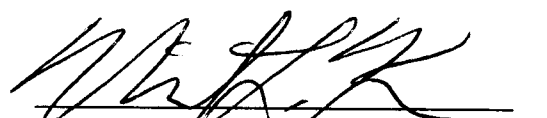
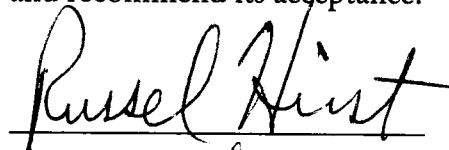
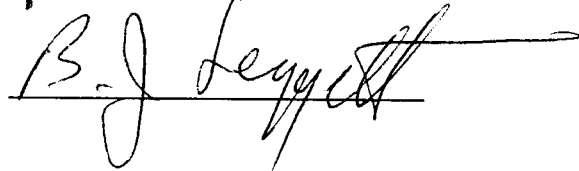


To the Graduate Council:

I am submitting herewith a thesis written by Christina G. Orr Tolliver entitled "The Process of Technology Transfer from the Perspective of Technical Communication." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in English.


Michael L. Keene, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:


Associate Vice Chancellor and
Dean of the Graduate School

the process of

Technology Transfer

from the perspective of
technical communication

A Thesis Presented for the
Master of Arts Degree
The University of Tennessee, Knoxville

Christina G. Orr Tolliver
December 1996

Dedication

This thesis is dedicated to the greatest communicator of all—Jesus Christ. He is the one in whom I live, move, exist...and write.

And to my husband Bob. Because of him, my life is truly blessed and deeply happy.

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If I have been a good student, it is because of my dad who is himself...always in school. If I have been a committed, hard-working student, it is because of my mother who taught me that all work is worthwhile.

Finally, I want to thank my husband whose encouragement steeled me to the task again and again and who played, with love and sincerity, the less than glamorous roles of gopher and editor as I finished this thesis.

Abstract

Technology transfer is defined in this thesis as a process aimed at moving technology developed with federal funds to the private, commercial sector. The main argument of this thesis is that technology transfer is, at heart, a *communicative* process.

Part One examines the background for technology transfer, paying particular attention to the influence of the Cold War and economics on technology transfer legislation. Part Two takes a look at the principal players in technology transfer: universities, industries, and federal laboratories. Part Three concentrates on the need for cooperation among participants for successful transfers. Part Four approaches the topic of technology transfer from a communication perspective and examines the role of technical communicators in the technology transfer process.

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Introduction

Technology transfer is defined in this thesis as a communicative process aimed at moving technology developed with federal funds to the private, commercial sector. Interest in technology transfer and its effects on the US economy has been steadily increasing since the early 1980s. The basic idea behind this interest is that federal labs could be doing more to strengthen the nation's competitive position in the global, high-tech marketplace. Many also feel that, as the demand for defense-related research decreases, federal labs should prove they are viable investments of taxpayers' money by contributing directly to commercial, high-tech research and development.

Legislators have endorsed this "return on investment" view of technology transfer by enacting several pieces of legislation to mandate and regulate the transfer of technologies from the federal laboratory system. Much of the literature on technology transfer is devoted to examining this body of legislation and its effects on technology transfer efforts in the US.

An important theme found in the literature on technology transfer is the need for cooperation among the federal labs, universities, and industries to achieve successful transfers. As the literature points out, cooperative efforts bring together groups whose goals and values are disparate, if not conflicting, requiring tremendous commitment and effort on the parts of all involved to be successful.

Of particular interest for technical communicators is the the examination of technology transfer as a communicative process. As many point out, the communication necessary to successful transfers is often hindered by “gaps” which exist among transfer participants. The literature emphasizes the need for those gaps to be filled in or “spanned.”

The final section of this thesis looks at ways in which the writing process often reveals differences among transfer participants and then provides a way for those differences to be resolved. Attention is also given to the role that technical communicators can play in spanning rhetorical gaps among transfer participants and to technology transfer as a career field for technical communicators.

Part One: Economics and Technology Transfer Legislation

The driving factor in the creation of technology transfer legislation has been economic need (Spann, Adams, and Souder 63; Winebrake 54). This economic need was caused, to a large extent, by an emphasis on defense-related research and transfer, to the neglect of commercially relevant technology transfer after World War II in the US. Ironically, it was in part the contribution the scientific community made to the Allied victory in World War II that gave rise to an economic environment that fostered a national concentration on defense rather than on the marketplace.

Beginnings of a Relationship

The history of the relationship that exists now among the federal government, the university, and the federal lab research programs has its roots in the Second World War. It was the contribution the scientific community made to the war effort, especially the atomic bomb, that linked high-tech research in the US to defense efforts. Before discussing these events, however, we should take a look at the pre-World War setting for scientific research in the US.

Matkin writes that universities in the US began to supplement traditional liberal arts education with scientific research programs based on the German model in the early 1900s. Funding for this research was supplied primarily by private individuals or foundations, but industries and the federal government also made contributions. The most significant contribution the government made in this era came in the form of the Morrill Act of 1862. This Act gave land to universities on the condition that the state preserve "at least one college where the leading object shall be, without excluding other scientific and classical studies...to teach such branches of learning as are related to agriculture and the mechanic arts" (17). The establishment of these "land-grant" institutions led to the forming of a network of strong research universities across the US.

Research universities continued to grow in strength, wealth, and numbers through and beyond WWII. It was during this time, however, that the federal government recognized the benefits of scientific research to its defense efforts and became the major source of research funding, both for universities and for the federal laboratories, which had their inception in the making of the atomic bomb. Matkin points out that, before the War, "the federal government continued to confine its research support to a few narrow and applied fields, and there was no clear national

or federal science policy” (19). After the War, however, the beginning of the relationship which exists now between the federal government and research in the US was marked by the advent of “a clearly articulated federal science policy and the establishment of a number of government agencies whose task was to allocate research funds” (20). This strong, interdependent relationship between the federal government and public research institutions has helped give rise to what we know today as “the defense industry.”

