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**NAVAL  
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**MONTEREY, CALIFORNIA**

**THESIS**

**CROSSING THE TECHNOLOGY ADOPTION CHASM IN  
THE PRESENCE OF NETWORK EXTERNALITIES:  
IMPLICATIONS FOR DOD**

by

Suzanne L. Schang

June 2007

Thesis Advisor:  
Second Reader:

William Gates  
Peter Coughlan

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**CROSSING THE TECHNOLOGY ADOPTION CHASM IN THE PRESENCE OF  
NETWORK EXTERNALITIES: IMPLICATIONS FOR DOD**

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Lieutenant, United States Navy  
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Submitted in partial fulfillment of the  
requirements for the degree of

**MASTER OF BUSINESS ADMINISTRATION**

from the

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## ABSTRACT

This thesis explores factors inhibiting technologies from crossing the technology diffusion “chasm” in between early and wide-scale adoption. It focuses on cost and benefit uncertainty as well as network effects applied to end-users and their organizations. Specifically, it explores Department of Defense (DoD) acquisition programs bringing promising technologies to the field; defines successful technology adoption as realizing its full potential return on investment by achieving the widest potential warfighter use; draws parallels between the private and public sectors’ technology adoption experiences; identifies recurring issues ultimately affecting end-user decisions to adopt new technology; and provides a framework for future economics experiments to verify that the identified issues correspond to observed technology diffusion patterns.

Recurring issues that inhibit technology diffusion include:

- (a) loss of control and autonomy
- (b) misperceptions about broader mission and organizational pressures
- (c) misaligned system incentives
- (d) uncertainty regarding management’s commitment
- (e) discontinuity of a program champion
- (f) uncertain availability of complementary goods

Identifying, analyzing, verifying, and addressing these issues will facilitate technology transfer. If technology falls short of its diffusion potential then resources will be wasted and national security compromised; if technology reaches its potential, then the warfighter will have the best available tools to do the job and DoD will achieve maximum return on investment of valuable public resources.



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# I. INTRODUCTION

## A. PURPOSE

This thesis identifies specific variables critical to successful technology adoption in the Department of Defense so they can be verified and studied further through experimentation. Background research was broad both in the private and public sectors and identified key concepts in the arena of technology adoption, drew parallels between the civilian and military worlds of technology adoption, and examined civilian and military case studies that best exemplified the reappearing end-user critical issues. This thesis attempts to provide the reader with solid footing to evaluate new technology transition issues and to begin to build an economic experiment to identify and validate the factors believed to most affect technology transition within the Department of Defense.

## B. BACKGROUND

The full and successful adoption of joint technology into the operational Department of Defense requires coordination among various stakeholders in the presence of externalities, where the benefits of one player adopting the technology affect benefits of others adopting the technology. When new technology is replacing an old technology, the adoption process runs the risk of partial adoption or de-adoption, independent of considered decision by top management.

To date, there are few case studies on the failure of technology adoption within the Department of Defense. There are also limited data and analysis (real or experimental) on how decision-makers respond to various technology adoption policies, process roadblocks, or other issues on the road to full adoption.

### **C. RESEARCH QUESTIONS**

Primary Research Question: What are the critical variables of the technology adoption process that determine its successful operational implementation?

Secondary Research Question: What techniques can the Department of Defense employ during the adoption process to ensure that the technology is successfully diffused?

### **D. BENEFITS OF THESIS**

This thesis will help educate the reader on the issues surrounding technology adoption in general, illuminate specific issues that affect the success of a technology adoption attempt - specifically within the Department of Defense – and provide a springboard from which to develop an economic model to test these assumptions in a controlled environment. This thesis also conveys the importance of technology adoption within the Department of Defense due to the ultimate life-saving benefits to the warfighter protecting American freedom abroad and the order of magnitude of the money invested in such critical projects. Ultimately, it provides recommendations for future technology transition efforts to save time and capitalize on money invested.

Areas of further research are introduced in the last sections of this thesis, including a potential economic experiment that would provide evidence about factors playing a significant role in technology adoption; if appropriately managed, these factors would be valuable tools to increase the probability of successful Department of Defense technology adoption. Conclusions and recommendations from the research provide future budget and acquisition personnel tools to more effectively manage attempts at full technology adoption in Department of Defense.

## **E. THESIS SCOPE**

Research was conducted in the larger field of technology adoption to include civilian as well as military technology adoption issues and case studies. This research isolated specific critical issues related to the end-user's decision to cooperate with the technology adoption. A model was developed that can be used to test human responses to different technology adoption situations. This process involves enduring through the cumbersome initial stages until the technology reaches critical mass and is fully implemented in the field, abandoning the technology entirely, reaching some level of adoption along a continuum, or a recession of adoption after partial adoption takes place.

## **F. METHODOLOGY**

This thesis reviews the background of technology adoption, parallels the field with the Department of Defense version of technology adoption, highlights certain critical issues through the use of civilian examples, identifies critical factors affecting end-users in the technology adoption process, and uses two Navy case studies to highlight the critical end-user issues within the Department of Defense. This thesis begins to develop an experimental model to determine if theoretic and experiential observations can be reproduced in a laboratory setting with the intent of addressing policy matters further down the road. Finally, conclusions are drawn and recommendations are made for future technology adoption ventures as well as further studies in this field.

## **G. LIMITATIONS**

This thesis is limited in the sense that it takes a very broad sweeping approach to the subject of technology adoption. Because the topic is so encompassing and so prevalent in today's rapidly changing world, research was very wide but not very deep. Consequently the issues identified were a result of

reoccurring themes observed from the broad survey of literature and case studies. This is appropriate for initial research in a field and will hopefully serve as a solid platform for further research.

It is possible that a deeper look at individual cases will illuminate more pointed items that might also be relevant to this topic. There will always be specific issues that need to be carefully considered by the appropriate leadership in each unique situation of technology adoption. The intent of this thesis is to provide a framework from which to start the exploration of factors affecting network technologies adoption within the DoD.

## **H. ORGANIZATION OF THESIS**

This thesis is organized into eight chapters. The first chapter is an Introduction to the topic and covers the highlights of the entire work. The second chapter is a literature review, pooling and summarizing popular literature and academic background on the issues surrounding adoption of network externality technologies. The third chapter is meant to familiarize the reader with the United States Department of Defense (DoD) Acquisition Process, highlight the mission and fiscal criticality of successfully getting an important technology into the hands of the warfighters, and draw parallels between important definitions and models within the overall field of technology adoption and the DoD experience. The fourth chapter examines four civilian technology adoption case studies and issues that affected their diffusion success or failure. The fifth chapter distills critical issues associated with the end-user and common to the public and private sector technology adoption experience and begins to group them into a economic framework. The sixth chapter discusses two DoD technologies that exhibit these critical end-user issues that ultimately affect the technology's successful adoption. The seventh chapter outlines a potential economic experimental model that could validate the expected effects of the critical issues discovered in this thesis. The eighth and final chapter summarizes findings from the previous sections and draws conclusions relevant to potential future work in

this area of research and experimentation, and punctuates with the impact this field of technology adoption has on the Department of Defense as it strives to give the warfighter the best technology available at the best price to the taxpayer.



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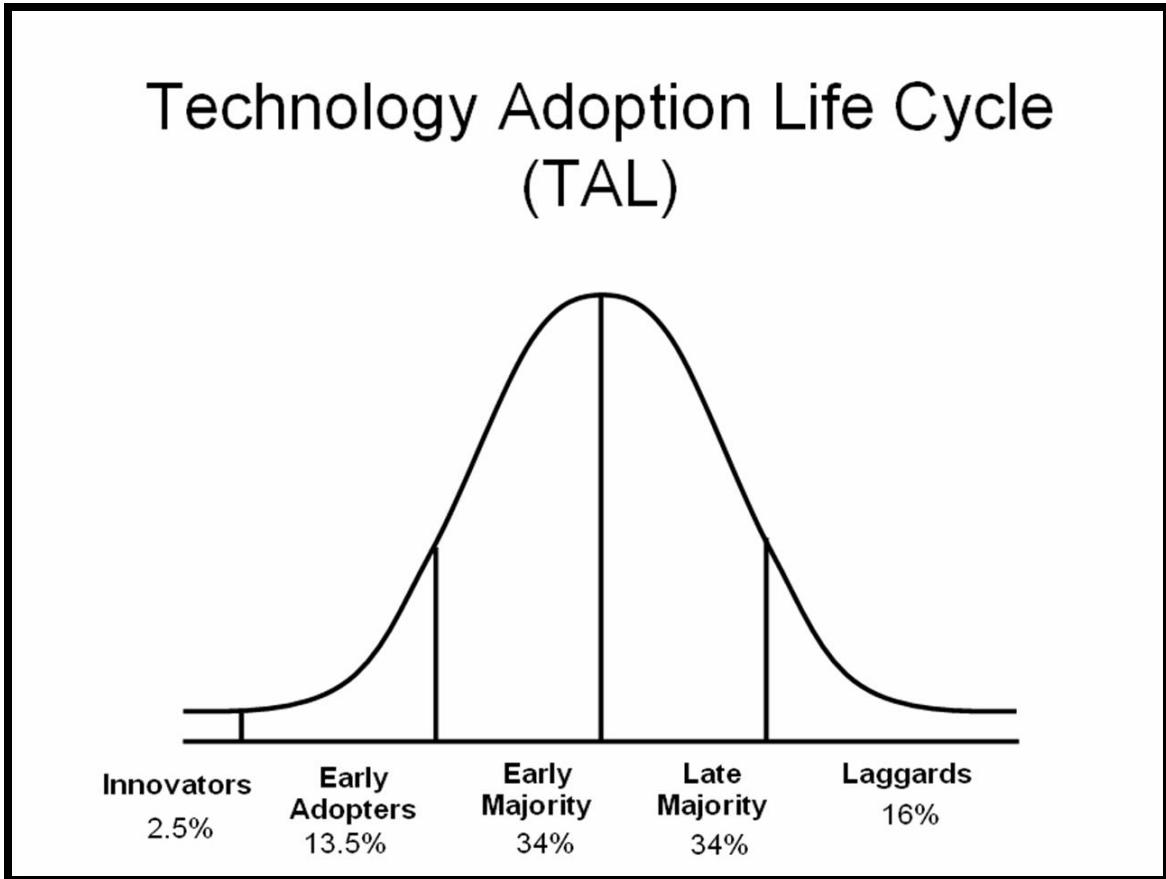
## **II. LITERATURE REVIEW**

This chapter provides the reader with the necessary background to understand the issues associated with network externalities within the larger field of technology adoption, as discussed in the popular and academic literature. Resources consulted include popular culture books, textbooks, and academic journals.

### **A. POPULAR LITERATURE**

#### **1. Technology Adoption Life Cycle (TAL)**

The process of introducing a new technology to a group of consumers is thought to follow the natural distribution of the Bell Curve and has been divided into different segments of end-users based on their unique characteristics and motivations (Moore, 1999). Geoffrey Moore's Technology Adoption Life Cycle (TAL) curve includes five categories of end-users spread out over the normally distributed Bell Curve. They are, starting from the left and earliest and proceeding to the latest in the adoption cycle: the Innovators, the Early Adopters, the Early Majority, the Late Majority, and finally the Laggards. Each group is distinguished by its own unique characteristics and motivations. It is important to note that this model is traditionally used to describe the private sector technology adoption experience where the end-user is also the buyer. This distinction matters when there exists a long organizational chain in between buyer and end-user, each representing different parts of an organization, such as the Department of Defense.



**Figure 1. Technology Adoption Life Cycle (TAL)**

The Innovators are known as Technology Enthusiasts. Their motivation aligns with the excitement of a new technological break-through. They are not necessarily concerned with money or even general utility. The Innovators want to get their hands on the new technology right away to see what it can do. These end-users represent the section to the left of the second standard deviation, extending into the left tail.

The Early Adopters are known as the Visionaries. These are the end-users who see utility for the new technology within their industry and are eager to capitalize on the savings or new capabilities first, before their competitors or colleagues. They are willing to take chances with technology immaturity recognizing that all the glitches in the new technology probably have not been worked out. These adopters are so anxious to apply the improvement to their

project that they run the risk of choosing the wrong standard for the industry, maybe simply because the best technology has not been developed or optimized for the industry. These end-users fill the section of the Bell Curve between the first and second standard deviations to the left of the mean.

These first two segments together – the Innovators and the Early Adopters – are known as the Early Market, while the remaining segments – the Early Majority, Late Majority, and the Laggards – are known as the Late Market (Moore, 1999).

To the right of the Early Adopters sit the Early Majority, also known as the Pragmatists. These adopters are much more conservative than the Early Adopters. They might be excited about the new technology but they are not as short-sighted as the first two groups and are highly influenced by their peers. The Early Majority is characterized as conservative and risk-averse. They want to make sure that the new technology will fit the needs of their organization, have wide utility across their industry, and be the best, most mature product for the job. They do not want to run the risk of committing to a technology that has not been tested, still has bugs that reduce its efficiency or efficacy, or is not the natural one that a competitive market would settle upon (socially optimal). These end-users fill the Bell Curve from the first standard deviation left of the mean to the mean.

The Late Majority is made up of Conservatives. These adopters value tradition over progress and are against discontinuous innovation (an innovation that calls for a change in processes or procedures and is very disruptive to an organization). They won't commit until they are certain there are no glitches with the technology and will wait until it is professionally uncomfortable in their business to remain loyal to the old technology. These end-users fill the Bell Curve up from the mean to the first standard deviation to the right of the mean.

The final group is the Laggards. These adopters are also known as the Skeptics. They will stubbornly keep using the old technology until forced to change to stay in business or simply to function (Moore, 1999).

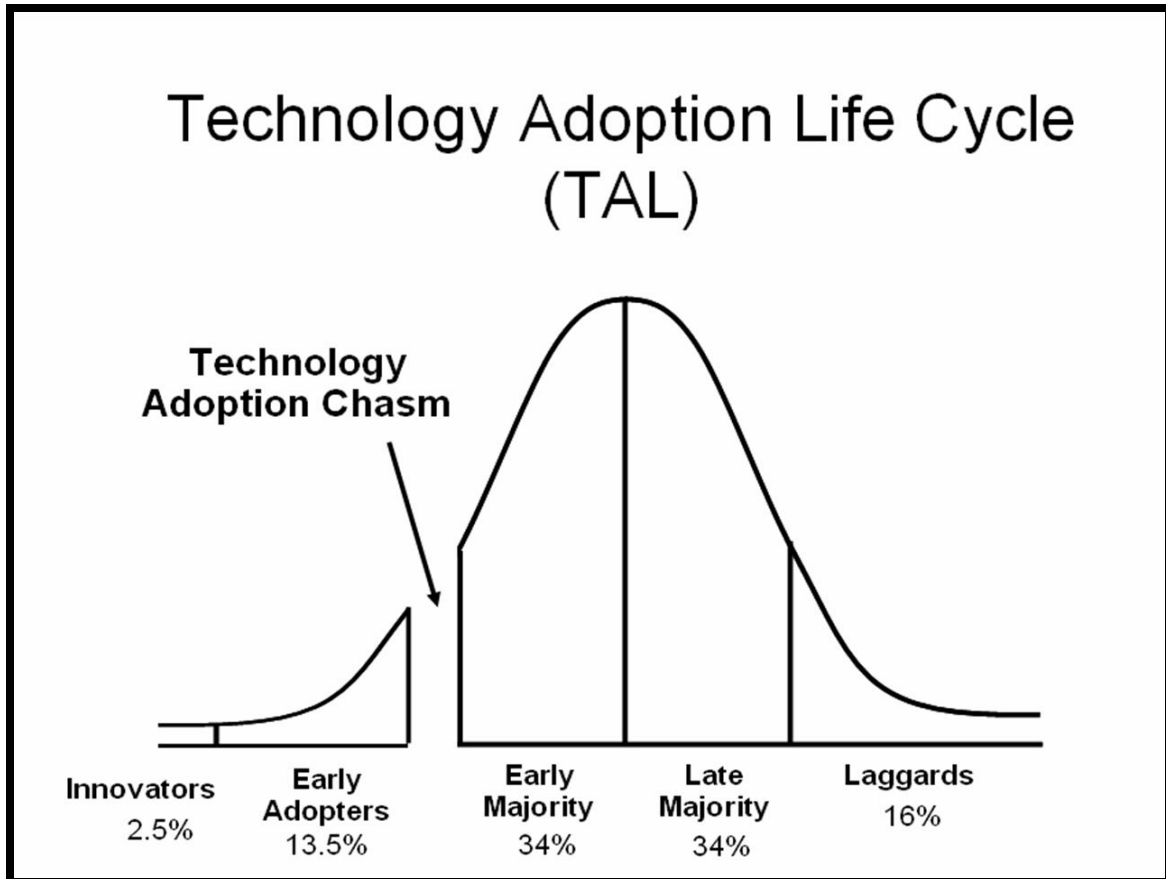
The traditional marketing tactic for taking a new technology through total diffusion is to “work the curve” from left to right. Jumping from one group of adopters to the next is merely a function of capitalizing on momentum and seizing the window of opportunity before another company comes along and snatches it up (Moore, 1999).

When the Department of Defense contracts for a new technology, it is sponsored by one of the services which buys it for subordinate commands. The technology is finally put into the hands of the warfighter, who might have had input into which technology was purchased, but does not make the final purchasing decision. This is a significant departure from the private sector where the end-user and the person making the selection and purchasing decision are often one and the same. There are civilian organizations that make big selection and purchasing decisions at the top, as well. Consider, for example, Wal-Mart’s market leading decision to invest in passive Radio Frequency Identification (RFID) mandating its external suppliers along with its internal distribution centers adopt this technology as their supply chain standard. In the military, many of the selection and purchasing decisions are made by people who are very far removed from the actual end-user, the warfighter, creating a problematic buyer-user gap and a potential for misaligned incentives.

## **2. The Chasm**

“The Chasm” refers to the gap in the TAL between the Early Adopters and the Early Majority and is sometimes referred to as the Valley of Death (VoD), particularly within the DoD. The chasm reflects the significant problems as well as important implications for moving from the second group of adopters (Early Adopters) to the third (Early Majority). The problems occur when businesses and marketers don’t recognize the unique motivations and characteristics of the Early

Majority. The significance, however, is that once the Early Majority is seduced, the new technology is often set on a self-propagating path towards total diffusion.



**Figure 2. Technology Adoption Life Cycle: The Chasm**

The Early Majority is characterized as being a reference group. Of the five segments of adopters, Moore recognizes the Early Majority as a critical market segment; because of its size and unique characteristics capturing the Early Majority is the gateway to the rest of the marketplace and can mean the difference between success and failure of a new technology's diffusion. The Early Majority is the first of the two largest groups in the TAL, and hugs the left side of the Bell Curve's centerline. If a technology is successfully adopted by this

segment of the TAL, then the technology simply has to ride the momentum created by the Early Market until the Late Majority is coerced into adoption. Therefore, its sheer size and placement makes it a critical segment.

There are certain fundamental differences between the Early Adopters (Visionaries) and the Early Majority (Pragmatists) that make the leap between the two groups a significant challenge. First, the respect the Pragmatists have for their peers' opinions and experiences far outweighs their desire to be on the cutting edge of technology. In other words they are a referencing group (Moore, 1999). This means that in order to break into this segment, the product needs to secure an Early Majority supporter who can recommend the product to his peer. This presents a Catch-22 situation because how can one secure an Early Majority supporter if that supporter won't adopt unless he has a peer in the Early Majority to recommend the product to him? In contrast, the Visionaries are concerned with being the first to recognize and use a new technology for a particular purpose within their business.

Secondly, the Pragmatists have stronger interest in the major benefits the technology application could bring to their industry. The Visionaries are more interested in the new technology and innovation in general. This difference in priorities contributes to the Early Majority stigma of being populated by Pragmatists rather than Technology Enthusiasts or Visionaries.

Thirdly, the Pragmatists are much more acutely aware of the existing infrastructure and are very wary of discontinuous innovations that would disrupt operations and productivity. The Visionaries are less respectful of established standards and infrastructure – they are simply excited about the new technology and are eager to use it for any purpose in their field, regardless of incompatibility with existing infrastructure, disruptions to operations, or money lost attempting to use the new technology.

Finally, Pragmatists are more likely to thoroughly investigate a new technology, ensuring its overall value to the industry as well as the feasibility of

their company being able to capture that value, and then commit to the new technology for the long haul, expecting to reap the benefits of their thoughtful decision. The Visionaries are not so calculated and are more likely to shift to the next new technology when it comes out, disrupting the whole system again. In other words they are not as loyal or committed to the status quo as the Pragmatists of the Early Majority (Moore, 1999).

