

## **CHAPTER I INTRODUCTION**

This dissertation examines the process and impact of government laboratory technology transfer. This introductory chapter provides background on government technology transfer, briefly highlighting recent trends in government technology programs. Next, it discusses the purpose of the dissertation in more detail. Then it outlines the research design, a qualitative comparative analysis of successful pre- and post-legislation cases, including the philosophical basis, methodology, and potential obstacles. Lastly, it explains the core elements involved in the government technology transfer process.

### **TECHNOLOGY TRANSFER LEGISLATION**

Government laboratories as well as corporate and university laboratories perform federally-funded research and development (R&D). Because taxpayers support this research, the federal government has gone to great lengths to make the results of this R&D publicly available. In recent times, society has experienced rapid technological progress along with a rise in the availability of scientific and technical information. As a result, research discoveries have been applied to a wide variety of commercial products.

Much of the technology transfer-related legislation of the 1980s was enacted to provide industry and other users greater access to federally-funded R&D. The following is a listing of the major legislation in this area with a brief summary of the focus:

- Stevenson-Wydler Technology Innovation Act of 1980 - Required the creation of offices within many federal laboratories to facilitate access to the laboratories.
- Bayh-Dole University and Small Business Patent Procedures Act of 1980 - Waives ownership of federally-funded R&D to not-for-profits (universities, small businesses) performing the research.
- National Cooperative Research Act of 1984 - Stipulates that antitrust criteria do not apply to consortia of companies (eg., SEMATECH) registered as such with the Justice Department.
- Federal Technology Transfer Act of 1986 - Gives federal and defense laboratory directors the right to enter into cooperative research and development agreements (CRADAs) with private parties.
- National Competitiveness Technology Transfer Act of 1989 - Gives contractor-operated national laboratories the right to enter into cooperative research.

In terms of the role of government laboratories, the key pieces of legislation occurred in 1986 and 1989 with passage of the Federal Technology Transfer Act and the National Competitiveness Technology Transfer Act.<sup>1</sup> These two laws dramatically changed the basic nature of both federal laboratories and national (contractor-operated) laboratories by encouraging cooperative research between the public and private sectors. Previous to the 1986 and 1989 acts, technology transfer from government laboratories was most often accomplished through informal collaboration and technical assistance or through the more traditional licensing fashion. It has been shown that technology transfer is most effectively accomplished, not by “passing off a baton” as in technology licensing, but by joint cooperative technology development between the laboratory providing the technology and the technology user or commercializer.

## **BRIEF BACKGROUND**

In the past two decades, three interrelated trends or series of events have profoundly affected federal science and technology, ultimately impacting government technology transfer. The first is the end of the Cold War, resulting in defense conversion and the movement toward dual use technologies. The second is globalization and the rise of the international “economic wars,” resulting in a wider understanding of how technology can contribute to improving the economy. The third is attention to the federal budget deficit at a time of increased emphasis on high-technology industrial sectors by government policies and programs, including an emphasis on public-private partnering. This resulted in partisan “budget wars” over science and technology.

### **End of the Cold War Brought Defense Conversion, Dual Use**

During the period from late 1980s to the early 1990s, the end of the Cold War unfolded. Defense conversion resulted not only in the closing of military bases and converting facilities from military to civilian purposes, but also in funding cutbacks for R&D, testing, and evaluation of defense systems by large defense contractors. As a result, the military-industrial complex is now turning towards the commercial marketplace and dual uses for its technologies,<sup>2</sup> and is teaming with many buyers and suppliers in contrast to having a single customer in the past (the Defense Department). This is contributing to a convergence of interests by a number of communities, including this military-industrial complex, academia and universities, and certain elements of the scientific community like the biomedical establishment which is ripe for commercialization.

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<sup>1</sup>The National Technology Transfer and Advancement Act of 1995 is another piece of major technology transfer legislation. However, it was not passed before the events in the cases, so it is noted only where relevant. It gives CRADA partners the right to an exclusive license to any technologies developed. It also sets a minimum royalty return for government inventors.

<sup>2</sup>U.S. Economic Development Administration, *History of Defense Conversion*, 1995.

## **Competitiveness Brought International Economic Wars**<sup>3</sup>

In terms of their contribution to the economy, high-technology sectors tend to have certain advantages over more traditional ones.<sup>4</sup> First, high-technology companies tend to conduct more R&D, which is associated with greater innovation, resulting in more new products and processes for the marketplace. Also, high-technology companies tend to pay higher wages<sup>5</sup> Therefore, high-technology industries and companies contribute more to the economy than traditional industries, and have actually become the engine driving economic growth.<sup>6</sup> This makes technology the basis for international competitiveness and for the rise in international economic “wars.”<sup>7</sup> Early-on in the 1980s, the United States’ economy was faced with Japanese and German competition, and the threat of the European single market. More recently, Pacific Rim nations have been rising to prominence in technological areas.

Consequently, government policies and programs have been putting increased emphasis on high-technology industries at the national level. And because high-technology firms tend to cluster regionally, this makes them amenable to state and local government programs and economic development.<sup>8</sup> In addition to direct subsidies to certain sectors, government incentives also include R&D tax credits, loan guarantees, and other financial measures.

On a related note, both industry and government are becoming more “global” due to communications technologies and international mobility.<sup>9</sup> Companies are exporting more to overseas countries and/or partnering with foreign firms.<sup>10</sup> Government technology programs and

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<sup>3</sup>Industrial policy is not mentioned here because, to an extent, “competitiveness” is the politically-correct way of referring to “industrial policy” which is not regarded highly by those in the corporate world and certain political parties.

<sup>4</sup>Until the 1990s, technology was thought to cause unemployment as new technologies displace workers. Lately, this view has been replaced. See National Research Council et al. *Conflict and Cooperation in National Competition for High-Technology Industry*, Washington, DC: National Academy Press, 1996, pp. 33-35.

<sup>5</sup>U.S. Department of Commerce, Economics and Statistics Administration.

<sup>6</sup>One-third to 49 percent of economic growth and productivity is technology-based, according to the White House Office of Science and Technology Policy and the Commerce Department.

<sup>7</sup>Economic Strategy Institute.

<sup>8</sup>Annalee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge, Massachusetts: Harvard University Press, 1994. See also Michael Porter, *Competitive Advantage of Nations*, Cambridge: Harvard University Business Press, 1992.

<sup>9</sup>Council of Academies of Engineering and Technological Sciences, *Globalization of Technology: International Perspectives*, Washington, DC: National Academy Press, 1988.

<sup>10</sup>National Academy of Engineering, *National Interests in an Age of Global Technology: Prospering in a*

policies are now interrelated with globally-oriented measures such as trade and investment practices, international patent regimes, international industry standards certification, and international environmental regulations and standards.<sup>11</sup> In addition, with the high cost of big science projects, nations are co-funding these projects with other nations where possible. Examples are the international space station and the major particle physics facility in Switzerland known as CERN.<sup>12</sup>

### **Budget Wars Caused Science/Technology Dichotomy**

In order to understand the issues underlying the budget problems related to science and technology, it is important to understand the longer-term historical context and more details on the recent government programs. The build-up of the nation's R&D infrastructure was first proposed by Presidential Science Advisor Vannevar Bush in the mid-1940s.<sup>13</sup> The post World War II period became known for "big science" characterized by mega-projects like the space missions and many others. During this 50-year era, the science community was well-endowed.

The big science era came to an end in the late 1980s and early 1990s with the growing attention to the federal budget deficit and its effect on the economy in the long run. At this time, in terms of the budget, science began being treated differently from technology. Federal funding for fundamental science began to decrease,<sup>14</sup> particularly funds for large expensive facilities conducting basic research. For example, the superconducting supercollider in Texas was abandoned. At the same time that federal funding for basic science was decreasing, federal funding for technology programs increased. This includes (1) industry consortia, (2) technology development funds, and (3) technical assistance programs.

