this is directed by Congress, this must be included in the process. This concept is addressed in this thesis in the literature review.

The author agrees with the interviewee that earmarks must be spent as directed, but disagrees that DoD laboratories should allocate funding in a way that might degrade military capability beyond repair or produce efforts that take longer than needed to provide important developments to the war fighter unless forced to do so after thoroughly explaining the consequences.

Summary

This chapter synthesized data collected based on exploratory case study methodology developed by Yin and Creswell. Creswell spiral method and pattern matching were used to interpret views and collect themes into quantifiable results. After analyzing the data, it appears that despite outcries to the contrary, individuals within AFRL are typically technically capable, well trained, and generally making internal versus external development decisions based upon sound principles rather than automatically contracting out a project. In fact, it may be possible that that the opposite is true, that internal development is arbitrarily chosen if resources are available. Synthesis of the various themes that emerged during the analysis portion should provide a solid foundation for drawing conclusions and making recommendations in chapter five concerning internal versus external acquisition efforts.

V. Conclusions and Recommendations

Introduction

The purpose of this thesis was to explore the possibility of internal laboratory development, testing, and fielding versus the traditional system which encourages customer pull and contractor development. Assumptions were made using literature reviews and preliminary discussions with laboratory personnel as a basis. Areas important to outsourcing were taken from commercial and government information sources and used to develop an interview instrument. DoD laboratory personnel were then interviewed to gain insight into their activities, thoughts, and actions concerning internal development. This research was meant to ascertain if DoD laboratories had gone too far in only developing though contract efforts. This chapter provides conclusions and recommendations based on insight provided by this research. This chapter also covers limitations and recommendations for future research.

Conclusions

First, the assumptions need to be addressed by examining each interviewee's response to the lines of questioning.

Assumption 1: Current funding allocations (primarily in 6.2, 6.3 and 6.4) do not allow internal agencies to achieve full participation in product development.

During question testing with the SMEs, questions dealing directly with funding allocations were removed because some personnel were not aware of how the funding streams mapped to TRLs. Instead the individual distinguishing characteristics of funding streams and TRL range were compared for abnormalities. In 60% of the interviews, TRL levels and technology designations did not match. This mismatch provided evidence that funding streams

were not being used exactly as designed but were, instead, being used as needed to advance technologies.

In addition, the twelve individuals that complained about technology transition during interviews were asked if the division of money into separate funding streams affected their efforts. All twelve denied that this was a serious issue. Two individuals noted that the division aggravated the situation and direct access to 6.3b and 6.4 funds within the laboratory would help. However, all twelve stated that if planned correctly, funding stream divisions did not affect transition.

Given these two pieces of information, it is safe to conclude that Assumption One is false. The funding allocations do not prevent internal agencies from fully participating in product development. It therefore, stands to reason, that money already available is sufficient to produce internal efforts, so any lean toward external development must be due to another area.

Assumption 2: DoD has not taken full advantage of push opportunities.

This assumption was addressed directly within the interview instrument. Question 1-1 specifically asked if there was an avenue present to produce internally developed ideas. This question was further broken down by immediately available funding and funding that required a two year wait on the PPBS cycle. A seen in Table 5 (from question 1-1), although some funding was slow, 82% of interviewees had access to money needed to push internal ideas. The slow nature of the PPBS cycle can be construed as an issue for overall development, but it does not present a bias against push systems. Therefore, only 17% of respondents felt there was no avenue available to enact a requirements push system.

Given this information, it is safe to conclude that Assumption Two is suspect. DoD definitely does take advantage of push opportunities more than 80% of the time, but that still

leaves opportunities that are lost due to lack of an avenue for a push process. Still, opportunities are available in sufficient quantities to produce internal efforts, so any lean toward external development must be due to another area.

Assumption 3: No one acquisition method has proven itself better than others.

This assumption was addressed in-depth within the literature review. Multiple documents and occasions demonstrated the truth of this assumption. Extensive support was provided through an in-depth look at historical success and failures of the acquisition process and methods. The section demonstrated that all modern acquisition methods have been attempted throughout our history and that no one method has proven best. In fact, history was ripe with successes and failures of each method and confirmed the process in use today is just a more formalized system with no fundamentally new ideas or new acquisition vehicles.

