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Indentifying and Assessing Effective Mechanisms for Technology Transfer

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IDENTIFYING AND ASSESSING EFFECTIVE MECHANISMS FOR TECHNOLOGY TRANSFER

THESIS

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Abstract

The ability to shift knowledge and resources from federal laboratories to industrial and academic partners and vice versa is the primary reason that technology transfer (T^2) exists today. Without the cooperation of federal, state, and private agencies working together to resolve today's technology quandaries, a lot of the breakthroughs experienced today would not exist. This research was focused on uncovering which mechanisms are utilized by scientists and engineers. The research entails uncovering both official and unofficial mechanisms and ascertaining why some methods are preferred over others. It is also a secondary focus, to determine which barriers are impeding T^2 from occurring in a more fluid fashion and what lab employees are doing to overcome these obstacles. An interview methodology was utilized and interviews were conducted on all levels of personnel throughout the Air Force Research Laboratory population to identify those preferred mechanisms and the reasons associated with their use. It was discovered that official and unofficial mechanism usage is about equal, but there were organizations that did not utilize them as prevalently; this was because of a lack of total infrastructure. Infrastructure must be improved for official mechanisms while leveraging the use of those unofficial mechanisms; laboratory leadership must concentrate their efforts on eliminating barriers to allow T^2 to be done more efficiently.

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To My Wife and Son

Acknowledgments

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IDENTIFYING AND ASSESSING EFFECTIVE MECHANISMS FOR TECHNOLOGY TRANSFER

I. Introduction

Background

For the past 20 years, both Congress and presidents have joined efforts to establish a formalized policy that allows federal organizations to transfer technology to non-federal organizations [1]. These non-federal organizations include industry, state and local governments, and academic institutions. Technology Transfer (T^2) policy was created as a simple way for the government laboratories and other non-federal entities to share a vast knowledge base of information that includes personnel, facilities, methods, expertise, technical information, and of course developed technologies [1]. T^2 is unique in the sense that it does not need formal acquisition contracts in place in order for two organizations to interact, although contracts have been used in the past to accomplish T^2. This uniqueness allows information exchange to occur without the impedance of all the bureaucracy government contracts bring to the table.

T^2 has evolved tremendously since its first inception in the 1980's. Changes have been made to both how T^2 is conducted and who is targeted in the process. In its early days, the transfer of technology was intended as a means of commercializing technologies developed in laboratories; government employees saw this new mandate as just another meaningless directive and was handled as such [2]. In more recent years, T^2 has taken on a different role in that it is concentrating mainly on adding value to currently existing Air Force programs [2]. The Air Force Research Laboratory (AFRL)

community defines T^2 as, "the process by which knowledge, facilities, or capabilities developed in one place or for one purpose are transferred and utilized to another place for another purpose to fulfill actual or potential public or domestic needs [3]." Yet another entity defines T^2 as, "an umbrella term that refers to an entire range of activities involved in developing new technologies and their applications for the marketplace [4]." This new way of looking at transferring technology includes techniques like bringing in additional outside funds, expanding capabilities through the sharing of facilities and equipment, and reducing the schedule of programs through the collaboration of projects [2]. T^2 can be accomplished in one of three distinct ways: spin-off, spin-on, or co-development. During spin-off, a technology developed in a government lab attempts to be commercialized by industry, while in spin-on, the complete opposite occurs; a technology developed by industry is adapted for government use. Co-development is the preferred technique and involves both parties' involvement from the beginning of technology development. The overall outcome of these combined efforts usually results in a successful transition of technology to the user.

Although technology *transition* is often used interchangeably with technology *transfer,* and even though both terms are related, there is a definite distinction between the two expressions. Within the AFRL community, technology transfer occurs when this interchange of knowledge, facilities, or capabilities happens between a government agency and a private or commercial entity, whereas technology transition is often referred to as an interchange between government agencies for the sake of delivering a product to the user. Figure 1 demonstrates this relationship. There are those out in the field that

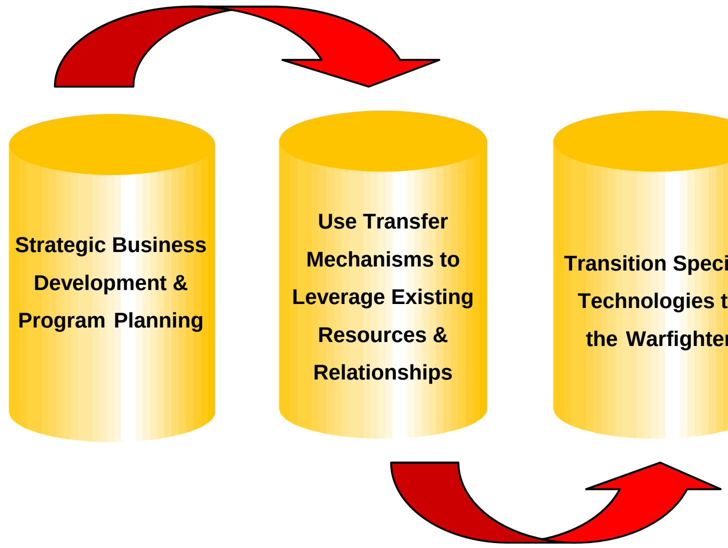


Figure 1. Technology Transfer Concept [2]

believe that transfer facilitates an easier transition process and those that believe that transition is impossible without adequate transfer [5].

Unfortunately, even though the Air Force has gone to great measures to establish and disseminate official mechanisms to accomplish T^2, it is feared that these instruments are not as extensively used as anticipated [5]. There also exists the possibility that individuals are using unofficial mechanisms to bridge the gaps that are required. The Air Force T^2 program manager desires to discern which official mechanisms are being used more frequently and identify those unofficial mechanisms which are being applied with success. In addition, the AFRL T^2 office is greatly interested in recognizing the actual players that are involved in the everyday transfer of technology.

Motivation and Relevancy

The Air Force T^2 program office has been given the daunting task of implementing a series of T^2 directives. These directives involved the establishment of a physical office as the focal point for all T^2 activities within a particular agency called the Office of Research and Technology Applications (ORTAs) and that these agencies plan and budget for technology transfer efforts. It was expected that these supplementary efforts be accomplished with already existing resources; there was little or no mention of whether additional resources might be needed or provided. The program office understands that the apparent success of federal laboratories depends highly on the ability to transfer technology effectively to industry. It is the feeling of this office that although T^2 is being accomplished within their labs, it is only occurring within small pools of personnel; they believe that most of the T^2 is not being reported or tracked [5]. The goal of this research is to investigate and identify those key personnel within the labs that are involved in large amounts of successful T^2. As players are identified, the next logical step is to divulge which mechanisms they are utilizing most and why. This research hopes to establish a relationship between the mechanisms utilized, the distinct aspects of the technology, and the personnel involved. The Air Force and other defense organizations have much to gain from a study of this type.

The failure and delay of past programs can never be attributed to one single reason. Instead, it can be said that failing at transferring or transitioning a technology can at times lead to an unsuccessful program; these failures could be minimized through the dissemination of best practices used throughout the Air Force. T^2 should be looked at as a program "enhancer" and not so much as a simple criterion that establishes the failure or

success of a program. Through the proper use of T^2, not only can government agencies benefit and make their programs more successful, but they can also be encouraging industry to be an active participant in the transfer process.

Research Objectives

The objective of this research is to identify and assess the inner workings of how and why scientists and engineers at all levels interact with industry to accomplish T^2. This research will focus on where in the chain is the interaction and communication occurring and where it is being most effective. Thus, the overarching research question to be answered by this study is:

"How do scientists and engineers at the AFRL interact with industry to accomplish technology transfer?"

The term "how" is all encompassing in that not only is the research focused on the mechanisms used, but it also covers the players involved and the conditions surrounding the practice of these mechanisms. This piece leads to the assessment portion that this research is aimed at discovering. In order to answer this question, both official and unofficial tools and mechanisms employed are to be uncovered; it is also important to determine why these specific tools were used. Again, the "why" in question, is the second piece to the assessment. And lastly, the research will determine whether the use of certain mechanisms is correlated with performance reports or tracked metrics. All these topics lead up to the formulation of the investigative questions which will be more closely looked at in Chapter III.

Scope of Work

This research is specifically focused on how scientists and engineers within the AFRL community are interacting with industry to accomplish T^2. It is specifically focused on directorates within AFRL located at Wright-Patterson Air Force Base (WPAFB). Appendix D gives a visual representation of all AFRL research sites, their directorates, and their geographical locations. Besides those labs found at WPAFB, there are other Air Force organizations that involve themselves in T^2; Air Logistic Centers (ALCs), Test Centers, Product Centers, and other independent Air Force organizations all involve themselves in T^2 as well [3]. A complete list of these organizations can be found in Appendix C. The decision to select this group as the sample size for this research was based on both the interests of the Air Force T^2 program office and the knowledge that approximately 70% of all reported Air Force T^2 occurs within the AFRL community [6]. A group of 26 interviewees was chosen at random from the AFRL directorates. Because of the type of results gathered from the interviews, an interview methodology will be utilized and a qualitative analysis will be used to interpret the data collected.

II. Literature Review

Introduction

The overall objective of the literature search is to encapsulate all of the historical data that has been uncovered. Staying true to the research objectives, the first sections concentrate on giving factual information pertaining to official T^2 mechanisms and the history of T^2 legislation leading up to today. The next four sections partition the barriers that impede T^2 from occurring. The following two sections, pertaining to strategies and industry, give a brief synopsis of practices currently being used outside of the government sector. The final segment concerning metrics and measures is important because of the future recommendations expressed in Chapter V. Appendix A contains an acronym list and is provided as a quick reference for the reader.

Official Technology Transfer Mechanisms

The Air Force T^2 program office recognizes about 19 different mechanisms that can assist with T^2 between government and industry. One hundred percent of these mechanisms were mentioned in the interviews conducted for this research and will be discussed within the results of Chapter IV of this thesis. Below is a compilation of these official mechanisms, their definitions, and their intended uses.

Contracts are by far the most recognized and most used method; a contract is entered into by a government and industry entity in which the contractor is required to supply services to the government [7]. The reason why this method is so widely used is because most of the contracts utilized have been in place for a long time and no extra effort is necessary to create one. One of the benefits of using contracts is the possibility

to fund Research and Development (R&D) projects that will eventually be transferred to the private sector; this allows the government to retain Government Purpose License Rights (GPLR) to be used for future technologies [8]. The drawbacks of using contracts include the massive amounts of bureaucracy to include competition laws, requirements process, and Federal Acquisition Regulation (FAR) compliance [8].

A *grant* is considered an agreement between the government and a recipient, which grants funding and/or property to the recipient to support or stimulate research [7]. Department of Defense (DoD) policy stipulates that research grants be awarded only to educational institutions, nonprofit organizations, and state/local governments. Educational grants are offered on a competitive basis [8]. Even though the recipient may retain titles to inventions, the government will still keep its GPLR [7]. Some of the downsides to grants are that during the performance period, very little interaction occurs between the two organizations and cost is usually fronted by the government side [8].

In an effort to increase competition within industry and allow smaller companies to become more competitive, the government has established both the *Small Business Technology Transfer Program (STTR)* and the *Small Business Innovation Research (SBIR)*. Within the STTR program, awards are made on a competitive basis to small business firms to conduct research and development jointly between the small business and a research institution [8]. STTR programs are categorized in phases according to the amount of money being awarded and the length of their work period; there are also strict stipulations that regulate the percentage of total work to be done by the small business and the research institution [8]. Although similar, SBIRs differ in the manner that they are awarded based on scientific and technical merit for meeting Air Force R&D needs

along with the potential for commercialization [8]. As with STTRs, SBIRs are also categorized under phases that dictate the amount of money awarded and the length of the work period [8].

Whenever a technology is encountered that has both military utility and sufficient potential to support a viable commercial industrial base, the T^2 community encourages the use of the *Dual Use Science & Technology (DUST)* Program [9]. DUST programs are competitively selected and may even be jointly funded; this grants the DoD access to more affordable and advanced technology by leveraging commercial know-how and markets for military use [8]. The DUST program initially began as a pilot program and since then has been officially closed out, although some remnants still remain in certain agencies.

Cooperative Research Agreements (CRA) are simple agreements between the government and a recipient whereby money or property is transferred to support or stimulate research. The two distinguishing traits that make this mechanism stand out are the ability for the government to provide direct funding to the participant and its use is guided by the FAR [8].

The *Commercial Operations & Support Saving Initiative* (COSSI) is not so much a mechanism as much as it is a suggested methodology which targets specific DoD Operations & Support (O&S) costs and tries to reduce them by routinely inserting commercial items into already fielded military systems [10]. When the government is accepting proposals from industry in its first stage, one of the proposals must include a for-profit firm and all proposals must include a written support from the "military

customer" [8]. The COSSI also began as a pilot program and since then has been officially closed out, as well.

As part of the ever growing challenge for DoD to create a stronger economic base, the *Mentor-Protégé Program* (MPP) provides initiatives to large contractors to encourage them to assist smaller disadvantaged businesses (SDBs); this aid will enhance this company's capabilities and allow them to better satisfy subcontract requirements [7]. This interaction results in a win-win situation because it provides additional knowledge to the SDBs at no cost from their prime contractors and it fosters a long term relationship between prime and sub contractors for future contracts [8].