The technology funding trend began with the creation of R&D consortia allowed by the 1984 National Cooperative Research Act. In addition to anti-trust exemptions for joint R&D, several of these private-sector consortia were heavily funded by the U.S. Department of Defense, including SEMATECH and Microelectronics Computer Corporation (MCC), both located in Austin, Texas.

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*Global Economy*, Washington, DC: National Academy Press, 1991.

<sup>11</sup>National Research Council et al, *Conflict and Cooperation in National Competition for High-Technology Industry*, Washington, DC: National Academy Press, 1996.

<sup>12</sup>European Laboratory for Particle Physics.

<sup>13</sup>Vannevar Bush, *Science: The Endless Frontier*, 1945.

<sup>14</sup>R&D funding reached its lowest levels in FY1995, although funding for the National Science Foundation remained steady. As this dissertation is being completed, Congress is considering increasing R&D budgets again.

The government also has several new high-visibility government technology funding programs with cooperative research as their underlying theme. They are high-visibility because they involve large amounts (multi-millions, and in some cases, billions of dollars) of government funding. For example, the 1991 American Technology Preeminence Act established the Advanced Technology Program (ATP) during the Bush Administration, which has since been expanded by President Clinton. ATP supports “pre-competitive” technologies, and has recently focused on specific technology areas. As another example, President Clinton’s DOD Technology Reinvestment Project (TRP) was enacted by the 1992 Defense Conversion, Reinvestment and Transition Assistance Act. Although this program was subsequently killed by a new Republican Congress, it was replaced by a Dual Use Applications program. Another example is the Partnership for a New Generation Vehicle program for fostering new technologies in the automobile industry, a collaborative project between the big three auto makers. Both of the latter two programs have encouraged public-private teaming and interagency co-sponsorship.

Companies are also partnering with the federal government through cooperative R&D and other direct technology transfer activities with government laboratories. By entering into such agreements with laboratories, companies gain new technologies and intellectual property, thereby leveraging their resources to better compete in both domestic and global markets.

Another area of cooperation on technology programs has involved federal-state cooperation. Several decades ago, only a small percentage of the larger states had some form of technology development programs. Now all fifty states have not only technology funding programs, but also well-funded technology-based economic development and technical assistance programs that are often regionally-oriented within states.<sup>15</sup> These state programs are often partially or jointly funded by the federal government. For example, the Manufacturing Extension Partnership now has hundreds of sites across the country supported by a combination of federal, state and local funding, and corporate fees. Like the ATP program, this program was created during the Bush Administration (as the Manufacturing Technologies Centers program by 1989 legislation<sup>16</sup>) and vastly expanded by the first Clinton Administration.

In the 1990s, support for federal technology programs erupted into a highly-partisan political battle between the new Democratic Administration and new Republican Congress. Funding for basic research was pitted against funding for the industry R&D consortia, technology

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<sup>15</sup>See, for example, *State Funding for Cooperative Technology Programs*, State Science and Technology Institute, June 1996, Columbus, Ohio; Christopher Coburn and Dan Berglund, editors, *Partnerships: A Compendium of State and Federal Cooperative Technology Programs*, Columbus, Ohio: Battelle Memorial Institute, 1995; Paul B. Phelps and Paul R. Brockman, *Science and Technology Programs in the States*, Alexandria, Virginia: Advanced Development Distribution, Inc., February 1992; Marianne K. Clarke and Eric N. Dobson, *Increasing the Competitiveness of America’s Manufacturers: A Review of Industrial Extension Programs*, Washington, DC: National Governors’ Association, 1991; Charles Bartsch, *Enhancing Competitiveness: Selected State Technology Transfer Initiatives*, Washington, DC: Northeast-Midwest Institute, January 1994.

<sup>16</sup>The 1989 Authorization Act for the National Institute of Standards and Technology.

development programs, and technical assistance programs. This caused the programs in these areas to become controversial and contributed to a strong call for program evaluation at the same time that program evaluation was becoming more important government-wide.

So, the encouragement of government technology transfer is one policy area among a variety of interrelated policy and program areas. This will become more apparent in this dissertation as the topics of funding and financial incentives, dual use, state economic development programs, and others are addressed in the context of technology transfer. The broad context for technology programs is discussed in more detail in Chapter II.

## **DISSERTATION PURPOSE**

This dissertation most directly relates to the effects of the federal technology transfer legislation. In enacting key legislation in 1986 and 1989, Congress presumed that federal technology transfer activities would benefit the economy in the long run by creating new spinoff companies, jobs, products, and other beneficial outcomes. Lawmakers also assumed the legislation would impact government laboratory activities, resulting in, for example, an increase in the number of public-private cooperative R&D agreements. It is important to measure these resulting outcomes in order to understand the impact of the legislation.

This dissertation secondarily examines the process of technology transfer and how it is implemented by the laboratory personnel. For example, in earlier decades, government-funded science and technology were viewed as “public goods” not to be promoted for private gain. The problem is that the private sector won’t become involved in many forms of technology transfer unless there is some economic benefit to be gained via private rights to the technology. Thus, there is a “catch 22” inherent to public sector technology transfer, and government personnel have been struggling to adjust to the new paradigm for public action in this area. This is illustrated by the fact that agencies and laboratories at first responded weakly to implementing the technology transfer laws.<sup>17</sup>

One aspect of this study is to provide an understanding of technology transfer from the perspective of bench scientists and researchers in the government laboratories, as well as their industry counterparts. In this sense, the study enhances our level of understanding from the actor’s frame of reference. This approach works to uncover powerful social forces operating within the laboratories (powerful in the sense of information sharing). This effect, in turn, works to create a dynamic for action.

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<sup>17</sup>Only laboratories that had active Federal Laboratory Consortium representatives implemented the provisions of the act early-on; few agencies bothered issuing regulations for implementing that act. It was not until the 1986 amendment to the act that agencies started to pay attention to technology transfer, yet the regulations for the 1986 law were also slow in coming. This is documented in various reports described in Chapter II.

The findings point out the policy implications in terms of the need for new or different lenses to evaluate government technology transfer. For example, what sort of time frame is required for technology transfer and commercialization? Particular emphasis is placed on policy recommendations or perspectives proffered by the scientists and industry partners directly involved with technology transfer, so that these recommendations can serve as a point of comparison -- if distinct -- from existing policies.

The dissertation findings also point to factors that are relevant for agencies in evaluating government technology transfer. Some federal agencies have established data collection guidelines and evaluation methodologies, yet there are still many questions related to the line of study on evaluation.

## **RESEARCH DESIGN INVOLVED QUALITATIVE SURVEY**

Methodologically, this dissertation involves a survey research approach to perform a qualitative comparative analysis of two time frames. In order to examine government technology transfer from two time periods, interviews were conducted with award-winning laboratory scientists and industry partners who successfully transferred technology in the mid-1980s (pre-enactment). The responses were compared to those involving similarly successful transfers in the early 1990s (post-enactment).

### **Philosophical Basis - Fourth Generation Evaluation**

The epistemological framework for this dissertation is based upon Guba and Lincoln's concept of "fourth generation evaluation."<sup>18</sup> Fourth generation-type evaluations are very different from traditional evaluations based upon scientific methods which employ random samples, objective survey instruments and controlled settings, and cause-effect relationships. The problem, according to Guba and Lincoln, is that the "value-free" approach associated with scientific methodologies is logically inconsistent with evaluation's goal of making value judgments. The following are some key features of a fourth generation evaluation:

- Fourth generation evaluations involve a more subjectively-based view in that the stakeholders' views are the basis for exploring needed information, as opposed to traditional before-the-fact postulates.
- With fourth generation evaluation, qualitative methods such as case studies are preferred over quantitative methods because they are more adaptable in dealing with complex multiple realities (versus generalizations) and with exploratory discovery.

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<sup>18</sup>Egon G. Guba and Yvonna S. Lincoln, *Fourth Generation Evaluation*, Newbury Park, California: Sage Publications, Inc., 1989.