There are a couple of noteworthy hazards for a technology that finds itself in The Chasm trying to cross the Valley of Death. First, there is a distinct lack of new customers and secondly there will be no refuge or assuredly safe course of action (Moore, 1999). The challenge is to figure out how to break into the Early Majority and overcome the hazards of the VoD.

When a technology is crossing the Chasm, it has already exploited most of the Visionaries in the market and notably finds itself without customers. The Pragmatists are not yet comfortable with committing to the new technology because there aren't enough trusted references within their peer group to vouch for the product (Moore, 1999).

The new technology will find itself without sanctuary. It cannot simply continue to serve existing Early Market accounts because the market is too small to focus on these end-users alone. It has already reached capacity serving clients in the Innovator and Early Adopter markets, which each have limited influence over the industry as a whole because they have their own unique ambitions and enterprises. While a technology loiters in the Chasm, it has gotten the attention of the incumbent companies serving the other side of the Chasm who may feel threatened by the segment-hungry company and its new technology; they will likely gear up their extensive resources to defend their territory with fancy marketing ploys and research and development (R&D) of their own. There may be similar competing technologies eager to cross the Chasm as well. The venture capitalists who funded the new technology are anxious for a return on their investment (ROI) and there will be vulture capitalists ready to pick



the company apart when they see it has expired in the Valley of Death, never making it to the other side where the Early Majority could have endorsed its product and funded its salvation.

To recap, the gap between the Early Market (the Innovators and the Early Adopters) and the Late Market (the Early Majority, the Late Majority, and the Laggards) is commonly referred to as The Chasm or Valley of Death and there are serious dangers associated with loitering in this danger zone for too long. Much has been written on how best to cross the Chasm, whether referring to a new technology or simply a product for the marketplace.

### **3. Crossing the Chasm**

There are many experts who claim to hold the key to crossing the Chasm of product adoption. Moore suggests that the best way to ensure a new technology crosses the Chasm is to pick a niche market on the other side of the Chasm – a business among the Early Majority – and develop a positive client relationship with them. He stresses the importance of not being sales-driven or distracted by all the other potential clients in the Early Majority. Malcolm Gladwell branches out from technology-specific advice in *Tipping Point* (2000) and looks at factors that affect simple product diffusion. He advocates the importance of identifying and capitalizing on the qualities of certain personalities, making the product memorable, and warns never to underestimate the importance of context (Moore, 1999).

Moore relays that the best way to do this is to select the niche market to focus on, create the irresistible offer, prepare your position against the companies that will be defending the territory they've already secured in the Early Majority section, and then finally deliver on the promises made in the offer so that the client can recommend you to their peers. Once you have successfully secured a client within this section of the TAL, then others within the Early Majority will have a comforting and reassuring reference and will want to adopt the new technology for their own business (Moore, 1999).

Gladwell takes a broader approach to product diffusion in general. He stresses the importance of what he calls the Law of the Few (the kinds of people), the Stickiness Factor (the delivery), and the Power of Context (the environment). All of these elements can be critical when determining the best course of action to reach the other side of the Adoption Chasm (Gladwell, 2000).

The premise of Gladwell's Law of the Few is related to the 80/20 notion, which observes that 20 percent of the people often do 80 percent of the work; 20 percent of the people cause 80 percent of the trouble; and so forth. Maxwell claims that the success or failure of a product attempting to cross the Chasm resides with a small number of individuals that have a majority of the influence over the decisions and actions of the rest of us. These special few he calls the Connectors, the Mavens, and the Salesmen. These characters in this play of product diffusion can make or break a product's ultimate reach and success.

The Connectors could also be referred to as the "social glue." These are the people-specialists who find everyone interesting and seem to collect relationships. They circulate easily among many different socioeconomic groups and exhibit a combination of energy, self-confidence, social agility, and curiosity. They don't shy away from the obligations that come with relationship ties, strong or weak. The importance of the weak tie is often underestimated but is of critical importance to spreading ideas.

The people with whom one normally associates and develops strong ties with are normally within one's own social circles. These people tend to be very similar – thinking the same, acting the same, living the same way. When a new idea penetrates a social circle from outside, it normally comes from an association with some other social circle in the form of a relationship called a weak tie. Connectors are the people that have the most weak ties and are responsible for linking the rest of us with each other through these informal social channels. Maxwell concluded a product's successful diffusion is highly correlated with its proximity to a Connector (Maxwell, 2000).

While Connectors link everyone to each other, the Mavens inform the public what is available and how it works. Maven is the Yiddish word for “one who accumulates knowledge” (Maxwell, 2000). This is the second special kind of person important to successfully crossing the chasm. Mavens are information specialists who actively collect, process, simplify, and disseminate market information for the rest of us. They are the “data banks” or the “translators,” connecting people to the marketplace in meaningful and tangible ways. The widely accepted Efficient Market Theory lends credence to the importance of the Maven because of its assertion that perfect knowledge is immediately incorporated into the marketplace (Random Walk Theory). If information is what makes the marketplace tick, then the Mavens are critical components because they get the information from the marketplace to the people in meaningful ways. These characters are both teachers and autodidacts, passing along their understanding of the way things work as well as always seeking to improve their own understanding. They are also more socially conscious and take a broader more synergistic view of the world than the typical consumer. Mavens are compulsively helpful, unselfish, and lend credibility to a new product.

While Mavens inform, the Salesmen push the product. Salesmen are the motivators. They are masters of all the subtle ways humans communicate with each other and can promote a product with their enthusiasm, persuasive skills, and meta-language. Salesmen also promote products simply by using them, as in the case of celebrities or public officials that people monitor and imitate. Finally, they can be considered champions of a particular product, either within or outside an organization.

Connectors, Mavens and Salesmen are three important characters that make up the Law of the Few and can be critical in helping a product cross the Chasm from the Early to Late Market. One could imagine how Mavens and Salesmen might help convince – with the help of Connectors – members of the Late Market (specifically the Early Majority) to adopt certain new technologies. The “stickiness” of the new technology also helps its transition.

The Stickiness Factor includes both the delivery of the product and the inherent quality of the associated ideas that are trying to cross the Chasm. It's not enough for the idea of the product just to be contagious; it has to be memorable and move people to action. The marketer must pay attention to the method of delivery, the audience, the selection of medium, and the amount of repetition used in the message. The product and idea of the product must be "sticky" in order to have much success crossing the Valley of Death.

The Power of Context is even more important but is often underestimated. Human beings like to attribute effects to causes that they either have some control over or can at least explain away, not all the minute details that come together to form the larger environmental context, which are largely uncontrollable and many times even undetectable. Maxwell's third element suggests that a product's trip across the Chasm is extremely sensitive to the context of the situation in which it is operating.

Maxwell's elements – the Law of the Few, the Stickiness Factor and the Power of Context – along with Moore's recommendations of focusing on capturing a niche market within the Early Majority first are all purported solutions to the problem of successfully navigating the Valley of Death.

In reality, what works best is probably very specific to the organizations, personalities, and the technologies involved, requiring conscientious leadership and teamwork, paying attention to all these elements along with the way the world is evolving. There is rarely a clear-cut answer to questions such as "How do I cross the Technology Adoption Chasm?" Ultimately if the end-user chooses not to use the technology, then the diffusion is unsuccessful. In the civilian world, typically this means they just don't buy it. The challenge of technology diffusion is a little more complicated in the public sector because leaders and policy-makers need to ensure the end-users (warfighters) are using the technologies purchased for them by the department.

## **B. ACADEMIC BACKGROUND**

This section explores some technical definitions and concepts related to the field of technology adoption. Specifically, it addresses technology innovations in general, the various types of externalities, the various types of network externalities, and concludes with a discussion on natural monopolies.

### **1. Technology**

A shovel is an improvement on moving dirt with one's hands. A car helps move people around faster than walking or bicycling or riding a horse (although maybe not as enjoyable). A computer helps organize data so that human beings can more easily and effectively manage lives.

Since the explosion of the internet, computer terminals storing this useful data for managers have been able to share their information with every other computer on the internet, exponentially increasing the amount of data available to managers, giving them the potential to improve the quality of their leadership.

This is true for any technology that links users with a larger database of information. A manager of merchandise at Wal-Mart can make a more educated decision about purchasing and placing merchandise if he is able to observe buying trends in a particular area over a particular period of time. He can know exactly where his merchandise is in the supply chain and restock it just in time, thereby reducing inventory carrying costs and maximizing profit through near real time knowledge of demand.

A Navigator on a United States Navy warship can more effectively keep her ship off the rocks when she can constantly update her knowledge of the weather at the current and future ship's position by using communication technology to connect with the land-based meteorology department. These are all technologies that help managers do their jobs better.

## **2. Externalities and Network Externalities**

An externality is a side-effect of an economic decision – in this case, to use a technology – that imposes either a positive or negative consequence. Network externalities are characteristics of certain products where the benefit for each user of the technology increases as some other element increases, typically the total number of users or the user-base.

There are specific characteristics of network technologies that this research should recognize. These include complementarity, compatibility, standards, switching costs, and supply side economies of scale. The degree to which the world is being connected increases the meaning of each and supports the need to consider them when contemplating the best way to promote the diffusion of a network technology (Shy, 2001).

Complementary items are all the support elements associated with a technology. A new technology with complementary support elements is important so that users do not have to update the infrastructure they have already invested in just to use the new technology. Examples of complementary items would be the supporting equipment to your computer – the monitor, keyboard, mouse, printer, etc. They must be able to communicate with your central processing unit (CPU), so that when you buy new equipment for your computer system, it will work successfully with all the other components.

Compatibility refers to a new technology's ability to work within an existing infrastructure that is currently employed by a set of users. There are two types of compatibility: forward and backward. Backward compatibility is the ability of a new technology to run old applications. Forward compatibility is more difficult to achieve since it requires technical foresight into future innovations but happens when a technology manages to make itself compatible with succeeding versions. An example of these compatibilities would be a new version of Microsoft Office

software that is able to open files saved in the old Office format (the software is backward compatible) or a Microsoft Office file that is able to be opened in the new version of Microsoft Office (the file is forward compatible).

Both complementarity and compatibility are facilitated by the successful establishment of standards, which are generally specific to a product line or industry, so that every producer and user knows what specifications to make or buy so that the new technology will work within the existing infrastructure.

Attention to these standards of network technologies ensures that a new technology can be seamlessly inserted into existing web of technology, making best use of resources already expended to put that infrastructure into place. Producers of new technologies may also find it advantageous to produce products that establish new standards so that they can dominate the market and render the old standards useless. This direction is not without its risks and involves a correct prediction on the choices their customers will make about which standard to commit themselves.

If different standards exist within an industry then commitment to a set of standards involves some risk for the users because of switching costs. Switching costs represent the cost to the user of switching from one set of standards to another and can serve to deter customers from adopting a new technology. On a similar note, the customer often pays loyalty costs in the form of special benefits and preferred status. These benefits are abandoned when the user adopts the new technology, and this can serve to deter adoption.

All of these elements - complementarity, compatibility, standards, and switching costs help define whether a new technology is continuous or discontinuous. Continuous technologies do not require users to shift between architectures or habits, while discontinuous technologies do. Note that mainstream markets (comprised of the majority of the technology's users) are hard to seduce with discontinuous technologies because they disrupt operations.

These kinds of large-scale operations prefer continuity and standards for smoothness of operations. Any deviation can be extremely inconvenient and costly for large organizations (Moore, 1999).

### **3. Direct and Indirect Network Externalities**

There are two basic types of network externalities: direct and indirect. Consider the utility of e-mail through the internet as an example of a network externality. If only one person (or organization) subscribes to e-mail, the information they might have to share is of no use to anyone because there is no one to receive the information. If someone else subscribes to e-mail, it creates value for both subscribers. The new subscriber can receive information from the first member, but the first member can now also receive information. If five people join, it increases the value for all members because now there exists the possibility for ten relationships. As more people join the network, the utility for each is magnified at an exponential rate! This unique externality of increased value for each user as the technology's user base expands is called a direct network externality.

Another popular example of a technology that exhibits direct network externalities is the telephone. The value of owning a telephone is inherent in the fact that it connects people, therefore if only one person owns a telephone, then the technology holds no value for that user. If two people own telephones and can talk to one another then the individual value of owning the technology increases for each user. Similar to the e-mail technology, the larger the user base, the greater the value of the telephone to each individual user because it increases the number of people they can connect with using the technology.

Network externalities of the indirect nature address the notion that the value of a technology increases as the market of complementary goods improves. This type of network technology does not have to exhibit direct network externalities such that the user-value is tied to the size of the user-base. Consider the Beta and VHS VCRs of the 80s, the two technologies were



incompatible and each was vying for market segment and to become the standard of the industry. Even though economists agree that the Beta tapes were better quality than VHS, the VHS VCRs held more benefits for the users because of the vast complement of VHS compatible tapes that had been produced and were in circulation. So even though the value of the VHS VCR for the individual users didn't increase directly as a result of their user-base (like the email would), it did increase indirectly as a result of the available set of complementary goods available (number of movies made in VHS format). Indeed, many economists agree that VHS became the standard *because* of the fast-growing market for its complementary goods. A similar case has been made for the QWERTY keyboard, which this thesis addresses in a later section.

The economic concept of economies of scale refers to the fact that when total cost of a commodity increases, the per unit cost of the lot decreases. When there are significant supply side economies of scale (such that the more supplies provided by the market, the cheaper each one is to provide) there tends to be a few competing companies that manage to capture most of the market. The industry cannot function as a competitive marketplace which inhibits the competitive equilibrium. This is because the product has proportionally high fixed costs, including those associated with research and development, relative to the per unit variable costs of the final product sold to the end-user. It comes as no surprise then that there tends to be only a few market leaders for each technology of this nature, because of the resources and fortitude needed to invest in the high-cost infrastructure and the long wait for return on investment (ROI).

In capitalistic free market economies, competition is used as a mechanism to find the market equilibrium. The thought is that if each individual is allowed to choose for himself what an item is worth to him (through the act of buying or abstaining), then the group of buyers and sellers on aggregate will settle on the socially optimal standard and reach the socially optimal levels of supply (goods

available for sale) and demand (goods purchased), otherwise known as the market equilibrium. In theory, this happens all without government interference.

#### **4. Natural Monopoly Discussion**

In the past, it has been generally accepted that market equilibria do not exist for network technology markets and that they will experience market failure (Shy, 2001). In other words, the market settles on a socially suboptimal standard, meaning that instead of people naturally selecting the best product, they are forced to select the product that the market leader chooses to produce and sell, which may not be the one that the customers would have naturally settled on if they were given other options.

At one point, the popular solution was for the government to intervene and force the natural monopolist to settle on a particular standard. With the government forcing standardization, at least others could proceed with producing complementary goods. Unfortunately, this could also result in a socially suboptimal standard. The government has on-going relationships with large defense contractors and does billions of dollars of business with them every year (Table 1). In some cases, the government is investing taxpayers' money in building a technological architecture or establishing a certain brand or version of a technology as the market standard by initially buying so many of them. But the government may not necessarily choose the correct standard when making these big-dollar commitments to purchase weapons or information systems for government agencies, particularly the U.S. military. This symbiotic relationship between the private sector market leaders and the government for both civilian and military technology development can also settle on the inferior technology when using their enormous resources to set the standard. If this happens, the marketplace should fix itself, but the U.S. government is now stuck with a supply of product that is inferior to the standard and may not be the best tool for the warfighter.

Top 10 World-Wide Defense Contractors, 2005					
Rank	Name	Country	2004 Rank	Defense Revenue (US\$ million)	% of Total Revenue
1	<u>Lockheed Martin</u>	<u>U.S.</u>	1	34,050	95.8
2	<u>Boeing</u>	U.S.	2	30,464	58.1
3	<u>Northrop Grumman</u>	U.S.	3	22,126	74.0
4	<u>BAE Systems</u>	<u>U.K.</u>	4	20,345	80.0
5	<u>Raytheon</u>	U.S.	5	18,771	92.7
6	<u>General Dynamics</u>	U.S.	6	15,000	78.2
7	<u>EADS</u>	<u>Germany/France</u>	8	10,506	24.2
8	<u>Honeywell</u>	U.S.	12	10,240	40.0
9	<u>Thales</u>	France	7	8,869	63.1
10	<u>Halliburton</u>	U.S.	16	8,000	39.1
<a href="http://www.defensenews.com">www.defensenews.com</a>					

**Table 1. Top 10 World-Wide Defense Contractors (2005)**

“Natural monopoly” was a popular designation bestowed upon firms that managed to pay the high costs to develop an infrastructure and whose autonomy and jurisdiction was regionally licensed and supported by government regulation. This was due to the assumption that it wouldn’t make financial sense for any other company to duplicate the infrastructure to compete with the already established company. A good example of this is Public Telephone and Telegraph (PTT) used widely until the early 1980s to provide telephone and mail services and Cable TV, both of which had heavy infrastructure investments but marginal unit costs. The government licensed the PTT in part because it didn’t want competitors stringing up duplicate sets of telephone wires all over the place.

The theory that competition and natural monopolies were incompatible began to break down as technology changed as two outcomes evolved. First, people noticed that service, maintenance, and technological upgrades were suffering under these so-called natural monopolies. Information asymmetry meant that government regulators were unable to determine true production costs and therefore unable to properly control prices. The second reason is that as the technology matured, the economies of scale advantage was reduced, making it more feasible for firms to enter the industry and compete.

So, despite the previous sentiment that significant supply-side economies-of-scale rendered competition inconceivable or impractical, the government opened up these markets to competition to see if social welfare would improve. What they found was that consumer welfare did improve and that there were no real adverse effects to the supply side of social welfare.

The practice of access pricing was also discovered during the breakup of the world's largest telephone company (AT&T) and the deregulation of the airline industry in 1979 (Shy, 2001). An access price is a "reasonable" price paid to the infrastructure owner to "ride the highway" with a product or service that is compatible with the standards. This serves as compensation for the company that funded the infrastructure and the standards while allowing for competition among products and services that utilize the infrastructure. This allows competition to drive down prices despite large set-up costs and encourage continued improvements in end-product quality, just as in a competitive market.

This chapter discussed background definitions and models in the larger field of technology adoption. It defined the different sections of the TAL, the location of the Technology Adoption Chasm (between the Early Adopter and the Early Majority), some suggested techniques for crossing the Chasm, as well as explaining some academic background on technology adoption concepts, including defining externalities and network externalities. The next section

explains the DoD acquisition environment, explores the magnitude of the resources expended in the field, and attempts to draw parallels between the worlds of civilian and military technology adoption.

### **III. DEPARTMENT OF DEFENSE TECHNOLOGY ADOPTION**

The intent of this chapter is to acquaint the unfamiliar reader with the Department of Defense technology adoption experience - including the Joint Capabilities Technology Demonstration Process, drive home the importance of succeeding in efforts to cross the Technology Adoption Chasm in today's military, and draw parallels between the public and private sector technology adoption experience.

#### **A. DOD TECHNOLOGY ACQUISITION**

This section provides an overview of the Department of Defense Acquisition system and its place among other departmental decision-making systems, gives an introduction to the DoD world of budding technologies via the Office of the Deputy Under Secretary of Defense (Advanced Systems & Concepts), and takes a closer look at how various partners in the chain of technology adoption define success.

##### **1. Overview**

The three decision-making support systems within the DoD are the Planning, Programming, Budgeting and Execution process (PPBE), the Joint Capabilities Integration and Development System (JCIDS), and the Defense Acquisition System. The PPBE process matches resources (money) with programs, under the guidance and direction of several federal documents, including the National Security Strategy. This process of managing the budget takes a long-term approach. There are three budgets being worked with at any one time: the current budget being executed, next year's budget being reviewed and approved, and the following year's budget that is being formulated for submission.

The budget that the commands (which are full of all the warfighters, the end-users) submit based on what they need stands to be changed many times as it passes all the way up the chain of command to the President's office. After review and approval by the Office of Management and Budget (OMB) it is submitted to Congress, which has the authority to change it again. The entire chain of command is trying to predict what they will need 2-3 years out and with all the priorities of the chain's different members, it's difficult to know exactly what acquisitions to plan for and how much they will cost especially with combat requirements changing at a rapid pace and technologies becoming obsolete only months after they are released. The PPBE system is a challenging one to work in with such a long lead time but it is just one of the decision-making support systems within DoD.

The JCIDS system is the second DoD support system. It was developed by the Joint Chiefs of Staff to identify capabilities (and gaps) in joint military missions and effectively integrate them into Defense acquisition processes. The Defense Acquisition System is the management process by which the military buys weapons and information systems for use within the Department of Defense. The process claims to be both centralized to ensure discipline and accountability as well as decentralized to facilitate efficient acquisition (Defense Acquisition Guidebook, 2004). The last system is the focus of this discussion: Defense Acquisition.