Personnel Exchanges (PE) are usually conducted informally and typically end up being the first initial contact on the path to a more formal mechanism, i.e. contracts [7]. During these exchanges, arrangements are made for personnel to be swapped between government, education or industrial facilities; in general, proprietary information is not exchanged, the exchange is short-term, and is paid by the organization sending the personnel [8].

The *Manufacturing Technology Program* (ManTech) is not used as widely throughout the labs because of its specific focus; it develops new and improved manufacturing processes which facilitate more affordable production of weapon systems and individual components [8]. The large concentration of these efforts are focused on processes for manufacturing metals, composites, electronics and improving their factory floors and maintenance facilities [7].

Through *Commercial Test Agreements* (CTA), the DoD is given the authority to sell, rent, or lend government equipment or materials to any person or entity; some of the

uses in the past have included circumstances dealing with independent research, developmental programs, and demonstrations to friendly foreign governments [8].

Although *Partnership Intermediaries* (PIs) are not what has been described as an official mechanism, they are still deemed an important method in facilitating the transfer of technology. These intermediaries consist of state or local government agencies that operate on a not-for-profit basis and enter into contracts or memorandums of understanding (MOUs) with the government to increase the likelihood of success of T^2 [8]. Entering into these agreements is quite lucrative because these partnership intermediaries tend to have the pulse on the technology available from those local companies and the interests they are pursuing. One such example is the case of the development of TechMatch, a system produced under a Partnership Intermediary Agreement between AFRL and the West Virginia High Technology Consortium Foundation [11]. This tool is a web-enabled knowledge management system that assists the ORTAs by bringing pertinent information together into one source.

Independent Research and Development (IR+D) is a program sponsored by DoD that encourages contractors to pursue independent research and development projects that could be of potential interest to the DoD [12]. Some of the benefits allow contractors to recover some of the costs incurred in doing this independent research which in turn reduces acquisition costs and overall life-cycle costs of military systems [12].

The government has learned over time that educational institutions can provide a much needed benefit when it comes to developing new technology; the *Education Partnership Act* (EPA) consists of a formal agreement between a federal agency or agencies and an educational institution to transfer and enhance technology applications

and provide assistance for all levels of education [7]. These institutions will have the assistance from laboratory personnel to teach or assist in developing courses and course materials and also provides manpower for laboratories in need of technicians to conduct experiments.

Patent Licensing Agreements (PLAs) and *Patents* are two related methods of protecting exclusive new technology and the rights that go along with them. Developing a patent is the first step in which a grant is issued by the U.S. government, thereby giving the inventor the right to exclude all others from making, using, or selling the invention within the United States; patents are upheld by both Federal law and the U.S. Constitution [7]. Patent Licensing involves consent by the patent owner to practice the patented invention in return for some valuable consideration, sometimes known as royalties [8]. These can be established from government to the private sector or vice versa, although depending on the situation, different rules do apply.

One of the more common mechanisms is the *Cooperative Research and Development Agreement* (CRADA); its wide use can be attributed to the fact that the successful stories and lessons learned reported by the DoD involve T^2 assisted by a CRADA [6]. The CRADA consists of a formal written agreement between one or more federal laboratories and one or more non-federal parties under which the government, through its laboratories, provides personnel, facilities, equipment, or other resources with or without reimbursement; although the collaboration involves the expenditure of funds, at no time may funds flow directly to a CRADA partner [13]. There must be a heavy emphasis placed on the fact that this tool is not a contracting instrument and therefore does not fall under normal FAR compliance. The benefits of using CRADAs consists of

allowing the rights to inventions and other intellectual property to be negotiated within the agreement [8].

Alliances are considered to be an informal T^2 tool that allows a laboratory to enter into either an MOU or a Memorandum of Agreement (MOA) with a group of companies, laboratories, or educational institutions in order to pursue common interests [7]. The MOU/MOA is just the catalyst for what later develops into a more formal T^2 mechanism. Depending on how it is perceived, these memorandums are non-binding documents which just outline the principles between partners [8].

There are occasions when either the government or a contractor owns a unique and expensive facility or piece of scientific equipment. Instead of investing funds into purchasing a completely new system, the government prefers to utilize the *Use of Facilities and Loaned Equipment* as a formal means to transfer technology. This method is used when certain facilities are unique and complex and the facilities contain experimental equipment and human expertise that would be hard to duplicate elsewhere [8].

Everything not mentioned above falls under the realm of *Other Transactions* except for contracts, grants, or cooperative agreements; these transactions are flexible agreements used to accomplish various legal purposes [8]. For the most part, they are used when developing a formal contract is not feasible and formal statutes and regulations will hinder the interaction.

As demonstrated above, this is an all encompassing list of the mechanisms officially identified by the T^2 program office; as this research will further prove, there are

other mechanisms being utilized on a consistent manner by many of the directorates within AFRL that often go unreported.

Technology Transfer Legislation

Early in the 1980's, Congress enacted a series of laws to promote the use of T^2 and provide T^2 mechanisms and incentives [1]. These regulations were created with the sole purpose of promoting collaboration among federal and non-federal organizations. Table 1 includes a brief summary of some of those regulations and their implications.

One item to notice about this list of legislations is the trend they follow and the issues they address; as this research will demonstrate in Chapter IV, most of the problems discovered in this study, are not addressed by regulations. Even though CRADAs are in heavy use throughout the AFRL community, they are only one mechanism being addressed. Although the Federal Laboratory Consortium (FLC) existed from the beginning, it didn't receive any power until an official charter and funding mechanism were established in 1986 with the Federal T^2 Act. The FLC would be in charge, along with the guidance of the laboratories affected, of developing and administering techniques, training courses, and reading materials to further increase awareness among the T^2 community. In essence, the FLC would serve as a focal point for all T^2 activities across the entire spectrum of labs, universities, and industry [1].

Table 1. Legislation Highlights [1]

Steven-Wydler Technology Innovation Act of 1980 (P.L. 96-480)	1st of a continuance of laws that forced labs to budget & engage in T^2; established an Office of Research and Technology Applications (ORTA) in every laboratory to coordinate these activities.
Bayh-Dole Act of 1980 (P.L. 96-517)	Revolved around the granting of licenses and patents; allowed non-federal organizations to obtain patent rights to products and processes developed with federal funds.
Small Business Innovation Development Act of 1982 (P.L. 97-219)	Established the Small Business Innovation Research (SBIR) Program; required federal agencies to set aside funds for small business initiatives.
Federal Technology Transfer Act of 1986 (P.L. 99-502)	Second piece of major legislation addressing T^2 as a requirement for all laboratory employees; permitted agencies to enter into CRADAs.
Executive Order 12591 (1987)	Written to ensure that federal laboratories assisted universities and the private sector by transferring technology; individuals would be identified and encouraged to serve as conduits.
Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418)	Realizing the benefits of R&D, it emphasized the need for public/private cooperation by establishing centers for T^2.
National Competitiveness Technology Transfer Act of 1989 (P.L. 101-189)	Provided additional guidelines on how to conduct CRADAs; it concentrated on protecting innovations brought or developed in a CRADA from disclosure to third parties.
American Technology Preeminence Act of 1991 (P.L. 102-245)	Further described provisions pertaining to the Federal Laboratory Consortium (FLC) and the use of CRADAs.
Small Business Research and Development Enhancement Act of 1992 (P.L. 102-564)	Increased the budget of laboratories dedicated towards small business initiatives.
National Department of Defense Authorization Act for 1994 (P.L. 103-160)	Broadened the definition of a laboratory to include weapons production facilities at the Department of energy (DOE).
National Technology Transfer and Advancement Act of 1995 (P.L. 104-113)	Ammended the Stevenson-Wydler Act by making CRADAs more attractive to both federal laboratories and private industry.
Technology Transfer Commercialization act of 2000 (P.L. 106-404)	Recognized the success of CRADAs and broadened the CRADA licensing authority.

Technology Transfer Channels

Even though T^2 is an Air Force mandated instruction, it is still unclear within the policy how this T^2 interaction is to occur. This is how channels and mechanisms differ; channels involve how the interaction is to occur while mechanisms are the tools used to enhance the interaction. This initial contact phase is where it is expected that most of the problems occur or what causes T^2 to ultimately be unsuccessful. It is known that initial contact is made at many levels within the hierarchy of organizations and depends heavily on the situation encountered [5]. The T^2 program office is familiar with four distinct channels in which T^2 currently occurs. There exists the traditional method known as top-down interaction where the upper management of an organization instructs subordinate workers to involve themselves with T^2. This usually occurs as a result of a previous established relationship or through mutual interests shared among organizations. T^2 is also known to have occurred through scientist-to-scientist interaction which is aided through the attendance of formal and informal gatherings. A third way communication happens is when an ORTA facilitates the communication process between the government office and industry [5]. Essentially, the ORTA representative serves as an honest broker in connecting the essential people to facilitate T^2 [14]. ORTAs are usually represented within each laboratory through specific individuals that have been assigned the duty. Although ORTAs are ultimately responsible under federal law to assist in the T^2 process, it does not always occur in that manner. The fourth and final channel of communication is when non-profit PIs put forth the effort to bring together industry and the government [5].

Technology Transfer Infrastructure

It is a recurring theme in both government and in the industry arenas that the proper infrastructure to conduct T^2 in an efficient manner is mostly absent. It has been demonstrated through countless case studies that T^2 is usually conducted in an ad-hoc fashion and that dedicated resources are rarely applied to work these efforts [15]. In a recent Government Accountability Office (GAO) report given to Congressional committees, the report pulled some of the more renowned best practices from industry and tried to offer suggestions to the DoD on how to conduct T^2 more cost effectively and more efficiently. In particular, the document pays mention to two important resources that are currently missing within the DoD arena. Throughout this document, the GAO report refers to "technology transition" as the overall effort to hand off and integrate mature technologies; this research has already addressed the difference between transition and transfer.

Although this report is concerned with the entire process of transitioning a technology, for the purposes of this research, only the results relating to transferring technology were used. The report suggested that DoD establish and utilize relationship managers to help the transfer process along; it also suggested the dedication of R&D funds to facilitate the evolution from a lab product to one that can be utilized by a program office [15]. The DoD believes that they are already doing the work of the relationship managers through the various types of formal agreements that can be established with industry; they are still failing to understand that there is a certain level of person-to-person interaction and dedication that must occur to aid these agreements. This of course takes extra man-hours and can incur travel costs as well.

One of the major findings from the GAO report that deserves mention is the ability for an organization to be able to strategically plan. They define strategic planning as the effort to identify desirable technologies and prioritize resources. Leading companies tend to organize their research and development efforts into what they call technological "thrusts [15]." These thrusts are revisited on an annual basis to ensure that long-term company needs are being met and that the correct people are being assigned to these projects. Figure 2 is a representation of the general flow of technology on its way to transition. It shows where strategic planning is to occur and it shows where T^2 occurs also--in the first shaded box labeled "explore."

Along with having the appropriate strategy, an organization must also have the correct policies in place. In a recently published article, Goth examined the T^2 culture of other countries, in particular that of the Chinese. He found that many Chinese companies, although committed to T^2, could not demonstrate what policies were in place to address such issues as the rights to licensing and patents [16]. This is because of the undue top-

down pressure the research community is facing which is resulting in pools of unused technology with questionable value.

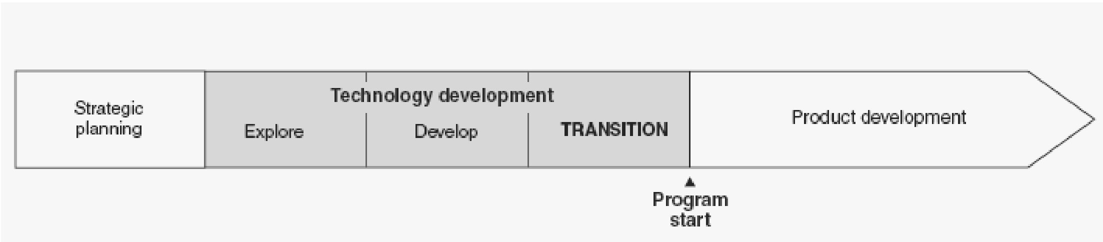


Figure 2. Technology Flow [15]

A perfect example of how commercial companies are handling some of these issues is briefly explained in a case study done on Siemens Corporate Technology. From their studies and their experiences, they have taken away some key factors that have aided in their success. They found that early and ongoing collaboration between academia and industry proved to be favorable in guiding the technology in the right direction; this of course can only be done with the appropriate dedicated resources. They also placed heavy emphasis on acquiring early sponsorship for the technology and be able to set aside resources to develop prototypes that can demonstrate a capability [17]. Putting this into perspective, it can soon be realized that a successful transfer depends heavily on the resources that are already in place.