- The sampling procedures used in fourth generation evaluations differ from conventional research samples which provide statistical representativeness and randomness. Qualitative sampling is “purposive” because it expands information such as by sampling extreme cases, deviant cases, typical cases, critical cases, politically-important cases, or sensitive cases. In this study, the sample of cases were all successful award-winning cases.
- With qualitative research, the criterion used to determine when to stop sampling is informational redundancy, not a pre-determined statistical significance or confidence level. The research design “unfolds” as data is collected and as the analysis proceeds, and there is continuous interplay between data collection and analysis. Therefore, the data collection instrument must be adaptable and flexible, as opposed to controlled, because information from early analyses is used to structure the data collection that follows. This “emergent design” process continues until a consensus appears.
- The data analysis techniques used are inductive rather than deductive. Deductive analysis involves reaching a conclusion through reasoning, and shows whether cause-effect statements were true or whether initial conditions were met. Inductive analysis involves deriving general principles from actual facts or cases and, in this study, the cases were assembled without a preconceived notion of how the results would turn out. The findings evolved as the research progressed.

### **Implementation Framework - Case Survey Method**

While Guba and Lincoln’s concept of fourth generation evaluation is used as the underlying philosophical framework for the methodology of this dissertation, case-study-expert Robert Yin’s<sup>19</sup> approach to analyzing evidence is used as the underlying framework for implementing the methodology. This study uses Yin’s “qualitative case survey approach”<sup>20</sup> to examine government laboratory technology transfer. This approach involves analyzing a number of cases by applying the same survey instrument to each case. The answers are tallied and analyzed in the same way as those of a regular survey.”<sup>21</sup> This dissertation is an example of the desirable situation<sup>22</sup> in which multiple individual cases are developed as part of the same study, whereas most case survey research expands upon existing cases which represent the “literature” of numerous unrelated studies.

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<sup>19</sup>Robert K. Yin, *Case Study Research: Design and Methods*, 2nd edition, Newbury Park, California: Sage Publications, Inc., 1994.

<sup>20</sup>Yin, 1994.

<sup>21</sup>Ibid, p. 124.

<sup>22</sup>Ibid.



## **Level I Analysis - The Sample**

The cases for this study are drawn from a listing of awards and nomination sheets on actual technology transfers compiled by the Federal Laboratory Consortium for Technology Transfer (FLC). The FLC, a Congressionally-created network of federal and national laboratory technology transfer officials, has held an annual awards program since 1984. As part of its overall awards program, the FLC Special Awards for Excellence in Technology Transfer recognize laboratory scientists and teams of researchers in government laboratories (as opposed to laboratory technology transfer officials) who did outstanding work in transferring technology. About 20 to 30 such “special awards” are presented each year, totaling 333 awards from 1984 until 1996.

The award criteria are three-fold: uncommon creativity and initiative must be demonstrated in the transfer of technology; the benefits to industry or state and local government must be significant; and, the achievements must be recent. The laboratories nominate individuals and teams of individuals for the FLC Special Awards. The nominations are judged by a panel of technology transfer experts, including representatives from industry, state and local government, academia, and the laboratories.

## **Level II Analysis - Time Frame Delineation**

The FLC cases identified for this study spanned two different time frames. The two years chosen to represent the pre-legislation period were 1985 and 1986; the two years chosen to represent the post-legislation period were 1992 and 1993. A total of fifty FLC Awards of Excellence were made in the 1985/1986 period (21 in 1985, and 29 in 1986). A total of 57 awards were made by the FLC in the 1992/1993 period (29 in 1992, and 28 in 1993).

Of those 107 awards from pre-legislation and post-legislation times, a subset of awards was chosen for further information gathering through in-depth telephone interviews. The subset was derived from a series of cases updated by the FLC in 1993. Based upon updated information from the laboratories, the FLC created one-page summaries for its 1994 publication, *Winners in Technology Transfer: Success Stories from the Federal Laboratory Consortium*.<sup>23</sup> For the identified pre-legislation and post-legislation periods, there were a total of 25 cases in the “Winners” document; eight of those were from 1985-86, and 17 were from 1992-93.

Exhibit A illustrates the three levels of analysis used in this dissertation and indicates the time frames and number of cases at each level.

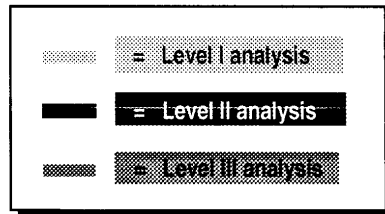
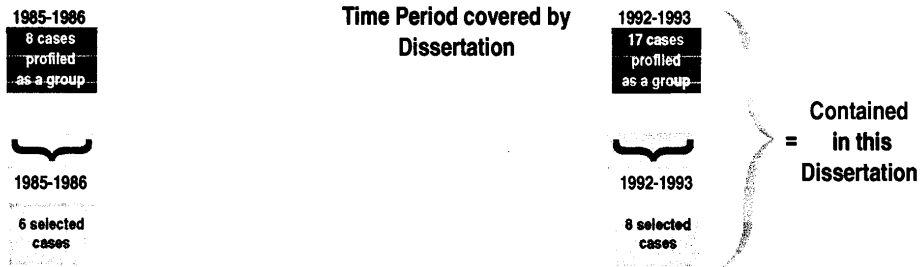
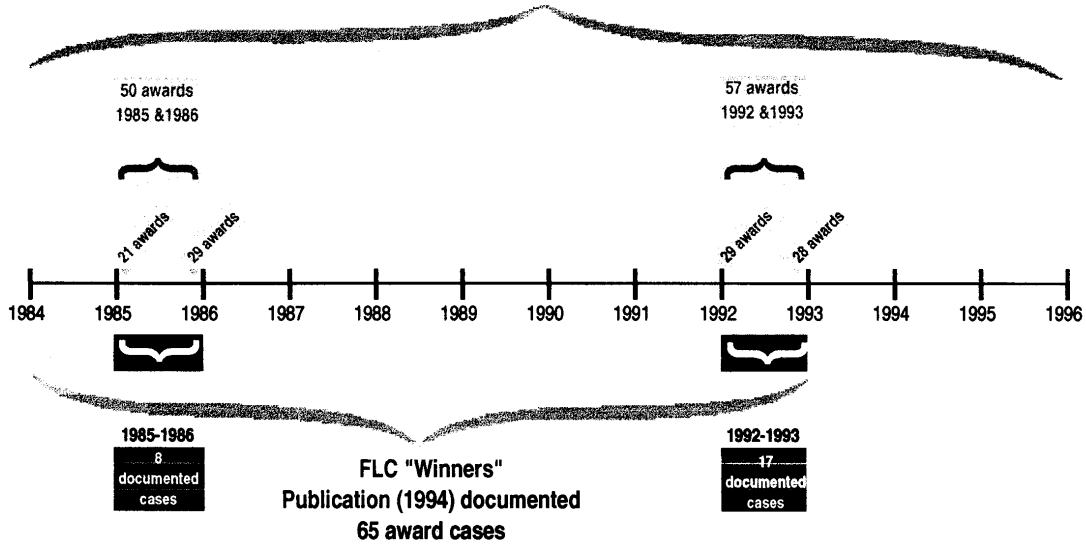
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<sup>23</sup>The “Winners” document contained a total of 65 cases (of the total awards) covering the years 1984 through 1993.

# Exhibit A

## Levels I, II, III Analyses

FLC Awards Program - 333 awards  
1984 through 1996



The information contained in the 25 one-page cases in the Winners document were analyzed from the perspective of the interview questions (see Appendix A). Briefly, the topics of the questions were:

- Role of the Laboratory Researchers and Other Personnel
- Technology and Applications
- University Involvement
- Funding, Financing
- Intellectual Property
- Technology Transfer Mechanisms
- User Groups
- Barriers to Commercialization
- Other Factors
- User Benefits/Economic Impact/Outcomes
- International Activity
- Government Gains
- Economic Development, Technical Assistance
- Elapsed Time

Background on the laboratories is also included in the cases, as compiled from available materials on the laboratories.<sup>24</sup> The one-page cases in the Winners document did not go into a level of detail that provided answers to all of the topics; regardless, the information was only current up to 1993.