The purpose of the Defense Acquisition System is to "manage the nation's investment in technology, programs, and product support necessary to achieve the National Security Strategy." Its objective is to "acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price" (Defense Acquisition Guidebook, 2004).

The Defense Acquisition System is primarily governed by two DoD directives: 5000.1 (The Defense Acquisition System) which puts forth the policies and principles that govern the system and 5000.2 (Operation of the Defense

Acquisition System) that outlines the management framework responsible for executing the policies and principles in DD5000.1. The management framework is events-based and tracks acquisition programs through three significant milestones (A, B, and C) along a continuum of steps from program inception all the way to disposal of the system at the end of its life cycle, each phase having its own reporting requirements (Defense Acquisition Guidebook, 2004). The system pays special attention to the integration of the acquisition to the organizational elements of DOTMLPF – doctrine, organization, training, material, leadership, personnel, and facilities – in a systematic effort towards a smooth transition from concept to fielding, use, and support.

Each acquisition program is evaluated and categorized based on its cost and criticality to the capability gap it fills or the national objective it helps to address, and each category has proportionately different levels of oversight and reporting requirements as well as different Milestone Decision Authorities (MDA). There are various teams and boards that meet to discuss and evaluate an acquisition program and help the MDA make his milestone decisions regarding the progress of the program. The Acquisition Program Manager is in charge of the acquisition program and is responsible for meeting the program's goals, which include certain minimum criteria of cost, schedule, and performance parameters required to meet the program's objectives.

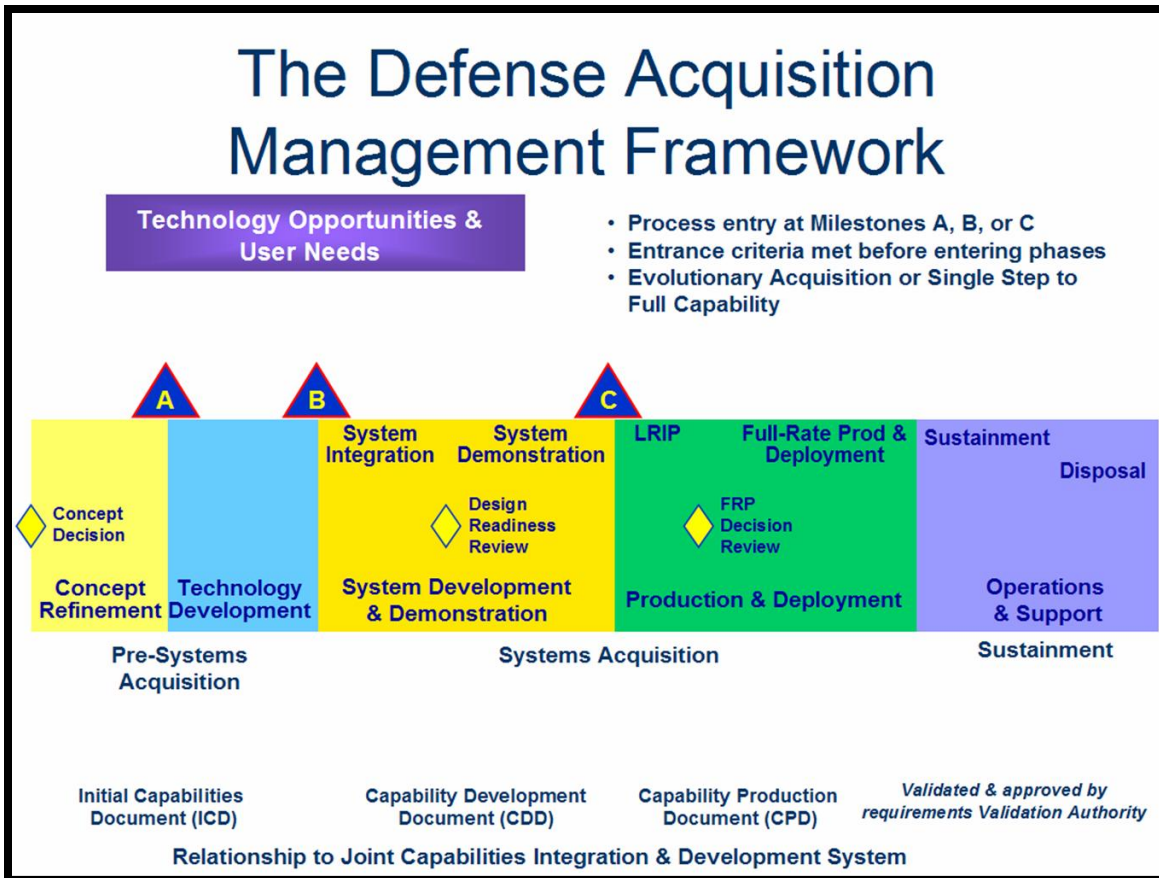
The program's objectives help form the Acquisition Program Baseline (APB) and involve the end-user such that the objective values and threshold values of each parameter of the system are determined and assigned dollar values. The objective values are selected based upon what the end-user needs or desires. The threshold values are the minimum levels of that parameter that will still satisfy the end-user's capability need. Early in the process, the program manager discusses trade-offs with the end-user, trading any amount of cost, schedule, or performance for another. The technology being used is also evaluated to make sure it is mature enough to fill the capability gap for which it was commissioned..



Many considerations and collaborations go into formulating the Acquisition Strategy, including a thorough understanding of the program as well as the greater defense environment. Approval requires concurrence of the Program Executive Officer (PEO) for all acquisitions and the DoD Component Acquisition Executive (CAE) for acquisitions in the largest category.

The program's approach to developing its Life Cycle Resource Estimates could either be Single Step or Evolutionary. The single step approach the program plans for one step to achieve full capability. The Department prefers Evolutionary presumably because it provides intermediate steps along the way with specific criteria for evaluation at each increment, inviting oversight throughout the acquisition process. There are two types of Evolutionary Acquisition: Incremental Development and Spiral Development. Incremental Development requires complete planning for each incremental stage of the acquisition, including funding, development, testing, production, and support. Spiral Development is the preferred method and fully defines the first increment but uses a management approach to define the requirements of the remaining increments as the program evolves.

The Defense Acquisition Management Framework includes the phases of Concept Refinement, Technology Development, System Development and Demonstration, Production and Deployment, and finally Operations and Support. Milestones A, B, and C are associated with completion of the first three phases which enable the acquisition to roll into Low Rate Initial Production (LRIP), Initial Operational Capability (IOC), and finally Full Operational Capability (FOC) (Figure 3).



**Figure 3. The Defense Acquisition Management Framework**

The MDA can authorize a science and technology project to “transition” into the acquisition process as a Program of Record (POR) at any point in the cycle as long as the program meets the regulatory and statutory requirements specific to that phase. Entering at Technology Development requires that the program be suitably justified and calls for an approved Technology Development Strategy (TDS) and a valid Initial Capabilities Document (ICD), among various other items. Entering at Systems Development and Demonstration requires that the system be mature, have full funding and a valid Capability Development Document (CDD) so that it is ready for LRIP. Entering at Production and Deployment requires an approved Capability Production Document (CPD) in addition to a list of other criteria to ensure that full-rate production and deployment makes financial, strategic, and common sense.

The Department of Defense's acquisition process has gotten more involved and cumbersome over time, typically taking five to ten years to field a new technology (FY2007 ACTD/JCTD Congressional Report, 2006). The mission of the Office of Advanced Systems & Concepts attempts to reduce that transition time.

## **2. Advanced Systems & Concepts**

The Office of the Under Secretary of Defense (Advanced Systems and Concepts) – which reports to the Under Secretary of Defense (Acquisition, Technology and Logistics) – has ten offices with the mission of productively and expediently connecting the world of science and emerging technologies to the warfighters who need it to combat crafty and technologically savvy adversaries. While legacy acquisition traditionally takes eleven years to field a technology, the AS&C office boasts a much faster fielding rate of 2-4 years.

This is where the science and technology communities are paired up with Combatant Commanders in the field in an attempt to steer developing technologies towards maturation in filling a capability gap that exists for U.S. and coalition warfighters. The AS&C offices consider themselves the “solutions people” (Opening the Doors to the Future, n.d.) and are full of transition specialists who can skillfully integrate technologies.

The ten AS&C technology transition and transfer programs and their evaluation criteria are as follows:

The Defense Production Act (DPA) Title III facilitates the 2-4 year production goal by providing gap funding for technologies that are not quite mature enough or have not been picked up for full funding by a service sponsor. This office is evaluated on the number of technologies that it has enabled.

The Manufacturing Technology (MANTECH) program, in 1-3 years, develops manufacturing processes that result in more advanced, more affordable weapons for the warfighters. This office is measured by the number of processes that are used by the industry.

The Independent Research & Development (IR&D) program consorts with private technology industry to develop partnerships and find the best emerging technologies with which to arm the U.S. warfighters. This office measures its success by the effective uses of IR&D projects.

The Technology Transfer (TT) program leverages private industry resources to further the development of a technology and make it more affordable through economies of scale. This program measures success through the number of commercialized defense technologies.

The Foreign Comparative Testing (FCT) program scouts foreign technology developments in order to leverage world advances in the field and provide them to the U.S. warfighter. It measures success by the number of foreign technologies that are evaluated to meet DoD requirements and are fielded to the warfighter.

The Technology Transition Initiative (TTI) program is a funding line that facilitates the rapid completion of transition requirements in order to get a technology into the field more quickly. It addresses issues of service commitments, value-added to the warfighter, clear exit criteria, and technology maturity. The goal is to get the technology fielded in under four years and have the service sponsor share up to half of the transition costs. This program has potential joint applications. It is graded on the number of projects successfully transitioned from the lab to a POR and finally to the field.

The Defense Acquisition Challenge (DAC) program provides an opportunity for the scientific community and government to conspire and introduce innovative new technology and equipment solutions to the DoD. If the

project is completed, a technology is improved upon, equipment is successfully tested, the service sponsor's requirements are met, and the technology is transitioned and fielded, then the program has a success.

The Joint Coalition Operations Support (JCOS) program provides management oversight, leadership, business process development, policy guidance, and horizontal integration of efforts for responsive joint and foreign acquisition. There was no measure of success in AS&C literature for this program but it seeks to balance and avoid redundant investments, support joint experimentation, integrate coalition and DoD experimentation activities, and encourage communication across the board.

The Advanced Concepts Technology Demonstration (ACTD) and Joint Capability Technology Demonstration (JCTD) programs aim to evaluate mature technologies early for their ability to fill capability gaps for the warfighter and facilitate their rapid fielding, with an emphasis on joint warfighting. This program measures its success by the number of products that the warfighters are using in the field.

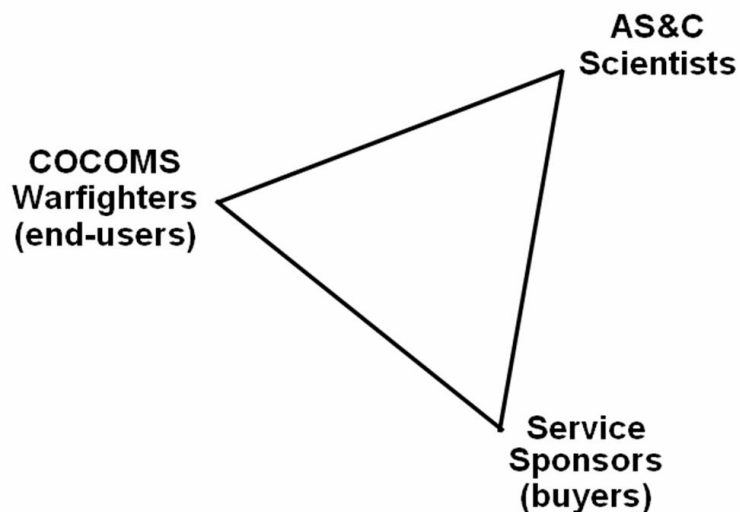
These ten programs are where the emerging technologies with the most potential have the opportunity to be catapulted through the acquisition process via rapid funding and fielding capabilities. They each officially define success in their own way, often by the fielding and actual use of a technology product. However, the metrics used to evaluate these programs and how they are perceived by their members may be different than advertised.

### **3. Joint Capability Technology Demonstration (JCTD)**

In order to explore the various definitions of success as perceived by members of this community of technology acquisitions, first understand the elements involved in the transaction. Taking a closer look at one of the offices under AS&C– the JCTD program – a triangle of players emerges.

The JCTD process takes a nominal 2-4 years and involves three players: the scientists, the warfighters, and the financiers. The office connects their scientists with exciting new technology that have potential military applications to operational Combatant Commanders (COCOMS) to see if there is value to be gained from its use in the joint operational field in which they are fighting. If determined, after a successful Military Utility Assessment (MUA), that the technology would benefit the joint warfighter in the field, then the program tries to obtain a service sponsor to finance the new technology acquisition.

The funding for the technology does not come from the operational command that will be using the technology but from a sponsor and in the world of planning for military operations vice executing them. This is a difficult pairing because the COCOMS, often operating jointly (with all the U.S. services), have specific emerging combatant needs or capability gaps but no procurement money to meet them. The service operations and support commands are courted to fund the technology acquisition when they probably had not been planning for it within the PPBE system nor will they be using it or being evaluated on its use.



**Figure 4. DoD Technology Acquisition Triangle**

The JCTD program formally measures its success by “the number of AC/JCTD products that warfighters are using” (AS&C – Opening the Doors to the Future, n.d.). 156 AC/JCTDs have been initiated since the program’s inception and products from 63 of them have been used in U.S. conflicts (AS&C – Opening the Doors to the Future, n.d.). The program focuses on spiral technology insertion into the formal acquisition process and embraces risk mitigation for any transformational or “game-changing” capabilities (FY2007 JCTD New Starts).

The JCTD office recognizes fiscal limited resources as one of its future challenges because the joint requirements funding still has to come through each of the individual services. Even if the services supported the new technology and the joint efforts, the cumbersome PPBE process requires planning three to ten years into the future, making it hard to be responsive to changing technology and current immediate combat needs. The JCTD office recognizes that DoD’s future will involve serious collaboration among the services, other government agencies, the private sector, and even coalition elements. Therefore, it tries to plan funding and transition for its collaborative and transformational capabilities upfront (AS&C – Opening the Doors to the Future, n.d.).

The traditional DoD Acquisition process and the PPBE process are comprehensive and thoughtful, spanning many years into the future. They are still very useful for long term acquisition goals and fiscal planning. However, the adversary the U.S. warfighter faces today is not hindered by such a large and involved government and can rapidly exploit emerging technologies. The U.S. warfighter cannot afford to give him that agility edge. Programs such as the JCTD Program help match promising emerging technologies to current needs of warfighters in the field more expediently.

The JCTD program and these emerging technologies have experienced encouraging successes but still face challenges. A service has to sponsor the technology to fund its development and delivery and sustain it in the field. In addition, near-term funding resources are already committed years into the future as the service operates within the PPBES.

#### 4. Defining Success

The Advanced Systems & Concepts (AS&C) office formally defines “success” as the number of products the warfighter is using. It is easier to measure the “transition rate.” “Transition” is defined as a Science and Technology (S&T) project that has a successful Military Utility Assessment, is picked up by a service sponsor, and inserted into the larger formal acquisition process as a Program of Record (POR).

However, perceptions of the definition of “transition” and “program success” vary quite a bit across different organizations within the Department of Defense, as do opinions regarding potential barriers to successful transition. This is demonstrated by examining the responses to a Voice of the Customer (VOC) survey conducted by a NAVAIR Lean Six Sigma team in March of 2007 among members of the following offices:

- Naval Research (ONR)
- Defense Advanced Research Projects Agency (DARPA)
- Director of Defense Research and Engineering (DDR&E)
- academia
- industry
- Naval Aviation, Program Executive Officer
- Naval Aviation, Assistant Program Executive Officer
- Naval Aviation, Performance Management Agendas (PMA)
- Naval Aviation, Science and Technology
- Naval Operations (OPNAV),
- Assistant Secretary of the Navy for Research, Development and Acquisition (ASN RDA),
- Commander Naval Air Forces (CNAF).

There were concerns and opinions among respondents about “transition” being defined as an S&T project that had been converted into an acquisition POR. Subjects were asked to agree or disagree with the following:



**“TRANSITION is the implementation of a science and technology project into an acquisition program of record or the start of an acquisition program of record.”** Responses follow:

Some queried how to give credit to a technology effort that never received a POR but was useful in some other function like supporting product development through modeling? Some disagreed with the definition, declaring that the technology needed to make it to the Fleet. Still others thought the definition was too narrow and raised questions about projects that never had a POR but were sent directly to the Fleet or projects that were picked up by industry and then used by the government, achieving some amount of success not reflected in a POR. Some defined transition as the project receiving other-than S&T funding. One respondent suggested that a technology is transitioned not when it receives a POR but when the user agrees that it is ready for application and no more development is required (i.e., the technology is mature).

Additionally, there were concerns and opinions about “success” being defined as a science and technology project that had been converted into an acquisition POR. Subjects were asked to agree or disagree with the following: **“PROJECT SUCCESS is the implementation of a science and technology project into an acquisition program of record or the start of an acquisition program of record.”** The responses follow:

Some claimed that there should be two metrics of success – transition through the S&T phases and the level of the technology actually in the Fleet. Some said that the definition was incomplete because it did not include such things as learning from mistakes. Some said the definition should also count projects that transitioned into acquisition programs that weren’t initially targeted as well as ones that were put on the shelf for a later spiral. Still others said that success should be able to subdivide a project into the parts that transitioned and parts that did not.

Some agreed with this definition of success but acknowledged that the technologists don't deliver technology to the Fleet; that's the Program's job. Some said that there needs to be two metrics: one dependent on POR transition and the other on successfully achieving technical objectives, including the improvement of some element of a capability.

Some said that success is determined by the objectives of the project. There were some who said that even tracking the success of S&T projects is difficult because of the long and circuitous development phase, sometimes taking 10-12 years and rarely going directly from the laboratory to the warfighter.

Some said speed was important. Some stressed the importance of ensuring the technology works in the field as well as the lab. Comments argued that S&T ventures should fail frequently at rates between 50-70 percent as they test boundaries in an effort to increase efficacy of the technology.

Some took exception to the definition, saying it was too restrictive and argued that success was simply to prove or disprove a hypothesis by applying a science to a problem. Some argued that to say success is related to transition into a POR was far too removed in time from the actual S&T work conducted.

Some cited the intrinsic value of science expanding the collective body of knowledge as an element of success. Some argued that just because a technology doesn't transition, it shouldn't be considered a failure. One organization specified that success would come if a project managed to transition to a POR before Milestone B so that it could help sell the program to development.

From this feedback, one can see the variance in the definitions of transition and program success. These questions and answers bring up an interesting point in terms of "failure." S&T professionals working at the Pentagon say that an 80 percent success rate is good. This is because of the nature of the field of science and technology. Experimentation in the name of advancement is not always going to produce the best technology. Set-backs and mis-steps are

desired to learn how everything works and fits together. These “set-backs” can sometimes serve to focus the research. Without these “failures” didn’t happen, the “successes” wouldn’t be complete or as valuable. In other words, if an S&T organization achieves a 100 percent success rate, then they aren’t taking enough risks. This is contrary to what some say about a POR being risk-averse. If this is true, then it is not the place to continue development and – for the health of the program – the technology should be mature by this point.

Finally, there were varied and interesting responses to the question **“What potential barriers to success have you seen?”** Responses follow:

There were many comments on the budgeting process being cumbersome and some cited “institutional inertia.” There were also many comments about insufficient funding, particularly in the out-years. They said the POM is “rigid, inflexible, slow, and resistant to change,” rendering it incapable of meeting emerging needs in a timely manner. Transition sponsors’ (the services) lack of flexibility to realign funding within their budgets was cited as a barrier. Others said the awareness of Performance Management Agendas (PMAs) was a problem because they were unable to keep up with rapidly changing technology, rendering some projects obsolete by the time they finally got fielded.

There was some talk about the contractors driving certain products due to differing agendas and incompatible incentives. Often the technical goals that makes the project a military success for the military may not be the driving factor in the contractor’s BCA.

Improperly defined requirements and not meeting requirements were believed to be barriers. The POR being risk-averse was also cited as a barrier. The unwillingness to end a program or pet project that is no longer viable was also cited as a barrier.

Some acknowledged the end-user was insufficiently involved from the beginning. Some cited the lack of shared vision of “success,” and said that the

Program Manager cannot absorb further development costs during the implementation process. If the technology is not mature enough, completing the maturation process - once a POR - is expensive.