Intellectual Property Rights

Intellectual Property Rights (IPR) can be thought of as a subset of infrastructure; how the federal government handles IPR is a mentality that makes up an important cornerstone of how T^2 is conducted. IPRs are related to GPLRs; IPR is the generic term given to those ideas associated with a technology that are developed by an entity, while GPLR refers specifically to rights associated with a product that the government owns. Throughout the results discussed in Chapter IV, the factor of IPR playing a role in how T^2 is conducted proves to be a significant issue worth mentioning. Furthermore, in a recent publication dated June 2006, Bellais and Guichard, believed that the lack of an intellectual property rights culture strongly inhibits the ability to spin-off technology [18]. They explain that T^2 from a defense to a civilian application is hardly a simple process where the technology can be commercialized after a few uncomplicated

modifications. Transfer mechanisms tend to be long and complex processes in which co-development is occurring.

The civilian perception concerning defense activities resides in the idea that defense innovations must be protected through secrecy rather than through patents. There is a distinct manner in which civilian technology is protected; even though secrecy is one option, as is the case with the Coca-Cola formula, it is not the most viable one because it does not provide legal protection from imitation and unwanted use [18]. Because of the business the military is in, that is providing strategic superiority while denying access to such information to potential enemies, the DoD has not promoted an IPR culture within the industrial and technological base. Through their research, the authors have been able to demonstrate that this lack of adopting an IPR culture has (1) shown that protecting every piece of information is not always relevant because not all information has strategic value and therefore counteracts the possibility of commercializing defense R&D results, and (2) the lack of an IPR culture has acted as a brake when interaction between industry and the government was warranted [18].

IPR also affects the mechanisms that are chosen and utilized more often; it is believed that transfer is more likely to occur when there is a formal contract in place that clarifies each party's duties and rights [19]. In fact, a lot of companies will be reluctant to invest additional funds into R&D when they are unsure of the possibility of recovering their return on investment (ROI). The type of mechanism used, and more importantly the contract design within, is a crucial aspect in making T^2 a success since it will define IPRs and provide guarantees on the sharing of technology commercialization [19].

Barriers that Impede Technology Transfer

According to the article, "Improvement of T^2 from Government Laboratories to Industry", one-sixth of all scientists and engineers in the U.S. are employed by federal laboratories and spend about $20B annually, yet have produced only 5% of all patents licensed for commercial use [20]. The barriers that exist today which affect the progress of T^2 have been known and identified as far back as the mid 1990's. These barriers can take on a variety of different forms that include information type, environment, relationship context, and subtle cultural barriers [21]. These different barriers will be described in more detail below.

Technological information that is ready for dissemination must be prepared in a form that is useful to the recipient. In a study completed in 1996 which focused on the transportation industry, Local Technical Assistance Program (LTAP) centers were used in translating T^2 topics and orienting them towards the proper audiences through the use of summary articles and quarterly newsletters [21]. Because of the great quantity of reports these centers were receiving, they had little choice but to distribute these reports in their original format and encouraged those agencies submitting their reports to adapt them to target audiences.

The LTAP centers have recognized that where T^2 is occurring, or the environment, is also important to the audiences involved [21]. A lot of these local agencies are working with limited travel budgets that prevent them from attending workshops or seminars where T^2 often occurs; the problem of limited manpower also puts them into a predicament since it forces them to shut down their operation for the day [21]. LTAP centers have resolved these problems by sending the workshops directly to

the local agencies when possible and also by hosting conferences at reasonably priced establishments. Bringing together these conferences with the right people is just the first dilemma; the real challenge begins with the manner in which audiences are educated on T^2. Everything must be evaluated, from the type of medium used to present material, to the size of the audiences being utilized; it must all be tailored around the message intent [21].

When relationship context is talked about, it is the ability for the outside community to trust that one person that is serving as the conduit for T^2. LTAP centers have realized that if there is a previous relationship established with one particular person in the community, that person is an invaluable asset in making T^2 occur; these people should be key respected leaders that have already established networks [21]. This provides a much needed face-to-face contact that the community can relate to and therefore grow accustomed to interacting with.

Cultural barriers are applicable when discussing obstructions that impede T^2 because of the differences that exist in the motivations to transfer technology between government R&D labs and private companies. Federal labs are guided by strategic vision that is based on national needs while the private sector's sole interest is to commercialize a product [22]. Table 2 summarizes these discrepancies that exist between the two cultures over different ideas.

The LTAP centers have done a tremendous job in identifying those areas that need improvement to make T^2 succeed, although their challenge lies in the continuance of feedback from the field to be able to refine those processes that are already in place.

Table 2. Cultural Differences in R&D Labs and Private Industry [22]

	Government R&D Laboratory	Private Enterprise
1. R&D purpose	National needs	Commercialize
2. R&D stage	Basic or applied	Development
3. Business goals	Fact-finding or to make a prototype product	Production at low cost and high quality
4. Incentives for technology transfer	Few	Many and strong
5. Intellectual property	Open (or secret)	Monopoly

Technology Transfer Strategies

Having discussed the legislation that guides T^2 and the obstacles that have been encountered, this section will discuss some of the different strategies in use throughout industry that can be applied to diverse situations. Depending on the players involved and the type of technology being transferred, a study done between Swedish academia and industry proved that a written strategy was necessary. Below are some of their targeted strategies.

Intensive collaboration implies that there are continuous and frequent meetings with the intended receiver of the technology during the project execution. People from both sides tend to work on the project together [23]. During *user buy-in,* the intended users of the technology see the value of the technology and help advocate the transfer [23]. *Management buy-in* compares in some ways to the first T^2 strategy mentioned above; management at the receiving unit is convinced of the technology value [23]. *Continuous updates* are related to intensive collaboration and report on the project progress given from the transceiver to the receiver during the project execution. This does not necessarily entail that people from the receiving unit are involved in the project as if it were an intensive collaboration strategy [23]. *Technology push,* in this instance

relates directly to the first T^2 strategy mentioned above and is used if upper management takes a top-down decision of particular technology usage. The mentality is that technology is being developed without a prior need established and is later pushed on the user. *Technology pull*, on the other hand, involves user involvement and interaction at all levels and is developed for a specific need or deficiency.

Along with the more traditional strategies mentioned above, there are more practical means of succeeding at T^2. Establishing an organization as a known and reliable technology source within a community is one of the hardest tasks to accomplish. In his article “Building Relationships for Technology Transfer”, John Bennett, believes that there are certain key ingredients that should be in place in order for T^2 to occur seamlessly. He mentions that building a base of mutual respect and trust is essential to carry on an on-going relationship with a certain entity. When T^2 is thought of, long-term and careful considerations must be taken to achieve a certain level of mutual benefits from the endeavor [24]. This will be demonstrated as an important factor among the interviewees, discussed in Chapter IV.

Technology Transfer in Industry and Academia

Although this research focuses on T^2 from the perspective of the government labs, there should still be focus on what it is that industry and academia are doing to facilitate T^2. Even after more that ten years after the inception of T^2 regulations in the early 1980’s, in 1993 experts still believed that federal government R&D and the U.S. industry plodded down parallel paths on their ways to better technologies [25]. In particular, the U.S. Bureau of Mines (BOM) found it difficult to perform T^2 in an efficient manner until

they discovered the use of CRADAs. If there was one lesson to be learned by the BOM, it was that in order to succeed with industry, they must focus their efforts on partnerships, collaborative research, and on encouraging input and guidance from customers [25].

Trune and Goslin revealed in an article concerning U.S universities that the most productive T^2 occurs in those that are centered around medical schools and technological institutes [26]. It wasn't until 1980, with the Bayh-Dole Act, that universities were granted the right to patents; this piece of legislation showed a large peak in the interest of universities in T^2. Universities have different goals and motivations that direct them to want to participate in T^2. When they involve themselves in these efforts, they must worry about aspects like higher faculty salaries, maintaining a T^2 office, gap funding for high potential research projects, additional space to conduct research, and lawyer fees [26]. All of these expenditures sometimes are a deterrent for smaller universities that don't have the adequate overhead to cover these costs.

From an industry point of view, it is believed that the success of a transfer of technology is dependant on the quality of the communication between two organizations and the quality of written documentation that is filed [27]. According to a study done at the Computer Sciences Corporation (CSC) technology center, it was discovered that the government tends to hire consultants to introduce new technologies but they end up against a one-way communication barrier [27]. Technology developers have also had the experience of having to implement some of these methods through poorly documented information. These hurdles combined with an incorrect blend of people involved in the process, CSC found to be detrimental to the T^2 process. CSC found their success when

everyone from management, developers, and process groups attained an equal voice and when their efforts where documented correctly to be used and refined in the future [27].

In order for T^2 to occur, and to occur correctly, it has to follow a rigorous process approval from inception. According to a study done at the Technical University of Eindhoven in the Netherlands they called this initiation stage the Technology Engineering Phase; the success of a T^2 process depends on this phase being done correctly [28]. The main attraction for introducing a new process revolves around either cost cycle reduction or product quality improvements. In their first step, a business case must be established that incorporates the benefits expected from the T^2 and takes into account obstacles to be overcome. In the second step, a stakeholder analysis must be developed in which users must be convinced of the technology; in this step it is imperative that the users become involved and that they provide as much feedback as possible. The third and fourth steps involve identifying the methods used to implement these new processes and also to look ahead for potential risks and how to mitigate them [28].

This research also uncovered that there are three distinct methods in which T^2 occurs within industry. Communication can occur through a variety of mediums ranging from company conferences and symposiums to journals and reports. No matter what the medium used, the research revealed that presenting T^2 examples in a case study format proved to be the most effective [28]. Researchers also discovered that the level of involvement within the organizations implicated also played a large part in the success of T^2. The more management levels that were involved in the process, the more chances for misinterpretation existed; companies with lower hierarchical staffs proved to be more

efficient in applying T^2 methods. The second factor they attribute to successful T^2 implementation is through the use of what they call "champions." Champions are responsible for the motivation of other employees and initializing steps towards incorporating new methods [28]. They accomplish this through a process they call change management. With change management, champions are able to direct the efforts of their organizations and help control expectations of the new process. Partially associated with the communication effects, is the measuring and reporting of RoI. RoI is important when it comes to demonstrating expected outcomes and paves the path for future T^2 endeavors [28].

Metrics and Measures

There has been an ever growing perception that the federal labs are not getting a good return on investment from its R&D budget. Because of this perception, there has been a growing demand for more measurable T^2 [29]. Most of these measures tend to be unique to the organizations they represent. The number of licenses granted and the amount of royalty income are just one example where federal labs have developed a metric which does not distinguish between simple and revolutionary breakthroughs, nor does it track whether these licenses are evolving into fruitful products [29].

There are no formal methods dictated by policy for measuring the success of the T^2 process. The Air Force T^2 program office explained that within their realm they keep track of certain metrics that help them measure the level of success of T^2 ventures. The first metric calculates the amount of funds being brought into the government organization [5]. This strictly applies to funds being paid to government agencies for

work performed; this includes the use and renting of certain testing facilities. Secondly, the T^2 offices track the amount of resources and capabilities that a federal office might gain and try to associate a dollar figure with these assets. Thirdly, and most difficult, is calculating the amount of man hours saved by implementing the successful cases of T^2 [5].

This research's intent is not to analyze effective measures and metrics, but they are discussed briefly due to the recommendations for future work that Chapter V proposes. The leading companies reviewed by the 2006 GAO report use a variety of product metrics to evaluate the success of their transition programs. Table 3 is a compilation of the metrics utilized in assessing lab projects and processes. Unfortunately,

in companies like Motorola, these metrics are not treated with the same severity as those used after product development begins.

Table 3. Metrics Used to Assess Lab Projects and Processes [15]

Categories of metrics	Examples of metrics	Use of the metrics
Process		
Status	Number of ongoing projects Number of projects with a technology transition agreement Number of projects completed by labs Number of technologies transitioned Number of projects terminated	Provides lab managers information on how many technology projects transitioned, were terminated, and are still ongoing. Companies expect that almost all technologies that make it to the final stages of technology development will transition. If they experience a lower transition rate than expected, officials will examine their processes to determine what changes are necessary to improve transition or determine why the project was not terminated earlier.
Timeliness	Development cycle time Percentage of tasks on time Task slippage Time to market	Measures the amount of time it takes labs to develop technologies. The metrics allow lab managers to identify and focus on projects that are moving slower than expected. A lab project may be terminated or additional resources may be allocated to speed up development. Use of the metrics allows product line managers to decide whether a technology will be ready in time to include on a given product.
Impact	Number of technologies commercialized Number of multiple transitions Return on investment Profit growth Market share growth Orders captured Cost reduction Number of patents/influential papers Customer satisfaction People rotation	Provides lab and corporate managers feedback on the market impact of their technology investments in terms of revenue and market share. The metrics also provide information on product line satisfaction of lab performance. Satisfaction survey results are a useful tool for identifying development and transition problem areas that need management attention.

The government has a difficult time quantifying the measures in Table 3 because it is a complicated task associating dollar figures with some of these processes. On the other hand, companies like Motorola have an easier time quantifying these measures because they are able to calculate their results into a ROI. They tend to measure everything to what they call a profit/loss statement; within this document they measure net sales, cost of sales, general and administrative costs, and R&D expenditures [30].

III. Methodology

Introduction

It was decided that an interview methodology would work best for the type research that is to be conducted. Since this research has an interest in discovering the habits of how scientists and engineers conduct T^2, surveys would not provide sufficient insight and interaction with the interested subjects. Person-to-person interviews were the preferred method for acquiring data. A qualitative assessment was then chosen to analyze the data. This section will also cover how question formulation was refined and how interviews were conducted. It will also describe in detail which investigative questions were utilized in the interviews and what process was required to approve these questions. This segment will conclude with how the subject sample was selected.