### **Level III Analysis - Case Development**

In preparing for the interviews, since the FLC award nomination forms did not necessarily contain phone numbers, a first step was to locate the laboratory contacts. A variety of sources were used to determine the telephone numbers, addresses, and other contact information.<sup>25</sup> With some cases, it was necessary to go through the laboratory technology transfer office for which a phone number was more readily available through the FLC. Other sources of information for locating the interviewees included:

- National Technical Information Service's "Directory of Federal Laboratory and Technology Resources: A Guide to Services, Facilities, and Expertise" (5th Edition);

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<sup>24</sup>Several publications describing the laboratories are listed in the next subhead.

<sup>25</sup>Contact information other than telephone numbers were obtained or verified because in a couple of cases, the sources wanted to review the pieces of information so they were sent copies.

- individual agency telephone books and technology transfer office listings, such as “Technology Transfer 1994: U.S. Department of Energy”; and,
- six FLC-sponsored regional directories of laboratories, as follows: “Federal Laboratory Consortium for Technology Transfer Far West Region Directory,” “Federal Laboratory Consortium Mid-Continent Region Directory: A Guide to Technology Transfer Resources,” “Federal Laboratory Consortium for Technology Transfer Northeast Region Directory,” “Industry Guide to Federal Laboratories in the Mid-Atlantic Region,” “Technology Resources: Federal Laboratory Consortium Midwest Region.”

Once the laboratory scientist was contacted, that individual provided leads to the outside sources in companies or universities. As noted, information about each laboratory was also gathered in conjunction with this step.

Telephone interviews with the laboratory awardees and industry personnel updated and expanded upon the data in the original FLC nomination forms, and filled in missing information (see Level III Analysis on Exhibit A). The interviews covered a variety of dimensions and factors related to technology transfer, and the interviewees were asked a number of open-ended questions about their work related to receiving the FLC award. The complete list of interview questions is shown in Appendix A.

At this point in the research, ethnographic interviewing techniques outlined by James Spradley<sup>26</sup> were employed. Ethnographic interviewing differs from other types of interviewing or from ordinary conversations in that the researcher/interviewer slowly introduces new elements to assist the interviewee. Spradley says that ethnographic interviewing is one strategy for getting people to talk about what they know. The point is to avoid having the interview seem like a formal interrogation so that rapport is not achieved. For example, the interviewees were asked whether they were aware of any benefits to the users resulting from the technology being developed and transferred. If there was a pause in response to this question, some options were suggested like, “. . . product sales, or jobs created or saved?”

A list of the individuals interviewed is contained in Appendix C. Some forty people, or an average of two to three people per case, were interviewed over five months. This necessitated over 85 calls out (to locate sources and interview them) and countless returned calls, averaging 30 to 45 minutes per interview, and in some cases an hour or more. Callbacks tended to be longer because the calls were at their convenience. A ledger of names, telephone numbers, fax numbers, and email addresses was used to track calls out, dates, availability, and other data.

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<sup>26</sup>James P. Spradley, *The Ethnographic Interview*, Ft. Worth, Texas: Harcourt Brace Jovanovich College Publishers, 1979. See also, Norman K. Denzin, *Interpretive Ethnography: Ethnographic Practices for the 21st Century*, Newbury Park, California: Sage Publications, Inc., 1996.

Due to the inherent nature of ethnographic interviewing, the analytical technique for this research involved content analysis of the interview notes organized by interview questions. Summary notes were constructed after each interview so that the data and emerging themes could be analyzed throughout the research process.<sup>27</sup> This way, themes emerged cumulatively as the interviews unfolded. Glaser and Strauss<sup>28</sup> call this a “constant comparison technique,” where the researcher identifies differences between the groups of cases, and trends within the groups, as the cases proceed. This way, each interview could be re-tailored appropriately as the trends emerged. “Saturation” occurred after six to eight interviews for each of the two-year time periods. Saturation refers to that point in data collection where “nothing new” emerges in terms of data, patterns, and themes.<sup>29</sup>

Once the private partners were located, as it turns out, their information did not always correlate with the basic information provided by the federal laboratories up front (nomination forms, etc). In some of the cases, the information conflicted simply because the information gained directly from the partners was more up to date. Similarly, information contained in government databases was incomplete or not up to date. In some of the cases, the private partner had a different perspective from what was included on the laboratory’s nomination form. This made it apparent, for example, that in conducting a technology transfer impact study, one must go directly to the outside user as the source for information.

## **ADDRESSING, OVERCOMING RESEARCH OBSTACLES**

As with any such study, obstacles cropped up while the research was being conducted, but they were addressed and overcome.

### **Implementing Fourth Generation Evaluations Using Software**

The first challenge with this study was the sheer difficulty in implementing a fourth generation-type evaluation. Guba and Lincoln’s comments on conducting this type of research are as follows:

“It may be a difficult and cumbersome process, and may take much longer than we are accustomed to thinking evaluations should take. More resources may be required. But in

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<sup>27</sup>Miles and Huberman call this documentation “contact summary sheets” because they contain the rich narrative answers to each question posed to the “field contacts.” Matthew B. Miles and A. Michael Huberman, *Qualitative Data Analysis: An Expanded Sourcebook*, 2nd edition, Newbury Park, California: Sage Publications, Inc., 1994.

<sup>28</sup>Barney G. Glaser and Anselm L. Strauss, *The Discovery of Grounded Theory*, Chicago, Illinois: Aldine, 1967.

<sup>29</sup>Glaser and Strauss, 1967; this is comparable to what Guba and Lincoln refer to as “consensus.”

the end, it works . . .”<sup>30</sup>

Keeping track of the interview notes and accumulated documents for the study was a major undertaking.<sup>31</sup> Organizing the data traditionally involved manual cutting and pasting which is time-consuming and cumbersome. Therefore, a computerized software package<sup>32</sup> was used so more time and attention could be devoted to the interpretive aspects of the analysis. The software allowed creation of a document system whereby text was stored, and words and phrases were automatically indexed. Information about the cases, as well as emerging thoughts (in the form of “memos”), were organized according to a “tree-like” structure via the software.

### **Making Contact with Laboratory Researchers, Companies**

A second obstacle was that the interview process hinged largely on the availability of the original laboratory researchers and industry partners. Some of these people moved on to new jobs and had to be tracked down. Fortunately, many of the cases involved teams of researchers, making it possible to locate at least one person involved in each laboratory transfer.

Most everybody contacted was helpful and willing to cooperate. There were no refusals to cooperate. However, a certain level of trust and respect had to be built with the interviewees, so they would be willing to open up and share their information. Many were eager to talk about their technology before too many questions were asked, and in many cases, it turned out that most of the questions were answered before being asked.

At least two laboratory attitudes toward their company partners surfaced. One was protective, and the other encouraged outside interaction. In certain cases, the laboratory response depended upon the type of company involved. For example, one case involved a workers’ cooperative building customized machines with a reputation for ultra-high quality and detail. Until a level of trust was developed through several interviews, the laboratory wanted to serve as the intermediary in providing information from the company. In another case, on the other hand, the laboratory researchers recommended that a new company executive be interviewed so he could have his chance at doing some marketing.

Contacts with the private sector were more difficult to make than those with the government personnel. Sometimes, smaller companies had been bought out by larger companies.

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<sup>30</sup>Guba and Lincoln, pp. 226, 227.

<sup>31</sup>In addition to papers and descriptive brochures, the laboratory researchers and company partners even forwarded laboratory and product samples.

<sup>32</sup>Qualitative Solutions and Research Pty, Ltd., *QSR NUD-IST: Non-numerical Unstructured Data Indexing Searching and Theorizing*, Version 3.0, Newbury Park, California: Scolari, Software Division of Sage Publications, Inc., 1996. Also useful in this effort was: Eben A. Weitzman and Matthew B. Miles, *Computer Programs for Qualitative Data Analysis: A Software Sourcebook*, Newbury Park, California: Sage Publications, Inc., 1995.