The same command noted that if the program loses sponsorship, it is dead. There were some that believe the short-term view of leadership is a barrier, saying that the transitions are invisible to the leaders. The Valley of Death between the S&T community and the project becoming a POR was also mentioned.

As evidenced by these responses, the perception of certain definitions and criteria, including successful transition, varies widely across different Department of Defense organizations. Many of the perceptions of success or the criteria by which the federal employees are measured involve the technology being inserted into the formal acquisition process, obtaining a service sponsor and becoming a POR. This is contrary to the notion of success being defined as the technology's ultimate use by the warfighter, as is declared by most of the AS&C literature, including the JCTD section. As they say, what you measure is what you get. Many of the definitions or metrics of success ignore the full potential of the technology being realized by the warfighter at all.

This misalignment throughout DoD could prove problematic without proper oversight and leadership, ultimately ignoring the end-user's decision to accept or reject adoption and standing to waste billions in government acquisition resources, not to mention deprive the warfighter of the advanced tools he may need to beat his adversary on the battlefield.

## **B. MAGNITUDE OF RESOURCES**

This business of investing in new technologies to give U.S. warfighters a leading edge over adversaries is no trivial matter, especially when considering the magnitude of public funding involved. An idea starts small with Basic Research and, if successful, blooms throughout the Department of Defense

budget which was more than 50 percent of the approved discretionary Budget Authority in the 2007 federal budget. The amount of resources involved in equipping the U.S. warfighter deserves proportionately appropriate oversight, and that includes ensuring the technology is successfully diffused and reaches its potential in the field.

The Research, Development, Test, and Evaluation (RDTE) piece of the Department of Defense budget is 12.8 percent of the \$602 billion requested for 2007. But when the RDTE projects grow up, they become acquisition programs and move through the acquisition process to full rate production and deployment and fielding, subsequently taking up bigger portions of the DoD funding pie – Procurement and Operations and Maintenance (O&M). The 2007 Procurement request was \$130.547 billion (21.7 percent) and the O&M request was \$240,693 billion (39.9 percent) of the total \$601.858 billion DoD Budget Authority (Figure 5).

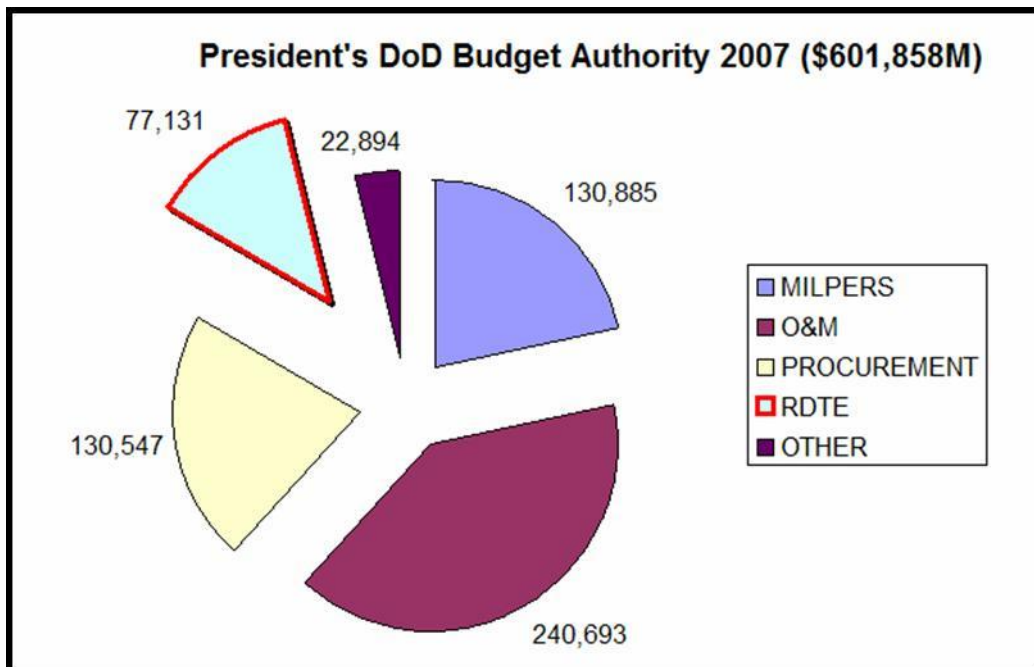


Figure 5. President's DoD Budget Authority 2007 (\$601,858M)

The U.S. government has a responsibility to the nation to maintain a leading edge in research, development, test, and evaluation (RDTE) to ensure the warfighter stays equipped with the best technology to fight adversaries in increasingly dangerous combat situations. The research funded now is what the warfighter will be equipped with tomorrow. The \$72.97 billion requested in 2007 for RDTE includes Budget Authorities 1-7, which range from Basic Research to Operational Systems Development (Figure 6). This is where the Advanced Systems & Concepts (AS&C) funds its ten offices (including the AC/JCTD program office) that facilitate the transfer of emerging technologies to the field.

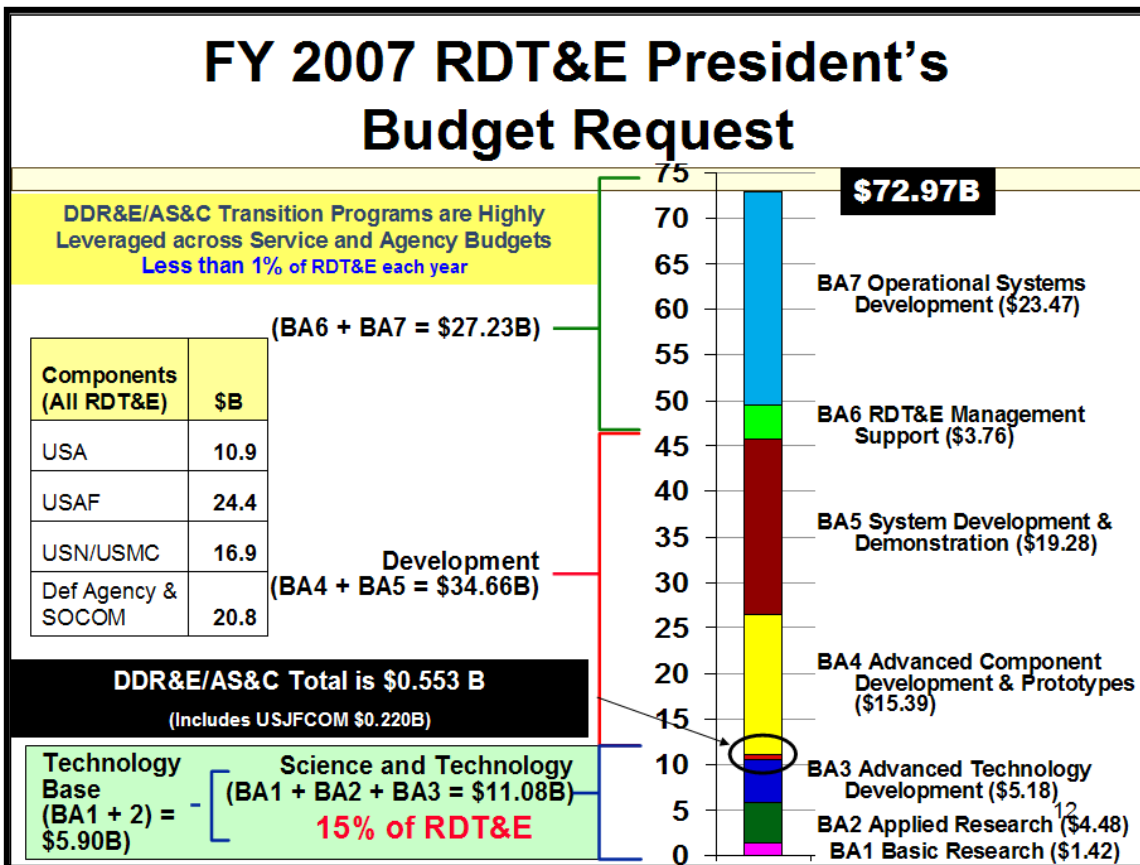
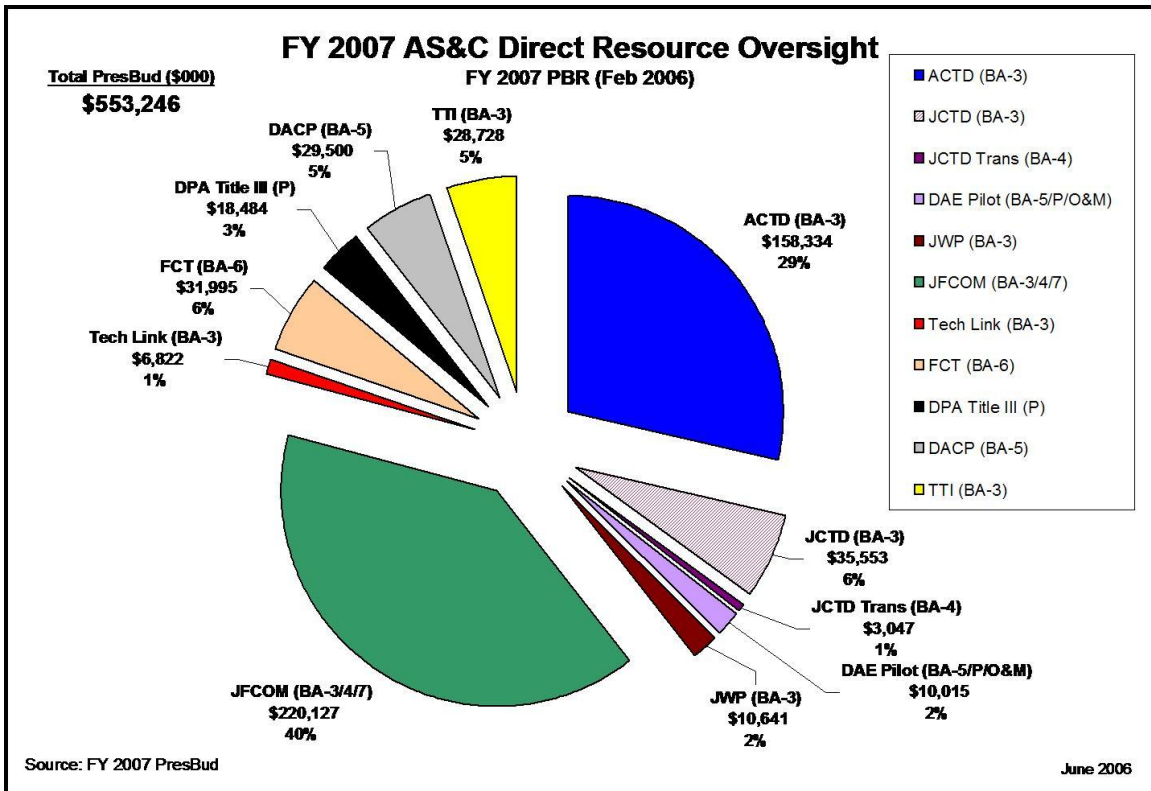


Figure 6. FY 2007 RDT&E President's Budget Request

The \$553 million in the AS&C bank is divvied up even further into the ten technology transfer programs of the Office of the Deputy Under Secretary of Defense (Advanced Systems & Concepts). The JCTD and its predecessor ACTD programs together take up nearly 30 percent of the total AS&C resources.



**Figure 7. FY 2007 AS&C Direct Resource Oversight**

Due to the amount of resources involved in equipping the U.S. warfighter, mature technologies with strong BCA's deserve attention to ensure that they successfully diffuse from the laboratory to the warfighter so their benefits are fully realized. This requires addressing the factors that affect the technology's diffusion completely down the chain. These factors can be identified by drawing parallels between the structures that describe the private sector's technology diffusion efforts and the Department of Defense's own technology diffusion experience.

### **C. POPULAR LITERATURE PARALLELS**

The Literature Review described the segments of the Technology Adoption Life Cycle, identified the Technology Adoption Chasm, and discussed strategies for crossing it before addressing several definitions and concepts from the academic world of technology adoption.

The literature review primarily focused on the private sector. The public sector is also heavily invested in the advancement and procurement of new technologies, as these are considered critical government responsibilities. No place is it perhaps more critical than within the Department of Defense, which is charged with defending United States freedom abroad, other important missions.

There are significant differences between the private and public sectors, including both their sources of money that flows through the system and for their motivation that drives the system.

The source of money for the private sector is based on individual choice, free market principles, and is designed to reflect how much the buyer values the purchase. The source of money for the public sector is the taxes that each citizen pays to the government to protect their ability to participate in the country's free market enterprises and enjoy their life, liberty, and pursuit of happiness.

The motivation for each sector also differs significantly. The private sector is busy living life, enjoying liberty, and pursuing happiness, which in this country often means increasing the bottom line. Measuring the motivation of the public sector is a little more complicated.

The public sector has been charged with protecting and supporting each citizen's rights. The evaluation of this goal is not measured by the bottom line but has a moral component of quality. The government also has a responsibility to judiciously use the tax dollars with which it's been charged. The profits for people who work for the government are fixed. Government employees and



public officials do not get more money as a direct result (bottom line) of their job, although they may be promoted to a higher pay grade for the quality of their work. Therefore, our trust in them to do their best with citizens' money is largely a function of their morality, professionalism, and skill, as well as being directly affected by government regulations and procedures.

To mitigate the risk of trusting so many people with so much money simply based on their own professionalism and morality, the system has incentives meant to move everyone in the right direction. The government strives to take advantage of a healthy economy and advance technologies to fulfill its public sector missions.

Despite these fundamental differences between the private and public sectors, parallels between the two can still be drawn where technology adoption is concerned, particularly within the Department of Defense. Some technologies adopted by the DoD exhibit characteristics of externalities and network externalities. The Technology Adoption Life Cycle can be matched up with the DoD Acquisition Process, which also has to cross an Adoption Chasm, or Valley of Death, to achieve successful technology diffusion. Finally, there are private sector diffusion techniques that hold potential in the public sector, too.

## **1. DoD TAL**

The Bell Curve model of the Technology Adoption Life Cycle applies to the motivations of the end-users, an important distinction when trying to match it up with the Department of Defense Acquisition Process where the purchasers are often very high up the chain of command while the end-users are at the other end of that chain.

The five segments of the TAL are the Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. These five segments can be grouped into two segments, each on one side of the Technology Adoption Chasm (or the Valley of Death). The Innovators and the Early Adopters together make up the

Early Market and they sit on the left side of the Chasm. The Early Majority, Late Majority, and the Laggards comprise the Late Market and sit on the right side of the Chasm.

The differences between the Early Market and Late Market are important to understanding the challenges to crossing the Chasm. The Early Majority immediately on the other side of the Chasm are largely a self-referencing group, they are more interested in the progress of their industry vice the development of new technologies. They are more respectful of infrastructure and standard practices and are not fond of discontinuous technologies that disrupt operations, but – though cautious and critical – once committed to a new technology, are more likely to stick with it than move on to the next new technology that comes along.

It is possible to match up the TAL to various parts of the Department of Defense for the purpose of analyzing and making analogies between the private and public sector's technology adoption experience. The DoD Early Market includes commands that volunteer to participate in new technologies before other commands because they see potential use (not necessarily economic use) for the technology to improve either the efficiency or efficacy of their operations. They might be the commands that end up using the prototypes or the residuals from a JCTD program or the commands that actually spend their own money to participate in the evaluation process of a new technology. Their incentives are driven by interest in the technology and not by mimicry or command and control. They might be the recipients of the LRIP (low-rate initial production).

The DoD Late Market includes commands that receive and use a new technology after it has entered full-rate production and deployment. For the AS&C programs, this also includes the criteria of becoming a Program of Record (POR) or otherwise being inserted into the DoD Acquisition Process. However, a technology that accomplishes all these things has not necessarily successfully transitioned in the overarching sense of the definition.

## 2. DoD Chasm

The DoD Technology Adoption Chasm (or the Valley of Death) – like its counterpart in the private sector - exists between the Early Market and Late Market. It lies between the LRIP and the full-rate production and deployment, between where prototypes and residuals are being used up and where the technology gets a service sponsor, an actual POR, and is inserted into the DoD Acquisition Process. But this definition is incomplete. These things are not the only criteria for crossing the DoD Valley of Death (VoD).

In order to be considered successfully diffused – having crossed the Chasm into the Late Market – the technology must be mature and reach its potential by being used by the most effective number of warfighters in the field in the most effective way. In other words, it must reach the warfighter and he must be using it. For the overarching definition of successful technology diffusion, it's not enough to give the technology a POR and have it enter full rate production and deployment because that doesn't ensure that the warfighter is using it, which is where the return on investment (ROI) lies for the tax dollars spent.

As in the private sector, there are hazards to being in the DoD Valley of Death while working to be adopted by a service sponsor, obtain a Program of Record, reach full production and deployment, and eventually be used by the warfighter. For one thing, there are limited resources. That's one reason the technology needs a service sponsor – funding.

Time is another danger of the VoD. For the military it's not other competitive companies that need to be cut-off at the pass, but the enemy's advances in technology that threaten the lives of our warfighters and the missions underway. Another less critical issue of time, but important nonetheless, is the high turnover rate. In the military, leadership and forces rotate from job to job, increasing the urgency to implement new technologies

quickly at the risk of the technology champion moving on to another position and jeopardizing the continuity of the vision the new technology fueled or facilitated.

### **3. Crossing the DoD Chasm**

Some of the strategies outlined for the private sector in their attempts to cross the Chasm could also prove useful for the DoD. Technologies wishing to reach and help the warfighter in his mission might consider starting off with a niche application, enlisting the aid of certain types of people (Connectors, Mavens, and Salesmen), making the technology memorable, and weighing all the factors of context when evaluating a technology diffusion situation and how to best approach the leap.

Sometimes a technology might be so new and exciting with so many possibilities that it's almost over-useful. In this case, potential customers (the services) are not really sure what it can best be used for because the potential is so vast, they have trouble seeing its specific application to improve their core competencies. The technology needs to pick a certain application and market itself to the associated service. In this way, DoD is picking and catering to a niche market to get a foothold within DoD's Late Market and make it through the acquisition process and into the hands of the warfighter, much like Geoffrey Moore suggests for civilian companies in Crossing the Chasm (1999).

An example of this would be the Global Positioning Recovery System (GPRS), currently a JCTD program that is advertising for a service sponsor. The technology could be gainfully employed by any one of the services in some capacity as a GPS locator. This is because its application is so generic at this point. Costs are still relatively high due to learning curve, economies of scale, working out the maturity glitches, and a host of other issues normally accompanying an emerging technologies. These issues don't make the promising technology overly appealing to any of the services who haven't been specifically courted by its application to their competencies. The services don't have much fiscal flexibility to sponsor another program anyway.

People can certainly help with the diffusion of a new technology across the DoD, particularly a Salesman in the form of the technology champion. Connectors and Mavens that bring new ideas into the laboratories, the Pentagon offices and to the operational commands can help spread ideas that could become technologies and eventually aid the warfighter in his mission. Mavens can also help educate the user population to the benefits of the new technology, particularly if it is discontinuous in nature, involving a revolutionary way of doing business that will disrupt the current system of operation.

Another important tool for successful technology diffusion in the DoD involves crafting the message that describes the impact of a new technology so that it is memorable and inspires action among decision-makers, implementers and users. It is also critical that the message be communicated all the way down the chain of command, from the high-level champion to the end-user, or the true success of the technology diffusion is in jeopardy. This concept of “stickiness” can be a useful tool when management is trying to communicate its commitment down the chain.

Finally, the Power of Context provides some guidance for diffusing technologies throughout the DoD. When attempting to diffuse a good technology throughout the DoD to the warfighter, it’s important to remember that there are lots of emerging requirements pulling at scarce resources. Many things affect whether the warfighter decides to cooperate with an adoption. But even if all these issues are addressed, the technology still may not become a successful adoption. Resources are tight and so funding may have needed to go to something more critical. The assessment of the technology maturity might have been incorrect or incomplete. The adversary might have already found something to beat the technology attempting transition. Context needs to be remembered when a technology fails to diffuse – the reason may reside in an unexpected place and if appropriately addressed may reverse the effects.

When the organizational system is so large that it has to be broken up into many small components that are responsible for only a piece of the total diffusion

to the end-user, the final goal can get lost. This is why intermediate metrics such as research projects becoming Programs of Record or the securing of a service sponsor are important as a measure of success. It would be impractical for each office to be measured or evaluated on the technology's final diffusion. A technology champion provides total oversight and has a professional interest in ensuring that the technology is successfully diffused all the way down to the warfighter using it in the field. Similarly, the champion can create an environment where interest and commitment is felt all the way down the chain, which increases its chance for a successful adoption.