Qualitative Assessment

Much thought was given to the type of assessment that would be conducted in this research. After careful scrutiny was given to the needs of the Air Force T^2 program

office, it was concluded that it would provide the most benefit to present results in a qualitative manner. The foundation of this research is to discover those mechanisms that are used by the scientists and engineers to accomplish T^2 with industry. It is not only an interest to identify these mechanisms but to understand the motivations of lab employees to use these methods.

Qualitative results are not meant to provide statistical backed results; instead, this research is expected to reap results which represent more of a behavioral pattern among laboratory personnel. There are many aspects that make qualitative studies unique from quantitative ones. First, the technique used to collect data for this research was through personal one-on-one in-depth interviews. Second, the use of open-ended questions is another facet which allows for findings that are more exhaustive. Although generic questions were presented to all interviewees, there was latitude given to expound on certain topics. Third, because of the manner in which questions are formulated, responses tend to give a bit more insight into people's behavior, attitudes, and motivation [31].

Some of the drawbacks to using this type of analysis revolve around how subjectively results are interpreted. It is believed that most qualitative research is based on small sample sizes and often does not represent the entire population well. In the case of this research, it is fair to say that the population used is a reasonable representation of the whole. Because of the flexible processes that are used, it is also hard to replicate any previous results; experts believe this gives these types of experiments a low reliability [31]. For the purposes of this research, the interest does not lie on replicating results, but

on observing the behaviors of scientists and engineers and their interaction with industry for which this analysis is well suited.

Question Formulation and Interview Process

Once a qualitative analysis was decided upon, the next step was to begin the creation of the questionnaire. The questions were written with one major thought in mind; they were written and asked in a manner such that the interviewee would be comfortable and not feel as if their work was being scrutinized. Every individual was approached by the interviewee as a casual observer and not so much as an inspector that would report their findings. Most of the interviewees were selected because of the successes their offices had reported in official documentation. They were approached in a manner that identified them as a potential source of information on how to conduct T^2 and asked to share their experiences. Additional interviewees were selected as a result of a recommendation from others interviewed. This proved to be an exceptional method for acquiring contacts because it placed interviewees at ease knowing they had been recommended. Questions were written and delivered in a manner that would not lead the interviewee to specific answers; this is a means of receiving sanitized answers from subjects. Questions were also tailored specifically for certain people depending on their position and responsibilities within the organization. As the interviews began, biases towards what felt were pertinent questions and what were the important aspects to focus on changed and helped in the refinement of the investigative questions mentioned in the below section. The approach to how interviews were conducted to different levels of supervision also matured as the research progressed. This allowed the research to

become more focused and also permitted the ability to avoid pursuing responses that were of no importance to the overall results of the research.

Investigative Questions

Listed below are the finalized questions as they were presented to the interviewees in each session. Interviewees were given the necessary latitude to expound on their responses, but were asked to specifically answer these questions.

1. "What official tools/mechanisms are you aware of to assist the efforts of technology transfer?"

2. "What methods do you actually use? Are there other types of interactions occurring besides the common used mechanisms? Why do you prefer the use of these methods?"

3. "What obstacles do you see or do you encounter that prohibit the effective transfer of technology? Can you or do you do anything to avoid these obstacles?"

4. "Is the use of certain mechanisms or methods at all correlated/influenced through incentives, rewards, recognition, metrics being tracked, or personal performance reports?"

These four questions were developed with only one thought in mind. The purpose was to answer the overall research question presented in Chapter I. The "how" in the overarching research question is covered by the topics in these four investigative questions.

Institutional Review Board Approval Process

The Institutional Review Board (IRB) Process is a unique method employed by the Air Force to approve any type of research that involves human subjects. Although this process is intended more for medical research done on human subjects, nevertheless, since the interviews involve people, it must still be accomplished.

The approval process involves a couple of steps that must be accomplished before interviewing can commence. The first step requires the researcher to complete the online Basic Collaborative IRB Training Initiative (CITI) course. The CITI course is tailored to teach researchers on the protection of human subjects involved in research. Once the course is completed, a package must be drafted that includes the proposed questionnaire along with a letter requesting exemption from human experimentation requirements in accordance with Air Force Instruction (AFI) 40-402. The request will be based on Code of Federal Regulations, title 32, part 219, section 101, paragraph (b) category (2):

> *Research activities that involve the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior unless: (i) Information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) Any disclosure of the human subjects' responses outside the*

research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation [32].

Appendix B contains the final approval letter received from the IRB to conduct interviews.

Subject Sample Selection

Selecting an appropriate sample size that would be representative of the entire Air Force T^2 community was one of the more daunting tasks of this research. The DoD Office of Technology Transition reports to Congress every five years on T^2 efforts throughout all DoD agencies. Included in this report is a breakdown by laboratory and center of all reported T^2 mechanisms that occurred between 1998 and 2003 [6]. With the aid of this document, it was possible to pinpoint where all reported T^2 mechanisms had occurred within the Air Force for those six years. A summary of all Air Force agencies which reported T^2 mechanisms for this span of years is summarized in Appendix C. This was a good starting point for identifying which agencies would provide this research the largest benefit by providing the specific projects that had proven effective mechanisms in place.

After careful evaluation of the document, it showed that close to 70% of all T^2 that occurs within the Air Force, takes place in the AFRL community and their directorates. Even though the Air Force Material Command (AFMC) also showed large numbers of reported T^2 mechanisms, they were not included in this study. One agency within the Aeronautical Systems Center (ASC) was also included because of the advisory role they provide to the AFRL. This document was also helpful in identifying the

specific organizations within each of these directorates that had had reported achievements; this was accomplished through their reported success stories.

Once the organizations were identified, it was a simple task to contact specific people working within these groups. All initial contacts were identified at random while all subsequent interviewees were based on recommendations. In the end, a total of 26 different individuals were interviewed spanning multiple directorates, different levels of hierarchy, and different technology specializations. Table 4 summarizes these interviews by directorate only. Contacts in certain directorates were more accommodating than in others, thus the discrepancy in numbers among agencies.

Table 4. Interviews Conducted

Directorate	Number of Interviews
Materials & Manufacturing(M&M)	14
Air Vehicles (AV)	1
Propulsion (Prop)	4
Human Effectiveness (HE)	6
Aeronautical Systems Center (ASC)	1
Total	26

IV. Results and Conclusions

Introduction

This section is written in a format to aid T^2 users to identify themselves through certain criteria. This criteria is the basis for the separation of the results. The first section pays mention to the major focus of this study and that is identifying those official mechanisms used to accomplish T^2. This section also analyzes and discusses reasons why some of these mechanisms are preferred and why some are not; this represents the assessment portion of this study. Once official mechanisms are talked about, the next logical step is to discuss those mechanisms that are considered unofficial; these were built into eight distinct categories. The third portion of this chapter discusses those barriers that were perceived by interviewees to prevent them from fully engaging in T^2. Subsequently, an examination was conducted on the top five official and unofficial mechanisms. This chapter will conclude with an analysis that demonstrates that labs

interviewed fall under either a technology push (investigative) or technology pull (support) system.

Preferred Official Mechanisms

It is not difficult identifying which mechanisms are used more abundantly; however, it is difficult to link mechanism use to specific organizations, technology type, or people involved. The results demonstrated that amongst all the interviewees, they admitted to using all 19 mechanisms mentioned in Chapter II in one form or another. Some mechanisms were favored over others and it could be inferred that this partiality is associated with technology type or the organizations involved. This section will only focus on a select few mechanisms that stood out in the results. Table 5 shows a synopsis of all 26 responses and which official mechanisms they admitted to using. The STTR and SBIR programs were combined due to their known similarity concerning focus and funds used, as were PLAs and Patents; PLAs only derive from an already approved patent. The table shows both cumulative mechanism usage among all interviewees (shown at the bottom of the table) and partial use amid the different directorates (shown within the cells). Percentages are not meant to be cumulative and should not be expected to add up to 100%. Results will show overlaps due to interviewees employing multiple mechanisms.

Sixty-five percent of the interviewees acknowledged having used CRADAs in their everyday work, although the remaining recognized to having known someone who had. The interviewees attributed their use of CRADAs to the availability of information and people with the knowledge to use them. This information and knowledge is found

within the ORTA offices mentioned earlier. Although CRADAs are not easy to establish, they do make it simple to utilize by other related organizations once they are in place. CRADAs, like other official mechanisms, take time to establish and must go through a series of revisions by lawyers that represent both interested parties. Sometimes this is a deterrent for inexperienced organizations. Those groups that had previously gone through the rigorous approval process reaped the benefits of having multiple CRADAs in place. Because of their flexibility, federal organizations with similar interests can piggy-back off of already existing CRADAs and therefore forego the approval process.

Table 5. Official Technology Transfer Mechanism Usage

Directorate (#)	CRADA	Contract	Grant	STTR/SBIR	DUST	CRA	COSSI	MPP	PE	ManTech	CTA	PI	IR+D	EPA	PLA/Patents	Alliances	Loaned Equip
M&M (14)	9(64%)	7(50%)	1	5(36%)	1			1	1	1		1	1	1	1		
AV (1)											1						
Prop (4)	4(100%)	1(25%)		1(25%)	1	4(100%)	1					1				1	1
HE (6)	4(67%)	1(17%)		3(50%)										2	2	2	
ASC (1)																	
Total(%)	65	35	4	35	8	15	4	4	4	4	4	8	4	12	12	12	4

**Results are not meant to be cumulative; will not add to 100%

There were several examples worth mentioning were CRADAs have proved successful. The Prop directorate achieved a great accomplishment when they finalized a CRADA with Chevron™. Since a big percentage of their work relates to investigative work with fuels technology, fuel additives, and alternative fuels, it makes sense to team up with one of the leading commercial fuel experts [33]. This relationship was originally established through the attendance of conferences at which they presented papers. The

relationship matured from there and evolved into a formal mechanism. The directorate has been involved in many co-development projects in which cost sharing has been used and benefits garnered by both sides.

In the HE directorate although the interviewees declared that most of their work revolved around support to the user, a lot of their breakthroughs could be considered investigative in nature. Most recently, they established a CRADA with Boeing which allowed them to fully equip a battle lab. This battle lab was set up to simulate the Airborne Warning and Control System (AWACS) which is currently found on the Air Force's E-3 Sentry aircraft. The lab is trying to solve a problem that has been plaguing operators on this platform for years--the organized delivery of voice communication traffic that operators can understand and utilize efficiently. The lab has developed a technology called "spatial audio" in which separate and distinct communication channels can be heard over a single set of earphones. Since testing on the actual platform proved to be too expensive, they opted to construct a simulated lab. Boeing was the obvious choice for this CRADA because of their involvement as the prime contractor for the airframe. The initial contact had already been established through either a past developmental contract or a current support contract. The government labs received all the equipment necessary to equip the lab at no cost to them while Boeing has been receiving results from tests conducted.

The M&M directorate appeared to have the most diverse thoughts on the use of CRADAs. As has been the case with other directorates, the M&M directorate was no different when it came to leveraging existing CRADAs. One of the divisions teamed up with a company known as Excera™ whose expertise lies in materials manufacturing. In

particular, the government labs have been investigating the use of different materials for body armor. When they discovered that there was an existing CRADA with this company, it was a simple process to modify and insert the additional requirements. Other interviewees expressed that even though CRADAs were widespread in their division, they lacked the expertise to know the benefits of their use. Still yet another situation involved an interviewee at the branch chief level who believed that CRADAs were not appropriate for their organization. Their workload consists of providing responsive information back to the field units on a variety of airframes. Because of the nature of this work, they consider that teaming up or requiring the aid of an outside organization could result in the appearance of contaminated outcomes. Therefore, they choose to do most of their work in-house, without the support of industry.

It appears that the use of CRADAs is highly favored among those directorates that have the in-house and past experience. It can also be concluded that CRADAs are a great benefit to the government when they do not have the funds available to enter into formal contracts. It allows both parties to reap the rewards with a minimal investment.

Approximately 35% of the interviewees admitted to having some type of contract in place with industry that helps them facilitate T^2. Contracts that have been in place for extended periods of time serve a great purpose due to the rapport already established between the government and the outside agency. Although contracts require FAR compliance which involves high levels of bureaucratic involvement, if the relationship is a good one, modifications can be inserted with ease.

AFRL appears to have an established link with the University of Dayton Research Institute (UDRI). All of the directorates interviewed admitted to having a

contract in place with UDRI except for ASC. Although the intricacies of each contract were not discussed, the purpose for each was. For the most part, the labs utilize these contracts to supply additional manpower to government labs in the form of scientists, lab technicians, and engineers. In addition to providing this extra manpower, UDRI is also bringing a specific skill set that might not be present in the lab. Some of the branches within the directorates also provide the latitude to these contractors to accomplish investigative research; all of this work must be related to the established needs and mission of the particular lab.