Where larger companies had changed hands, it was particularly difficult to track down company personnel. Not everybody contacted was still associated with the technology being tracked.

### **Addressing Questions of Validity, Reliability With Consistency, Redundancy**

As with any research methodology, the chosen method had advantages as well as limitations with regard to validity and reliability.<sup>33</sup> For example, bias is inherent to any study that uses inductive analytical techniques, and uses interviews as the primary data source. Since bias was purposefully built into the methodology, there was no attempt to eliminate it, but rather to keep it consistent. To address this, the interviews were largely transcribed verbatim.

In addition, a process called triangulation was used. Triangulation involves multiple data collection methods to study the same thing. The multiple methods included: (1) a review of the legislation, Congressional testimony, regulations, agency documents, policy reports, background studies, and scholarly papers, and (2) compilation and analysis of the case survey interviews. Step one provided an in-depth understanding of the underlying philosophies and assumptions on a government-wide and agency-by-agency basis. The Literature Review chapter brings together the policy studies and other materials, and subsequent chapters present the cases. The cases are factual descriptions, but they show the complexity of the relationships among the actors involved in technology transfer activities. They also capture the “contexts, emotions, and webs of relationships” described by Denzin<sup>34</sup> and show how technology transfer is accomplished in a real-life context.<sup>35</sup>

### **Maintaining Survey Instrument Confidence, Adaptability**

An early issue related to ensuring a reasonable amount of confidence in the survey instrument. It was impossible to predict what would come from the one-on-one interviews, so the use of a questionnaire was intended to provide structure to guide them (see Appendix A). It was difficult to develop an interview questionnaire that was comprehensive, yet also adjustable enough to fit the adaptable research format. Therefore, the questionnaire was tested and refined throughout the study. Questions were tailored for each interview, depending upon what other information had already been gathered. Also, the use of “probe” questions promoted flexibility in data collection. Even more probe-type questions became apparent as the interviews proceeded. When it appeared that a case could be analyzed in terms of additional dimensions, then those factors were integrated.

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<sup>33</sup>Inter-researcher reliability was not a problem, because there was only one researcher (see Yin, 1994).

<sup>34</sup>Norman K. Denzin and Yvonna S. Lincoln, editors, *Handbook of Qualitative Research*, Thousand Oaks, California: Sage Publications, Inc., 1994.

<sup>35</sup>Yin, 1994.

**Generalizing to “Award-Winning” Situations**

Finally, the generalizability of research findings is an issue regularly debated by scientists, and the issue can become complicated because there are different types and levels of generalizations. For example, this study’s findings only relate to the award-winning series of cases analyzed. It is not assumed that the findings are generalizable to all conceivable technology transfer situations because it is possible that a series of non-award-winning cases might generate entirely different findings.<sup>36</sup>

Table A summarizes the sources of each aspect of the dissertation research design: epistemological framework, methodology, data collection and analysis techniques, and software. The next section provides activity-level background for understanding this study. It presents the core elements of the government technology transfer process.

**TABLE A  
RESEARCH DESIGN SOURCES**

	<b>Primary Basis</b>	<b>Secondary Basis</b>
<b>Epistemological Framework</b>	Guba and Lincoln (1989)	Miles and Huberman (1994)
<b>Methodology</b>	Yin (1994)	Denzin and Lincoln (1994)
<b>Data Collection and Analysis*</b>	Spradley (1979) Denzin (1996)	Glaser and Strauss (1967) Guba and Lincoln (1989)

\*Software: QSR NUD-IST 3.0 (1996)

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<sup>36</sup>However, it is conceivable that another sample of successful cases could be generated from the same FLC master database of over 300 cases identified since 1984, making the sample logically replicable (if one were using traditional scientific methods).



## GOVERNMENT TECHNOLOGY TRANSFER PROCESS - CORE ELEMENTS

This section defines the topics and key words used in this dissertation. Terms useful for understanding the background appear first, followed by terms related to the interview topics (Appendix A). For self-explanatory terms and topics, background information is provided to explain the “lenses” used in collecting the data.

### Introduction

The first definitions will be useful for understanding the literature review and broad context presented in the next chapter.

### **Government Laboratory**

In this dissertation, the phrase “government laboratory” refers to the spectrum of federal (not state) government laboratories -- both civilian and defense -- including DOE’s national laboratories, NASA’s field centers, and the military services’ R&D laboratories. Most of these are government-owned and government-operated, with the exception of the national laboratories which are often contractor-operated. Some laboratories have been transferring technologies since the early 1900s, although not under the auspices of the 1980 and 1986 legislation discussed in this dissertation. For example, the Department of Commerce’s National Institute of Standards and Technology (NIST) has been working with industry since 1905. The Department of Agriculture’s (USDA) centers have been disseminating technologies to outside users since 1914. Today, some 700 federal laboratories and research centers from a variety of departments and agencies across the country, with approximately 100,000 researchers, perform \$24 billion in R&D each year.<sup>37</sup>

### **Research and Development**

The National Science Foundation uses the following definitions for basic and applied research and development (R&D):<sup>38</sup>

**Basic research** is for gaining an understanding of the subject under study.

**Applied research** is aimed at gaining knowledge to determine the means by which a specific recognized need may be met.

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<sup>37</sup>National Technology Transfer Center estimates.

<sup>38</sup>National Science Board, *Science and Engineering Indicators - 1993*, Washington, D.C.: U.S. Government Printing Office, NSB 93-1, 1993.

**Development** is the systematic use of the knowledge gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

## **Technology Transfer**

The Federal Laboratory Consortium for Technology Transfer defines federal technology transfer as “the process by which existing knowledge, facilities or capabilities developed under federal R&D are utilized to fulfill public or private domestic needs.”<sup>39</sup>

## **Interview Topics**

The remaining key words and definitions germane to this study relate to the interview topics listed earlier in this chapter. They are discussed further in the paragraphs below.

## **Roles of Laboratory Researchers and Other Personnel**

Government scientists perform everything from basic and applied research to technology and prototype development, including experiments and test and evaluation work of all kinds. There are many types of prototypes with varying degrees of sophistication, ranging from laboratory prototypes and pre-production prototypes to commercially-oriented production prototypes developed by outside engineering groups. Laboratory scientists conduct experiments and demonstrations for a variety of purposes, such as to determine feasibility or proof-of-concept or for technology marketing.

The laboratory technology transfer staff serves as a point of contact for outside users, thereby acting as a buffer for the laboratory researchers if necessary. The laboratory technology transfer function is generically called an “office of research and technology applications” (ORTA) by the 1980 Stevenson-Wydler Technology Innovation Act which mandated creation of such an office or function.

Technology transfer is a responsibility of both laboratory technology transfer officers and researchers,<sup>40</sup> so both researchers and technology transfer personnel perform technology marketing. In the literature, this role of “technology champion” has proven to be an important success factor in technology transfer. Technology transfer is often described as being a “body contact” sport, and it is generally acknowledged that effective technology transfer requires good communication skills. Proactive marketing includes packaging the technology, and planning and

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<sup>39</sup>As noted, the Federal Laboratory Consortium is a Congressional-institutionalized organization of U.S. government laboratory technology transfer offices.

<sup>40</sup>The 1986 Federal Technology Transfer Act makes this clear, and points out that it is consistent with laboratory missions.

implementing marketing strategies such as demonstrations or technology transfer conferences. Somewhat more passive approaches may include, for example, making technology-related databases available for access. Laboratory efforts to promote technologies to outside users are commonly referred to as “technology push.” User-initiated interest in a technology is often referred to as “market pull.”