End of the Cold War

After the Allies won World War II, the US took upon itself the calling and task of world peace and safety through the spread of democracy and the containment of communism. In economic terms, the threat of communism created a demand in a large part of the world for protection. The US aggressively sought to meet this demand—by acting as a promoter of peace, a pro-active advocate of democracy, and a formidable deterrent to the spread of communism. Because of its wealth and military power and sophistication, the US was in a position to play the role of “world police” as no other country could.

Acting as a world police and meeting the demand for global protection from communism fueled the economy in the US while the government both funded defense research in academic, private, and federal laboratories and then bought the products of that research. Federal defense spending became one of the pillars that supported the economy in the US. And because this was where the money was, research efforts were focused on defense, to the neglect of research that would benefit other consumers and sell in other types of markets. With the fall of the Berlin Wall in 1989 and the subsequent collapse of the Soviet government, however, the US found itself without a market for its vast supply of military products and research.

Several authors writing about technology transfer in the US have commented on the detrimental effect the end of the Cold War had on the economy of a nation whose research industry was not organized or prepared to compete in the global market. Shama notes that “Historically, the mission of the Department of Energy’s laboratories...centered on deterring threats to US national security. National resources committed to this mission included more than \$10-billion and 53,000 employees” (18). Shama subscribes to the generally held understanding that, although the demand for some economic benefit from the nation’s investment in its

labs had been steadily growing, it has greatly increased since the end of the Cold War because national security is no longer perceived as being at risk.

Effect of Cold War Policies on the Economy

A group of students from the Johnson Graduate School of Management at Cornell University have written that economic and research policies developed with the intent of containing communism have had a negative impact on the economy. They point not only to long-term problems created by the tendency of research programs in the US to neglect non-military, market-oriented areas of research but also to the fact that the US often sought to ensure its position as world leader by strengthening the economy of its trading partners: "...the US encouraged the rapid economic development of its trading partners, including its wartime adversaries Germany and Japan. It did so (and continues to do so) at the expense of its domestic economy" (58).

Another policy that has prevented industries from benefitting from federal research is that of keeping almost all defense-related research classified. Mendelsohn and Carr

have both argued that keeping research information secret hinders technology transfer and high-tech growth in the US because it prevents others from making use of that research for commercial purposes (Mendelsohn 80; Carr "Part 1" 18).

Mendelsohn says,

The goals of strengthening national security and the U.S. economic and technological position can frequently conflict with one another. This is because growth requires...free exchange of scientific and technical information among governmental, academic, and industrial research centers and free and competitive domestic and international trade in high technology...while security requires restrictions on trade and information exchange.

Carr predicts a relaxing of "national security criteria for evaluating new technologies in order to commercialize some previously classified technologies to enhance national competitiveness" ("Part 1" 18). Godkin also notes that the classification of technological information has hindered technology transfer (593).

Loss of Competitiveness

There is no question that the US no longer holds the position of the most technologically advanced nation. And other countries, especially Japan, have a firmer hold on the high-tech market (Mendelsohn 83-84). In addition to the fact that the US companies cannot offer consumers the kind of technology at the price that many Japanese companies are able to, the US also faces what Carr has called "a serious deterioration in the US trade balance" ("Part 1" 8). These two factors together are hurting the US economy.

Matkin notes that

attention began to be drawn to technology transfer and its potential for boosting the economy in the 1970s when it began to be apparent that, although the US still led in basic research, other countries were more adept at developing commercially viable technological products.

(20-21)

As awareness of this situation has continued to increase, and as the situation itself has worsened, so has pressure increased on federal labs and universities to help US

industries regain a competitive position through high-tech research and development.

Return on Investment

Besides competitiveness, another idea that has prompted more and more demanding technology transfer legislation is that federally-sponsored research is an investment made by taxpayers that should reap them significant returns. Legislators who take this view promote legislation that requires federally-funded research labs to focus on the high-tech market and not only on defense research. Carr describes the return on investment perspective of federal lab technology transfer when he says, "...there is a widespread perception in industry and government that the nation is not realizing an adequate return from the substantial investment in the federal-laboratory system" ("Part 1" 8).

Sink and Easley take a different tack on the subject of return on investment. Their argument is based on an article written in 1984 by Dr. Leon Lederman, Director Emeritus of the Fermi National Accelerator Laboratory and Nobel laureate. His

article, as they interpret it, claims basic research is “inherently beneficial” to society, though they admit that these inherent benefits are difficult to quantify. According to this argument, American society and its legislators should be willing to make investments in basic research without expecting to see quick or clearly identifiable returns.

It seems that Dr. Lederman’s comparison of basic research to the fine arts, as described in Sink and Easley, is an apt one because, although basic research may be beneficial to our society, if those benefits are not somehow made to seem immediate and obvious, they will not be taken into account when budgets are drawn up and spending cuts are made. Basic research may suffer from the same type of funding reductions that are being experienced in fine arts departments in universities and in public television and radio.

Technology Transfer Legislation

The 1980s saw a marked interest in the effect that technology transfer, specifically from federal labs to private industries, could have on the economy. During this

decade, Congress passed several legislative acts that aimed to increase technology transfer in the US. These pieces of legislation show a progression of demand for technology transfer, where the first few legislative acts could be characterized as incentive-based and the last few as outright mandates (Papadakis 54-55). The two most significant technology transfer acts of the 1980s are the Stevenson-Wydler and the Federal Technology Transfer Acts.

The Stevenson-Wydler Act of 1980 was the first piece of technology transfer legislation to be passed. It called for federal labs to make more concerted efforts to find industrial partners and commercial applications for their technologies (Larson 3). Although this act has been criticized as “toothless” because it was unfunded (Rahm, Bozeman, and Crow 970-971; Sink and Easley 55), it nevertheless brought technology transfer to the attention of the legislature, federal labs, and the public (Bozeman and Fellows 65).

The Federal Technology Transfer Act of 1986 amended the Stevenson-Wydler Act, formalizing the Federal Laboratory Consortium for Technology Transfer and granting government-owned and -operated labs the right to enter into contractual research agreements (CRADAs—Cooperative Research and Development

Agreements) with private industries. These rights were later extended to all federal labs. CRADAs now form a major part of the technology transfer efforts of labs such as Oak Ridge National Laboratory.