Perhaps the continual loop is caused by the constant search for a silver bullet that will always be the correct answer. A chase for the perfect acquisition solution to all needs makes for easy management, but, it seems, poor performance. Given the overwhelming historical information, it is safe to conclude Assumption Three is true. Therefore, in order to increase the chance of developing a successful system, DoD should keep options open by perusing all reasonably available methods.

Assumption 4: External development is the method of choice for decision makers

This assumption was addressed through multiple questions in the interviews. Specifically questions 4-2, 5-2, 8-1,8-2, and 9-1. Questions 4-2 and 5-2 gave an indication of the current state of the system. Responses to question 4-2 indicated that almost 70% of laboratory personnel spend 70% or more of their time managing contracts versus conducting internal development efforts, and almost one-quarter of laboratory personnel spend over 90% of their time managing

contracts. These numbers indicate a definite lean toward contract work. Responses to question 5-2 paint a similar picture. Twenty-one of the twenty-nine interviewees stated that training was centered on contract management rather than engineering. This is another indicator that contract work is preferred. Overall, these responses seem to support the assumption that external development is the method of choice.

Questions 8-1, 8-2, and 9-1 explore guidance and the interviewee's personal thoughts. Question 8-1 indicated that most interviewees did not know of or did not follow any official guidance regarding when to contract out and when to use internal resources. This implies that any lean toward contracting must be due to personal preference. However, the responses to 8-2 and 9-1 indicated the opposite. In both questions, the majority of responses were either to consider a business case or default to an internal effort if resources are available. Very few respondents indicated that development efforts should default to contracts unless they needed to spend money quickly. These responses do not support the assumption that external is the method of choice.

The conflicting evidence of what actually exists and what individuals plan makes it difficult to draw a defensible conclusion about the validity of Assumption Four. Possible explanations are that AFRL has a significant amount of money which requires rapid allocation (which results in numerous contracting efforts), internal resources are rarely available (forcing external contacting efforts), or employees are actually performing business case analysis and the results are often that the contractor is cheaper. In any of these cases, it seems that Assumption Four may be false. Individuals are thinking about the decision rather than automatically defaulting to external efforts.

Component Questions

Now conclusions related to the components of the research question will be addressed.

Which method involves less cost?

Questions 6-1 and 6-4 directly relate to this component. Responses to question 6-1 indicate that two-thirds of respondents think that it is cheaper to develop internally. Question 6-4 is the opposite with more respondents claiming internal development efforts lead to higher production and sustainment costs. However, the responses to question 6-4 are more evenly split with a margin of eleven to four with the other fourteen respondents claming it depends upon the situation or neither method is superior. Based on these areas it seems that internal development is believed to usually cost less overall.

Will concurrent efforts reduce cost?

This component is addressed in questions 2-3, 2-4, and 6-3. Unfortunately, the sample of individuals with actual concurrent experience was limited to just thirteen individuals; however, twenty-one individuals still volunteered opinions on the subject. Responses to both questions 2-3 and 2-4 indicate that concurrent development can reduce costs. Out of the twenty-one responses to question 6-3, thirteen claimed the effort would directly reduce cost. No one indicated that that it would raise overall costs because the potential of getting a better product return was believed to be worth the investment. Based on these responses, concurrent efforts can help reduce cost either directly or by producing better products at a lower total cost.

Which method produces better capability?

This component included several subcomponents which will be addressed individually. The overall component addresses capability of products. A conclusion on this topic requires reviewing input from question 1-5, 2-3, and 2-4 to glean information on the results of internal

efforts. Based on responses, it seems that internal development is just as capable, but there is no conclusive evidence that one is better than the other.

Can internal be done?

All questions within the area of feasibility relate directly to this component. Other questions applied as well and were used as checks to ensure conclusions drawn from feasibility were valid. The answer was overwhelmingly (82%) yes with just over half (52%) indicating they had everything they needed on-hand. Eighty-six percent had personally been involved in at least one internal development effort. Based on this information, it seems internal methodology can be done. The political environment was the most often cited stumbling block preventing internal development.

Does one method produce a better customer interface?