Attention must be paid to those mechanisms that are used less often but are nevertheless important to the transfer of technology. Patent licensing and patents were mentioned in various interviews but the consensus demonstrated that their use is very limited to specific technologies. Some interviewees expressed concerns that many of the technologies licensed finish up without a customer need. The HE directorate, on the other hand, develops many technologies, such as “spatial audio”, that have important commercial applications as well. Being able to control IPR issues is one of the primary reasons for the significant use of PLAs within this directorate.

SBIRs were also a mechanism that was heavily utilized even though most interviewees agreed that the results from these efforts usually end up unused, too. Many of the offices have dedicated funds that must be used towards SBIR initiatives; this is the main reason why they involve themselves in these endeavors. The HE directorate also showed to contain the bulk of the users for EPAs. The interviewees explained that they favored the use of EPAs because it not only established a good rapport with a learning institution for future studies, but it also afforded them the manpower to conduct a lot of

their research. Since operators are hard to come by because of overseas deployment demands, the HE directorate has resorted to using trained students to conduct their AWACS battle lab experiments.

Throughout this research, only one partnership intermediary was encountered that served as the specific liaison for that directorate. Other organizations admitted to using them in the past, but the M&M directorate was distinct in that they had hired an outside not-for-profit agency to provide a body in-house to specifically concentrate on T^2. Personnel exchanges played an important role in some agencies; it allowed them the exchange of knowledge without incurring any additional costs. The benefits ended up being similar for both parties and costs were incurred by the traveling side. In the case of the use of facilities and loaned equipment, those agencies involved in this form of T^2, admitted that it tended to occur only with the help of an already established contract.

The Prop directorate also showed a trend of having the only interviewees to favor the use of CRAs. A possible motive for using CRAs lies in the fact that the propulsion directorate is heavily involved in basic research. Their type of basic research must be very focused and does not afford the possibility of squandering funds on wasted efforts. Through the use of CRAs, they are allowed to write very specific contract proposals that are competed to the best bidder. These contracts bind the government and contractor to specific terms.

It can be concluded from these results which mechanisms are most favored by these labs and the circumstances associated with them. It can also be deduced which mechanisms are seldom utilized; the qualitative results provide insight into why these mechanisms are not favored as much.

Unofficial Technology Transfer Mechanisms

Besides those official mechanisms mentioned above, there were other methods implemented by many of the labs which were utilized in accomplishing T^2. Many of these unofficial mechanisms were not referred to as such by the interviewees, but as everyday procedure. For the purpose of this research the unofficial mechanisms were divided into eight distinct categories. A summary of the findings can be found in Table 6. The table shows both cumulative mechanism usage among all interviewees (shown at the

Table 6. Unofficial Mechanism Usage

AFRL Directorate (# of interviewees)	Lessons Learned Reports/Activity Reports/Publications	Conferences/Symposiums/ Seminars	AFRL Sponsored Events	FLC & TTIPT Events	Specialized Commitees/IPTs/Technical Interchanges/Working	Co-Locates	ICR&D	Fellowships/Scholarships
M&M (14)	4(29%)	6(43%)	2	1	4(29%)	5(36%)		
AV (1)				1				
Prop (4)	2(50%)	3(75%)		1	1(25%)			
HE (6)		3(50%)		1	4(67%)	1(17%)	2	1
ASC (1)		1(100%)			1(100%)			
Totals (%)	23	50	8	15	38	23	8	4

**Results are not meant to be cumulative; will not add to 100%

bottom of the table) and partial use amid the different directorates (shown within the cells). Percentages are not meant to be cumulative and should not be expected to add up

to 100%. Results will show overlaps due to interviewees employing multiple mechanisms.

According to the results acquired, informal gatherings which are comprised of conferences, symposiums, and seminars were the most prevalent among the interviewees; fifty percent of all interviewees were involved with these. Gatherings are established for many purposes and the participation varies greatly. There are instances where these assemblies are focused on particular technologies as is the case with the M&M directorate; their interests lie within areas like non-destructive inspection, composite materials, and aging aircraft issues. They are a great forum in which to present best practices and establish a rapport with commercial partners. For the most part, these congregations are open to everyone, both government and industry, as long the information being disclosed is not classified. Not only does DoD implement these methods, but organizations like NASA also utilize symposiums to bring together researchers, sponsors, and other programs [34]. There are other instances where less formalized gatherings occur and they involve more general sharing of information. Both government and commercial agencies are responsible for setting these up. One of the limiting factors to these gatherings is that they are heavily governed by the amount of funds an organization is allowed to spend on these efforts which ties back in with the overall strategic vision of that agency.

The next most widespread method utilized, involves the use of specialized committees, integrated product teams (IPTs), technical interchanges, and working groups. These will be referred to as formal gatherings. These differ from the other gatherings in one aspect. These groups have been established for a common purpose.

Members are hand-picked out of a sea of experts to come together and resolve specific issues. The experts will include individuals from the research labs, end users, and industry partners. Their relationship tends to be bound first by some type of formal agreement which initially brings them together. Since the goals of these groups are so specific, once problems have been resolved, this collection of people will disband until the next time they are required.

Within the Prop directorate, they bring together on a consistent basis, a panel of experts to discuss new technologies that could have a commercial viability. Once they have agreed on those that have the greatest chance of being successful, they bring in industry partners to discuss ways of transferring this technology [33]. In the HE directorate one of their main focuses includes improvements to the operators on the AWACS platform. Since the AWACS is an aircraft that is utilized by other countries besides the U.S., they have formed a working group specifically to resolve those issues. This working group is comprised of U.S government employees, U.S. industry, and international governments and industry [35]. These gatherings prove to be a very beneficial mechanism for T^2; the most difficult aspect is bringing together the precise type of people collectively. As the next paragraph will show, certain directorates have developed methods to counter this problem with bringing the right people together.

One of the more interesting results brought out by this research was the finding of individuals referred to as “co-locates”. Co-locates are usually government employees, either military or civilian, which although employed by the federal labs are positioned physically in places where they can interact with both industry and the end user in a simple manner. Having their offices sometimes half way across the U.S. from their labs,

they make use of their location by reaching out to both the user and industry to receive feedback on both party's needs. Co-locates are responsible for initiating the first contact between the federal labs and industry in what could later develop into a formal T^2 mechanism. In the case of the M&M directory, they choose to place their co-locates at aircraft and logistics centers. These centers are responsible for implementing new techniques developed by both laboratories and industry concerning their related platforms. Having the co-locates situated there allows them to get the pulse of the platform's user and relay that information back to the lab and commercial partner through person-to-person contact. In a recent descriptive analysis conducted less than two years ago, results showed that person-to-person contacts were the most effective method for knowledge and T^2 [36].

The use of co-locates has proven to serve a few distinct purposes. First, their location allows them to interact and establish a link among the important players handling T^2. This places them in a situation that cannot be duplicated by those scientists and engineers located in the laboratories. And second, by being so close to the user, they are able to experience first-hand the dilemmas encountered by the user. All of their feedback can be transmitted simultaneously to both the laboratories and industrial partners involved.

Besides the everyday person-to-person communication, two of the directorates interviewed acknowledged using written reports and publications as a means to facilitate T^2. The positive aspect in using publications is that it grants access to almost anyone that is interested in the topic. In the case of those agencies that utilized activity and lessons learned reports, it was less clear to who was given access to these reports. These reports

were usually a mandatory part of communicating their progress to their superiors. Only one interviewee admitted to knowing where their reports ended up; they were filed at that organization's headquarters level. It appeared that these reports were used mainly in an intra-organizational fashion. There were no specific avenues for outside entities to get a hold of these reports except in those cases where articles were formally published. One of the more important findings dealing with written reports was the so called "language" they were written in. This does not refer to a particular country's dialect, but to the style of writing and the intended audience. Many of these reports use certain colloquialisms that are specific to certain areas of technology or that are known only in close circles. This poses a serious dilemma when outside observers are trying to apply these methods to their own organizations; it will undoubtedly render the reports ineffective. This is a fairly common problem and has been identified previously in other research, such as in, "Effective-Industry Technology Transfer [37]." The author explains that T^2 tends to only work in environments where the technology level shared by everyone involved is the same.

The FLC and Technology Transfer Integrated Product Team (TTIPT) are two federal entities whose key purpose is to handle T^2 issues for the government. Part of their efforts are directed towards the events they set up annually at which important T^2 issues are discussed. Attendance to these meetings is quite firm. TTIPTs are intended only for DoD professionals involved in T^2. The FLC has to two types of gatherings they hold, one at the national level and the other at the regional level. The national level conference is much like the TTIPT in attendance, although other federal organizations like DOE and the National Aeronautics and Space Administration (NASA) are also

included. The regional conferences are the only gatherings in which industry and academia are present.

A great amount of the interviewees that attended these functions, admitted to utilizing these events as a means to create a rapport with other federal agencies which in turn have helped them get in touch with industry partners. These conferences also play an important role in disseminating new legislation, best practices, and lessons learned to the rest of the T^2 community. The few interviewees that admitted using these forums were not aware of the attendance constraints. At the regional FLC conference, one interviewee mentioned that little effort is placed on agenda content and what might attract industrial partners to attend. It is difficult to get a good response rate from the commercial and academic world unless they are brought in by something of interest.

AFRL also sponsors a similar event to that of the FLC and TTIPT for local organizations; attendance includes AFRL directorates, WPAFB legal office, UDRI, Wright State University, and the University of Cincinnati. These monthly meetings are used to share lessons learned and to disseminate new legislation involving T^2. What wasn't made clear and is important to note, was who specifically attended these meetings and how was that information later circulated throughout their individual agencies. Another form of T^2 mentioned only by the HE directorate was the use of International Cooperative R&D (ICR&D). This interaction occurs primarily government to government, additionally, interviewees admitted that it helped them establish international industry partners in this manner. The HE directorate was also the only one to mention the use of fellowships and scholarships to establish a rapport with academia. Their main purpose for this was to establish that initial contact with another research

institute while providing students an environment in which to develop their skills. This initial contact has proven itself practical for future co-development projects between the two organizations.

Official and Unofficial Mechanism Analysis

The interviews conducted have shown that within the M&M, Prop, and HE directorates in particular, the top mechanism used was an official one. As one starts to venture down the list, it is obvious that the use official mechanisms begin to taper off rather suddenly. On the other hand, although unofficial mechanisms are on the decrease as well, they don't taper off as abruptly. The data collected could not prove with certainty if within each particular directorate they favored the use of official or unofficial mechanisms. Table 7 below shows a side by side comparison of the top five official and unofficial mechanisms. Specialized committees, IPTs, technical interchanges, and working groups were all included into one category called formal gatherings. Although CRADAs appear to be the overall most utilized mechanism, the significant usage of the top five unofficial mechanisms demonstrates an important role in how laboratories conduct T^2. From these results we can observe that by combining all mechanisms into one category that unofficial mechanisms account for three of the top six methods used for T^2. This is an important consideration to understand when it comes to supervision mandating which mechanisms to utilize.

Table 7. Top Five Official & Unofficial Mechanisms

Official Mechanisms	Total (%)	Unofficial Mechanisms	Total (%)
CRADA	65	Conferences/Symposiums /Seminars	50
Contracts	38	Formal Gatherings	38
STTR/SBIR	35	Lessons Learned Reports/Activity Reports/Publications	23
CRA	15	Co-Locates	23
EPA/PLA/Patents/ Alliances	12	FLC & TTIPT Events	15

**Each percentage represents usage of that mechanism among the 26 interviewees

Perceived Barriers which Impede Technology Transfer

In the previous sections, emphasis has been placed on the official and unofficial mechanisms that are preferred by the scientists and engineers within the AFRL community. This next segment will focus on the barriers perceived by lab employees which hamper the progress of T^2. Table 8 provides a synopsis of these results; the data is again separated by directorate and barriers perceived. The table shows cumulative barriers perceived among all interviewees (shown at the bottom of the table). Percentages are not meant to be cumulative and should not be expected to add up to 100%. Results will show overlaps due to individual interviewees perceiving multiple barriers.

The overwhelming response among interviewees which contributed the most detriment towards an effective T^2 process is associated with funding issues. The first

aspect of funding that will be looked at is what is referred to in the DoD as “color” of money. As with most federal agencies, funds are distributed to labs in a manner in which they must be used for a specific purpose. In the case of the labs at AFRL, funds are separated by the type of work being performed. Figure 3 gives a visual representation of the different stages of research that AFRL is involved in. The Science and Technology (S&T) stages are designated by the numbers 6.1, 6.2, and 6.3 which is where the majority of T^2 occurs. Stages 6.4 and 6.5 encompass where technology transition to the user occurs and further refinement of products is done. The increase in numbers also exhibits a change from general investigative work to a more refined and focused effort.