Finally, leaders – military and civilian - sometimes think they can influence and control everything within their jurisdiction, sometimes just by issuing an order. It is important to realize that the flatter the world becomes, the more everyone is virtually connected to everyone else, the more rampant the spread of information is as it becomes more instantly and reliably available to more people – the less of an impact the command and control solutions will have. The best tool to address this declining power is education. Gathering as much knowledge as possible becomes the best preparation for controlling outcomes.

#### **D. ACADEMIC PARALLELS**

The topics of technology, externalities, network effects, and natural monopolies will be touched upon in this section. There are parallels between the public and private sector that should be drawn in order to examine further the issues that affect end-user adoption.,

##### **1. Technology**

From the shovel to horses to the internet to weather satellites – the U.S. military has done it all, albeit history holds this governmental organization to be about 10-20 years behind the technological advances of society. Closing that

gap between the technology advances made in the private sector and the equipment made available to the world's most powerful military continues to be a priority of the United States.

## **2. Externalities and Network Externalities**

The fact that an organization as large as the DoD is charged with acquiring technologies that improve its operations naturally leads to externalities and network externalities as a result of its various technology implementation efforts. There are also issues of complementarity, compatibility, standards, switching costs, and serious supply side economies of scale issues in DoD ventures, arguably to a much larger scale due to the sheer size of the organization and the resources at its disposal.

Standards are critical to the Department of Defense for a number of reasons. The military deals with explosives and other firepower; standard training, procedures, and specifications all help ensure the safety of the servicemembers working with ordinance. Standards in procedures and equipment also help reduce the costs of training and operating that equipment throughout the forces.

Switching costs have the potential to be much greater in the Defense Department due to the sheer size of the organization, as well as the large fixed costs and support structure characterizing many DoD technologies. Choosing the wrong (suboptimal) standard or technology and then having to switch to another could prove very costly for the taxpayer in terms of the infrastructure already paid for and equipment and complementary goods already purchased. In some contracts, there are monetary penalties for switching standards in the middle of an acquisition deal.

Large organizations such as the Department of Defense are typically not fond of discontinuous technologies. When an infrastructure is already in place (including physical infrastructure and standard operating procedures that are

commonly accepted, trained for, and practiced), the Defense Department prefers not to disrupt operations with discontinuous technologies unless the expected benefits are significant.

### **3. Direct and Indirect Network Externalities**

The DoD experiences both direct and indirect network externalities. A technology's accompanying complementary goods market can include both hardware and software. The software includes "humanware," which are the policies, training, practices, and standard operating procedures that govern the use of a technology and its incorporation into the larger system of operations.

In an indirect network externality situation, the availability and maturity of the complementary goods market increases the value of the technology. In an extreme example, the most efficient design of a keyboard might be sitting in front of the servicemember but if he doesn't have the right training to use it, then no value can be extracted. The fastest computer and biggest monitor might be in a space on a ship, but if there's no keyboard to interface with the system then no value can be extracted.

On the flip side of the coin, the size of DoD and its resources introduce the possibility of serious supply side economies of scale. The size of the organization and the amount of resources it can leverage to enable infrastructure and buy-in to a standard or technology on a grander scale than smaller organizations. With control of such powerful resources, the Department also runs a greater risk of inadvertently choosing the wrong standard or technology in its frenzy to speed technology development and adoption along to get the advantage to the warfighter. In such an instance, DoD also runs the risk of bearing the majority of the set-up costs as the market leader – not a good position to be in when also charged with the wise use of taxpayers' dollars.



#### **4. Natural Monopolies Discussion**

If ever there were an organization large enough to establish a natural monopoly, it would be the U.S. Department of Defense. With its vast amount of resources available with which to invest in infrastructure and establish standards in the name of national defense, it would be very hard for just any private firm to “compete” with the DoD. However, there is no statutory prevention of competition and if an investment in infrastructure and establishing department-wide standards helps DoD deliver better national defense and is economical for department with taxpayer resources, then the military will do what it needs to do.

Care should be taken to ensure the technology is mature and the socially optimal product for the marketplace for the sake of DoD as well as the private sector, for whom the DoD could be inadvertently setting standards for. If the DoD invests in the suboptimal technology and it becomes the standard, then all of society suffers. If DoD invests in the suboptimal technology and a competing private firm comes along and corrects the marketplace to the socially optimal standard, then the money DoD laid out for the infrastructure and initial purchasing costs will have been wasted.

This chapter provided an overview of the Department of Defense Acquisition System, specifically highlighting the Advanced Systems & Concepts Office that brings the science and technology community together with the warfighters and the various DoD services. Differing definitions of success and transition were pondered and then defined in an overarching sense for the purposes of this thesis. The chapter then outlined the parts of the President’s FY2007 Budget that are dedicated to farming science and technology with the potential for these projects to move into the much larger funds of procurement and operations and support. The chapter drew parallels between the civilian and military worlds of technology adoption, specifically touching on issues discussed in the literature review.

With these concepts solidly breeched, this thesis takes a look at four civilian case studies that hold echoes of the Department of Defense and begin to tease out similar kinds of critical issues that appear to affect the end-user's ultimate decision to complete the diffusion of a new technology or resist the adoption.

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## **IV. CIVILIAN CASE STUDIES**

Four case studies are examined in this section, each highlighting the importance of the critical issues found to affect end-user adoption. CASE is computer-aided software engineering that was not ultimately adopted after an attempt in the late 80s, and the case examines why. Health Technology Assessments (HTAs) are a tool used to improve technology in the area of health care but meet some resistance. This case has many structural similarities to the Department of Defense as an organization. Radio Frequency Identification (RFID) is an on-going case of adoption that runs somewhat parallel to the DoD adoption of the technology, discussed in a later chapter. Finally, the classic case of the QWERTY keyboard is used to illustrate several of the critical end-user issues discovered in this thesis.

### **A. COMPUTER-AIDED SOFTWARE ENGINEERING (CASE)**

Computer-aided software engineering (CASE) is a technology that was thought to hold great potential for improving company productivity by automating software life cycle processes. The technology manages the life cycle processes of the computer software that the company uses to run its business. CASE emerged in response to the growing number of software systems waiting to be updated to current industry standards.

CASE is considered a discontinuous technology because it disrupts operations by changing processes as well as tools to adopt the technology. This requires organizational change and addressing employee user issues. In this case, the company's own computer programmers were asked to change.

A Management Information Systems (MIS) organization that was in the process of adopting CASE agreed to participate in a study of its effectiveness. At the time, the company had 100,000 employees and \$9 billion in annual sales at the time (circa 1989). Its employees numbered around 280 and its development

budget was \$12 million. The CASE implementation was considered a failure, and the study attempted to investigate why (Norman, et al, 1989)

The software engineers at the MIS organization could not see the benefits of adopting the technology, so the implementation was problematic. Software engineers, by nature, are change agents of an organization, constantly making improvements in their own systems and requiring the users of those systems to adjust themselves to the change to increase productivity or improve service. This is an interesting technology adoption case because the employees required to change are normally the change agents themselves (the software engineers). These engineers would have to adopt a technology that encroached on their territory of systems improvement, potentially making their engineering skills obsolete.

To reconcile themselves to adopting this technology, the software engineers needed to adjust their view of the CASE to see the benefits they stood to gain. The technology would free the engineers from mundane computing tasks, allowing them to focus on larger, perhaps more visible problems. This is much in the same spirit that the software engineers themselves advocate process changes within their organization that free employees to focus on other tasks. The software engineers needed to recognize the potential benefits of the technology before they would be willing to adopt.

In a similar manner to being able to see the benefits, the company's software engineers needed to recognize the value of the advancement and not succumb to their fear of losing control over their operations. The control, in this case, would be lost to the CASE, which would manage the software life cycle; CASE would replace the physical person that used to manage that aspect of the company. Again, this would have allowed the software engineer to improve or use his skills in more creative/constructive, less mundane ways. The engineer's willingness to adopt was affected because he didn't take this perspective but instead saw the technology as removing some of his autonomy (giving it to the CASE technology).

The software engineers that were asked to implement CASE didn't understand how critical the move was for the company to stay competitive. There was an increasing disparity between the demand for software and the engineers that could provide it. At the time, competitive industry pressures moved companies to adopt CASE to capture efficiencies that allowed them to keep up or move ahead of the pack of similar companies running the same bottom-line race. The software engineers didn't recognize that their company needed this move to remain viable, and they were therefore resistant to the adoption.

The software engineers implementing CASE could not perceive the management's commitment to the technology adoption. This could have been a critical element in their motivation to adopt the technology. Even though corporate commitment was high, the message wasn't transmitted to the users (software engineers). The degree of perceived management commitment is consistently cited as a driving factor in the success or failure of a technology adoption (Norman, et al, 1989).

On a similar note, there was the noticeable absence of a CASE technology champion in the MIS organization. This was cited as a critical factor in its failure to diffuse throughout the organization. The software engineers did not have a highly visible and well-respected advocate of the controversial technology they were being asked to implement (Norman, et al, 1989).

The MIS organization's attempt to adopt CASE to keep its company up-to-date with rapidly changing computer software was unsuccessful for several reasons. Some of the more prominent reasons involved the users' inability to see the benefits of the technology, the fear of losing control to CASE, their lack of situational awareness regarding industry pressures and how CASE could help, their perception that management was not committed to the adoption, and the distinct absence of a technology champion for CASE. These factors are all related to the software engineer, the end-user of the new technology.

## **B. HEALTH TECHNOLOGY ASSESSMENTS (HTA)**

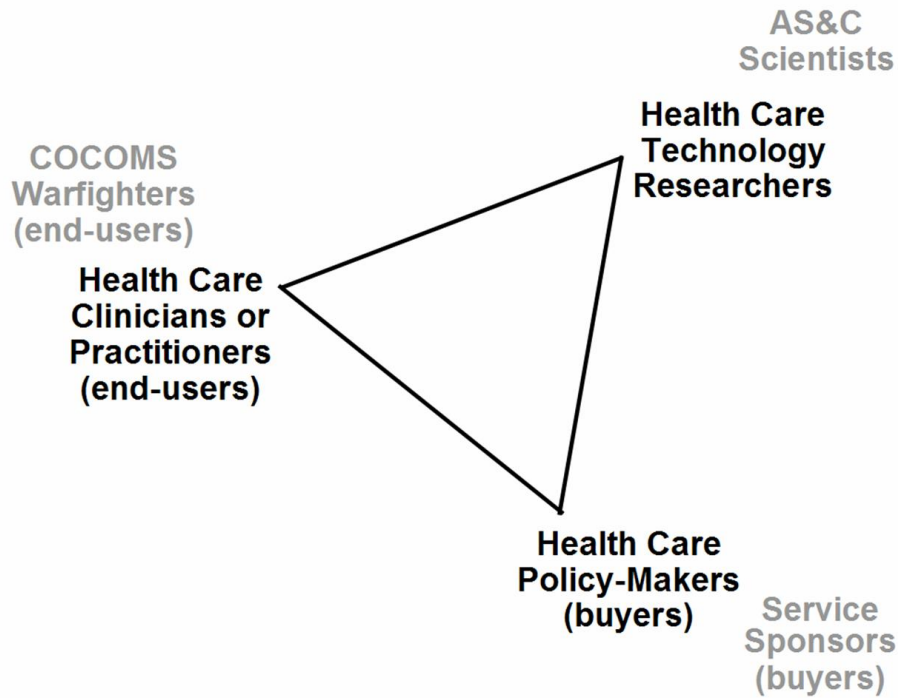
Health Technology Assessments (HTA) in the medical field provide an interesting case study regarding the factors that affect technology diffusion, especially considering the organizational parallels between the medical field and the Department of Defense. In the arena of health care, there are policy makers. The policy makers can be compared to the services that decide to spend money on certain technologies, the researchers are like the scientists who attempt to introduce new technologies into the field to improve performance, and the clinicians are like the warfighters – ultimately the end-users of the technology.

In this case, the players that form the field of medicine in the United States are sometimes subject to misaligned incentives which affect their motivation to act in the socially optimal way. Likewise, the large organization of different DoD actors sometimes have opposing incentives due to the different natures of the criteria they are evaluated on.

Health Technology Assessments help “improve decision-making about the diffusion and use of health technology” (Drummond and Weatherly, 2000). They are characterized as an iterative process that uses “synthesis and implementation” as a critical step in the Technology Assessment Iterative Loop (TAIL) (Drummond and Weatherly, 2000) which seeks to improve the use of technology to improve work within the field of medicine. In addition, HTAs are charged with reducing inappropriate or inefficient treatment.

Throughout the years, HTAs have contributed significantly to this loop of technology improvement (the TAIL) by developing methods that assess efficacy and efficiency of health technologies. They “synthesize and channel the information derived from scientific practice into the public policy domain” (Drummond and Weatherly, 2000).

Much of a person’s actions are determined by how they are evaluated in their career fields. Consider the following Health Care Technology Acquisition Triangle analogy to the DoD Technology Acquisition Triangle.



**Figure 8. Health Care Technology Acquisition Triangle**

In the arena of health care, the policy maker's career is evaluated on his ability to make expedient policy decisions with sometimes insufficient information. Sometimes he is given very little time to veto or concur on new policies brought forward as a result of the HTAs. These policies often result in determining how resources are expended (i.e., making the use of a new technology a standard approach).

On the other hand, researchers are rewarded professionally by publishing their works in reputable journals or getting their research funded. Their motivation runs concurrent with these actions on which they are ultimately evaluated (many times informally by their colleagues) and are not aligned with those of the policy makers, who are motivated to find solutions to problems quickly, effectively, and cheaply.

The clinicians – or practitioners - are key personnel in this decision chain; they ultimately must choose to adopt new practices or use new technologies in



order for the policy changes or research findings to be of any use to the general public – the consumers of healthcare. Practitioners tend to be a risk-averse group – quite willing to spend money for “peace of mind”. They order tests or conduct procedures that may not be cost-effective because they are not comfortable with uncertainty. This seeming disrespect for costs is unsavory to the policy makers, who must answer to the public for the money spent on health care and so their incentives are opposed.

The reward systems of these opposing careers can lead to different decisions regarding HTA implementation because their incentives are not aligned. This system rewards very different behaviors, even though their charge of delivering quality affordable health care to the public is the same.

The study cited another reason that HTA findings are resisted at the clinical level: control. If there is a conflict between clinic autonomy and compliance with policies mandated from outside the clinic, there will be resistance towards adopting HTA findings. The clinics want to maintain some control over their own practices and policies, perhaps guarding with their sense of ownership.

This case parallels with the DoD because the policy makers can be compared to the service sponsors that decide how much money will be spent on technology, the researchers are like the scientists conduct R&D for the DoD, and the clinicians are like the warfighters – the ultimate users of the technology. The attempt to use HTAs for improvements in the medical field may fall subject to misaligned incentives within the system or they may threaten the autonomy of the clinics. The perception of both of these issues will affect the implementers of the HTAs at the clinician level.

### **C. RADIO FREQUENCY IDENTIFICATION (RFID)**

Passive Frequency Radio Identification (pRFID) is a technology with an incredible amount of potential for increasing supply chain efficiency and provides

a good example of weakest link, indirect network externalities. In addition, while this adoption story is still unfolding, the evolving case study of RFID diffusion throughout both the civilian and military marketplaces provides a good forum for discussion regarding the role of leadership in technology adoption, particularly the presence and visibility of a respected technology champion. This section will discuss the civilian attempt to adopt RFID by examining one company: Wal-Mart.

Wal-Mart rolled out an aggressive strategy for adopting RFID, starting in 2005. The plan included the company's own infrastructure, its top 100 suppliers, and a timeline that could be used by the manufacturers of the new technology. Wal-Mart's widely publicized implementation plan was used as a coordination point by other companies in the retail business. The other firms, including Target, presumably wanted to leverage Wal-Mart's bold move of taking on set-up costs and reap the benefits assumed to be associated with early adoption (Dew and Read, 2007).

RFID has all the characteristics of a network technology. Its value increases for each individual user as the installed base of users increases, increasing supply chain visibility along with making the components cheaper through economies of scale. It deals with the issues of complementarity, compatibility, standards, switching costs, and supply side economies of scale.

The set of complementary goods (both hardware and software) required to extract all the benefits of managing the supply chain using RFID is extensive. They include having retailers imbed saleable products with the pRFID tags, hardware installed to read the integrated tags, and the middleware or software necessary to absorb the data being collected and process it in a way that is useful to managers. This middleware has typically been engineered for niche markets using RFID technology, and there is some question as to whether it is mature enough to handle the magnitude of supply chain management that Wal-Mart would require.

This required accompanying hardware and software (including humanware – the change of policies and practices) are what make this technology a weakest link, indirect network externality. Without the readers, the technology is useless. Without the software to process the data that the readers collect from the tags, the technology is useless. Without the change in policies and practices by Wal-Mart employees to exploit the new way of collecting information, the technology is useless. RFID needs all of these complementary goods to realize the benefits.

The tags used must be standardized so that they are compatible with all the complementary goods and services associated with the technology adoption. Once readers, middleware and procedures are in place and successfully make up the infrastructure, the incremental or variable costs of the passive RFID tags themselves will be a more manageable business expense. The gain, however, has the potential to be enormous by generating instant information about the status of the supply chain. An example of this is the improved ability to manage stock-outs. For faddish merchandise or seasonal items, the ability to react quickly to a change in demand can save the company money and improve its bottom line. This introduces the element of supply side economies of scale.

With RFID being courted by both the military and the civilian sector, an enormous amount of resources could be leveraged to move this technology adoption into full gear. However, caution is advised and coordination is required in the marketplace because if the wrong (socially suboptimal) standard is adopted, the switching costs required to change would be costly, especially considering the influence of the market leaders involved. This would make the original set-up company vulnerable to competition that has the resources to advertise the correct standard.

Using its power in the retail industry, Wal-Mart has leveraged its position as a market leader and become the focal point for coordination regarding private adoption of RFID. Sam Walton, owner of one of the biggest retail companies in the world, can be considered the reputable and highly visible technology

champion in this case. It is his involvement through the industry giant company he represents that has championed RFID technology and hastened its adoption both within his empire and among his various merchandise suppliers.

Wal-Mart invited its 100 top suppliers to an RFID conference and then issued a mandate among them that they would implement the technology, along with its own infrastructure, in January 2005 if they wanted to continue business relations with Wal-Mart. Not only did Wal-Mart's top suppliers comply with the industry giant's mandate, but 46 additional firms coordinated their adoption of RFID around Wal-Mart's move (Dew and Read, 2007).

Wal-Mart also established an aggressive timeline for producing tags and installing reader equipment. This gave tag manufacturers a fairly reliable schedule around which to plan production. These efforts to coordinate RFID technology adoption in the retail business were meant to hasten the diffusion process, make this particular type of pRFID the standard and capture the benefits of leading the adoption edge (realize benefits first - get a head start on the savings). The coordination was also intended to reduce the burden on Wal-Mart from bearing the high set up costs associated with inflated infrastructure product prices before reaching critical mass as well as realizing economies of scale (Dew and Read, 2007).

RFID implementation in supply chain management provides opportunity to examine the effects of weakest link indirect network externalities as well as the influence of a powerful technology champion on the adoption process. Without the complementary products, the users cannot realize the benefits of the new technology. Technology champions, when highly respected and suitably visible, can hasten adoption. The danger is that this can lead to a market that settles on a suboptimal standard because its technology adoption process has been accelerated and artificially stimulated (users buy because of their faith in the champion to be able to significantly move the entire market towards adoption, thus creating standards that everyone can count on). This thesis will discuss the military's implementation of the RFID technology.

## **D. THE QWERTY KEYBOARD**

Perhaps the most infamous story of a market failure involving network technologies is the story of how the QWERTY keyboard managed to become the standard, even though it was not the best technology for the job (socially suboptimal). The story demonstrates the criticality of weakest link complementary goods. Perhaps the suboptimal keyboard would not have made it across the Chasm if all the necessary complementary goods had not accompanied it (or rather the lack of necessary complementary goods accompanying its more socially optimal competition - a keyboard with a more efficient key arrangement).

The QWERTY key arrangement dates back to the 1870s and stems from the age of typewriters where the keys were purposefully arranged to slow down the typist preventing the typebars (the arms holding the letter stamps) from physically jamming inside the machine, causing repeated impressions of a single letter as the typist continued to work. When the typebars jammed, the typist would continue to type because the print was hidden inside the machine. The typist did not see evidence of the jam until they had gotten far enough so that the print scrolled out of the typewriter. These two elements - the jamming keys and hidden print - constituted the engineering problems facing the first typewriters, and led to the first arrangement of keys (Parker, 1986).