Question of Effectiveness

The most important question we can ask about legislative policy concerning technology transfer in the US is "Has it been effective?" Most authors who attempt to answer this question have concluded that policies have fallen short of the mark in some way or another.

Papadakis has found the legislation to be in conflict with itself: "policy expectations of commercial impacts are inconsistent with policy requirements that labs conduct precommercial basic and applied research" (Papadakis 54). Rahm, Bozeman, and Crow have criticized technology transfer legislation for what they see as its glossing over of major differences among the many different federal research agencies.

Roessner and Bean, on the other hand, conducted a survey of “210 U.S.-based firms that were members of the Industrial Research Institute in 1988” and found that these firms had “a surprisingly high level of awareness of, and interaction with, the 600 [sic] U.S. national laboratories” (22). They suggest that the technology transfer legislation of the 1980s has been successful. Their study, however, measures success by how much interaction industries have with federal labs, as though interaction alone implies that technology has been transferred in a way that definitely benefits industries and the economy.

Part Two: Three Players in Technology Transfer

There are three principal players associated with technology transfer: universities, industries, and federal labs. This section will take a look at who these players are and what they contribute to technology transfer efforts in the US. This division of technology transfer efforts into its three contributors could be somewhat misleading if it were not also taken into account that much work in this area is accomplished as a result of collaborations between two or three of these players. Collaborations come in many forms, such as research parks, research and development contracts, and consortiums. These alliances will be further examined at the end of this section.

Universities

Several writers have noted that high technology growth in any given region is closely connected to the presence of a strong research university in that area (Bass 125; Wigand 133, 135). In addition to helping foster the growth of high technology, universities also make significant contributions to technology transfer efforts in the US. Carr finds that industries are more comfortable working in collaboration with

university researchers than with those in federal labs, and that universities like Stanford and MIT, which employ a marketing model of technology transfer, are generally more successful than federal labs (“Part 1” 21).

Who are they?

Matkin’s book *Technology Transfer and the University* (1990), based on a study of the history of university technology transfer and of four major research universities in the US, is a good source of information on universities and the role they play in technology transfer. Matkin devotes a section of his introduction to defining “the American research university” as those “100 universities having the largest volume of research funding” (9).

What role do they play in technology transfer?

First and foremost, universities contribute a foundation of basic research upon which other, more specific research efforts can be based in the future. Many universities also conduct applied research, but it is basic research that makes up the

bulk of university work. Most of the funding for university research comes from the government. The amount of that support, however, is declining, while industry support is increasing (Matkin 9).

Once basic and/or applied research has been performed, researchers make the results available to industries and to other researchers by writing it up in journal articles or by patenting it. These two activities have different audiences and purposes: journal publications are directed at an audience of other (most likely academic) researchers, whereas patenting aims at an industrial audience. Researchers who patent their work do so in hopes that it will be picked up and eventually commercialized by industries.

There are several definite ways in which university patenting can contribute to technology transfer efforts. First of all, the patent process makes the results of research available for commercial development. Second, the selling of a patent to a particular company can open up a continuing relationship between the university and industrial communities that can lead to further technology transfers (Matkin 114). Third, the royalty income from the successful licensing and commercialization of a technology can support further research efforts in the parent institution.

Other ways universities contribute to technology transfer are training industry professionals, providing networking opportunities in their classes, supplying the industrial workforce with trained graduates, and sponsoring collaborative technology transfer efforts (Stewart and Gibson 114-115); providing and maintaining computer networks (Williams and Brackenridge 177-178); offering continuing education programs; and providing faculty consultation services through technical assistance programs (Matkin 237, 245). The foregoing are ways in which universities can contribute to the technology transfer process, but it is a fact that many universities do not make concerted efforts in this area.

In her survey of the literature, Godkin finds that while relationships between an industry and the appropriate department(s) of a university are beneficial to that industry, the universities themselves do not generally use sophisticated technology transfer mechanisms and tend to have only weak ties to industries (590). Rahm, Bozeman, and Crow's "empirical assessment" of university laboratories reveals that 72 percent of university labs are involved in basic research, 62 percent are involved in applied research, 23 percent are involved in development efforts, and only 36 percent participate in technology transfer. Their study also shows that "only medical sciences and agricultural sciences are correlated with technology transfer" in

American universities (973-974). These researchers also find that university research tends to generate "articles, books, and conference papers" (975), which are generally not considered effective methods for communicating research results or technological advancements to industries.

Conclusion

As universities become more closely associated with commercial interests, especially high-risk ventures such as start-up companies, they begin to take on a new role in American society (Matkin 175). Universities contribute to the society and economy not just through the classroom but through a variety of means, depending on what resources are available to the university and what needs exist in that geographical area. The potential benefits of a closer association between academia and the market exist on both sides. Industries stand to benefit from the education and the many applicable areas of expertise within the university; universities stand to benefit from having contact with the "real world" through industries and from increased private funding. Universities do take on risks when investing in collaborative research and start-up companies, but these risks can be controlled to a great extent (Matkin 153).

What is abundantly clear is that American universities have much to contribute and much to gain in the transfer of technology.

Industries

In the technology transfer situation, industries can be thought of as passive recipients of technology that originated in universities or federal labs. Or better yet, industries can be thought of as consumers of federally sponsored technology—groups whose interests and needs must be taken into consideration during the research, development, and transfer of a technology. It is better still, however, to think of industries as active participants in the transfer of technology, players capable of making significant, even critical, contributions to the process.

Who are they?

Tressel writes that as a “target audience” for communication on technology transfer from federal labs, industry “is large and scattered, poorly defined, and comprises a broad spectrum of goals and interests” (93). The sector of industry this thesis is

concerned with is the high technology industry. Within this sector, there also exists a wide variety of types and sizes of companies, not the least of which are the small- and medium-sized businesses Carr writes about. He says they are

critical to the US economy....They are responsible for most of the new jobs created in the United States over the past decade. They are also responsible for much of the high technology innovation that is critical to productivity growth. Since they are often supplier firms providing services and intermediate goods to larger companies producing a final product, their efficiency is critical to the competitiveness of the entire US economy. ("Part 1" 11)

Federal labs and universities are being encouraged through new policy and legislation to seek out cooperative relationships with small businesses and to prefer contracting with small businesses over large firms ("Part 1" 11).

