to our state and local governments. Progress has been made in heightening the awareness of policymakers and top administrators at federal, state, and local levels of government with regard to the potentials of better use of the country's science and technology resources in dealing with domestic issues. Mutual interests have been highlighted and linkages have been developed. Also, beneficial changes have been achieved that will never disappear.

# Overview of Federal Programs and Activities

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**A general overview of technology-transfer activities of federal agencies is provided in this paper. Major emphasis is placed on factors and processes that appear necessary for successful transfer programs. U.S. Department of Transportation policy and activities are highlighted as examples of ways in which technology, including hard products, processes, and knowledge, can be transferred for greater utilization in the public sector.**

There is now a great deal going on in the area of technology transfer at the federal level. It is rather heartening to those of us who have been in the business for quite a few years. I would like to first define what I mean when I talk about technology transfer. There are many phrases used to describe such activities. For example, we call our program technology sharing. The classical definition for technology transfer has really been associated with spin-off or secondary applications, that is, where you take a technology developed for the National Aeronautics and Space Administration (NASA) or the U.S. Department of Defense (DOD) and try to apply it to another sector, such as transportation, health, education, or other private sector. The federal government looks at technology transfer from a much broader definition, trying to get products, processes, knowledge, or whatever results from research, development, and demonstration programs, applied and used in the public or civil sectors. My definition encompasses secondary spin-off, but also includes the case where we are trying to transfer from the federal level to the state or local level, in a specific mission area, such as is the case in the U.S. Department of Transportation (DOT). Basically, the purpose is getting the products out and used. It has become a very important subject, and one of the reasons for this is because of fairly extensive interest from state and local governments and an expressed concern that a great deal of money was being spent at the federal level on research and development that had very little benefit to the public sector.

Although one could argue that numerous benefits accrued to the public sector, there was not enough emphasis on transfer. The concerns were also logical when one considers that from 1966 to 1976 the federal government spent $185 billion on research and development; a majority of that was for defense and space. NASA and DOD have their primary missions; their research and development is for products for their own use. But, even during that 10-year period, $50 billion was spent on research and development for the civil sector. What has resulted from that expenditure in the way of useful products for state and local governments and the public and private sectors? Such questions are being asked, and I believe an increased emphasis on technology transfer can help ensure positive answers.

The National Science Foundation (NSF) has been a leader in trying to establish mechanisms for the process of technology transfer. The disjointedness of technology-transfer activities is being addressed by many of the NSF programs. Other agencies are doing different things. Some agencies are moving aggressively in this area, others are not moving as rapidly. This paper will talk about some subtle key factors that will make or break the success of technology transfer, both now and in the future. If we look at some programs that have been successful in this area, I think some of these factors will become evident.

As an important aside, if you are interested in the technology-transfer activities of various federal agencies, there is a document titled the Directory of Federal Technology Transfer (1). This document summarizes the activities of some 40 agencies of the federal government in the area of technology transfer.

The factors I will cover are the following:

1. A commitment to technology transfer;
2. The rewards for people doing or trying to achieve technology-transfer successes;
3. Understanding of the intended users and tailoring of products and information for them;
4. User involvement throughout the process, not only at the end;
5. Public and media acceptance of technology transfer (which is really the acceptance of research and development or science and technology); and
6. Expectations that we and others might have on achieving successful technology-transfer programs.

## COMMITMENT

The achievement of anything of significance and substance generally requires commitment. This is especially true in a relatively new field of emphasis (technology transfer is in this category for most agencies). Ideally, the commitment has to permeate the entire organization responsible for the area of interest. You can have an individual in the bowels of an organization who is totally dedicated and committed to technology transfer as the critical element in the process of solving problems, but if there is no commitment on the part of

his or her superiors to the same objective, he or she will have a hard time getting support for such activities (support meaning budgets and time to devote to the activities). Unfortunately, up until recently, the above scenario has been the rule. That is, commitment for such activities was not coming from the higher levels but rather from midmanagement and working levels. There are, of course, exceptions to this rule and, additionally, the recent signs of change indicate that commitment to technology transfer is reaching the highest levels.

One major indication at the federal level is reflected in the National Science and Technology Policy, Organization and Priorities Act of 1976 (P.L. 94-282). The act establishes a science and technology function within the executive branch by law, rather than previous precarious functions and associated offices that were at the whim of the President. The act has numerous references to technology transfer, information dissemination, and utilization.