The keys on the center row of the QWERTY keyboard are only used 51 percent of the time, making the finger activity of the QWERTY typist relatively inefficient. More efficient keyboard versions were developed. In contrast, the British developed an arrangement that placed 91 percent of the most frequently used letters in the English language in the center row.

By the time that the economy was climbing out of the 1870s recession,, improvements in typewriter engineering had rendered the justifications for the QWERTY keyboard arrangement obsolete. In addition, economic analysis done by the U.S. Navy (completed in the 1940s) proved that the increased efficiency of

a properly arranged keyboard would exceed the retraining costs incurred within 10 days. Therefore, the adoption of the more efficient keyboard was economically sound.

So why, then, did the market settle on the socially suboptimal technology as the standard? One of the most widely accepted theories has to do with the availability of the complementary goods in the larger system of interrelated production.

The typewriter boom of the 1880s resulted in the mass production of competing versions of the typewriter (including competitive key arrangements) by businesses eager to capture a share of the emerging typewriter market. By 1896, the U.S. typewriter market seemed to be rapidly moving towards settling on the QWERTY keyboard typewriter as the industry standard, due to the widely distributed and popular base of Sholes-Remington versions as well as James Bartlett Hammond's QWERTY models.

Not only were there public and private companies already investing in QWERTY keyboard hardware, but training schools were being stood up all over the country, not to mention the production of supporting manuals and handbooks, all poised to support the keyboard arrangement that seemed most likely to become the standard. Typing classes aimed at women were experimented with and became popular. Speed-typing competitions were organized. The majority of these were based in the QWERTY standard.

The "technical interrelatedness" of the complementary goods and services surrounding the QWERTY keyboard is cited as one of the reasons this suboptimal technology became the market standard. This represents a weakest link in a network externality situation because the product, or keyboard, is essentially worthless without the related complementary goods (replacement keyboards, training manuals) or services (typing courses). If every person learns to type on a certain keyboard, it would be very troublesome to acquire keyboards

that require employee retraining, particularly when there aren't enough classes or manuals that support the different, albeit technically more efficient, keyboard arrangement to support choosing it over the QWERTY keyboard.

The QWERTY keyboard arrangement demonstrates the effect that necessary complementary goods have on the technology end-user. The more the user-base increased (the number of people who bought and learned how to type on the QWERTY keyboard arrangement), the more the value of this socially suboptimal standard grew. This drove the continuing development of the complementary goods that supported the suboptimal standard, which drove the base to increase even more. If the end-user of a more efficient keyboard evaluates the availability of complementary hardware and software as inadequate, he will be unlikely to adopt the new technology.

## V. RESULTS AND DISCUSSION

This chapter discusses the potential results of a technology adoption attempt, assumptions that must be held to examine certain related issues, and a list of theoretical issues thought to be critical in the successful diffusion of a new technology as they relate to end-user perceptions and reactions.

### A. POTENTIAL OUTCOMES

Attempts to successfully diffuse a new technology throughout the Department of Defense – from the developers all the way down to the warfighters – has four potential outcomes. The technology could be fully adopted, partially adopted, de-adopted (after some partial adoption), or not adopted at all.

Full adoption echoes the overarching definition of successful diffusion by suggesting that a mature technology must reach its maximum potential through its effective use by the optimal number of warfighters. Partial adoption is less than full adoption, where the technology is diffused to a level below its potential. De-adoption occurs when a technology is fully or partially adopted and then experiences backward momentum and its fielding utility falls below its full potential. A complete lack of diffusion where the new technology never reaches or is never used by the warfighter is a no adoption situation.

### B. MATURE SUPPORTED TECHNOLOGIES

The generic technologies discussed in this analysis are assumed to be mature for the required mission and are assumed to be supported by positive business case analyses; for all apparent reasons, top management should move forward with adoption. In other words, the total expected benefits to the organization of adopting the new technology exceed the total expected costs.

The assumption that total benefits exceed total costs leads to the deduction that total benefits also exceed *end-user* costs. The question then



becomes whether the end-user *benefits* exceed end-user costs. This is important because the technology's use by the warfighter (end-user) ultimately determines whether or not the diffusion is successful.

### **C. CRITICAL ISSUES**

When the warfighter is certain as to the costs and benefits associated with a new technology, then there is little question whether he will choose to adopt the new technology. If he is certain that his benefits significantly exceed his costs, then it can be assumed that he will choose to adopt. If he is certain that his costs are greater than the benefits he expects to receive, he will reject the new technology or provide substantive resistance if he is ordered to make the adoption. More specifically, higher net valued users should be the early adopters, while medium and low valued users can be expected to follow at later stages, if at all. The question facing potential adopters is whether they are high, medium or low valued users.

This question of whether end-user benefits exceed end-user costs can be complicated if either the true benefits and costs are not well known in advance or if all costs and benefits do not accrue to the end-user. In particular, economic theory suggests at least four different situations in which end-users' decisions might be distorted; these can be characterized as follows: (1) in the presence of end-user cost and benefit uncertainty, (2) in the presence of externalities, (3) in the presence of *direct network* externalities, and (4) in *indirect network* externality situations.

The first situation is when the end-user is uncertain of his costs and benefits. The second situation involves externalities such that there is an economic consequence of adoption where some of the benefits may not accrue to the end-user, but in fact accrue to an overall organization instead.

The third and fourth situations deal with network externalities but differ in what drives the user base to expand and what increases the value to the end-users. The third situation exhibits direct network externalities of each adoption

and increases the value of the technology for all users as a direct result of the increased size of the user base. Finally, the fourth situation is where the value of the technology increases as the quality and availability of complementary goods increases, which itself increases in response to increases in the size of the user-base (it would be more beneficial for the suppliers to improve and expand the complementary goods market if the user-base was sufficiently large and stable)

In addition, there are specific practical issues that have been cited in academic and popular literature that influence end-user understanding of his relative benefits. This affects whether he uses the technology, and finally whether or not the technology is successfully diffused. The most relevant of these issues are when the end-user:

- (a) Perceives a loss of control and autonomy
- (b) Has a lack of appreciation for larger mission and organizational pressures
- (c) Is influenced by the system's misaligned incentives structure
- (d) lacks faith in management's commitment
- (e) perceives the absence of a program champion
- (f) is uncertain of the availability of complementary goods

What this thesis is interested in is the effect of these factors on the end-user's decision to adopt, and specifically how do they affect the ability of the user-base to coordinate so that critical mass is realized when adopting network technologies.

In a situation where the warfighter is (1) uncertain of his potential benefits, he can eventually learn how he stands to benefit from the new technology through repetition and trial and error, by observing the experience of other early adopters (an appropriate reference group), or by further analysis to better estimate the expected return on investment in the new technology. This will help determine whether he's a low, medium, or high value user, which will drive the technology's successful adoption, partial adoption, de-adoption, or lead to no adoption at all.

When (2) externalities are present in a technology adoption situation, the benefits don't all accrue to the end-user, but may accrue to other end-users or to another entity within the same organization (e.g., a more centralized support function, such as information technology within DoD). Likewise, when there are (3) direct and (4) indirect network externalities present in a network technology adoption situation, the benefits don't all accrue to the end-user, but the end-users' benefits do increase as the user-base expands. In all of these cases, an end-user's decision to adopt may be more influenced when he is exposed to any of the theoretical issues. This could affect the coordination of various user-value types motivation to adopt and reach critical mass for their greater good and presumably the greater good of the organization (in these cases, since the subject is the Department of Defense and not just the general public).

An organization trying to increase efficiency - conserve resources and reduce costs – through centralization and standardization often does so at the expense of the (a) control and autonomy of the individual end-user commands and the associated warfighters. Being part of a larger infrastructure that is centralized and controlled from the top-down saves time and money in terms of training, controlling the number and variety of applications supported by the infrastructure, and maintenance. There is a trade-off when the limited number of applications approved and paid for by the centralized system are not the best tools available on the market for the individual commands and users to complete their missions. The total benefits exceed the total costs, but there is an externality when the end-user experiences costs that exceed his personal benefits because the benefits are siphoned off to be enjoyed by the centralized organization at the expense of decentralized control, autonomy, and perhaps even efficacy.

The public sector is fraught with (b) misaligned incentive systems because the goals of its employees cannot be unified under the simple mission to make more money like they are in the private sector. Total benefits might exceed the total costs, but system incentives could motivate the end-user to make a decision

that is not based on total net benefits. The various offices of the DoD are sometimes evaluated on very different criteria, which creates misalignment among incentives affecting the entire organization.

Another DoD source of misaligned incentives stems from the Planning Programming Budgeting and Execution (PPBE) process that reclaims any cost savings captured by commands for redistribution to other critical mission areas. If a new technology is cost effective, meaning the end-user's costs are more than offset by the expected cost savings, but the end-user doesn't capture the cost savings, the command, might not choose to adopt a new technology despite its actual utility or benefit to the overall organization.

A warfighter may (c) not appreciate or understand (or care about) the mission pressures that are driving a technology adoption within his organization. Again, the total benefits exceed the total costs, but if the end-user cannot appreciate the importance of the benefits that go to the mission of the overall organization, then his decision to adopt will be affected.

An end-user's decision to adopt will be affected by how many others he *believes* are going to adopt a network technology. In a centralized organization such as DoD, network externalities can be mitigated if the institution appears committed to the new technology. In the presence of complicating network externalities, the warfighter's decision to adopt might be affected by his (d) faith in management's commitment or the (e) his perception of a respected technology champion.

When an end-user is uncertain about whether the higher-level decision-makers support the new technology, his motivation to adopt will be affected. Here, total benefits exceed the total costs if the technology is adopted, but the network externality issue indicates that the value will increase for each end-user as more adopt the technology. If the end-user is unsure of the (d) commitment of the overarching management or the (e) continuity of the technology champion, then the system-wide level of adoption becomes less certain and his decision to adopt will be affected.

In an indirect network externality situation, greater benefits are realized if the set of associated complementary goods are equally mature and readily available to the user-base, then they will be more willing to adopt. If the user-base can coordinate and reach their critical mass – the point that makes it beneficial for all to adopt – then the complementary goods market will also find it beneficial to supply the goods and all will benefit. If the end-user is (f) uncertain of the availability and maturity of the necessary complementary goods, then he will be less likely to adopt. This risk can be mitigated by addressing end-user faith in the inevitability of the adoption which would ensure a competitive market and a natural free market solution to the problem of available complementary goods.

It is within this framework of (1) uncertain benefits, (2) the presence of externalities, (3) the presence of *direct network* externalities, and (4) the presence of the *indirect* network externalities that the theoretical issues can be applied and studied. Using this framework facilitates evaluating the theoretical issues relative to the end-user and ultimately affecting successful adoption, as identified in the academic and popular literature. Again these issues include end-user:

- (a) Perceives a loss of control and autonomy
- (b) Has a lack of appreciation for larger mission and organizational pressures
- (c) Is influenced by the system's misaligned incentives structure
- (d) lacks faith in management's commitment
- (e) perceives the absence of a program champion
- (f) is uncertain of the availability of complementary goods

The influence these issues have on actual attempts to diffuse new technology throughout the Department of Defense can be explored by examining the DoD's Radio Frequency Identification (RFID) program and its Navy Marine Corps Intranet (NMCI) program. These issues can also be explored using an economic experimental model.

## **VI. MILITARY CASE STUDIES**

Two Navy technology adoption cases currently underway can illustrate the relevance of the adoption issues discovered to be critical to the end-user: the Navy Marine Corps Intranet (NMCI) and Navy's acquisition of passive Radio Frequency Identification (RFID).

### **A. NAVY MARINE CORPS INTRANET (NMCI)**

The Navy Marine Corps Intranet (NMCI) is the U.S. Navy's attempt at a concept termed "Network-Centric Warfare." This idea involves connecting all naval military organizations via advanced information technology (IT) networks, enabling personnel to reliably and securely transmit large amounts of information and save time and money by centralizing and standardizing (CRS Report for Congress, 2005).

There are several programs underway to link different elements of the Navy/Marine Corps: Cooperative Engagement Capability (CEC) allows ships and aircraft operating in the same area to share radar pictures, increasing their tactical visibility and reach; Naval Fires Network (NFN) helps coordinate anti-ship and anti-land gunfire and missiles by connecting naval forces operating in the same area into a real-time targeting network; IT-21 (Information Technology for the 21<sup>st</sup> Century) uses commercial, off-the-shelf (COTS) computers and related networking hardware and software to connect navy ships to other navy ships via an organizational intranet, facilitating the transmission of tactical and administrative data; and Forcenet is the Navy's capstone networking effort, envisioned to link all the various Navy networks to each other in one single central naval forces network. Forecenet has been cited as central to the Navy's Sea Power 21 enterprise but has been criticized for being insufficiently defined (CRS Report for Congress, 2005).

The final Navy networking program is NMCI. It is touted as the shore complement to the relatively successful shipboard IT-21, the organizational network program that communicates within and between Navy ships. NMCI will reportedly be the largest existing federal intranet, connecting more than 300 Navy and Marine Corps shore installations and supporting 305,200 “seats” (computer workstations). Two U.S. joint military commands – Pacific Command and the Joint Forces Command – are also scheduled to join this network, adding 10,500 seats (CRS Report for Congress, 2005).

The contract was awarded to Electronic Data Systems (EDS) in a five-year all-inclusive contract that is paid on a per-seat basis. The program has experienced delays and Congress authorized a two-year extension in October 2002. Congress has expressed concern over the Navy’s ability to fund NMCI in conjunction with its on-going critical enterprise programs and has been closely monitoring the program’s progress for several years (CRS Report for Congress, 2005).

In February 2002, the Navy established a program office headed, by an admiral, and charged it with managing the NMCI program, a \$10 billion effort at the time. In September 2004, EDS reported more than \$1 billion in losses since project inception (Perkins, 2005). By May 31, 2005, 247,597 NMCI seats had been activated – 78 percent of the total Navy/Marine Corps joint seats (315,700) planned for the system (CRS Report for Congress, 2005); while user satisfaction had reportedly improved, stories of users’ efforts to “work around” the system were rampant (Perkins, 2005).

End-user reaction after transitioning to NMCI work stations has had mixed reviews, even though the contractor’s incentive bonuses are tied to user satisfaction (Perkins, 2005).

Consider NMCI in terms of the critical issues facing end-users when they make their decision to proceed with an adoption:

- (a) loss of control and autonomy
- (b) lack of appreciation for larger mission and organizational pressures
- (c) influence of the system's misaligned incentives structure
- (d) lack of faith in management's commitment
- (e) continuity of a program champion
- (f) uncertainty of availability of complementary goods

The first category is the end-user's uncertainty about the net benefits from adopting the technology. The overall benefits from centralizing an organization on the same network have been validated by the almost standard practice of doing so within any organization, be it government, corporate, academic, scientific, or any other. Users have the ability to communicate with any other user on the network with a few clicks of the mouse and retrieve data from any number of databases on the network. The NMCI is a much larger venture than any other existing network, which prompts the question: at what point does centralization and standardization in the name of saving money and manpower deliver diminishing returns? If the end-user questions his personal benefits from embracing NMCI, then his decision to adopt will be affected.

The second category involves externalities and includes the end-user issues of loss of control, understanding the organizational mission, and the affects of misaligned incentives.

When an end-user believes that adopting a new technology will affect his local control, ability to customize, and autonomy, ultimately affecting his sense of ownership over daily operations, the end-user's cost for adopting may be higher than his perceived benefits, which will influence his decision to use the new technology. NMCI has faced many hurdles during its journey toward diffusion, including the transfer of roughly 22 thousand reported applications (in February 2002 this list was over 100 thousand) to the new network, many of which were not in compliance with current security policy requirements (Perkins, 2005).



These applications were obviously worth the trouble to install on the end-user's system before NMCI, indicating that they were of some value to him. This begs the question of the impact of their removal on productivity.

The voluminous number of applications to be sifted through and sorted out has dramatically slowed the switch-over to NMCI, especially since the NMCI administrators – who are outsourced and not native military and lack concrete guidance or criteria for the necessity of the applications from the Navy – had difficulty determining what was really needed, and what was a superfluous luxury of the work station occupant. One analysis stated that 20-30 percent of the applications reported were not even being used (Perkins, 2005). Perhaps these numbers were inflated by commands attempting to resist the transition.

Central Navy got involved via Task Force Web, Navy Application and Data Task Force, and Navy functional area managers and began a call for commands to rationalize their list of applications. Previously end-users were able to install and use software of their choice without resistance or hassle from outside the command. Now they are forced to justify their terminal tools to the Navy, reducing their control, autonomy and ability to customize their work environment in the name of overall savings, centralization and standardization.

Dealing with “legacy applications” was reported by many as the “principal impediment to faster progress” (Perkins, 2005, p. 12). The perceived effect the new technology has on the end-user's ability to control his work environment will affect his personal attitude towards compliance and his decision to cooperate with the adoption.

The end-user's understanding and valuation of the technology's contribution to the overall organizational mission will affect his decision to adopt. Centralizing and standardizing shore-side IT would conserve resources for training, managing, maintaining, and upgrading the IT infrastructure, and enable commands to re-engineer the “back office” processes they use to manage their operations and internal affairs, potentially delivering “hundreds of millions” in

savings (Perkins, 2005). Saving time, manpower and money would come at a critical time for a military that is funding extensive ongoing combat and non-combat operations abroad, in addition to facing increasing requirements to man, equip, train, deploy, and support domestically stationed troops in the face of budget cuts and shortfalls. The potential savings in funding and resources for fully adopting NMCI could be substantive and even critical to the success of military core missions. The extent to which the shore-based end-users realize and value the potential overall benefits to be gained from NMCI will affect their decision to adopt.

Misaligned incentives occur when a command adopts NMCI and is able to save money that would have otherwise been spent on network maintenance and upgrades. However, as a result of its efforts to comply and cooperate in the venture, its budget is reduced as the savings are siphoned off to be used elsewhere in the overall budget. Additionally, the command is ultimately evaluated on how effectively it accomplishes its mission which can be affected by which application they are allowed to use. The seniors ordering the command to adopt NMCI are evaluated on how efficiently they can do business. These two grading criteria are contrary to one another representing a system with misaligned incentives and can lead to command resistance towards adopting NMCI.

Direct network externalities in this case refer to the fact that as the user-base increases so does the value for each individual user. In the case of NMCI, as more seats are activated, the number of people that are connected on the intranet rises exponentially. For the user to agree to adopt this disruptive technology, he must have some faith in the inevitability that the diffusion will happen so that he doesn't feel like he's wasting his time. This confidence can be greatly affected by management's perceived commitment to the adoption and the visibility of a respected technology champion.

Therefore, the end-user has two issues that are affected by first order network externalities: concerns over management commitment and the end-

user's confidence in a technology champion. NMCI implementation has been somewhat controversial at the end-user level because of the issue of legacy software attrition and the workstation's loss of control and autonomy. This resistance increased the importance of perceived management commitment and the visibility of a technology champion for the program. If the end-user is to see any benefits at all, even just that the program was able to be completely diffused, then in the management to stay the course will affect the amount of effort he feels is worthwhile to put forth.

IT-21 was implemented in just a few years, setting up three Program Executive Offices (with SPAWAR, SIPS and NAVSEA) who ensured full alignment with their program managers. At the cost of \$160 million per battle group, the Navy bought all the necessary hardware and software and was able to transition three groups a year until 1998, when every battle group was in compliance and the Navy had a fully operating "fleet-enterprise" network. All this happened without an IT-21 line item in the Congressional budget (Perkins, 2005). When management commitment is behind a program, it can affect the end-user's decision to adopt the new technology. With IT-21, the end-user knew that management was committed to making this program a successful reality and their decisions to participate reflected that commitment.

Senior Navy leadership commitment to the NMCI program was born out of the apparent success of the IT-21 program on the fleet side but was motivated by the business value it could bring to the shore side. The success of IT-21 can be partially attributed to senior leadership commitment to the initiative. "Moving the entire at-sea navy to network-centric technology became a priority for SPAWAR and several senior leaders" (Perkins, 2005, p. 3).

On the other hand, the management commitment issues facing the NMCI initiative were a little more challenging. The technology champion, Admiral Archie Clemins, held several retreats referred to as "Archie Camps" that were aimed at securing command buy-in for NMCI. Although these Archie Camps were largely successful in securing commitment and enthusiasm from the

Echelon II (EII) communities, these sentiments for the program apparently did not filter down to the lower commands. NMCI officials reported that “involvement by senior leaders in preparing commands for implementation of NMCI was ‘the single most important factor in how well the transition worked’” (Perkins, 2005, p. 11). The NMCI team met resistance with nearly every command it approached except for the NAVAIR command, which took a proactive approach to the adoption of NMCI vice avoiding the inevitable. If the organization’s leadership recognizes the significant savings potentially realized by fully adopting NMCI and transmits that commitment through the leadership layers to the user commands, the end-users may be convinced of management commitment; this will affect their decision individually adopt the new technology.