Of those that concluded that funding was a problem, approximately 90% of the interviewees admitted to have access to only 6.1 and 6.2 stage funding. This precludes these offices from continuing research once it has reached one of the described stage

Table 8. Perceived Barriers which Impede Technology Transfer

Directorate	Lack of Strategic Vision	Lack of Training	Funding Issues	Trust	Lack of Market Analysis	Filtering Needs	Insertion of Technology	Stovepiped Organizations	Lack of Infrastructure	Mechanism Bureacracy	Formal Gathering Involvement
M&M	4	4	7	2		1	1	1	1	1	1
AV											
Prop		1	2		1						
HE	3	1	1								
ASC		1	1	1							
Totals (%)	27	27	42	12	4	4	4	4	4	4	4

**Results are not meant to be cumulative; will not add to 100%

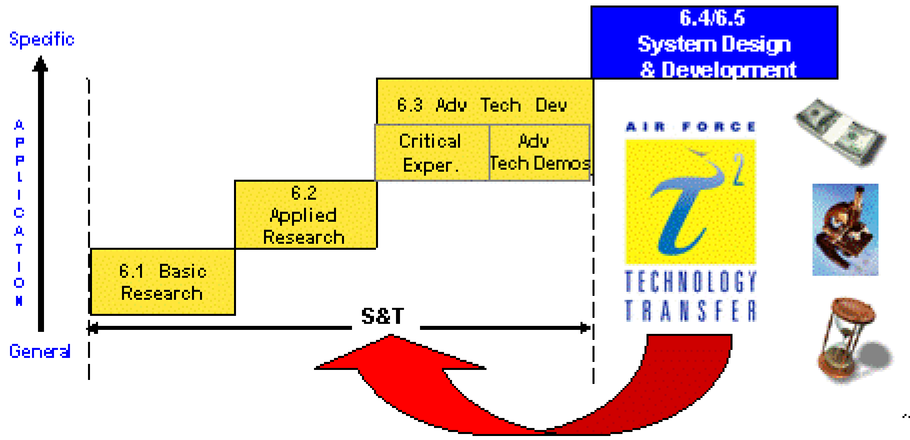


Figure 3. AFRL Research Stages [2]

boundaries. Scientists and engineers have had to devise ingenious methods to either request funds from other organizations or to re-appropriate funds to continue their effort. All this extra toil takes time and manpower that labs are not outfitted to handle. Along with "color" of money issues there is also the problem with overall lack of designated funds to accomplish T^2. Labs are forced to use out-of-hide funds to accomplish a mandated T^2 mission. Another interviewee mentioned a particular problem they had encountered when they were given congressionally linked funds. In essence their industry partner had already been chosen for them and their research efforts guided; there was little flexibility given to them. Even though the reality of acquiring specific funds to accomplish T^2 is nonexistent, laboratories should at least be given more latitude to use the funds they already have.

A lack of strategic vision and a lack of formal training were mentioned as trouble spots by 27% of the interviewees. Strategic vision was most commonly treated as the ability to receive support for T^2 by their superiors. This realm of strategic vision

included the ability to push a T^2 mentality forward, provide adequate manpower, and supply sufficient funding. Most interviewees agreed that T^2 was treated as more of a lip-service tactic by superiors and expected the lower level scientists and engineers to "just" handle it. In a recent article, "Causes of Weakness of T^2 from R&D Centres to Economy Practice and Ideas How to Make this System more Efficient", the author identifies this lack of support from upper management as a lead cause for failing T^2 [38]. For the majority of directorates involved in this research, formal training on T^2 was either absent or very minimal. Although there is training offered by many government agencies, interviewees were either not aware where the training was held or believed that it wasn't targeted specifically enough. Support from the top is an absolute need in order for T^2 to become successful. Individuals in leadership positions should be able communicate the needs and goals of their organization and be able to provide the proper tools to accomplish those goals.

Trust was mentioned as an important aspect of creating useful T^2 connections by three interviewees. They found that establishing a long-lasting rapport with industrial partners was a necessity to achieve good results in T^2. This issue was also discovered as a salient method for accomplishing T^2 in an article where they refer to trust as the people-mover model [39]. This trust matter is also associated with the previously mentioned IPR issue. When a healthy bond is established with commercial partners, the government tends not to worry about IPR issues, such as which side will own the rights to the new technologies being developed. They are understood either through prior expectations or through formal agreements. A lack of market analysis referred to the inability of lab employees to recognize the needs of the commercial world. Filtering needs applies to the

opposite end in which too many industrial partners flood the government labs with technologies that have little or no applicability on the federal side. The research showed that there is no specific process in place to sieve all requests coming in. This proved to be also true in an article titled, "T^2: A New Culture" [4], where the author expresses their concern with the inability for both sides to inventory and express their needs. Insertion of technology refers primarily to the timing at which a technology can be transferred appropriately. This timing depends heavily on the needs of both parties at that particular time. One interviewee mentioned that in their eyes, most government labs function in a "stovepipe" fashion. Because of the way they conduct business, they are not encouraged to work outside of their realm of responsibility. The same interviewee believed that T^2 is a multi-faceted practice in which many different fields come together to make it happen, not just scientists and engineers. It is their belief that the labs do not have the appropriate infrastructure to accomplish most T^2 [40]. The bureaucracy associated with constructing some of the official mechanisms also seemed to be a deterrent, but appeared to be only prevalent in those organizations that did not use many of the official means. Finally, one final perceived barrier was the difficulty behind getting both government agencies and industrial partners to participate in the many conferences, symposiums, and seminars that are available.

As expressed by the majority of the interviewees, although barriers will not preclude one particular division from conducting T^2, it will put a severe hamper on the way it is done. It is time and money wasted that could otherwise be used elsewhere. All of these barriers seem to have a common link which could be resolved by alerting the correct individuals in positions of authority.

The Push vs. Pull Dichotomy Among Directorates

There is a distinct variation made between technology that is pushed out from the laboratories and technologies that are developed in the labs as a result of user pull. Interviewees were frank about acknowledging that those projects that are pulled by consumer demand are more likely to succeed than projects which are pushed out to the user. Furthermore, the commercial success of a technology is often more dependent on user acceptance than on the technology itself [41]. Within the AFRL, user pull is often known as a lab with a supportive role while those that tend to push technology identified themselves as investigative laboratories.

Throughout the entirety of the research, interviewees had a simple time identifying their organizations as either working in a push or pull system. Whether their organization used a push or pull method to accomplish T^2 depended primarily on the structure of their organization and the technologies with which they were involved. Table 9 summarizes the 26 interviews conducted, distinguishes the organizations involved, and shows whether they used a pull or a push system. One interviewee was not considered; this was the individual that identified themselves as a PI. As a PI, they are a neutral entity, and do not initiate which system to use.

Close to 85% of the interviewees agreed that their organization was in more of a supportive role, 27% established they played more of an investigative role, and 15% admitted to being involved in both. Again, these percentages are not meant to be cumulative due to some interviewees using both systems. The organization type played a vital part in what type of interaction was being generated by that specific directorate;

those that tended to await user pull, had great techniques to keep the pulse of the users while those that involved themselves in technology push had less established means of communicating with the user. The type of technology the labs were involved in also aided in distinguishing them as either working a pull or push system. In the DoD, there are certain technologies for which they must always find something faster, lighter or more efficient; these are usually what the public refers to as “breakthrough” technologies. These require intensive amounts of investigative work without the possibility of an identified end user. Contrary to that, there are those technologies that have targeted users from their inception and are considered safe to develop.

Table 9. Directorate Push vs. Pull Usage

Interviewee (Directorate)	Push/ Investigative	Pull/ Support
1(M&M)		X
2(M&M)		X
3(M&M)	X	
4(M&M)		X
5(M&M)	N/A	N/A
6(M&M)		X
7(M&M)		X
8(M&M)		X
9(M&M)	X	X
10(M&M)		X
11(M&M)		X
12(M&M)	X	X
13(M&M)		X
14(M&M)		X
15(AV)		X
16(Prop)		X
17(Prop)	X	
18(Prop)	X	
19(Prop)		X
20(HE)	X	X
21(HE)		X
22(HE)		X
23(HE)		X
24(HE)		X
25(HE)	X	X
26(ASC)		X
Totals	27%	85%

**Results are not meant to be cumulative; will not add to 100%

The M&M directorate was one of the organizations within AFRL to collaborate in this research through the participation of multiple interviewees, fourteen total. With the

exception of one, all interviewees declared that at least 95% of their workload was comprised of a support role towards a specific Air Force program office. The majority of these program offices lead the efforts in sustaining Air Force airframes. Because the majority of their work deals with supporting these airframes, they are involved heavily in what they refer to as "quick-response teams." These teams are tasked to find a solution after either a deficiency has been identified or a mishap has occurred and a quick fix is required to prevent an aircraft fleet from being grounded. The entire process seems complicated, but works rather well because of the infrastructure that is already in place. This process involves the prime contractor of the airframe to be involved in the development of the new process or material. After all, they contain the utmost experts concerning most Air Force airframes. New processes are developed through co-developments that either involve day-to-day interaction with the contractors or established meetings to share expertise. It is important to note the pattern occurring within the M&M directorate. This directorate's primary focus is to support the end user in a direct fashion and careful attention must be paid to the type of mechanisms utilized.

Having analyzed the results pertaining to the M&M directorate, T^2 is occurring in this situation with no real formal mechanism in place. There is a formal relationship established between the government laboratory and industry through either a past or existing support contract. Because of this already established rapport, the means are already in place to begin T^2 and all that is left undone is to agree on the terms. This typically involves minor modifications to the already existing contracts. Both parties have vested interests; the government must keep their planes in the air and industry has an interest because it is a long-term investment for future business. Furthermore, any

new technologies discovered could be used in future products. This relationship proves that there are situations where T^2 will occur without the aid of formal mechanisms.

Although the use of technology pull far surpasses push, there are still instances where push is occurring within AFRL. The majority of the interviewees agree that technology push is ineffective and very time consuming, although it has proven groundbreaking at times. The Prop directorate demonstrates that within their organization, technology push is an essential key in conducting business. Because their work is focused on providing improved thrust performance for airframes through either mechanical means or fuels technology, they must always be on the cusp of novel concepts. In one example, the lab established an informal agreement with the Tampa Police Department in which they traded a new fuel additive for helicopters in return for usage feedback [33]. This initial form of T^2 could evolve into a more formal mechanism. Another form of push that occurs in many labs and is seen as an afterthought is the use of end-of-year funds. Funds left over at the end of the fiscal year, are utilized in the investigation of new technologies. Although results did not demonstrate that there were any significant outliers, it was noted through the interviewee's comments, that the Prop directorate had more of a propensity to use technology push than other directorates. This was attributed heavily to the type of technology mentioned above.

The overwhelming response to why more technology push was not being accomplished was due to both the lack of funding and strategic vision. The majority of the interviewees' work revolves around a project-oriented focus rather than finding innovative solutions to problems. Most labs that have been involved in technology push, find themselves squandering government funds on technologies that end up on a shelf

without a customer. The other cause of failing pushed technologies is attributed to a funding issue. Labs, because of the type funding they utilize and the constraints associated with them, are forced to utilize funds for very specific purposes. If technologies are to mature into something more than a prototype, development funds have to be introduced from another organization to complete the integration process. These are not always available and require additional involvement from another agency.

There was a definite correlation with those individuals that utilized technology push and also had a concrete strategic vision. These scientists and engineers were given the support they needed from their supervisors in the form of funding and guidance to accomplish investigative work. Although the support was present, many times the appropriate infrastructure was not. Many of labs admitted to not having the adequate knowledge and manpower in the right places to allow T^2 to flow more smoothly. Conversely, technology pull was demonstrated through the interviews to work better because it had the appropriate infrastructure and strategic vision in place.

V. Discussion and Recommendations

Discussion

The original intent of this research was to investigate scientists and engineers within the laboratories and discover how they accomplished T^2 on an everyday basis. Subjects were acquired completely at random and allowed for a perspective previously unknown to the Air Force T^2 program manager. This was a key in attaining the results presented in this study. The recommendations expressed in this chapter are solely based on the results acquired through interviews and the literature review conducted. Since the literature review for T^2 within the federal government is limited, some inferences had to be made from those commercial applications. As with any research, there are always limitations that could skew the data collected. This study was no different; there were various issues that could seriously distort the results. Taking into consideration these limitations, suggested future studies were recommended that could either supplement this study or give it a complete new twist.

The subsequent recommendations were based on the below conclusions summarized from the previous chapter:

(1) There are organizations leveraging the use of official mechanisms and are reaping the benefits. Those that are not using mechanisms are because they either lack the knowledge to do so or lack the infrastructure to implement them.

(2) Unofficial mechanisms are used almost as prevalently as official ones. The problem lies in that there is not a set guidance for these unofficial mechanisms and how to utilize them.

(3) Most organizations lack in one way or another a sense of strategic vision. This vision is linked to the other three barriers: lack of trust, funding issues, and lack of training. All of these barriers are related to the leadership of an organization.

Recommendations

The key purpose of this study was to identify all mechanisms utilized by scientists and engineers shown in the previous chapter. Through the use and interpretation of the qualitative results gathered, additional meaning can be provided to the recommendations. Recommendations are based from a perspective in which resources, both manpower and funding, are left untouched, but could be manipulated and moved around. These recommendations were made in a more general basis which could be applied to any directorate. The recommendations were structured in a manner where a perceived barrier discovered could be overcome by a proven mechanism found in this research. Specific solutions for specific directorates were not thought appropriate. Below is a list of those recommendations and some insight on how to implement them:

1.) Improve the infrastructure for the top-five most utilized official mechanisms.

Initially, there must be a proviso established that this suggestion should be implemented at least at the directorate level within AFRL. Employing a strategy at too high of a management level might undermine its intended purpose. Improving the infrastructure requires a lot of aspects. First, there must be a concentration on getting people the adequate knowledge about these mechanisms. This can be accomplished through the use of targeted training and providing access to more on-line resources.