The area of customer relations covers this component. Again, other questions where customer service was mentioned were used to validate conclusions. Question 3-2 was evenly split. The other two questions indicated that translation was often required between a customer and contractor and that it is easier to implement customer needs on internal projects. However, the majority of respondents were not overwhelming for either question (as indicated by the number of interviewees answering that it depends or does not matter). Based on the data, it does not appear that either internal or external methodology conclusively provides a better interface.

What defines personnel capability?

This component is addressed in both the training and capability areas. As discussed earlier, responses to question 5-2 would imply that contract management skills would indicate personnel capability. Responses to question 5-1 generally implied that training outside of contract management was self-initiated, and thus these responses do not contradict 5-2. Although some

comments were made in question 5-3 that engineering training was important, these were not overwhelming. Most responses center on how the training should be conducted rather than what should be taught. Based on these three questions, it could be concluded that personnel capability equates to good contract management skills.

Responses to questions 4-1 and 4-2 seem to reinforce this view. Question 4-2 indicated that most individuals spend the majority of their time managing contracts and 4-1 indicated that two-thirds of the respondents thought that at least 70% of their peers were technically proficient. This seems to indicate that technical proficiency is contract management.

However, in question 4-4, only a small number of individuals indicated that a substantial portion of the workforce would require turnover in order to switch to internal development efforts which indicates that most people responded to question 4-1 concerning their peer's true engineering ability. The deciding question is 5-4. Even though training and capability seem to be centered on contract management, when asked if technical degrees were required, twenty-six of twenty nine respondents claimed they were required. Comments generally centered around how important technical expertise and experience were to managing contracts. Based on this, it seems capability is defined based on an individual's technical expertise.

Does one method produce better personnel capability?

According to question 4-2, respondents overwhelmingly (twenty-eight of twenty-nine) believed hands-on experience produced more capable personnel. Based on this, internal efforts should produce more capable personnel.

Based on the conclusions for all the sub-components of *Which method produces better capability?*, it seems that internal may be slightly better because it has the upper hand in producing more capable personnel.

Which provides faster delivery?

The speed to war fighter area covers this question in-depth (specifically questions 7-1 and 7-2). Responses to both questions were evenly split, indicating that neither internal nor external efforts have a conclusive advantage.

Are there process problems in either acquisition method?

The conclusion to this component is yes. Question 7-3 details the process problems in each method in table 22. However, once again, each has their own issues leaving one no better than the other.

Are personnel given any guidance on the issue?

Although a few individuals claimed they followed their directorate's lead, almost all individuals claimed that there was no official guidance. This information comes from questions 8-1 and 8-2. This implies that there should be no pressure to make arbitrary decisions. However, responses to question 1-4, indicating that political environment discourages internal development, are still an issue.

Finally, the overall research question conclusions can be addressed: *Is there a difference in war fighter capability and delivery between internally and externally developed small weapons systems and, if so, why?*

Based on the analysis presented in chapter four and the conclusion to component questions above, it seems that there should be no difference in war fighter capability and delivery between internally and externally developed small weapons systems. Therefore, internal and external methods should be equally effective in providing war fighter support. Internal agencies should be provided the resources to achieve greater participation in product development when it makes sense.

It must be noted that there is a perceived difference in internal personnel capability. Specifically, internal efforts are believed to provide better personnel capability. This must be taken into account when making contract decisions. One might point out that according to responses to question 4-1, personnel capability is thought to be high, in fact, close to 80%. There are several possible reasons for this including: individuals are trained enough to be capable, individuals are keeping up capability through collaboration with the contractor, or much of this capability is concentrated in older laboratory personnel who are going to retire. A quick look at those personnel elgible for retirement indicates that up to 40% may be eligible in the next five years. It would be worth additional research to determine if non-retirement personnel are capable so that a plan can be enacted accordingly.

Recommendations

An environment needs to be fostered that encourages selecting the option (internal or external) that is most advantageous for the government. The fact that the political environment is believed to discourage internal development is an issue even if personnel are not basing decision on this fact. It is possible that some opportunities are lost because individuals consider the political environment.

Personnel should be provided the resources needed to perform internal developments when it is advantageous for the government. This includes breaking down barriers that prevent teaming, allowing funds to more easily flow between projects, and allowing internal project managers to have more control over variables (for example, who is assigned to the team for how long). An “internal contract” plan should also be developed to keep internal efforts on track, on time, and accountable for results.