The visibility and continuity of a technology champion will also affect the end-user’s decision to adopt. Admiral Archie Clemins was the champion for implementing IT-21 throughout the Fleet in 1996. He was an Early Adopter in Moore’s sense of the term because he was among the first to recognize the organizational benefits accrued from an IT network making significant amounts of relevant information readily available to workers. When he was working in the Pentagon in 1993, he wired his office for a Local Area Network (LAN) before the rest of the building was networked. He did the same thing with the command ship USS Blue Ridge as commander of the Seventh Fleet in 1994. As a result of his persistence with this program, the Blue Ridge and USS Washington were able to communicate and use the network as their command and control infrastructure during the Taiwan crisis in 1996 (Perkins, 2005).

Not only did Admiral Clemins work to make these networks a reality, he was committed to the maturity and quality of the technology, determined to deliver the best application to the Fleet. He stayed informed on the best technology available for his vision and how the civilian world used IT to transform their business processes. He visited leading American companies to learn how they leveraged this new technology in their business practices.

Finally, Admiral Clemins orchestrated the Archie Camps - Echelon II (EII) command meetings to educate his leaders and drum up support and enthusiasm for the Navy's networking efforts. If a technology has a champion that is committed to pushing the technology through to total diffusion, the end-user will be more willing to put forth effort to adopt because they will feel like their energies won't be wasted. The individual commands and end-users consider the commitment of a visible and respected technology champion when deciding whether or not to invest in a new technology.

The last category is indirect network externalities and refers to end-user uncertainty about the availability or maturity of necessary complementary hardware/software coordination issues. In the case of NMCI, capturing the associated benefits depends on the evolution of the appropriate "humanware" – the processes and policies that must accompany the new technology to capture the associated benefits. Regarding NMCI, there is a reputed practice of "getting around" the system (Perkins, 2005) by continuing to use old computers with legacy software (because of the hassle and impediments to moving more specialized applications to NMCI) to get their job done alongside the NMCI computer, where they log in simply to check their work email. These kinds of practices are not in line with NMCI's resource-saving goals and are counterproductive to realizing the benefits of the network technology. If the end-user either experiences or anticipates a cumbersome situation where he feels like this duality is necessary, his adoption effort will be affected.

The end-user will balance all these considerations when making the personal decision to use the new technology and complete its successful diffusion in the operational field. In the case of NMCI, the end-user's decision may be affected by his understanding of the associated benefits, his expectation of losing workstation control, his understanding of the impact of the new technology on his organization's mission, his faith in management's commitment, his perception of the technology champion, and his comfort with the ability of the

office humanware to adapt to the new technology, leverage full benefits, and make it unnecessary for him to use duplicate computer systems to deal get his job done.

## **B. RADIO FREQUENCY IDENTIFICATION (RFID)**

Radio Frequency Identification (RFID) presents an excellent example of an emerging technology that faces all the modern challenges of coordination in a network externality environment. RFID first emerged in the 1980s and was used mostly for tracking animals and in electronic collections on toll roads (Dew and Read, 2006 or Landt, 2001). The technology has had increased exposure and forced inertia in mainstream tracking methodologies from 1999-2007 (present).

RFID technology is a way of wirelessly tracking items (animals, vehicles traveling toll roads, merchandise, weapons, supplies, or anything that has been affixed with a tag) and replaces the Universal Product Code (UPC), which stores significantly less data.

Such a technology can either be active (aRFID - requiring a battery to transmit and a receiver to log its passage) or passive (pRFID - requiring a reader to actively and wirelessly search for any tags within its range). Both active and passive RFID are being used by the U.S. Department of Defense in their supply chains. Yet while active has diffused very successfully, the diffusion of passive RFID appears to have hit several snags (GAO-05-345).

RFID technology, if thoroughly diffused vertically and horizontally throughout an industry, would increase the speed at which items could be inventoried at various warehousing, transportation, and distribution centers (enabling the redirection of manpower) as well as provide analysts, managers, and decision-makers with a large amount of data from which to distill information regarding the performance of the supply chain and the goods it services.

Consider pRFID for military applications in terms of the issues facing end-users when they make their decision to adopt.

Because pRFID is not the normal way of doing business in the military supply world, the end-users may be uncertain of the benefits of using this new technology. This uncertainty would affect their decision to adopt. This is the reason why both the DoD and commercial users of pRFID (such as Wal-Mart) have engaged in several organized trials of the technology. The essence of these trials is to conduct controlled experiments with pRFID. Information gathered in trials has been used both in business case analyses (such as the Navy's BCA on pRFID) and publicized to the wider community of potential pRFID users through "white papers" (in particular, the Auto ID Center white paper series (2000-2003) in an attempt to educate a broad body of potential users about the potential benefits of the technology.

One such benefit from the diffusion of RFID was its value in improving "on-shelf availability" for the warfighter, or retail customer. While this potential benefit has been known of for several years, many trial experiments have been required in order to identify the precise costs and benefits of using pRFID for on-shelf applications, what kinds of goods most benefit from the information, and which particular technology adopters are likely to capture these benefits. It turns out that the cost/benefit calculus is strongest for items where demand is especially volatile. The increase accuracy and timeliness of stock-out information allows the supply chain to respond more quickly and accurately to "fads" in the consumption of items, whether razor blades or ammunition. The technology allows adjustments in manufacturing and shipping appropriately to maximize profits and minimize supply lags and use of inventory.

The second category deals with externality issues, the side-effects of using a new technology that end-users care about and might affect their decision to adopt. Two issues in this category relevant to RFID are organizational mission and misaligned incentives. The issue of control was discussed with regards to the Navy Marine Corps Intranet program.

The end-user's impression of the criticality of the new technology to the overall mission of their organization affects his decision to adopt. This is an

externality because the end-user does not capture this value; it accrues to the larger organization. Active RFID (aRFID) is claimed to have significantly improved the efficiency of the military's ordinance control efforts in its various campaigns around the world – an effort the department's calls Total Asset Visibility (TAV) strategy (Wyld, 2005). pRFID promises similar benefits in terms of savings to the organization in supply efficiency and resources.

In a informational brochure published by the IBM Business Center in October 2005, David Wyld borrows a list of reasons why the logistics of the military are fundamentally different than their respective civilian counterparts from Engels, Koh, Lai, and Schuster (2004, n.p.). The list includes readiness, long supply lines, variety of items, unstable demand, moving end point, priority, equipment reliability and maintenance, and detection. These drivers reflect organizational mission priorities that are very different from the drivers of priorities that are typically valued most highly in the civilian world (the most important of which is cost effectiveness).

aRFID was first used by the Army in 1993 to track the return of munitions after Desert Shield (1990) and Desert Storm (1991). It has been used in every overseas deployment since then, in increasing percentages, to improve visibility throughout the supply chain and get the warfighter “the right materiel, at the right time, and in the right condition” (Department of Defense, “Radio Frequency Identification [RFID] – Policy,” 2005). This effort increases reliability, informs decision-makers, introduces a just-in-time element for the tools made available to the warfighter, and helps the combatant commander do his job in the field more effectively. If the warfighter knew the organizational benefits reaped by using RFID, his decision to adopt might be affected.

Misaligned incentives occur when the improvements in technology, such as the adoption of RFID to make the supply chain more efficient, result in a reduction in a command's manpower or budget. When a command puts forth the effort to comply with the adoption of a piece of technology that is meant to increase efficiency and it is successful in these objectives, the command will be



able to reduce manpower or spending with regard to this process. But instead of being able to use the manpower or money somewhere else within their command, these resources are siphoned off to be used somewhere else in the overall organization. This reduces incentive for commands to fully cooperate with a technology adoption such as RFID because their reward is reduced manpower and budget.

The next category is first order network externalities, under which lie the end-users lack of faith in management commitment and the visibility and existence of a respected technology champion. As discussed previously, the level of perceived management commitment affects the end-user's decision to adopt. In the case of RFID, the military has a timetable for fielding RFID and its support structure to which incentives and evaluation criteria for subordinate commands can easily be tied (Wyld, 2005). The faith the end-user can put in management to actually follow through and spend the money to put the infrastructure, equipment, training, policies, and actual tags in place, will affect his desire to be a part of the process and adopt and use RFID.

This supposition holds true for components of an organization as well. The U.S. military is moving forward with adopting RFID throughout DoD but the onus to actually pay for it remains with the individual services because they fund their own enterprises through the Planning, Programming, Budgeting, and Execution System. The Army has been working on diffusing aRFID for many years as the technology helped get their troops through conflicts abroad for more than a decade. Recently the Marine Corp successfully adopted the technology. However the Navy and AF have been less aggressive in their adoption of both passive and active RFID (cite Navy BCA and George and Marcelo, 2003 thesis). The end-users – here the Navy supply personnel – note the hesitation by the senior leadership of their service and are loathe to spend their mission money on a technology when their management indicates that this technology adoption is not a service priority and will not be supported when it comes time for their seniors to evaluate them for promotion.

The BCA conducted by the Navy is shortsighted because it fails to recognize the network effects involved. If the technology is actually just shy of being reasonably mature or if the Navy ends up footing the more expensive end of the set-up costs (because economies of scale have not made this its most economical yet), then perhaps the Navy should reconsider the timing of its move towards adoption where RFID is concerned.

The presence and visibility of a technology champion would affect an end-users decision to adopt. RFID's champion within the military community has been the Assistant Deputy Undersecretary of Defense for Supply Chain Integration, Alan Estevez (2005). On September 28, 2005 he received the National Security Medal from the Partnership for Public Service in recognition of his contributions to the government's RFID use. He has been charged with managing the materiel and processes that ensure each warfighter gets what they need when they need it – an important responsibility considering lives may be at stake (Wyld, 2005).

Mr. Estevez is credited with paying attention to the development of global standards for pRFID, how it was being used by private sector counterparts (such as Wal-Mart) and putting that technology to efficient use in the military. The leadership and presence of such a proactive sponsor of a technology will influence the warfighter who is deciding whether or not to adopt, in part because it ensures the technology will be adopted throughout the enterprise, which is required to maintain Total Asset Visibility (TAV) throughout the supply chain.

Finally, the indirect network externalities coordination situation refers to the technologies that are accompanied by a group of complementary technologies and infrastructure that must all be used to enjoy any of the benefits of the new technology. The complementary hardware that accompanies the core RFID tag will have to be purchased and incorporated into the system for the command to collect the data. The data collected by RFID are useless if there isn't complementary software to analyze the data so the decision-makers can recognize and respond to trends.

Likewise, the benefits are not realized if the appropriate policies and procedures have not been changed to capture the efficiencies of the new technology, such as just-in-time inventories. If a depot has RFID equipment and shipments that are tagged but the law, organizational procedures or employee habits still dictate that they open each box and check the items inside for accuracy in order to pay their suppliers, then they don't save time or manpower necessary for RFID to achieve payback. The warfighter's expectation of the evolution and availability of complementary hardware and software (electronic and human) will affect the warfighter's decision to make the effort to adopt the new technology.

The end-user will weigh all these things when making the personal decision to use the new technology and complete its successful diffusion in the operational field. In the case of RFID, the end-user's decision may be affected by his understanding of the benefits, his understanding of the relevance of the new technology to his organization's mission, his incentives to adopt that might be misaligned with the incentives of his seniors, or other DoD offices, his faith in management's commitment, his perception of a technology champion, and his comfort with the adoption of complementary goods alongside the evolution of necessary complementary hardware and software.

## VII. EXPERIMENTAL DESIGN

When the warfighter is certain as to the costs and benefits associated with a new technology, then there is little question whether he will choose to adopt the new technology. If he is certain that his benefits significantly exceed his costs, then it can be assumed that he will choose to adopt. If he is certain that his costs are greater than the benefits he expects to receive, he will reject the new technology or provide substantive resistance if he is ordered to make the adoption. More specifically, higher net valued users should be the early adopters, while medium and low valued users can be expected to follow at later stages, if at all. The question facing potential adopters is whether they are high, medium or low valued users.

This question of whether end-user benefits exceed end-user costs can be complicated if either the true benefits or costs are not well known in advance or if all costs and benefits do not accrue to the end-user. In addition, the presence of the different types of externalities can complicate the situations in which end-users' decisions might be distorted.

For the sake of framework, these situations are characterized in the following four ways:

In all of these theoretical situations, the end-user is uncertain of his costs/benefits.

**(1) Situation One**

- there are no externalities to complicate the situation
- buyer is the same as the end-user

**(2) Situation Two**

- there are organizational externalities involved
- each end-user's benefit is determined only by his/her own adoption decision, but some external benefits accrue to the organization as more end-users adopt

**(3) Situation Three**

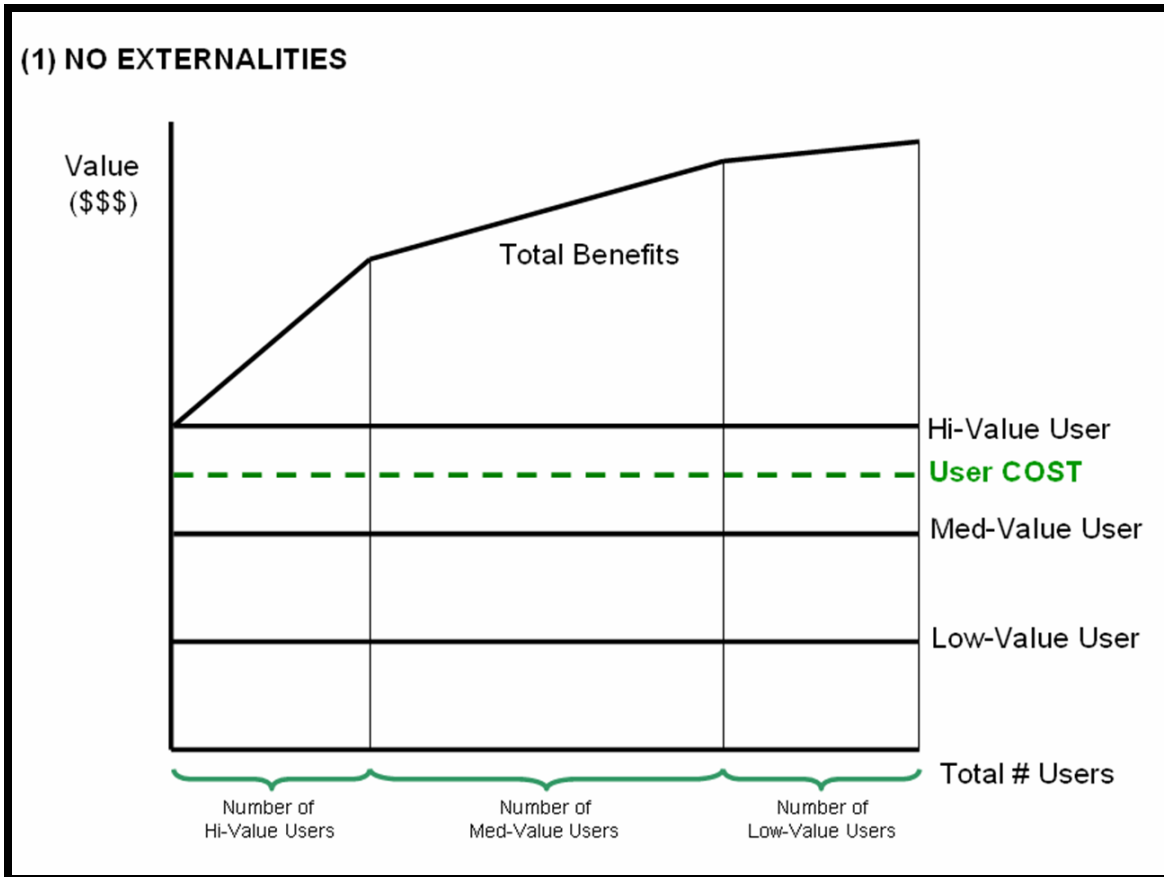
- there are direct network externalities involved (value depends on size of user-base)
- buyer and the end-user are different entities

**(4) Situation Four**

- there are indirect network externalities involved (value depends on number of complementary goods available which affects the size of the user-base)
- buyer and the end-user are different entities

The first situation is when the end-user is uncertain of his costs and benefits. The second situation involves externalities such that there is an economic consequence of adoption where some of the benefits may not accrue to the end-user, but in fact accrue to an overall organization instead.

The **first situation** involves very basic economic theory testing where the subjects are given a list of three types of users – low, middle, and high value – and are told that they do not know which type of user they are. This situation is typically resolved through trial-and-error where eventually the users discover what type of user they are and the market reaches equilibrium. This has little application here because rarely are the buyers and end-users the same in large DoD purchases. It is given here to illustrate the most basic economic situation that can be modeled and tested.



**Figure 9. Situation One**

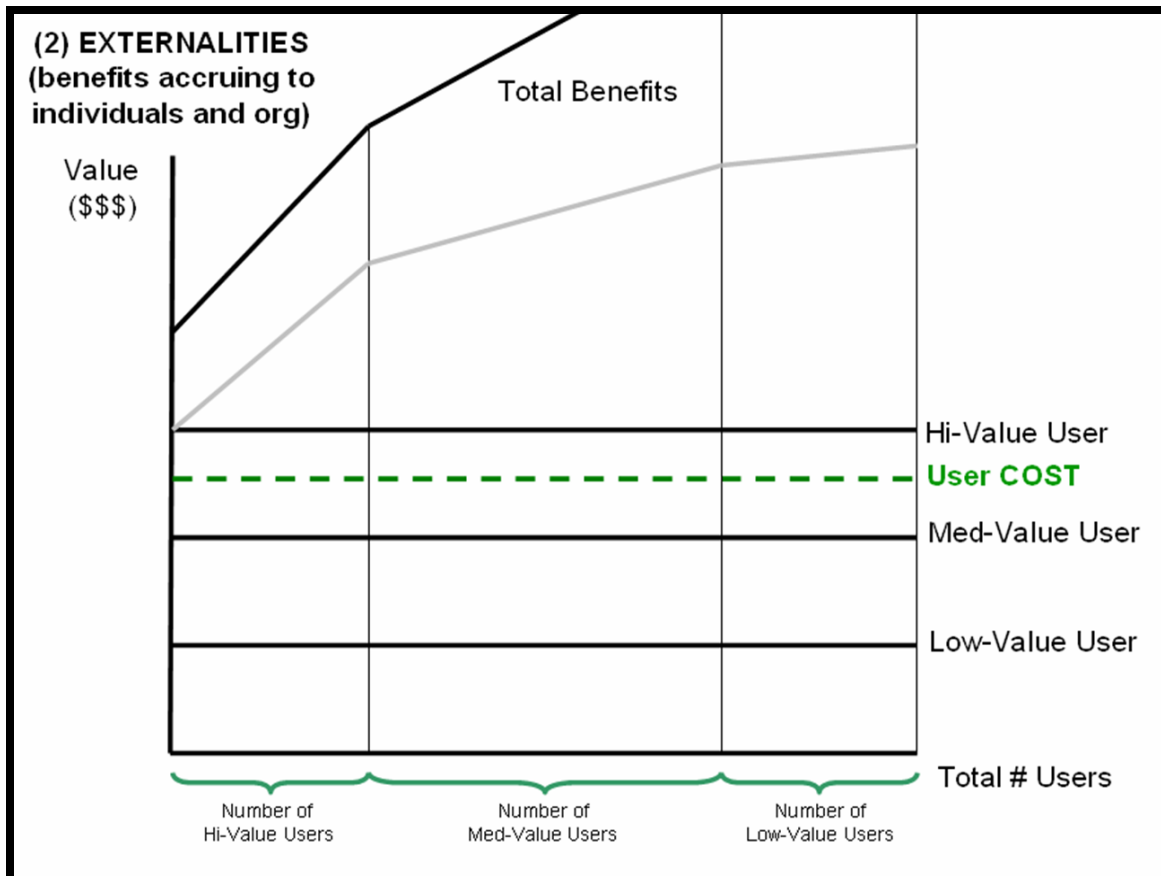
**(1) Situation One**

- there are no externalities to complicate the situation
- the buyer is the same as the end-user

The next three situations introduce two complications. The first is that the end-user and the buyers are not the same entities. This type of situation occurs in organizations when top management makes decisions and implements policies that the end-users within their organization are compelled to cooperate with. This complication is the same for the remaining three theoretical situations.