The Intergovernmental Science, Engineering, and Technology Advisory Panel is most active at this time. The panel is composed of state and local elected officials. The chairperson of the panel is the President's science advisor, Dr. Press (also Director of the Office of Science and Technology Policy), and the vice-chairperson is George Busbee, governor of Georgia. The basic purpose of the panel is to provide state, local, and regional input and advice to federal science and technology (research and development) policy and decision making.

The panel has structured itself into five task forces, all of which are active, and the panel and all task forces have a major emphasis on technology and knowledge transfer. Panel members have met with some cabinet officers and high-level policy officials and have received strong indications of support for the panel activities and concerns from the President and various federal departments. I conclude from all this that the commitment to technology transfer, broadly defined, is developing at high levels of the federal government and that, because of this, commitment will eventually show up or be endorsed and supported at all levels. This in turn will influence, in a supportive fashion, commitment to technology transfer in universities, industry, and other levels of government.

Such commitment should help relative to another important consideration, that is, rewards.

## REWARD STRUCTURE

Within the research and development community, rewards are based on doing or managing good research as measured by other researchers. The "publish or perish" philosophy in universities is also of this nature; that is, you are judged by your peers. Fortunately, I see many changes away from strict adherence to this philosophy, but we have a long way to go. It takes extremely dedicated people to concern themselves with whether or not the results of their efforts are being applied to real-world problems when the reward structure does not recognize such activities as being important.

To emphasize this point, I might ask the question, "How many heads or top policy officials of science and technology or research and development organizations or universities have been elevated to their positions as a result of a career dedicated to technology transfer?" Also, there are prestigious awards, such as Nobel prizes, for all types of scientific achievements in various fields. It seems time to have prestigious awards for great achievements in technology transfer. After all, in the final analysis, only after the technology (or product, process, and knowledge) is applied for the benefit of mankind does it have any real significance. I want to make clear that in no way am I advocating rewards in this area at the expense of rewards in the basic science and research areas. These must continue in order to ensure that the pipeline of new knowledge, products, and processes is always full and flowing. One system that has been the exception to the rather grim picture (for technology transfer) I have painted, is the agricultural research and associated Cooperative Extension Service, for which one will usually obtain unanimous agreement that it is the most successful program of technology transfer ever structured (or evolved). There are numerous reasons for its success, but I feel one of the more significant is that the reward structure was based on the transfer and application of the developed knowledge. A researcher's success was measured in terms of transfer.

Changes are occurring, but much more active attention needs to be given to ensuring that people working in this area are rewarded, through prestigious awards, monetary and position increases, and recognition. Human nature is such that this alone will significantly enhance the field of knowledge transfer to the benefit of all, in that more and better transfer will follow.

## USER UNDERSTANDING AND TAILORED KNOWLEDGE

In effectively transferring technology we need to know what factors are important to the user (and potential implementor) of the technology. If our objective is to transfer research or scientific knowledge to another researcher or scientist, then standard, scholarly, scientifically precise research documents are valid and necessary. But many research documents that are intended to provide the answer to some specific real-world needs or problems are sitting on shelves gathering dust. Many of these documents do in fact contain some of the answers; however, the real user (that is, the person or persons who will decide whether to apply the technology) cannot understand the document. It may be too complex and scientific, and the implications for his or her decision criteria may be too obscure or not addressed.

Complicating this is that in essentially all situations there is more than one decision to make, and their language, decision criteria, and technical sophistication vary across a wide spectrum. There are two generic groupings at the state and local levels; one is general-purpose oriented and the other is function or mission oriented. Although, in general, the federal government has been structured and programs have been established along functional lines, the elected and appointed officials (through their own initiative and through changes in federal legislation and procedures) are taking increased responsibility for decisions that quite often in the past were handled directly between federal and state or local functional organizations.

Within any given area of interest, such as transportation, technology and knowledge must be provided to a series or group of decision makers, each of whom may judge the application of the technology from a different perspective. What all of this means is that knowledge on one subject must be packaged in different forms, often with different levels of detail and sophistication.