Efforts should be made to perform more concurrent development when contractors are chosen for projects. The benefits touted are exceptional, and overwhelmingly, individuals who have participated in a concurrent effort think it produced a better product and more capable internal personnel.

This issue of internal personnel capability needs to be addressed. Specifically, is the high 80% personnel capability rating being skewed by retirement eligible individuals? If this is the case, additional internal and concurrent efforts must be included to bolster capability before the personnel with the experience retires.

Finally, transition needs to be addressed. Rapidly developed internal efforts that wait in the production cue for two years do not benefit the war fighter. Since transition issues were not due to funding obstacles, possible causes are outside the scope of this thesis. However, several insightful studies which may aid in understanding this issue are available (Espy, 2006).

Recommendations for Further Research

Due to time and resources, the thesis was limited to Air Force Research Laboratories rather than including multiple DoD laboratories. Generally, the results can be applied at any DoD laboratory, but some comments from other services would improve the validity. One possible line of future research is to expand this study to include multiple DoD laboratories. With the information provided in this exploratory case study, a survey instrument could be devised that allows input from a much larger group of individuals. Some suggested approaches based on the results of this study would be to expand the questions dealing with concurrent development and reduce the questions on speed to war fighter. This more detailed and extensive research would provide additional clarity into internal versus external development efforts.

Another option would be to redesign this study to get the customer's perspective on internal development. End user responses could be gathered concerning their impressions of support, speed, and capability of contracted versus internally developed products. The acquisition community could also be included. The perspective of a program management office might prove insightful. It is possible that this is an area in which the concept that contracting out is always better is actually being used. Acquisition personnel feedback combined with end user information and this case study would give an overall acquisition chain impression of the speed, support, and capability of internal versus external development, testing, and fielding efforts.

A final suggestion is to find examples of internally developed products and externally developed products which were developed for similar efforts. Collect all the cost, implementation, effectiveness, and results data for analysis. With enough examples and data a quantitative cost/benefit analysis can be conducted to determine if internal or external efforts produce a greater return on investment. Conclusive evidence that one is better than the other for certain projects would be very important data for future decision makers to use when determining whether to develop internally or externally.

The possibility exists to use this research in conjunction with other previous and future research to map out a decision tree for managers for which programs would be most viable internal and which programs most viable external. This is not recommended. Although it may provide an easy and quick management tool, it poses some of the same traps discussed throughout this study involving missed opportunities due to a one-size-fits-all tool.

Summary

The purpose of this study was to investigate internal laboratory development, testing, and fielding versus the traditional system. It was found that internal and external development were

believed to be equally as effective in providing war fighter support and that avenues to fund internal push efforts were available and being utilized. It was also found that funding stream divisions did not affect the laboratory's ability to push technologies and that personnel were making decisions based on business needs rather than assuming external development was always best. As discussed in the literature review, much research has been done on outsourcing and its effects on organizations and theory has cycled from internal to external throughout industrialized history. This study adds another viewpoint to that research by concluding that AFRL does not seem to be in any danger from swaying too far in one direction.

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14. ABSTRACT

The acquisition method used to gain access to new technologies can heavily influence whether our war fighters have the required tools to fight increasing and constantly shifting global threats (Kessler and others, 2000). The purpose of this study was to investigate the process and results of internal laboratory development, testing and fielding of small weapons systems as compared to traditionally acquired systems which encourage customer pull and contractor development. This research provides insight into how Air Force Research Laboratory (AFRL) personnel choose an acquisition method, retain personnel capability, and maximize product capability. This study consolidates the opinions of subject matter experts and program managers through a wide range of interviewees within AFRL. Data analysis and extensive literature review led to conclusions such as: it is believed that there is no difference in war fighter capability and delivery between internally and externally developed systems; and internal efforts provide better personnel capability, but the current status quo is sufficient. It was also revealed that a majority of AFRL personnel feel pressure to always develop externally. Recommendations include that: AFRL foster an environment where the best acquisition method for the government is chosen; AFRL design an internal contract plan to keep internal efforts on target; and AFRL invest in further concurrent development efforts.

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