What role do they play in technology transfer?

Research and development are conducted, to some degree or another, in federal labs, universities, and industries. However, the task of commercialization which requires marketing, economic, and production expertise lies solely within the realm of industry (Hecker 27). With commercialization come significant risks. Decker writes

Technology transfer and subsequent commercialization can be a very complicated process. After an idea has been carried through from conception to proof-of-concept, the difficult tasks of identifying and evaluating potential markets, attracting sufficient financial resources, and overcoming scale-up and manufacturing problems must still be undertaken by industry. This process involves high risk, long lead times, and many opportunities for failure. (15).

In addition to commercialization, industries contribute research funding to academic departments and internship opportunities to students; though less often, industries do contribute to federal lab research as well. Rahm, Bozeman, and Crow find a positive correlation between industries' funding of university or government labs and technology transfer. They also remark that this funding "is all the more notable

if one considers that the relative amount of industry funding tends to be small” (974).

Industry funding of university programs has been found beneficial to both parties:

industries receive research results and trained graduates, and universities gain an

access to the “real world,” giving a focal point to faculty and students alike (Stewart

and Gibson 117-118).

How can industries hinder technology transfer?

While industries make important contributions to technology transfer through

commercialization and funding efforts, certain conditions and practices within

industries have been found to hinder their ability to adopt technologies developed

externally. Researchers have identified several industrial characteristics and behaviors

which hinder the transfer of technology:

- individualism
- short-term focus
- ignorance of resources
- resistance to externally-developed technologies

In his study of industry partnerships at Oak Ridge National Laboratory, Siemens identifies two “cultural influences” that “limit the full potential of such partnerships [between industries and federal labs]” (158). Those two cultural influences or characteristics are the independent spirit or “rugged individualism” and industries’ “short-term focus”—their expectation of fast returns on research investments. Industries in the US have an independent spirit that often stands in the way of the cooperation with competitors and federal labs or universities that is essential to achieving competitiveness through technological advancement. And demanding a quick turnaround time on research “is not compatible with the long-term (greater than five years) strategy of a consortium” (158).

A study conducted by Spann, Adams, and Souder finds that the two greatest barriers to technology transfer are 1) industries’ lack of awareness of what is available to them through collaboration with federal labs and 2) industries’ tendency to resist both technological change and the long-term nature of investing in high technology research (67-68). The authors recommend that federal labs concentrate “their communication efforts [with industries] on clearly defined problems in target industries, rather than pursuing the current practices of mass prospecting.” They also

recommend that industries become "more receptive to federal technologies and proactive in learning about federal transfer programs" (73).

Conclusion

High technology industries in the US represent a wide variety of producers, with an equally wide spectrum of knowledge and capability, goals, needs, and organizational cultures. What they offer the US economy is stability through competitive growth. What high technology industries contribute to technology transfer is the capital and other resources necessary to take US technology into the market. As the need for a better and stronger high technology industry in the US increases, industries must become more involved with federal lab and university researchers in cooperative efforts that will result in higher rates of transfer and more advanced, more quickly produced technology.

Federal Laboratories

Federal or national laboratories are the focus of much of today's technology transfer research, writing, and legislation. The fundamental change they are undergoing from concentrating on defense to concentrating on the high technology market is generating much excitement in academia, the public, the legislature, and in the labs themselves. To the questions "Who are the federal labs?" and "What do they contribute to technology transfer?" the literature poses different and sometimes conflicting answers. The federal labs are hard to define because of their complexity and variety, and their contributions are difficult to assess.

Who are they?

Papadakis defines federal laboratories as those that are owned by the government, though they may be operated by an independent contractor such as a private company or a university (55). This basic definition of the term "federal," "national," or "government lab" seems to be prevalent throughout the literature. Some authors, however, use one of these terms in reference to labs associated with the Department of Energy (DOE), to the exclusion of those associated with the Department of

Agriculture, the National Institute of Health, the Department of Defense, etc. Some of the more familiar labs are the DOE multiprogram labs. They include Oak Ridge National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratory. Bozeman and Fellows write that "the U.S. Department of Energy multiprogram laboratories are among the largest federal laboratories....the multiprogram laboratories constitute a major source of basic and applied science in the U.S. ..." (65).

Carr writes that, in 1992, funding for federal laboratories accounted for \$25 billion of the government's \$71 billion R&D budget and that "The Federal Laboratory Consortium (FLC) estimates that there are 100,000 scientists and engineers working in federal laboratories, with an average of 20 years' experience in their fields" ("Part 1" 8). According to Papadakis, the federal laboratories "contribute to the national defense, space exploration, the development of nuclear power, the eradication of disease, air transportation safety, and forensic science" (57). Since the passing of the Stevenson-Wydler Technology Transfer Act in 1980, the federal labs also have a mandate to add technology transfer to their government, public-service related missions.

What role do they play in technology transfer?

Metz and Shama both advocate a strong leadership role for federal labs in US technology transfer. Metz argues that there is a need in the US for a government-affiliated entity to give strategic direction to R&D, taking into account more factors than just market pull. He finds the federal lab system capable of providing this kind of R&D and technology transfer leadership (167). In his study of technology transfer strategies used by different federal labs, Shama urges the importance of the "national competitiveness strategy." Labs employing this strategy decide which technologies to develop by what they can contribute to national competitiveness in the high tech market (21-23). Though Shama finds that few labs are using this strategy, those that do are clearly providing the kind of national leadership that Metz describes.

Many look to the federal lab system as a "treasure house" of knowledge, facilities, and experience which industries should be able to "tap into." Carr argues that "A shift of some of the value created by federal-laboratory R&D to industry could add significantly to the latter," that "federal laboratories have certain facilities, capabilities, and technologies that are not available in the private sector," and that "The potential of the federal laboratories to contribute to the nation's technology

development becomes even more evident when one considers the magnitude of human talent resident in these institutions" ("Part 1" 8).