Other than legislation and formal incentives, other factors influencing technology transfer success include laboratory-level aspects such as laboratory mission statements, management support, promotion criteria, informal culture, awards, and other forms of acknowledgment. These factors vary from laboratory to laboratory. Government laboratories run by maintenance and operation contractors have both for-profit and not-for-profit operators, so internal policies vary accordingly. Similarly, there is no overarching, federally-mandated conflict-of-interest policy that applies to all the laboratories across the board so those laboratory policies also vary. For example, at some laboratories, the researchers may leave their jobs to start new businesses without losing some of their government benefits. Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratories are two laboratories with “entrepreneurial” leave-of-absence policies.<sup>41</sup>

## **Technologies and Applications**

The cases cover a variety of technology areas because a wide range of highly-visible technologies have originated from government laboratories. Examples include: penicillin (from a Department of Agriculture center), global positioning and night vision (from Defense laboratories), and insulin and the hepatitis vaccine (from the National Institutes of Health). Products that are often mistakenly attributed to federal laboratories include Tang, Teflon and velcro. The technologies that went into these products actually emanated from university and corporate laboratories and from independent inventors.

In terms of the applications process, some technologies gradually become more sophisticated and eventually result in improved commercial products or processes; or, the technologies slowly branch out and spread from one application area to another. These are known as incremental improvements or applications. Other technologies develop within one discipline, and are then suddenly applied to an entirely different area. These are known as revolutionary applications.

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<sup>41</sup>Sandia’s policy allows researchers to leave up to two years to form companies or help existing companies apply laboratory-developed technology. PNNL allows its staff to leave up to three years or work part-time and still receive medical, dental and other benefits; they can access PNNL or Battelle technologies for commercialization purposes, and enter into agreements to use laboratory equipment to further develop technologies. See Pacific Northwest National Laboratory, *Exploring Entrepreneurial Frontiers: The First Year*, 1997.

## University Involvement

Government laboratories partner with universities for technology transfer purposes, just as they do with companies. For example, universities can be CRADA partners, or they can team with laboratories under the Small Business Technology Transfer (STTR) program. While the 1980 Stevenson-Wydler Act made technology transfer a mission of the federal laboratories, the comparable legislation for universities is the 1980 Bayh-Dole University and Small Business Patent and Trademark Amendments Act. This law gives universities and small businesses title to inventions they produce using federal funds. So, 1980 was the first time that universities or federal laboratories could profit commercially by licensing their technologies. It wasn't until 1986 (and passage of the Federal Technology Transfer Act) that GOGO laboratories could manage their inventions as universities do, or until 1989 for GOCO laboratories. Consequently, government laboratories are generally said to be about ten years behind universities in terms of related management and cultural changes.

## Funding, Financing

Government technology transfer activities enabled by the legislation do not involve the exchange of government funds. In government laboratories, the technology transfer office is funded as a percentage of each laboratory's budget (per the Stevenson-Wydler Act). Each laboratory is allowed to keep its share of license revenues after sharing with the laboratory inventor(s).<sup>42</sup> For example, Lawrence Livermore National Laboratory, with an annual budget of about \$1 billion, brought in about \$1 million in revenues from licensing royalties in one recent year. It is generally up to each laboratory director as to how licensing income is used. Regarding CRADAs, companies often contribute funds and the laboratories do not. Many federal agencies require company funds in order to implement CRADAs. Most agencies support laboratory CRADA activities through existing programs.

**Special Technology Transfer Funds:** The only other source of funding for laboratory technology transfer activities has involved "special" agency funding. In 1991, Congress created two funds for DOE CRADAs called the "Technology Transfer Initiative" -- one fund for the DOE defense program laboratories and the other for the DOE civilian laboratories. However, this special funding was drastically cut back when the new Republican Congress came in a couple of years later. For example, at the program's peak, the University of California system, which operates various DOE laboratories, signed 185 CRADAs worth \$218 million in 1994. In 1995, only 22 new CRADAs were signed by the same university operating contractor. In 1997, only \$59 million in special funding was available for DOE defense laboratory CRADAs, and there were no special funds for the DOE civilian laboratories. Certain DOE headquarters programs now provide some CRADA support, but these programs are very restrictive. For example, the civilian part of DOE funds only high-risk CRADAs at five specific laboratories in three technology areas: intelligent manufacturing, tailored materials, and sustainable

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<sup>42</sup>License revenues used to be distributed back into the U.S. Treasury.

environments.

**Follow-on Funding:** R&D and technology transfer comprise only a small part of the total cost associated with bringing a technology to market. Ramping up to full-scale production (including manufacturing prototype development, scale-up engineering, pilot plant implementation, and product testing and marketing) involves an investment of money, time, and personnel by the partnering company. A rule-of-thumb indicates commercialization costs five to ten times as much as the transferring laboratory's investment in the initial technology, or roughly \$5 to \$15 million per project. Therefore, follow-on funding or financing is usually needed by laboratory partners. Undercapitalization is a particular problem with small-firm partners.

Other than in-house corporate funds, additional sources of support include private venture and angel capital, government funding programs, and dedicated laboratory venture capital. Trends in the mid-1990s indicate the availability of more private venture capital funds and somewhat more early-stage seed capital. With venture financing, a company is generally expected to come up with a product within a couple of years. The Small Business Innovation Research (SBIR) program, implemented by eleven government agencies,<sup>43</sup> has been a competitively-bid source of R&D funding for small firms since the early 1980s.<sup>44</sup> The Small Business Technology Transfer (STTR) program was established ten years later, and is being implemented by five agencies. It is devoted to cooperative R&D projects between small firms and either universities, GOCO laboratories, or non-profit research institutions such as a Federally-Funded R&D Centers (FFRDCs). Several government laboratory contracting operators have initiated dedicated non-profit venture capital funds for their laboratories. Examples are ARCH Development Corporation established by the University of Chicago for Argonne National Laboratory, and Technology Ventures started by Lockheed Martin for Sandia National Laboratories.

## **Intellectual Property<sup>45</sup>**

Intellectual property rights for technologies most commonly involve patents, but they also involve trade secrets, trademarks, and copyrights.<sup>46</sup>

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<sup>43</sup>With SBIR-funded projects, government patents can be transferred (or title waived), the same as the government does for university and small firms contractors under the Bayh-Dole Act.

<sup>44</sup>By the 1982 Small Business Innovation Development Act.

<sup>45</sup>For more details on technology transfer procedures and mechanisms, see *Mining the Nation's Brain Trust: How to Put Federally-Funded Research to Work For You*, by Fred E. Grissom, Jr. and Richard L. Chapman, Reading, Massachusetts: Addison-Wesley Publishing Company, Inc., 1992.

<sup>46</sup>Patents are protected by federal laws; trade secrets are protected by state laws.

Researchers publicly disclose their inventions by formally submitting invention disclosures to their laboratories, publishing articles, and similar means. Inventions are protected in the United States for a year after disclosure. That is, once an article is published, the researcher still has a year-long grace period when a patent can be filed with the U.S. Patent and Trademark Office (PTO) without losing the opportunity. Beating the deadline for filing a patent application is now a more exact timing issue with the advent of real-time publishing on the world wide web.

Theoretically, each year, more invention disclosures are filed than patent applications. Similarly, more patents are filed each year than licenses are signed. Technology licenses are often, but not always, based upon patents.<sup>47</sup> For example, in 1995, DOE's Sandia National Laboratories received 275 invention disclosures from its researchers, filed 100 patent applications, and issued 40 licenses.<sup>48</sup>

The patent application process involves patent searches of prior art and the preparation of application papers by attorneys which can be a complex and costly process. The cost of applying for a patent with PTO varies by the type of patent (utility, design, etc.) and form of organization (e.g., there is a "small entity" fee category). Once the patent is granted, there is a recording fee, issue fee, and recurring maintenance fees. The fees for a basic utility patent total from about \$8,000 to as much as \$40,000 for the term of the patent. In the biomedical field, one of the most complex in terms of intellectual property issues, the average total cost of a patent can be as high as \$100,000 or more.

Until recently, patents provided seventeen years of protection from the date of issue. The 1985 General Agreement on Trade and Tariffs (GATT) and the 1986 North American Free Trade Agreement (NAFTA) changed the U.S. patent system. Patents now provide twenty years of protection from the date of filing. The GATT and NAFTA agreements also offered the new option of filing a "provisional" patent application, a low-cost (\$150) informal way to establish a patent filing date for a year.