Making the ORTAs responsible for knowing which mechanisms are more prevalent in their directorate and affording them the autonomy to conduct their own specific training in a pro-active manner could prove useful. Making lessons learned and sample documents available through directorate intranet services is also a solution. A perfect application of this method can be made to the prevalent use of CRADAs. In very distinct situations there were organizations that used another organization's CRADAs and were able to apply it to their own agency's needs. Having a database available which all authorized laboratory personnel can have access to and could do searches on specific commercial partners or technologies would be a huge benefit. Scientists and engineers could become more inclined to utilizing CRADAs if they had a system of this sort. Yet another solution could involve the streamlining for the approval processes of these select mechanisms. Ensuring that the approval chain for documents is well known and efficient and that the correct people are identified, would garner better results. This would alleviate the problem for those scientists and engineers that are deterred by what they refer to as a "lengthy bureaucratic" process.

Secondly, infrastructure also requires resources; it requires both the adequate manpower and funding. Individuals within directorates in positions of authority should be given the power to assign their personnel duties that label them as points of contact (POCs) for specific mechanism use. These POCs could be in addition to the already mandatory ORTA positions and should be someone that is involved in the everyday interaction with T^2; ORTAs are the experts in legislation but might not always be in practice. This position could even be incorporated into what a PI is required to do. As mentioned in Chapter IV, the M&M directorate was the only organization to have hired a

PI to work on-site issues. It is difficult to tell how effective having this position in-house really is, but it would definitely be an improvement over the lack of market analysis and filtering that is done today. Manpower is the second portion of resources and is a mentality that must be adopted at the strategic level. Since the idea of supplying labs with more personnel, is not a financially viable solution, the labs must discover a way to do with what they have already. It is imperative that all personnel within an organization are all on board with the mission and can identify with their portion of it. This is explained once more in Coursey's and Bozeman's [42] article where they state, "The mission of the laboratory has an influence on the director's assessments of the advantages and disadvantages of technology transfer." The director of a laboratory must know what their mission is and that of their organization and must be able to spread that to their subordinates. This strategic vision and how it is disseminated is the final portion that makes up the entire infrastructure. This can be best summed up with one of Lee's [20] conclusions presented in his article dealing with T^2 from federal labs to industry. "The government must develop an infrastructure for increasing the flow of technology. It has a leadership role in coordinating the development of an infrastructure focusing on effective communication and meaningful interactions. This can be accomplished through effective and efficient information transfer mechanisms."

2.) Leverage and expand the use of unofficial mechanisms.

The same proviso mentioned above concerning the application of this recommendation applies to this suggestion as well. Here again, the leveraging of these unofficial mechanisms is dependant on the infrastructure in place to support it. Since

they are considered “unofficial” means of conducting T^2, the first step should involve developing and disseminating the proper training to educate scientists and engineers on the intricacies of these mechanisms and how they can be applied to their specific directorates. The FLC, and in particular the use of their regional conferences, could be a great help in the development and the formal dissemination of these guidelines to government, academic, and commercial agencies. Information can also be propagated through the use of lessons learned reports and through the establishment of communities of interest (CoI) and communities of practice (CoP). CoIs bring together people with common interests, while CoPs bring people together that need a sharing of communication and knowledge to accomplish their job. With these types of gatherings, different directorates would be able to share the knowledge they have with other directorates and vice versa.

Strategic vision plays an even more important role in this situation because the leadership of an organization is the key to the proper adoption of methods that although proven successful, have not been accepted through Air Force regulation. It is a crucial ingredient that these individuals in positions of authority can identify which methods pertain to their specific organizations and direct their subordinates to comply with them. In an article titled, “Improving Federal to Private Sector T^2”, one of the conclusions stated that, “the T^2 culture starts with upper management providing an environment and culture that promotes T^2 [43].” Strategic support is also needed to make the top two most used unofficial mechanisms a success. Conferences, symposiums, and seminars require travel funds, as might committees, IPTs, technical interchanges, and working groups. Here is where the leadership of an organization will have to utilize all the tools

they possess in order to rearrange their funding to allow their people to travel to these important gatherings.

Those organizations that have used co-locates to aid them in getting other federal organizations and industry together to accomplish T^2 have proven their method to work. If travel funds became a problem, the use of co-locates could be further simplified by using some type of alliance mechanism between two federal organizations. An MOU or MOA could be drafted that allowed two federal organizations to benefit from already in place individuals that would serve as co-locates without the necessity of having to physically displace an employee half way across the U.S.

3.) Leadership should place more focus on eliminating barriers and less on specific T^2 use.

This research has proven that there are many unofficial mechanisms in use throughout the AFRL community. There has not been a study done to measure which types of mechanisms work better than others, but until that time, the benefit of the doubt must be given to the scientists and engineers in that their use of unofficial mechanism has proven successful. An environment must be created within the laboratories that is conducive for individuals to want to use T^2 mechanisms. The leadership must place their sole focus on providing the proper people with the precise tools they need and eliminating or alleviating those obstacles that retard T^2.

Funding issues were found to be the most prevalent perceived barrier in Chapter IV. There are obvious aspects of funding that are not within the realm of control of certain authoritative figures within each directorate. What the leadership can do is

involve themselves more and have personnel available at their level with both the expertise and authority to handle these types of issues. With the proper infrastructure and right amount of support, many of these problems associated with “color” of money could be resolved in a more efficient manner. Tackling funding issues requires a particular skill set that only trained financial experts have and it would behoove the leadership to involve these people to resolve these issues.

T^2 should not be seen as another mandated directive, but as a way of doing everyday business. It is the task of the leadership within each particular directorate to ensure that not only are people using the proper mechanisms, but that T^2 is a mentality that trickles down from the top. T^2 doesn’t necessarily have to take extra effort or manpower, but it will require some reengineering of processes that must be supported and guided by the leadership of each directorate. A formalized strategic vision that is understood and supported by all levels of employees is needed; it must be practiced and must become the “new” way of doing business.

Limitations of Study

There are several limitations that should be addressed in this research that could cause some results to be questioned for validity. For the purposes of this research, limitations were exposed in one of two ways. Discussion will include those limitations that were observed before research began, and those that were discovered after research concluded.

First, there must be focus placed on the qualitative analysis that was used in this research. As mentioned earlier, qualitative analysis focuses on the behaviors of the

interviewees used. All of the questions utilized were open-ended which allowed participants to expound on the answers as they pleased. Given this type of leeway and given that each interview was not conducted under the same exact conditions, could result in tainted responses. There also exists the possibility of distorted results when human behavior is involved in the research process.

Lastly, along with the human behavior aspect, consideration should also be taken of the results brought upon by this research; they represent just a mere point in time and symbolize the behavior of the sample-size today. This type of research would be deemed extremely difficult to replicate. There also exists a limitation with the sample size that was selected. There were only 26 interviewees involved in this research and although most major directorates within AFRL were included, not all were represented equally.

Future Studies

The continuation studies mentioned here are based on those deficiencies discovered through this research. First and foremost, there must be an established set of metrics that the entire T^2 community can agree to which are appropriate for distinct agencies. Not everyone is held to the same standards, but everyone that conducts a certain type of business is. This again is the role of the leadership of each directorate to establish. This future study should use some of the results discovered within this research and categorize directorates and other agencies by the type of work they conduct. A survey could be employed to poll these agencies and find what metrics they feel are appropriate in measuring T^2 for their particular organization. Results collected here could be used for additional research and could serve as a basis for future DoD tracking.

Once metrics have been established, another future study could involve a comparison of methods implemented over a period of time. These methods could include the suggestions provided in this research or the adoption of certain unofficial mechanisms. This study would reveal if the effort to implement these new techniques would show dividends or whether it was a wasted effort.

An additional future study could expound upon this research, and include a larger group of participants that represents the T^2 community better. Because of the lack of funds needed to travel to the different organizations shown in Appendix D and other locations across the U.S., the population for this research was constrained to local participants. If sponsor funds were acquired, it would allow travel to some of these locations to conduct personal interviews. A larger population could also be taken from the AFRL community located at WPAFB. Some directorates were keener on conducting interviews than others, but with the already established relationships, some of these difficulties could be lifted.

A final perspective could be taken that has not been mentioned yet. Among all the discussion concerning T^2, it seems that the perspective of industry and academia has been forgotten. There must be a concern and study conducted to uncover the opinions of those industry and academia partners and figure out if the mechanisms the government is implementing are appropriate and how they could be improved. This qualitative research could lead to mechanisms yet to be uncovered.

Appendix A: List of Acronyms

AFB	Air Force Base
AFI	Air Force Instruction
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
ALC	Air Logistics Center
ASC	Aeronautical Systems Center
AV	Air Vehicles Directorate
AWACS	Airborne Warning and Control System
BOM	Bureau of Mines
CITI	Collaborative IRB Training Initiative
CoI	Communities of Interest
CoP	Communities of Practice
COSSI	Commercial Operations & Support Initiative
CRA	Cooperative Research Agreement
CRADA	Cooperative Research & Development Agreement
CSC	Computer Sciences Corporation
CTA	Commercial Test Agreement
DoD	Department of Defense
DOE	Department of Energy
DUST	Dual Use Science & Technology
EPA	Educational Partnership Agreement
FAR	Federal Acquisition Regulation
FLC	Federal Laboratory Consortium
GAO	General Accounting Office
GPLR	Government Purpose License Rights
HE	Human Effectiveness Directorate
ICR&D	International Cooperative Research & Development

IPR	Intellectual Property Rights
IRB	Institutional Review Board
IR+D	Independent Research & Development
LTAP	Local Technical Assistance Program
ManTech	Manufacturing Technology
M&M	Materials and Manufacturing Directorate
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPP	Mentor-Protégé Program
NASA	National Aeronautics and Space Administration
ORTA	Office of Research and Technology Applications
O&S	Operation & Support
PE	Personnel Exchanges
PI	Partnership Intermediaries
PLA	Patent Licensing Agreement
POC	Point of Contact
Prop	Propulsion Directorate
R&D	Research & Development
RoI	Return on Investment
SBIR	Small Business Innovation Research
SDB	Small Disadvantaged Business
STTR	Small Business Technology Transfer
T^2	Technology Transfer
TTIPT	Technology Transfer Integrated Product Team
UDRI	University of Dayton Research Institute
WPAFB	Wright-Patterson Air Force Base

Appendix B: IRB Approval Letter

DEPARTMENT OF THE AIR FORCE
AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO

18 July 2006

MEMORANDUM FOR MICHAEL ROMERO
AFIT/ENV

FROM: AFRL/Wright Site Institutional Review Board

SUBJECT: Request for exemption from human experimentation requirements

1. Protocol title: Technology Transfer and the Interaction Between Organizations

2. Protocol number: F-WR-2006-0062-E

3. The above protocol has been reviewed by the AFRL Wright Site IRB and determined to be **exempt** from IRB oversight and human subject research requirements per 32 CFR 219.101(b)(2) which exempts "research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior."

4. This exemption applies only to the requirements of 32 CFR 219, DoDD 3216.2, AFI 40-402, and related human research subject regulations. If this project is a survey, attitude or opinion poll, questionnaire or interview, consult AFI 36-2601, Air Force Personnel Survey Program, for further guidance. Headquarters AFPC/DPSAS is the final approval authority for conducting attitude and opinion surveys within the Air Force.

5. The IRB must be notified if there is any change to the design or procedures of the research to be conducted. Otherwise, no further action is required.

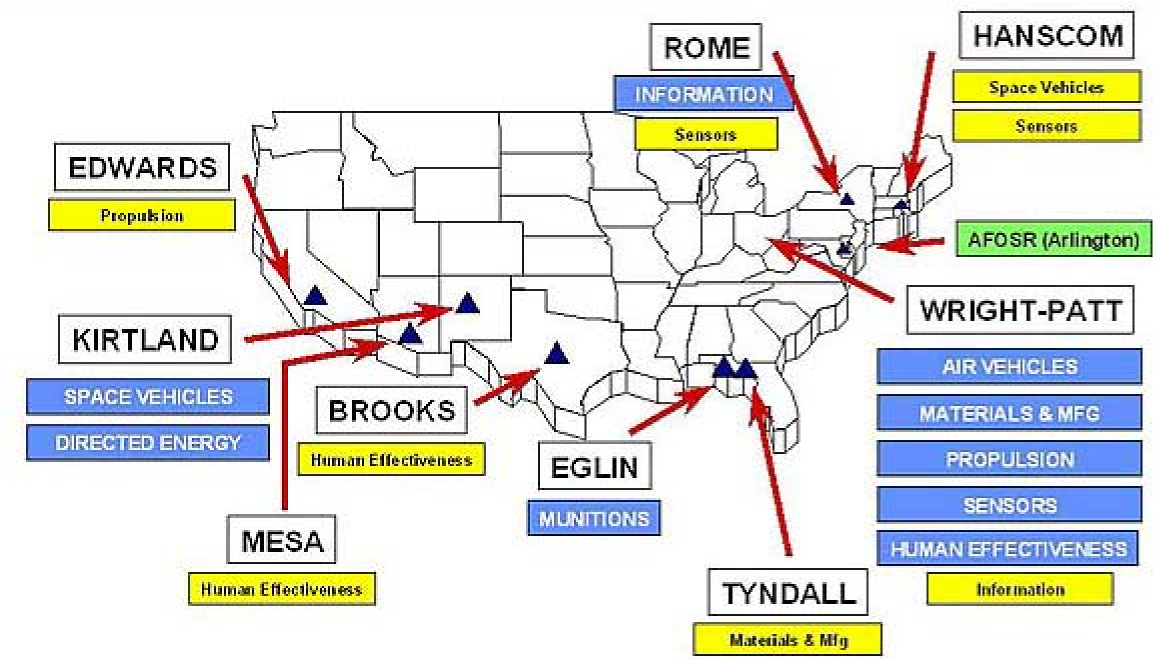
6. For questions or concerns, please contact the IRB administrator, Helen Jennings at (937) 656-5437 or helen.jennings@wpafb.af.mil OR Lt. Douglas Grafel at douglas.grafel@wpafb.af.mil or (937) 656-5431. All inquiries and correspondence concerning this protocol should include the protocol number and name of the primary investigator.