Papadakis, however, claims that federal labs have not been and are not positioned to contribute significantly to US competitiveness. She says that "the vast majority of the system (about 80% of the labs) has no meaningful role in American competitiveness" (55). Her conclusions are based on a study that "profiled" federal labs, looking at their overall organization, their missions, the nature of the R&D they perform, their number, and what they produce. What Papadakis ultimately criticizes are not the labs themselves but the policies and missions that guide them. Despite the technology transfer legislation that began to be enacted in the 1980s, Papadakis says, the labs' missions do not focus on transferring technology to industries or to the marketplace but to the government. She argues that the government continues to be not only the major source of funding for federal lab R&D but also its major consumer.

Some authors forego discussions of whether or not federal labs are capable of contributing to technology transfer and simply report what they are doing in that area. Rouse describes contributions to technology transfer made by NASA as a part

of its Technology Utilization program. First of all, she cites publications as part of the program. Most popular among these are the NASA *Tech Briefs*, which describe NASA technologies and recommend possible applications (117). NASA provides Information Dissemination Centers that are connected to a “data base of more than 20 million documents” (118). NASA distributes software programs of various types much less expensively than a company could develop a similar product itself (118). The NASA Applications Engineering Project works with engineers from a variety of other institutions and companies to take aerospace technology and adapt it for “terrestrial” application (118).

Similarly, Decker explains technology transfer-related programs run by the Department of Energy (DOE) labs. These programs aim to meet “two key R&D objectives directed at cooperation with industry”:

- To sponsor cooperatively with industry long-term, high-risk research efforts that are unlikely to be undertaken alone by the private sector.

- To facilitate the effective transfer of technology, making the results of research available widely and promptly in the marketplace. (17)

The DOE University Program offers support and unique research opportunities to university faculty and students (18). DOE user facilities, such as the high temperature superconductivity pilot center at Oak Ridge National Laboratory, offer “advanced scientific research facilities” in some specialized area and are made available to the scientific community. Decker reports that “Interest in and use of” user centers are increasing (19). In another technology transfer-oriented program, the DOE Industry Technology Exchange Program, industry scientists work with laboratory scientists at the lab site on a problem of importance to their industries. The cost for this research is shared (19). Decker reports wide success with these programs (20-22).

Conclusion

Arguments from the optimistic and pessimistic perspectives on federal labs, those that view federal labs as “storehouses” of information and equipment needed by

industries and those that criticize the present configuration of the labs and the policies that guide them, could agree that a fundamental change must take place in the federal laboratory system in order for the labs to make decisive contributions to US competitiveness. Whether by choice or mandate, the labs must finish the conversion, begun by legislation, from a government-oriented system to a market-oriented system.

Part Three: Cooperative Efforts

Many authors see increased levels of cooperation among federal labs, universities, and industries as the cure for what ails the technology transfer process in the US. Siemens says that “partnerships may be a very effective vehicle to rally the interest, create the momentum, leverage the dollars, and marshal the technological resources to a competitiveness challenge” (157). Contrary to the attention being given it now, in the past researchers took technology transfer for granted, assuming that it was a natural outcome of the research and development process. Kozmetsky writes,

Particularly since World War II, technological innovation—the entire process from R&D in the laboratory to successful commercialization in the marketplace—has been taken for granted. Traditionally, we have thought that successful commercialization of R&D was the result of an automatic process that began with scientific research and then moved to development, financing, manufacturing, and marketing. (23)

Another mistaken notion about technology transfer that has hindered its success in the US is that it is a one-way rather than a two- or three-way process. Carr refers to

the work of another author who described the transfer of technology “as being less like a relay race where a baton is passed from runner to runner on the way to the finish line, and more like a basketball game where the ball is passed back and forth between team members leading up to a score” (“Part 1” 9). Again, Kozmetsky explains the traditional attitude of research institutions toward technology transfer:

Managers and administrators continually strived for excellent performance in their respective institutions. They did not necessarily need to be concerned with linkages in the technology commercialization process. Insufficient attention was paid to the connections between the myriad institutions involved in moving scientific research from the laboratory to the marketplace. Most thought that there was little practical need to be concerned with the connections among academic, business, and government leaders involved in the commercialization process, in terms of understanding and evaluating their institutional performance for a better society. (23)

It is now generally understood that cooperation is an inherent part of technology transfer. As Wigand writes, "Cooperative research, by its very nature, leads to technology transfer" (149).

Having recognized this, leaders in government, federal labs, universities, and industries are working to emphasize the importance and increase the level of cooperation among the various involved institutions to improve America's technological competitiveness. As we have already seen, recent technology transfer legislation aims to make cooperation, especially between federal labs and industries, easier and more rewarding. This section will examine a few of the more prominent forms in which cooperative efforts are taking place. Those forms are CRADAs (Cooperative Research and Development Agreements), federal laboratory user centers, research consortia, research parks, and start-up and spinoff companies. We will also take a look at the facilitating role played by business incubators.

Cooperative Research and Development Agreements

Once a private company has made contact with a federal lab that has expertise in the area of their problem, the company may wish to work with the lab to find a solution. Cooperative Research and Development Agreements (CRADAs) provide a way for a company to come into such a contractual arrangement with a federal lab. The right to establish cooperative research agreements with industries was granted to federal labs in the technology transfer legislation of 1986 and 1989. Shama explains how CRADAs generally work:

To develop CRADAs, technology-transfer personnel match laboratory technology with industries' needs and proceed to negotiate cooperative-research projects designed to improve the market readiness of the respective laboratory technology....This way private business, especially small business, receives access not only to scientific experts but also to the best and most specialized computers and scientific instruments. (20)

Carr explains that CRADA activity is relatively new to DOE laboratories and that procedures for establishing them have not yet been systematized. Some industry

partners have found that the approval and funds for the cooperative work come too slowly to be useful—delays cause them to lose their window of opportunity (“Part 1” 13). Carr concludes that, while CRADA policies and procedures have not been fully “ironed out,” they

and other forms of doing R&D do have the potential to jump-start meaningful cooperation between industry and the laboratories.