PTO recently simplified its patent filing procedures and shortened the patent-pending period.<sup>49</sup> This is in spite of the fact that patent applications have been increasing over time. Federal agencies are pursuing patents more aggressively, as exhibited by the expansion of patent and legal support personnel, for one thing.<sup>50</sup>

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<sup>47</sup>In 1995, PTO granted 1,867 patents to the U.S. government.

<sup>48</sup>As a matter of interest, this can be compared to 129 invention disclosures, sixteen patent applications, and only two licenses just four years earlier at the same laboratory [presentation by Kevin W. Bieg, Sandia National Laboratories, Association of Federal Technology Transfer Executives Winter Conference, March 2, 1995].

<sup>49</sup>Regardless of PTO's streamlining effort, there are still problems with the system in certain overloaded technical areas (like genetic patenting).

<sup>50</sup>For example, the Agricultural Research Service system of more than a hundred laboratories and centers

It is not unusual for non-agency personnel (eg., graduate researchers, post-doctoral fellows, contractors, or Intergovernmental Personnel Act assignments) to be involved in government laboratory research. In these situations, the university personnel are entitled to their portion of any intellectual property they help to create.<sup>51</sup>

Any company claiming rights in a product name may use the “TM” (trademark) designation with that name on the package to alert the public to the claim and exclude others from its use. It is not necessary for the name to be registered with PTO in order to use it; however, when the name is registered with PTO, the “R” (registered) designation is used.<sup>52</sup>

GOCO laboratories often have different intellectual property and technology transfer procedures than GOGO laboratories. For example, GOCO laboratories can copyright software and other written material because the copyright is in the name of the operating contractor. Federal employees cannot copyright their work. Similarly, with GOCOs, license agreements are signed with the contractor rather than with the government laboratory it is operating. Most of the DOE laboratories are GOCO laboratories, which explains why the 1989 law was passed (in order to apply provisions of the 1986 law to the DOE system).

### **Technology Transfer Mechanisms**

The Interagency Technology Transfer Committee’s Working Group on Measurement and Evaluation<sup>53</sup> identified the major “technology transfer mechanisms” as: collegial interchange, cooperative R&D, exchange programs, licensing, reimbursable work, technical assistance, and use of facilities. Other mechanisms for transferring technology include standards-setting, procurement contracts, and cooperative research agreements. Various types of demonstrations and prototypes are sometimes viewed as technology transfer mechanisms when they serve a marketing purpose. Other mechanisms used less commonly include consulting to a laboratory, consulting by laboratory personnel, cost-shared contracts, educational grants and awards, and informal mentor-protégé relationships. Some consider technology funding programs as technology transfer mechanisms (such as the SBIR program, STTR program, or Defense-funded dual use programs). Also, certain agencies use special mechanisms unique to them (e.g., the

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grew from a couple of patent advisors to seven patent advisors and five technology transfer coordinators marketing a portfolio of over 800 technology patents.

<sup>51</sup>If the “outside” individual elects to exercise their rights rather than assigning them over to the government, the individual’s organization (eg., the university) may agree to file the patent on the individual’s behalf so that the technology is owned 50-50 with the government. The individual does not even have to allow their organization or “agent” to receive a portion of their half of any royalty revenues.

<sup>52</sup>Filing a trademark application with PTO costs \$245.

<sup>53</sup>This working group met for about three years in the late 1980s and early 1990s, and ultimately produced *Collective Reporting and Common Measures: Draft for Comment* in November 1994. The Interagency Committee and its working groups have been largely defunct during the Clinton Administration.

National Institutes of Health's Clinical Trial Agreements). The more common mechanisms are explained in more detail below.

**Collegial interchange** involves free and informal exchange of information among colleagues or through publications.<sup>54</sup> Journals and databases work to document and/or archive an R&D project's findings. In addition to publications, this category includes workshops and conferences, preparation and distribution of other written materials, and computerized databases and bulletin boards.

**Cooperative R&D agreements**, referred to as "CRADAs," also include NASA's similar Space Act Agreements. CRADAs allow joint laboratory-industry research to be conducted at the laboratories while minimizing the possibility of conflicts of interest for the laboratory personnel.

**Exchange programs** involve the exchange of technical personnel or equipment between government laboratories and universities or industry laboratories.

**Technology licenses** are usually royalty-bearing. That is, when a government technology is licensed by a commercial firm, the company pays the government an up-front fee and running royalty based upon product sales. There is usually a minimum annual royalty stream requirement, as well as a requirement for the licensee to submit a development or marketing plan, milestone dates, and projected sales in order to ensure commercial success.

Laboratory inventors receive the first \$2,000 and at least fifteen percent of royalties per year (with an annual cap of \$150,000), according to the 1995 National Technology Transfer and Advancement Act. Since DOE is taking the position that the 1995 law doesn't apply to its contractor-operated laboratories, they have different minimums<sup>55</sup>

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<sup>54</sup>Working with government technologies, classified information causes special challenges with regard to technology transfer. As of two years ago, about 6,000 U.S. invention disclosures (some dating from the 1940s) remained under government secrecy orders. This prohibits their discussion or publication and prevents their conversion into patents, all of which discourages technology transfer. Any related papers are "sanitized" and therefore are of lower quality and usefulness, and the technologies discussed are often less advanced. See Dr. David C. Sayles, "Anticipated Barriers Confronting the Implementation of Technology Transfer," *Technology Transfer Partnerships Proceedings, 19th Annual Meeting - June 22-24, 1994, Huntsville, Alabama*, Kenneth E. Harwell, Kathy Wagner, Carl Ziemke, editors, Technology Transfer Society, 1994.

<sup>55</sup>For example, through Battelle, Pacific Northwest National Laboratory's "Recognition and Reward" program provides: (1) a \$300 cash award on the issuance of a U.S. patent, for software development, or for development of trademarked material, and a \$500 cash award for receipt of a national award like an FLC award or "R&D 100" award; and (2) a cash award of \$100 to \$1,000 based upon the (up-front) license transaction fee, and ten percent of the gross royalty revenue stream up to \$1 million over time. Also, Battelle can take equity ownership on behalf of PNNL (government laboratories can't do this). In these cases, transactions involves stock or partnership shares (2.5 percent, up to \$1 million).



Licenses are generally negotiated based upon patents, but they can also be based upon other legal mechanisms such as trade secrets<sup>56</sup> or can include software which may be patented or copyrighted.<sup>57</sup> It is not uncommon for a technology license to integrate multiple patents or patent applications. Technology licenses are often limited to particular fields of use or geographical areas. Furthermore, they can be exclusive,<sup>58</sup> partially exclusive, non-exclusive, or co-exclusive.

Licensing can be considered as a stand-alone mechanism or in conjunction with a CRADA. The 1995 National Technology Transfer and Advancement Act guarantees exclusive licenses to CRADA partners in applicable fields of use. Although the principles of any licensing provisions are pre-negotiated along with CRADA negotiation, once a CRADA-related patent is filed, a laboratory has a year to complete the licensing before the technology is available to other potential licensees. In other words, the act gives company partners rights to their own inventions resulting from a CRADA along with the option to exclusively license the laboratory's portion of rights. All of this is intended to expedite CRADA negotiations. Before now, a typical license took one year to make it through laboratory/industry negotiations, and CRADA approval sometimes took even longer.

**Reimbursable work** is assistance provided to non-federal partners and outside users performed under the auspices of a laboratory. An example is the U.S. Department of Energy's "Work for Others" program.

**Technical assistance**, such as via telephone calls or face-to-face visits, is more informal and short-term than reimbursable work. Isolated statistics show that the laboratories are doing more non-reimbursed technical assistance than in the past. For example, Sandia National Laboratories provided some 300 instances of technical assistance to small businesses in 1995, up from sixteen instances in 1991.

**Laboratory user facilities** or scientific user facilities are those unique and often large-scale machines in laboratories available to industry for a fee. The availability of these facilities is touted as a technology transfer mechanism and marketed by laboratories housing these types of facilities (many DOE laboratories are in this category). With user facility agreements, the outside party comes to the laboratory.