JEFFREY BIDINGER, Maj, USAF, MC, FS
Chair, AFRL/Wright Site IRB

Appendix C: Number of Reported Air Force Technology Transfer Mechanisms by Agency [6]

Lab/Center	1998	1999	2000	2001	2002	2003	Totals
Aeronautical Systems Center	6	3	4	3	3	1	20
Air Force Academy	0	0	1	0	0	0	1
Eglin Development Test Center	3	3	4	6	6	1	23
Edwards Flight Test Center	13	15	22	18	8	0	76
Air Force Institute of Technology	0	7	9	10	9	5	40
Air Force Materiel Command	72	14	11	4	4	4	109
AFRL Eglin AFB, FL	0	8	9	10	10	10	47
AFRL Kirtland AFB, NM	0	32	40	39	44	26	181
AFRL Rome Labs, NY	9	27	33	41	39	45	194
AFRL Wright-Patterson AFB	0	110	117	123	133	120	603
Air Force Weather Agency	0	0	1	1	1	0	3
Air Intelligence Agency	2	12	4	3	2	1	24
Air University Maxwell AFB, AL	0	0	2	0	0	1	3
Armstrong Lab Brooks AFB, TX	0	1	1	0	0	0	2
Arnold Engineering Devlopment Center	0	0	0	2	2	3	7
Ogden ALC Hill AFB, UT	12	6	2	4	1	0	25
Oklahoma City ALC Tinker AFB, OK	0	0	0	0	2	0	2
Phillips Lab Edwards AFB, CA	0	12	3	1	1	1	18
Rome Lab Rome, NY	0	11	8	0	0	0	19
Warner-Robbins ALC Robbins, GA	13	11	6	3	2	0	35
White Sands Missile Range, NM	1	1	1	0	0	0	3
Wright Lab Wright-Patterson AFB, OH	22	5	2	1	1	1	32
Totals	153	278	280	269	268	219	1467

Appendix D: AFRL Research Sites [3]



The Air Force Research Laboratory (AFRL) is made up of more than 9600 government people. The blue labels designate the headquarters locations for nine of the laboratory's 10 technology directorates.

These include:

- Space Vehicles (Kirtland)
- Directed Energy (Kirtland)
- Information (Rome)
- Munitions (Eglin)
- Air Vehicles (Wright-Patt)
- Materials & Manufacturing (Wright-Patt)
- Propulsion (Wright-Patt)
- Sensors (Wright-Patt)
- Human Effectiveness (Wright-Patt)

The green label designates Air Force Office of Scientific Research (AFOSR) (Arlington), the headquarters location for the laboratory's remaining technology directorate.
The white labels designate AFRL research sites (areas where one or more directorate organizations are located).

These include:

- Edwards
- Kirtland
- Mesa
- Brooks
- Eglin
- Rome
- Tyndall
- Hanscom

The yellow labels designate directorate organizations that are geographically separated from their headquarters. These include Propulsion (Edwards), Human Effectiveness (Brooks), Human Effectiveness (Mesa), Sensors (Rome), Materials & Manufacturing (Tyndall), Space Vehicles (Hanscom), Sensors (Hanscom), and Information (Wright-Patt).

Bibliography

[1] Federal Laboratory Consortium, "Federal Technology Transfer Legislation and Policy," Universal Technical Resource Services, Inc. 2002.

[2] Technology Transfer Office, "Air Force Technology Transfer: General Overview Briefing," Dayton 2006.

[3] *Air Force Technology Transfer Program* http://www.afrl.af.mil/techtran_people.asp, 2006.

[4] K. A. Kaufman and R. M. Tebelak, "Technology Transfer: A New Culture," 1994, pp. 18-22.

[5] Name Withheld, "Air Force Technology Transfer Program Manager," 2006

[6] Office of Technology Transition, "Report to Congress on the Activities of the DoD Office of Technology Transition," The Office of the Secretary of Defense, Deputy Under Secretary of Defense for Science and Technology, Office of Technology Transition, Washington D.C. 2004.

[7] Air Force Research Laboratory Technology Transfer Program Office, "The Air Force Technology Transfer Handbook," 2002.

[8] *Technology Transfer Mechanisms*, http://infohost.nmt.edu/~ttsg/mechanisms/, 2006.

[9] V. L. John, *DoD and Industry - A Healthy Alliance*, Master's Thesis, Naval Postgraduate School, 2001.

[10] Office of the Under Secretary of Defense for Acquisition Technology and Logistics, "The Commercial Operations and Support Savings Initiative (COSSI) Challenges and Solutions for Success," 2001.

[11] D. Miller, "Partnership Intermediary Agreement," *AFRL Technology Horizons*, vol. 6, pp. 12, 2005.

[12] Department of Defense, "DoD Independent Research & Development Program Report," 2002.

[13] E. M. Rogers, E. G. Carayannis, K. Kurihara, and M. M. Allbritton, "Cooperative Research and Development Agreements (CRADAs) as Technology Transfer Mechanisms," *R&D Management*, vol. 28, pp. 79, 1998.

[14] Department of Defense, "DoD Technology Transfer (T^2) Program," 1999.

[15] Government Accountability Office, "Best Practices: Stronger Practices Needed to Improve DoD Technology Transition Processes," 2006.

[16] G. Goth, "Global Technology Transfer Infrastructure is Maturing," *IEEE Software*, pp. 93-97, 2006.

[17] P. Bhawnani, G. Ruhe, F. Kudorfer, and L. Meyer, "Intelligent Decision Support for Road Mapping a Technology Transfer Case Study with Siemens Corporate Technology," *Technology Transfer*, pp. 35-40, 2006.

[18] R. Bellais and R. Guichard, "Defense Innovation, Technology Transfers and Public Policy," *Defence and Peace Economics*, vol. 17, pp. 273-286, 2006.

[19] J. J. Petrillo, "Rules on Intellectual Property Change: DoD Gets it Right," *Government Computer News*, vol. 14, pp. 60, 1995.

[20] J. W. Lee, "Improvement of Technology Transfer from Government Laboratories to Industry," in *Technology Transfer Society*, 1992.

[21] D. Reaves-Divine, "Overcoming Communication Barriers to Effective Technology Transfer," *Transportation Research Record*, pp. 1-3, 1996.

[22] M. Eto, D. Wierengo, and E. M. Rogers, "Technology Transfer from Government R&D Laboratories in the United States and Japan," 1995, pp. 671-680 vol.4.

[23] M. Larsson, A. Wall, C. Norström, and I. Crnkovic, "Technology Transfer: Why Some Succeed and Some Don't," *Technology Transfer*, pp. 23-27, 2006.

[24] J. L. Bennett, "Building Relations for Technology Transfer," *Communications of the Association for Computing Machinery*, vol. 39, pp. 35-36, 1996.

[25] D. E. Ralston and S. L. Harris, "Industry/Government Agreements Aid R&D, Technology Transfer," *American Mining Congress*, vol. 79, pp. 6-7, 1993.

[26] D. R. Trune and L. N. Goslin, "Technology Transfer - Entrepreneurship and the University," in *International Conference on Management & Technology*, Portland, OR, 1997, pp. 905-907.

[27] J. A. Anderson and E. S. Ward, "Technology Transfer: Experiences in Introducing Object-Oriented Methods to Government Projects " in *Washington Ada Symposium*, Falls Church, VA, 1991, pp. 10-15.

[28] T. Punter, R. L. Krikhaar, and R. J. Bril, "Sustainable Technology Transfer," *Technology Transfer*, pp. 15-18, 2006.

[29] M. S. Spann, M. Adams, and W. E. Souder, "Measures of Technology Transfer Effectiveness: Key Dimensions and Differences in their Use by Sponsors, Developers and Adopters," *IEEE Transactions on Engineering Management*, vol. 42, pp. 19-29, 1995.

[30] D. Dorenbos, "Aligning Technology Transfer Using Basic Business Measures," pp. 19-21, 2006.

[31] A. Pulido, I. Ruisanchez, R. Boque, and F. X. Rius, "Uncertainty of Results in Routine Qualitative Analysis," *Elsevier Science B.V.*, 2003.

[32] Air Force Medical Command, "Protection of Human Subjects in Biomedical and Behavioral Research," vol. Air Force Instruction 40-402, 2005, pp. 81.

[33] Propulsion Directorate, "Fuels Technology Engineer Interview," 2006

[34] K. McGill, W. Deadrick, J. H. Hayes, and A. Dekhtyar, "Houston, We Have a Success Story: Technology Transfer at the NASA IV&V Facility," in *Association for Computing Machinery*, 2002, pp. 49-53.

[35] Human Effectiveness Directorate, "Interview with Branch Chief " 2006

[36] T. K. Sung and D. V. Gibson, "Knowledge and Technology Transfer Grid: Empirical Assessment," *International Journal of Technology Management*, vol. 29, pp. 216-230, 2005.

[37] M. Dalziel, "Effective University-Industry Technology Transfer," Montreal, Quebec, 1994, pp. 743-746

[38] R. Kozlowski, M. Helwig, G. Zagner, E. Budny, and S. Soja, "Causes of Weakness of Technology Transfer from R&D Centres to Economy Practice and Ideas How to Make this System More Efficient," *Molecular Crystals and Liquid Crystals*, vol. 374, pp. 1-12, 2002.

[39] E. Berniker, "Models of Technology Transfer (A Dialectical Case Study)," Portland, OR, USA, 1992, pp. 499-502.

[40] Materials and Manufacturing Directorate, "Materials Engineer Interview," 2006

[41] K. Ehrlich, "Factors Influencing Technology Transfer," *Special Interest Group on Computer Human Interaction Bulletin*, vol. 17, pp. 20-24, 1985.

[42] D. Coursey and B. Bozeman, "Technology Transfer in U.S. Government and University Laboratories: Advantages and Disadvantages for Participating Laboratories," *Transactions on Engineering Management*, vol. 39, pp. 347-351, 1992.

[43] R. M. Franza and K. P. Grant, "Improving Federal to Private Sector Technology Transfer," *Research Technology Management*, vol. 49, pp. 36-40, 2006.

Vita

Captain Michael Albert Romero was born on George AFB, CA. He attended elementary school in Madrid, Spain and Wiesbaden, Germany and graduated from the American High School of Madrid in 1994. The following fall, he was accepted to attend Texas Tech University and graduated in 1999 with a Bachelor of Science in Mechanical Engineering. Simultaneously, he received his commission in the Air Force at which time he began his service as an aircraft maintenance officer. In September of 2006, he was accepted to attend the Air Force Institute of Technology and pursue a Masters of Science degree in Research & Development Management. Upon completion of his program, he will return back to the acquisition career field and be stationed at the Defense Contract Management Agency located in Ft Worth, Texas, where he will be a program manager on the F-22 Raptor program.

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14. ABSTRACT

The ability to shift knowledge and resources from federal laboratories to industrial and academic partners and vice versa is the primary reason that technology transfer (T^2) exists today. Without the cooperation of federal, state, and private agencies working together to resolve today's technology quandaries, a lot of the breakthroughs we experience today would not exist. This research was focused on uncovering which mechanisms are utilized by scientists and engineers. The research entails uncovering both official and unofficial mechanisms and ascertaining why some methods are preferred over others. It is also a secondary focus, to determine which barriers are impeding T^2 from occurring in a more fluid fashion and what lab employees are doing to overcome these obstacles. An interview methodology was utilized and interviews were conducted on all levels of personnel throughout the Air Force Research Laboratory population to identify those preferred mechanisms and the reasons associated with their use. It was discovered that official and unofficial mechanism usage is about equal, but there were organizations that did not utilize them as prevalently; this was because of a lack of total infrastructure. Infrastructure must be improved for official mechanisms while leveraging the use of those unofficial mechanisms; laboratory leadership must concentrate their efforts on eliminating barriers to allow T^2 to be done more efficiently.

15. SUBJECT TERMS

Technology Transfer, Air Force Research Laboratory (AFRL), Mechanism, Cooperative Research and Development Agreement (CRADA), Department of Defense (DoD), Federal Laboratory Consortium (FLC), Office of Research Technology Assistance (ORTA), Wright Patterson Air Force Base (WPAFB)

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