CRADAs, in particular, break down barriers between two important sectors of the national R&D community and may be the vehicle by which industry comes to fully realize the value of the federal-laboratory system. Successful experiences with CRADAs may also generate new industry interest in other forms of technology transfer.

(13)

User Centers

User centers differ from CRADA arrangements in that they provide for industry or university researchers to work at a federal laboratory, collaborating with other

researchers working in the center and using lab facilities. Feldman writes about the high temperature superconductivity pilot center (HTSC-PC) at Oak Ridge National Laboratory (ORNL) which is one of three HTSC-PCs; the two others are at Los Alamos and Argonne National Laboratories. There are fourteen other user centers at ORNL, all specializing in different areas of research (Feldman 15). Siemens reports that "During its first year of operation, the ORNL pilot center signed agreements with ten firms...totaling \$2.5 million; \$1 million of DOE funds leveraged with \$1.5 million of private industry funding" (164).

Feldman explains that the purpose of the HTSC-PC is to help US industries develop superconductivity to the point that it can be commercialized by the individual companies represented at the pilot user center (15-16). Superconductivity is one of the areas that the US is urgently seeking to develop farther and more quickly than the Japanese, in order to dominate that growing market. But because US efforts at technology development and commercialization are generally slower than Japanese efforts, cooperative efforts like the HTSC-PC are attempting to get past the barriers that normally delay technology. Feldman writes:

The founding of the center was based on the belief that these barriers [to technology development] can be overcome most rapidly through cross-fertilization of ideas, establishment of a common research agenda, and an integrated, collaborative center that expedites invention, licensing, and sharing of royalties. (6) It is hoped that the HTSC-PC will hasten the waiver of patents from high-temperature superconductivity to operating contractors of national laboratories, and, ultimately, to industrial users. (16)

Siemens notes that the success of the pilot center is not only helpful to the industries involved but also useful in directing future collaborative efforts that, like the HTSC-PC, will "provide a way to combine the best of basic and applied research with the best capabilities in manufacturing and commercialization, a combination that many experts believe is essential if U.S. competitiveness and technological leadership is to be restored" (164-165).

Research Consortia

The purpose of research consortia is to allow participating companies to “cooperate to compete” by working together

on the precompetitive development of technology. Once that technology research reaches the point of ‘proof of concept,’ the consortium ceases to develop it and turns it over to the member companies who pursue specific applications and market opportunities.

(Avery and Smilor 94)

This begins to sound much like the purpose of the HTSC-PC. The difference is mainly in sponsorship. User centers are federal lab programs; research consortia are generally sponsored by the private companies themselves. The different sponsorship is clear in the consortia membership percentages reported by Avery and Smilor.

They report that research consortia memberships in 1989 included 83 percent private US companies, one percent US universities, and two percent state and federal government entities (95). Avery and Smilor cite the benefits of membership in a consortium are leverage of investments, reduction in duplicated efforts, promotion

of long-term research, and the reduction of risk for individual firms by “diversifying the portfolio of research projects” (95).

One thing authors agree about concerning research consortia is that it is difficult to make them successful (Hesselberth 152; Siemens 157). Hesselberth describes a poll taken periodically by his company, DuPont, to determine the success of its cooperative research efforts. (Success, Hesselberth writes, is judged by whether or not technology is transferred.) According to the data collected by these polls, DuPont has not had satisfactory experiences with research consortia. However, DuPont’s membership in the Center for Process Analytical Chemistry (CPAC), run by the University of Washington at Seattle, has exceeded the participants’ expectations.

The three reasons Hesselberth gives for this success are 1) CPAC “found an area that was very important to industry but was being virtually ignored by academia,” 2) “the University of Washington provided for energetic, capable, full-time administration,” and 3) “CPAC developed specific research objectives and programs that meet the needs of their industrial partners” (154). Conversely, unsuccessful consortia are established and joined because it is popular or convenient to do so or

for the purpose of drawing in extra funding for on-going research, not because there is an unmet need for that particular type of research (155).

Research Parks

In writing about a research park at Arizona State University (ASU), Wigand reports that in 1989, there were 100 “university-affiliated research parks” (137). Universities often sponsor research parks, for a variety of reasons. First of all, real estate is a good investment and one that, according to Matkin, universities are making more now than in the past (256). Also, Wigand notes that having a good relationship with industries so close to the campus (or on the campus) provides students and faculty with access to expensive equipment not in the university labs (138). Benefits for the university students and faculty also included the availability of industry funding and expertise (146). Other reasons Matkin gives for university establishment of research parks are

the sharing of research facilities and instruments; collaboration on research projects; increased consulting opportunities for faculty

members, and the resulting greater availability of professional expertise to industry; fuller utilization and support of university programs such as continuing education and industrial affiliate programs; improved education for students and industry researchers; and—most important perhaps—the earlier recognition of important breakthroughs and the more rapid commercialization of university research. Furthermore, a successful research park can be important in stimulating regional economic development, thus earning political support for the university. (257)

Research parks, perhaps more than other university-industry relations programs sponsored by universities, have the potential to affect a university's reputation in its region (267).

According to Wigand, the ASU research park has three main goals: 1) technology transfer, 2) economic development of the Phoenix area, and 3) endowment for the university through lease payments made on the buildings and lots occupied by industry tenants (138-139). The industry tenants are not required to engage in cooperative R&D with the university, but most do (139). One of the most important

benefits industries found in joining a university-affiliated research park was “access to university faculty and students” (146). Wigand reports that both ASU and the industry research park tenants were generally satisfied with the park (146). He also notes one of the major costs encountered: “The greatest cost of cooperative research—one identified by both groups of researchers—was the obstacles created by administrative red tape” (149).

Business Incubators

Business incubators are places where starting business can locate until they can afford to establish their own location. They are formed “to nurture start-up business ventures through their crucial early stages” (Matkin 251). What they offer is inexpensive rental space and a variety of relevant services, such as shared support staff, technical and/or business advice, use of equipment, etc. Matkin says that incubators connected with universities generally have more to offer young businesses than other incubators because they provide “access to university libraries and other facilities, often including sophisticated scientific equipment...technical assistance and managerial and business advice” (252). Matkin also notes that the

public eye is drawn to incubators, giving universities and the new businesses much-needed good press (251).