## User Groups

Technology users can be found in industry, academia, government, or even other countries. In other words, they are generally outside the developing laboratory. Users may

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<sup>56</sup>Unpatented "knowledge-based" or "proprietary" technologies are generally treated as trade secrets.

<sup>57</sup>Federal agencies cannot copyright, but they can patent software. Software protection is not an issue at contractor-operated laboratories because the contractors can copyright or patent software.

<sup>58</sup>Intent to grant an exclusive license must be published in the *Federal Register*.

represent large businesses, small<sup>59</sup> and minority-owned firms, universities, state and local agencies, other federal laboratories and programs, or foreign-owned businesses.

Technology users become laboratory partners once a technology transfer agreement is signed. Agreements can be implemented through a variety of configurations: individual users and companies, consortia of companies performing collaborative R&D,<sup>60</sup> joint ventures, universities, research foundations, private technology management groups, trade associations reflecting industrial sectors, or other configurations. In the case of other government users, agreements can be arranged on an inter-agency or multi-agency basis.

### **Barriers to Commercialization**

The interview question dealing with “Barriers” does not lend itself to up-front definitions because it is desirable to have actual barriers evolve from the interview discussions. However, as an example it can be stated that an obstructive management culture is often cited in the literature as a major obstacle to transferring technologies. For instance, in the military laboratories, officers sometimes inaccurately associate technology transfer with the security breach of exporting technologies to overseas enemies. Also, the DOD and DOE weapons laboratories have been described as having a structured, seniority-oriented, “follow the rules” mentality, which stifles innovation and is a product of their weapons era culture.

### **Other Factors**

This topic also does not lend itself to up-front definitions because it is intended to serve as a catch-all category. However, examples can be cited because there are some miscellaneous unresolved issues related to government technology transfer. For one thing, government laboratories are viewed by some as competing with the private sector, rather than helping it.<sup>61</sup> Another unresolved technology transfer issue is whether to require a preference for partners that are U.S.-owned or -based.<sup>62</sup>

### **User Benefits/Economic Impact/Outcomes**

User benefits and outcomes are considered to be broader than economic impact measures. Outcomes are “the longer-term results to which a program contributes, like military

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<sup>59</sup>The Small Business Administration defines a small firm as having 500 or fewer employees.

<sup>60</sup>The 1984 National Cooperative Research Act allows firms to perform joint research without breaking anti-trust laws; later amendments allow firms to perform certain types of joint production, as well.

<sup>61</sup>One of the reasons behind the creation of CRADAs was to avoid such conflicts of interest and competition with the private sector.

<sup>62</sup>At present, each agency has its own definition/interpretation of a “U.S. corporation.”

effectiveness or environmental improvement.”<sup>63</sup> For example, in the case of a Defense-oriented technology, “outcomes” could include: breadth and criticality of military applications, cost savings achieved through dual-use approaches, increases in DOD use of commercial technologies, impact of spinoffs on defense costs, or preservation of defense industrial base, skills, processes and facilities. Impacts are “the total consequences of [a] program, including both intended benefits and unintended positive and negative results”<sup>64</sup> (see “Government Gains,” below).

Traditionally, government laboratories have measured the success of their R&D projects in terms of technical performance, schedule and cost, while aiming for “better, faster and cheaper” results. With technology transfer projects, laboratories measure themselves in terms of the above criteria, plus their contribution to the economy and return on the taxpayers’ investment. For example, DOE and its laboratories generally evaluate technology transfer performance according to four measurement categories:

- (1) overall performance measures - involves counting the number of: CRADAs, patent licenses, royalties, new products (and processes), start-up businesses, and workers hired or trained.
- (2) value to the government - involves measuring the amount of economic stimulation, U.S. competitiveness, jobs and business, sales and exports, and leveraged research.
- (3) customer satisfaction - ascertains a partner’s level of satisfaction with the technology program or technical assistance, measured through repeat business, referral partnerships, favorable feedback, and support for technology transfer.
- (4) medical and environmental benefits.

Other agencies may measure additional indicators such as the amount of private capital leveraged or other outside investments and grants made in a transferred technology.

Measuring industry impact was more difficult for agencies before 1989 because partnering companies were leery of providing company sales and cost data due to the Freedom of Information Act (FOIA). However, the 1989 National Competitiveness Technology Transfer Act requires that CRADA-related information (such as partnering company names, and confidential and proprietary company information) must be protected from disclosure under FOIA stipulations for up to five years.

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<sup>63</sup>Ibid.

<sup>64</sup>Susan E. Cozzens, *Evaluation of Fundamental Research Programs: A Review of the Issues*, A Report on Discussions in the Practitioners’ Working Group on Research Evaluation, August 15, 1994.

The term “metrics” is often informally used to refer to general measurement and evaluation. Formally, however, it refers to “standards of measurement that rely on counts of discrete entities to infer levels of accomplishment; e.g., improved health status, increased production, bibliometrics (publications and references), or degrees awarded.”<sup>65</sup>

## **International Activity**

When an agency chooses not to file for a patent in another country, the option is open to the laboratory inventor to do so on his or her own. The 1986 Federal Technology Transfer Act automatically grants inventors foreign rights if their agency didn’t file within six months after the patent application. However, in 1996, the U.S. Department of Commerce issued an interim rule so that inventors must now wait eight months rather than six, and can only foreign file under certain conditions. The proposed provisions are intended to bring foreign rights into closer conformity with the domestic rights, but the final rule is still being worked out.<sup>66</sup>

As noted earlier, technology licenses can be limited according to geographical areas covered (eg., United States, another country, worldwide).

## **Government Gains**

Government gains are anticipated or unanticipated. Unanticipated government gains are also referred to as “spinbacks.” Dual use technology, an anticipated government gain, is intentionally developed for military or federal use but also planned to have civilian uses (or the reverse, where defense is the secondary use). Defense conversion, often confused with dual use, involves reductions in resources committed to national security and redirecting those resources to other purposes.

## **Economic Development, Technical Assistance**

Business assistance services are provided by state or local economic development agencies, university-based organizations, and even government laboratory-based organizations. The Commerce Clearinghouse on State and Local Productivity, Technology and Innovation<sup>67</sup> categorized business assistance services as: feasibility studies, market development, finance, location, business planning, patent searches, database searching, training, technical/engineering consulting and testing, legal services, and accounting.

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<sup>65</sup>Office of Science and Technology Policy, National Science and Technology Council, Committee on Fundamental Science, Subcommittee on Research, *Assessing Fundamental Science*, Washington, D.C. July 1996.

<sup>66</sup>Also, the GATT and NAFTA agreements produced changes to the U.S. patent system whereby U.S. inventors do not have certain advantages and filing privileges over foreign inventors that they previously had.

<sup>67</sup>The Commerce Clearinghouse is now defunct and other organizations are fulfilling this role.

## **Elapsed Time**

In the commercial world, who develops a technology first is not as important as who makes it to the market first. An early window of market penetration can mean the gain or loss of millions of dollars to a company because when competing products hit the market, the first-to-market firm does not necessarily maintain its market share. The issue of timing becomes even more crucial when a new product is based upon technology transferred from a government laboratory, which may involve taking the time to get a license negotiated or CRADA approved.

## **SUMMARY AND DISSERTATION ORGANIZATION**

This chapter highlighted the technology transfer legislation, purpose of this study, methodology, and core elements involved in technology transfer.

This dissertation is divided into six chapters. The next chapter, Chapter II, examines the broader context for technology transfer, paralleling the historical backdrop and recent trends briefly highlighted in this introductory chapter: defense conversion, international competitiveness, and attention to the budget deficit. Chapter II also explains how this study relates to existing studies in this area. Chapters III and IV discuss the pre-legislation (1980s) and post-legislation (1990s) cases, respectively. Chapter V presents the findings of the comparative analysis. Chapter VI provides a summary and conclusions.