The second complication is the introduction of types of externalities. **Externalities** are consequences to economic decisions that affect entities

external to the transaction; they could be benefits or costs. There are several kinds of externalities discussed here. The first type of externality is the most basic and refers simply to the consequences of an economic decision, positive or negative, that accrue to the organization but are not realized by the end-user and is represented in the **situation two**.



**Figure 10. Situation Two**

**(2) Situation Two**

- there are externalities involved
- the buyer and the end-user are different entities

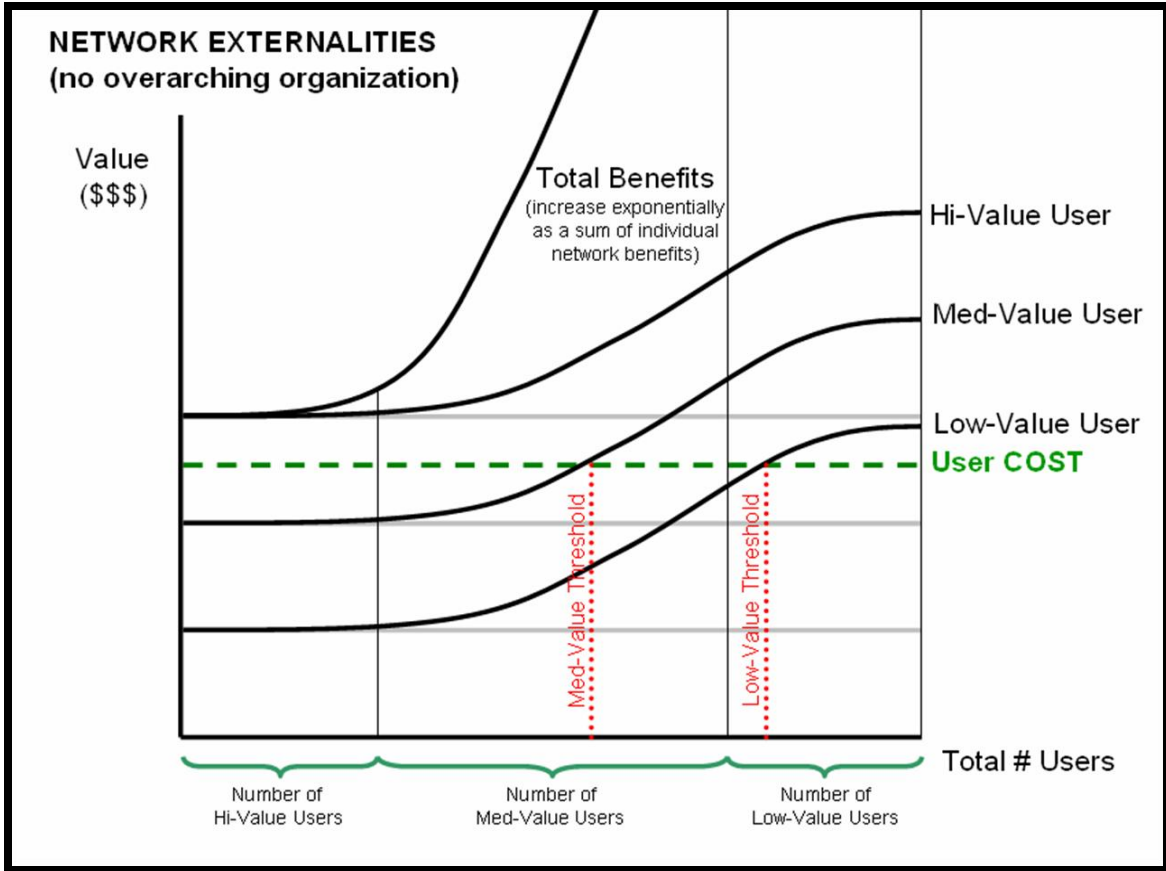
Following this are two types of **network externalities**. Network externalities occur when the value for each user does not remain static after the transaction but has the potential to increase as a related element increases.

There are two types of network externalities: direct and indirect. **Direct network externalities** refer to the value for each user increasing as the *user-base* increases. Examples of direct network externalities include the invention of e-mail and the telephone. The value of each of these technologies increases with direct proportion to the number of users of the technology. The more users of the direct network technologies, the more people each user can connect with, increasing the value of the technology for each individual user. These are represented in the **third theoretical situation**.

**Indirect network externalities** refer to the value for each user increasing as the quantity and quality of *complementary goods* increases. An example of an indirect network externality is the story of VHS versus the Beta VCR. The fact that there were more movies put into VHS format (the complementary goods) than Beta increased the value of the VHS VCRs for users and eventually led to the extinction of the higher quality Beta VCR. These indirect network externalities are represented in the **fourth and final theoretical situation**. There are other potential situations but they are not discussed here because these are the most basic and relevant to DoD situations and the issues being examined.

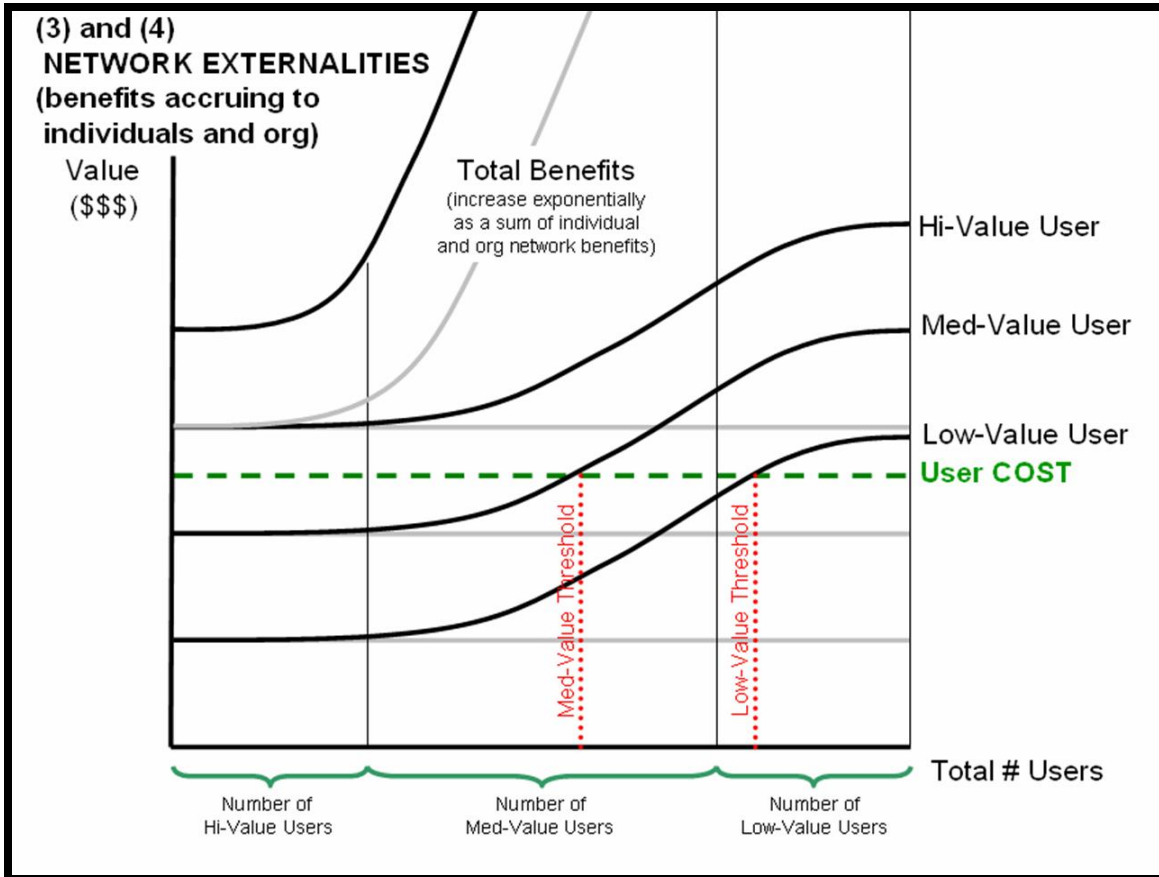
The following graph represents a **basic network externalities situation** (not one of the four listed – used here for pictorial introduction to network externalities). There could be direct or indirect network externalities but the individual value to each user increases as the user-base expands (whether the expansion is driven by the larger user-base increasing individual value or the larger base of complementary goods).





**Figure 11. Network Externality Situation with No Overarching Organization**

The following graph contains the last two theoretical situations such that there are network externalities (either direct or indirect) as well as organizational network externalities, where some of the benefits gained from the increasing size of the user-base are siphoned off to be enjoyed by the overarching organization.



**Figure 12. Situations Three and Four**

**(3) Situation Three**

- there are direct network externalities involved (value depends on size of user-base)
- the buyer the end-user are different entities

**(4) Situation Four**

- there are indirect network externalities involved (value depends on number of complementary goods available which affects the size of the user-base)
- the buyer and the end-user are different entities

In these last two, the benefits for each user goes up as the user-base goes up. The second of these refers to a situation where the value of the technology to each-user increases indirectly because of the availability and maturity of the complementary goods, which is ultimately a function of the size of the user-base.

The following graph again depicts situations three and four but uses two arrows to draw attention to where the user cost line intersects with the user benefit lines. This illustrates the point that if the user has the option, he will not adopt if his personal benefits are below his user cost line. Once the number of users increases, however, it becomes beneficial for him to adopt. This introduces the element of coordination.

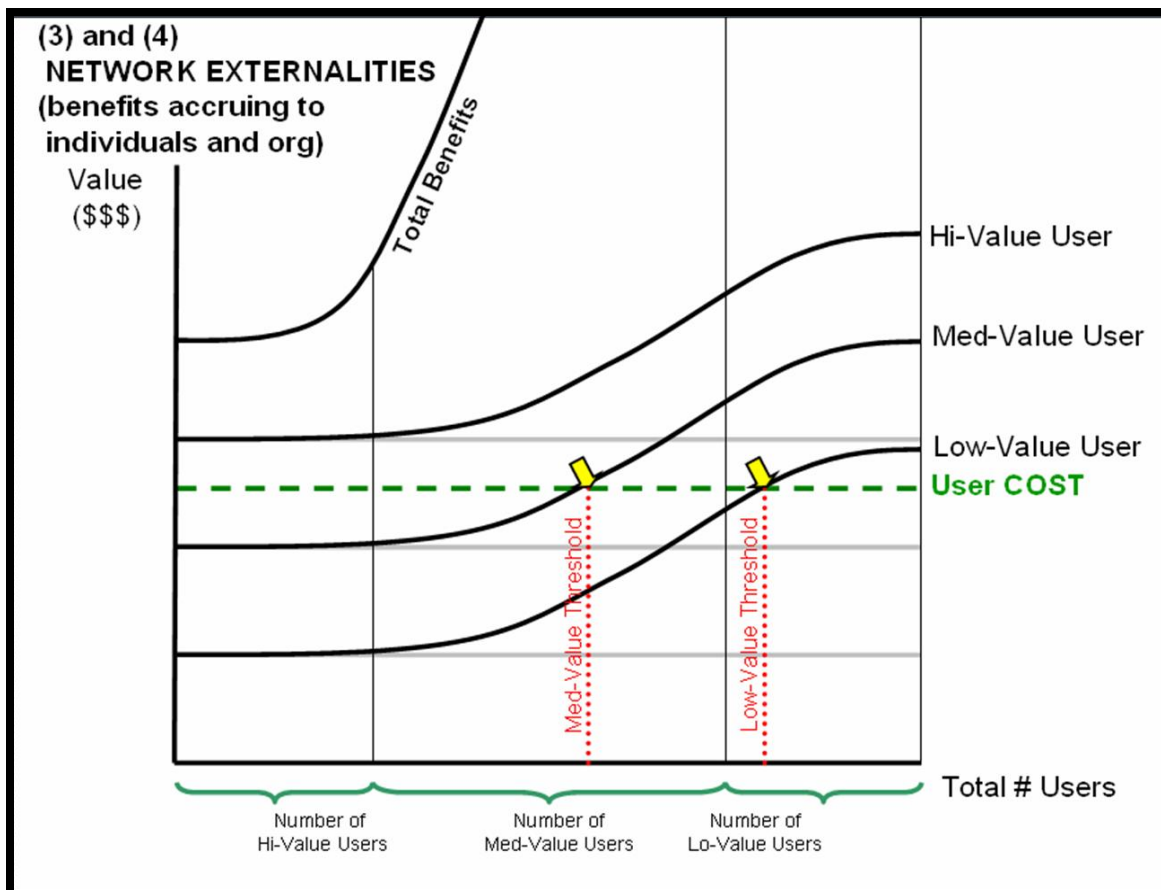


Figure 13. Coordinating Across Thresholds for Network Technologies

It turns out not to be beneficial for med-value users to adopt on their own but if the group can coordinate to where enough of them adopt so that the med-value curve crosses the user cost line, then the adoption has reached a critical mass and it becomes beneficial for all med-value users to adopt. The same holds true for the low-value user group.

Economic experiments done in this field would attempt to test which of the following factors can be manipulated to facilitate coordination among end-users so that the threshold is crossed. The question is how to address the end-user issues to most effectively get the end-users to coordinate so that the user-base reaches critical mass the technology's potential is realized in the field.

Issues that must be paired up with the above framework:

- (a) Perceives a loss of control and autonomy
- (b) Has a lack of appreciation for larger mission and organizational pressures
- (c) Is influenced by the system's misaligned incentives structure
- (d) lacks faith in management's commitment
- (e) perceives the absence of a program champion
- (f) is uncertain of the availability of complementary goods

The results of such experiments will help validate the impact of these issues on end-user behavior that has been written about in the literature and observed in technology adoption cases, both military and civilian. This type of research will go a long way towards helping policy-makers, the scientific community, and the warfighters to approach technology adoption situations with the best chance of reaching total diffusion and maximum potential. With so much money on the line and warfighter lives in the balance, this topic of investigation warrants much attention.

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## VIII. CONCLUSIONS AND RECOMMENDATIONS

### A. THESIS CONCLUSIONS

This thesis attempted to answer the primary research question -- What are the critical variables of the technology adoption process that determine its successful operational implementation? -- by identifying critical theoretical and evidentiary issues affecting end-user cooperation with organizational adoption of technologies, specifically network technologies.

Research consisted of studying and sifting through academic and theoretical research papers as well as case studies for reoccurring patterns that affected the success of various technology adoption attempts. The areas covered by the literature included information technology, healthcare, meta-analysis, agriculture, organizational, and miscellaneous. The results were six factors related to the end-user that specifically affected the success of the technology adoption attempt.

The six theoretical and evidentiary factors distilled from the research were:

- (a) loss of control and autonomy
- (b) lack of appreciation for larger mission and organizational pressures
- (c) influence of the system's misaligned incentives structure
- (d) uncertainty regarding management's commitment
- (e) continuity of a program champion
- (f) uncertainty of availability of complementary goods

The academic economic literature on technology diffusion also outlined three types of situations where the framework itself might affect end-user adoption: where there are uncertainties concerning the adoption benefits and/or costs, where there are externalities, and where there are network externalities. If the end-user is uncertain about the costs or benefits of adopting a technology, the decision to cooperate with the adoption will be affected. If there are organizational externalities involved, it is possible that some of the benefits will

be siphoned off to the larger organization and this will affect the end-user's decision to adopt. If there are network externalities involved, then the benefit to each end-user is linked with the size of the user-base, either directly through the technology itself or indirectly through complementary products. With network externalities, the critical mass of adopters must reach some threshold for adoption to be self-sustaining. Depending on the threshold (number of users), a network externality may require coordination in the adoption process to reach its full potential.

The six critical factors distilled from the case studies are consistent with the theoretical frameworks such that they are manifestations of the different economic situations. If, for example, an adoption attempt exhibits symptoms where an end-user is concerned that he is losing control over his system then there might be externalities involved and management should investigate. If an adoption attempt included an uncertainty that there would be available complementary goods then the adoption might be subject to network externalities and should be dealt with accordingly.

Concerns about losing control and autonomy, lack of appreciation for larger mission and organizational pressures, and influence from an organization's incentives structure are largely instances of benefit externalities, where some of the benefits accrue beyond the end-users who are ultimately adopting and using the new technology. Similarly, lack of faith in management's commitment, continuity of a program champion, and uncertainty of availability of complementary goods are symptomatic of network externalities that require coordination across end-users in the adoption process. Introducing any of these factors would affect the end-user's motivation to cooperate with a technology adoption.

In addition, these end-user factors appear to be consistent with on-going cases of public sector network technology diffusion programs. The Navy Marine Corps Intranet (NMCI) and the Department of Defense (DoD) adoption of passive Radio Frequency Identification (pRFID) technologies exhibit characteristics of the

issues described above and show evidence that their successful adoption depend on at least some of the critical issues also found in the literature.

NMCI is characterized by externalities (concerns about losing control and autonomy, lack of appreciation for larger mission and organizational pressures, and influence of the system's incentives structure) as well as network externalities (involving certification of legacy computer software). RFID is affected by externalities (lack of appreciation for larger mission and organizational pressures, and influence of the system's incentives structure) and network externalities (predominantly the availability of complementary items, but also adoption across the entire supply chain to ensure total asset visibility, or TAV).

This thesis drew parallels between the public and private sector technology adoption experiences, related popular literature techniques for crossing the technology adoption chasm to the Department of Defense, and focused attention to the drawn out decision-maker/buyer/end-user chain. Successful technology adoption (crossing the technology adoption chasm) was redefined in an overarching sense to include the entire adoption chain, specifically focusing on end-user's cooperation with the adoption attempt so that the organization can achieve full return on investment.

Discovering, studying, verifying, and then addressing the issues believed to affect the end-user's decision to adopt and the ability for the user-base to coordinate is of critical interest to those larger organizations where much stands to be gained or lost. If the organization gets it wrong and the technology is inappropriately de-adopted, then the potential to waste the many resources invested is high and misstep could put the American concept of freedom at risk. If the organization gets it right and is able to motivate the end-users to adopt and coordinate the user-base to reach critical mass so that the network technology benefits everyone involved, then resources will have been effectively expended and the warfighter will have the best tools available to do the job.



## **B. TECHNOLOGY ADOPTION RECOMMENDATIONS**

In cases where there is uncertainty about end-user benefits or the technology displays externalities or network externalities, the policy-makers, scientific community, and warfighters should be aware that these end-user issues might be the determining factor in a technology adoption attempt. The supporting research question -- What techniques can the Department of Defense employ during the adoption process to ensure that the technology is successfully diffused? -- can be addressed by paying attention to these end-user issues at the final end of the adoption agent chain: the end-user. If these issues can be adequately addressed, then mature technologies with good business case analyses stand a better chance of reaching their maximum potential and realizing full forecasted benefits, both for the individual users and the organization as a whole.

Given the similarities between public and private technology adoption ventures, it stands to reason that some of the solutions to crossing the technology adoption chasm offered by the private sector could prove successful in the public sector as well. For example, the salesman character in Gladwell's *Tipping Point* (2000) could easily be compared to the technology champion that adoption programs within the DoD seem to require for successfully crossing the chasm. Once the end-user factors are validated experimentally, private organizational policy and other solutions should be tested in a controlled environment for their effect on the public technology adoption experience.

Even before these issues are validated in a controlled experimental context, the communities mentioned above can take heed and use their professional leadership skills to address them during the process of the adoption. If the issues discovered in this thesis turn out to be important to the end-users, then it would make sense to pay attention to them throughout the diffusion of the technology.

## **C. FUTURE RESEARCH**

The factors thought to affect the level of end-user cooperation in technology adoption attempts should be tested in a controlled experimental environment. In such an experiment, human participants would play the role of end-users, differing according to how much they value the new technology. They would then be asked to respond to elements of uncertainty, externalities, or network externalities as they relate to the specific study. Their responses would be observed and recorded as results of the experiment.

If the outcomes of these experiments are consistent with the diffusion patterns observed in the historical cases and theoretical academic literature, then the impact of the issues becomes more certain. The next step would be to address policy, testing various solutions in a controlled environment to isolate the best techniques to deal with these end-user issues.

There are many other factors that could potentially affect the successful diffusion of a network technology within the Department of Defense. Future research should continue to identify issues affecting end-user cooperation with network technology adoption attempts, as well as factors also affecting agents farther up the adoption chain – the buyers and decision-makers.

Identifying, analyzing, verifying, and addressing these issues will facilitate technology transfer. If technology falls short of its diffusion potential then resources will be wasted and national security compromised; if technology reaches its potential, then the warfighter will have the best tools available to do the job and the DoD will reach expected levels of return on investment in resources expended.

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