Start-Ups and Spinoffs

It is interesting to note that when a group of concerned Idahoans began to consider ways to improve their state's economy, they eventually decided to promote start-up companies based on technology from the Idaho National Engineering Laboratory (INEL) by identifying commercializable INEL technologies and by opening business incubators (Warner 42). In 1986, a business incubator opened in Idaho Falls and, within a month, two new businesses marketing INEL technologies moved in (48).

Business incubators play an important role in fostering the initiation and growth of technology-based start-up and spinoff companies. "Start-up" and "spinoff" mean basically the same thing, except a start-up business is not necessarily technology-oriented, while the term "spinoff" denotes the commercialization of a technology that was researched and/or developed at a federal or university laboratory.

Carr reports that many ("estimated at more than 50") new DOE technologies have begun spinoff companies in the last ten years ("Part 1" 14). He also writes some

universities and federal labs have worked to promote spinoffs while others have not aided researchers in their new business ventures. Carr writes favorably of the potential of start-up and spinoff companies to help the local economy as well as the parent companies. He says,

Where they are technologically and commercially appropriate, spinoff companies have several advantages for laboratories. They generally locate in the area around the laboratory and contribute to local development more directly than distant firms....The new companies and the jobs they create generate local economic development which, in turn, provides support for the laboratory's technology-transfer program. ("Part 1" 14)

Carr encourages laboratories to work to support spinoffs and to eliminate barriers such as "uncertainty surrounding the fairness and conflict-of-interest issues" ("Part 1" 14).

In describing the entrepreneurial technology transfer strategy used by some federal labs, Shama explains more specifically the contribution that labs can make to start-up and spinoff efforts. He writes that a lab using the entrepreneurial strategy

is so committed to seeing laboratory-developed technologies used by the private sector that it will help develop new ventures to utilize these technologies and, as a result, create jobs and contribute to the domestic national product. An entrepreneurial strategy not only assesses the market potential of the technologies but also writes or helps in the writing of business plans that center on the utilization of these technologies by new ventures. (20-21)

Shama cites the success of ARCH, the technology transfer alliance between Argonne National Laboratory and the University of Chicago, as an example of a national lab that has in place a successful program for helping start new companies based on laboratory technology (21).

Matkin, likewise, speaks favorably of universities that promote the establishment of spinoffs by their researchers or that invest in technology-based companies

themselves. He says that, although investment in private companies by universities can be difficult to manage effectively and fairly, many benefits can be gained by the university, the community, and industries. Providing "seed money" for a faculty member to develop his or her research ensures the university a return on its investment in that research (150). The university that invests in private companies will also probably attract and be better able to retain a high-quality faculty (151). Its public image could also be enhanced. In addition, this kind of activity is beneficial to researchers. It allows them to see their research through development to the marketing phase, helps them establish vital links to industries, and enables them to stay current with what is happening in their field in the industry sector (152). The universities' investment in research-based companies is also essentially an investment in the local economy. A successful company not only creates jobs and brings revenue to the area, but it also can serve to attract other companies to that area.

Part Four: Technology Transfer as Communication

Several authors who have defined technology transfer have done so in terms of communication; a few, such as Williams and Gibson and Doheny-Farina, have argued that technology transfer is essentially a process of communication. Much is to be gained by understanding technology transfer as a process of communication, partaking of its give-and-take, constructive nature.

Definitions of Technology Transfer

For a simple understanding of technology transfer, general definitions suffice.

Following are a few general definitions that appear in the literature.

Technology transfer is the managed process of conveying a technology from one party to its adoption by another party, e.g., from a developer to a user, a seller to a buyer, one department to another, etc. (Souder, Nashar, and Padmanabhan 5)

...it [technology transfer] involves the development and commercialization of technological products. (Doheny-Farina 3)

In a broad view, technology transfer reflects all or some components of the process of moving ideas from the research laboratory to the marketplace. In brief, technology transfer is the application of knowledge. (Williams and Gibson 10)

Simply stated, transfer is the process of employing a technology for a purpose other than that for which it was developed. (Foster 111)

Scratch a simple definition of technology transfer, however, and you find complexity and contingency. Authors who try to understand the real and deeper nature of the technology transfer phenomenon usually do so in terms of the multi-layered interactions between human beings that characterize communication.

Avery and Smilor refer to technology transfer as a process of convergence, where representatives of the different players in the process must *come together* in order for the transfer to occur successfully.

At the interpersonal level, technology transfer can be viewed as a process of convergence (Kincaid, 1979) characterized by mutual causation and interdependence between technology transfer participants over time. From this perspective, communication in technology transfer does not carry the technology; rather, it provides a means for members of different organizations to teach and learn from one another.... (106)

The writing that occurs in association with a transfer often reveals how transfer participants differ from one another in their notions of the technology and its use; writing also provides a way for those differences to be resolved so the technology can be successfully transferred.

Writing to Converge

In his book *Rhetoric, Innovation, and Communication* (1992), Doheny-Farina writes that the differences between the ideas transfer participants have about the

technology hinder the transfer. Until participants can agree on what the technology is in the situation to which it is being transferred, the transfer cannot be successful.

This process of reaching a mutual understanding of the technology and of the transfer is the process of convergence mentioned in the above definition. In Chapter 3 of his book, Doheny-Farina presents a case study that illustrates not only how differing ideas of a technology hinder its transfer but also how the documentation process can reveal these differences and provide a means of resolving them.

The case study he looks at is the transfer of a “heart assist pump.” The pump is used to keep the patient’s heart going when complications occur during or just prior to open-heart surgery. This technology was first transferred from the university lab where it was developed (Research Medical School—RMS) to a company that would market and produce the pump (Biomed Corporation). Then, it was transferred from Biomed to a private hospital (Central Hospital) for the initial clinical trials.

Misunderstandings about the technology surfaced when user manuals were written at Biomed and at Central Hospital.

The Biomed manuals were first drafted by the clinical trials coordinator at Biomed, Rob Florio, and revised by Brian Bell, a technical writer who had spent time

gathering information at RMS. The manuals were then reviewed by the head surgeon in charge of the heart assist pump and by the two engineers working on the project. Doheny-Farina notes that the engineers made extensive comments and revision suggestions—some of which were incorporated and some not. The revised manuals were then sent to Central Hospital.

Mark Ivers was the Central employee responsible for training respiratory therapists who would operate the pump. He had read the manuals and related journal articles and made site visits to Biomed to gain experience in operating the pump himself. Ivers then developed training materials for the respiratory therapists by stripping down the Biomed manuals to what he saw as essential information on operating the pump, adding some things he had learned from the related journal articles and his own experience with the pump.

When the engineers at RMS read Ivers' training materials, they became disturbed over a particular passage which they felt gave dangerously inadequate information about controlling the pump. The engineers felt that the Biomed manual also needed to contain more and better information about pump operation.

Since Ivers' passage had been taken from the Biomed manual, Rob Florio met with the RMS engineers, and together they worked out a way to include the necessary information in the Biomed manuals.

The problem with the manuals, as the engineers saw it, was that the explanations of how the pump should be controlled focused on specific situations rather than on the overall purpose of the pump and the principles of its operation. They felt those who read the manuals might be able to operate the pump correctly in situations like those in the examples given but they would not understand the pump well enough to use it in other situations, when the probable variety of those situations was great.

The solution Florio and the RMS engineers arrived at was to revise the manuals in a way that would give the respiratory therapists a better understanding of the pump itself. They would then have a theoretical basis from which to make pump-operation decisions in actual, diverse situations.

Doheny-Farina interprets these revisions as resolving the differences between the engineers' and the other participants' (Florio, Ivers, and the respiratory therapists) knowledge of the pump. The lack of information in the written documents about

the theory or principles upon which the pump operated revealed a lack of understanding on the part of the writers—a lack which would be passed on to those who would operate the pump. Florio, Ivers, and the respiratory therapists needed to move more fully into the “discourse community” of the heart assist pump.

With the help of the RMS engineers, Florio was able to come to a more complete understanding of the pump and how it should be controlled, which he then passed on to those at Central. Ivers’ and the respiratory therapists’ ability to read, understand, and use the language of the heart assist pump discourse community signalled a functional understanding of the technology necessary for a successful and safe transfer.

Technical Communicators and Technology Transfer

There are abundant references in the literature to the critical role of the “boundary spanner,” the one who acts as a liaison between technology developers and adopters in a transfer. Such a person has an understanding of the technology but is not so technically-minded that he or she cannot see from the adopter’s perspective. An ideal

boundary spanner, in fact, is able not only to represent the developers to the adopters but also vice versa. He or she represents the needs, customs, and values of the adopter to the developer so that information can be used to shape the development of the technology.

Technical communicators see here a perfect niche for themselves, a contribution that their profession is uniquely capable of making to technology transfer. Doheny-Farina and Roberts both argue that technical communicators' understanding of the rhetorical give-and-take nature of communication and their non-technical background enable them to negotiate differences in those points of view in writing. Roberts notes that cultural differences among the federal labs, industry, and academia have often been cited as one of the great hindrances to technology transfer in the US. She says that there are

...a growing number of technology transfer critics who consistently cite cultural gaps as a primary problem in the tech-transfer business.

As technical communicators, we should pay attention to these criticisms and recognize them as a wake-up call to our profession. In the context of technology transfer, bridging cultural gaps is analogous

to bridging discourse communities. Because we spend most of our professional lives constructing rhetorical bridges in the form of high-quality communication products, we have a lot to contribute. (1995 41)

Likewise, Doheny-Farina sees the technical communicator as an important source of information on technology users. He contends that, while extensive market research can be cost-prohibitive, technical communicators can help technology developers keep the user's needs and wants in mind as the technology is being developed (168).

Many authors, such as Doheny-Farina, believe that the best way for technology developers and designers to take advantage of what technical communicators offer is to involve them in the process early on. Early involvement usually leads to the assignment of a technical communicator to the design team.

This kind of collaboration between writers and designers in the early phases of development has definite advantages. For one thing, collaboration is linked to improved products (Doheny-Farina 204). In addition, when writers work closely

with designers, they expand their technical knowledge, thus gaining the designers' confidence.

Integration has potential disadvantages as well. First, increased technical understanding may cause a technical communicator to lose the perspective of the adopter and/or their ability to identify themselves with the profession of technical communication (Doheny-Farina 177). Secondly, as writers' abilities and knowledge bases increase, so may the expectations and workloads placed on them increase (Liebetrau 25, 26).

According to Leibetrau, for a technical communicator who becomes involved in technology transfer, working closely with developers and adopters, there is likely to be no dearth of work, rather overwork. Liebetrau lists a few ways that becoming involved in technology transfer "can devastate a [technical communicator's] career as well as expand it" (23). Her list mentions the pressure to learn and stay on the "leading edge" and increased workloads and performance expectations (25). She writes,

The lure of a growing demand for this unique communication expertise can easily result in snowballing schedules, debilitating stress, and possible physical or mental overload. (26)

Conclusion

One of the ways that technology transfer could progress in the US is for technical communicators, in all sectors, to become more involved in the process. Technical communicators are able to contribute not only a high level of quality in their written communication, which is extremely important in technology transfer, but they also have the ability to see the whole process, which not only *involves* rhetorical communication but is at heart a communicative process, from the vantage point of their training and experience in rhetorical communication.

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Vita

Christina Tolliver was born in Lewisville, TN, in 1971. She grew up in Newbern, TN, a small town in the western part of the state. Christina graduated from high school in 1989 and then went to Oral Roberts University in Tulsa, OK. In 1993 she graduated from ORU magna cum laude with a degree in liberal arts.

In 1994, Christina began work on an MA in English, concentrating in technical communication, at the University of Tennessee, Knoxville. It was at UTK that she met Robert Tolliver, a graduate student in the geology department. They were married in 1995. In 1996, Christina earned her degree and graduated magna cum laude.

Christina has published one poem, "How We Come Apart," in POET magazine.