We try to involve representatives from the intended user group in the development and finalization of the document. This does two things: First, it ensures that the right kinds of information and level of detail are provided; and second, it results in a much higher degree of acceptance by the entire user community because their peers have been involved in its development. A lot of

free and enthusiastic advertisement results from this approach. User involvement, however, should not be restricted to only the final stages of the transfer process.

## USER INVOLVEMENT

One of the problems with much technology transfer is that it ends up being very much a push process. That is, a researcher or research organization will work long and hard on some process or product that it feels will have some benefit to a user community. However, there will be no contact with the user community until the person or persons wanting to transfer the knowledge come in and unveil their elaborate reports and briefings, stating, "I have the solution to your problem." Receptions to this approach obviously vary, but more often than not they tend toward the range running from skepticism to "get this snake-oil salesman out of here."

I believe such reactions are both to be expected and reasonably justified. If the user has not been involved at all up to the point of revelation it is unlikely (a) that he or she will feel that you really understand the problem or the institutional difficulties in implementing solutions, (b) that the important decision factors for the specific user have been considered and covered, and (c) that the feeling of trust necessary for effective and efficient transfer will have been established.

It has been shown that the most widely accepted successful transfer programs are those that involve the user from the identification of specific needs and problems, through the structuring and conduct of the research (or whatever is necessary for solution) to the packaging and dissemination of the process or product. The agricultural process was of this nature as is the cooperative highway program of DOT and the states.

## PUBLIC AND MEDIA ACCEPTANCE

My fifth point has to do with acceptance by the public of the importance of technology transfer, which will most likely be manifested in the importance of the programs that generate the technology. I believe it would be difficult to distinguish between the two in the eyes of the public.

I have begun to conduct an unscientific, ad hoc, personal survey relative to public perception of science and technology. I have two questions I ask. The first is, "When I say the words science and technology, what is the first thing that comes to mind?" After an answer to that question, I ask, "Do you feel science and technology have done anything for you?" As you can imagine, I have received some interesting answers. As one example, I asked these questions of a stewardess while flying cross-country. Her answer to the first question, after much thought, was "chemicals." Her answer to the second question was an emphatic "no." Here we were flying at 12 190 m (40 000 ft), at 965 km/h (600 mph), she wearing her outfit made of synthetic fabrics, having just served meals from microwave ovens, and the answer is no. If I had added the question, "Do you think it is important that we have programs to ensure the transfer of scientific and technical knowledge?" I think we would all agree on what the answer would have been.

If we want to cause a change in this regard, we obviously need to consider the news (and possibly entertainment) media. Disaster movies are the rage now, and, of course, the news media has operated on this same principle for some time. Crime, problems, and failures make the headlines. After a number of years of successful operation, the Bay Area Rapid Transit system, which incorporated some of the latest and best design and technical features, is still primarily remembered for the time, in the first months of operation, that one of the cars ran off the end of the track due to a malfunction in the automatic control system. I could give many other examples, but I am sure I need not convince you that failures make the news.

I do not have a prescription for how to solve this, but I believe it generally involves a greater effort on our part to make friends with the media, help them to understand the benefits of technology transfer and perhaps the benefits to them of reporting such. Perhaps we need to stimulate or sponsor the development of special public-oriented newspapers and magazines.

## EXPECTATIONS

Emphasis on technology transfer is growing at all levels of government, and at the federal level in both the executive and legislative branches. A major new program, for example, is the U.S. Department of Energy (DOE) Energy Extension Service (EES), which was established based to a large extent on the success of the Agricultural Extension Service. Great things are expected from the DOE-EES. However, the top-level officials in government must be cautious of expecting dramatic success overnight. The agricultural program started some 60 years ago; the Federal Highway Administration program, which is also a highly successful technology-transfer program, has a comparable age. It took a great deal of work and time with small successes following one another until, after some time, the overall programs could be viewed as a success.

We need to work as hard as we can, but we must also temper our, and others', desires to get problems solved immediately with realism in terms of how long it can take to achieve success.

## CONCLUSIONS

Effective technology transfer is crucial to meeting needs and solving problems. It is also a difficult and complex process for many reasons encompassing human, organizational, institutional, technical, and other factors. There is a growing body of literature, experience, and knowledge on this subject. I have tried to address what are perhaps the more subtle (but I believe critical) aspects that, in the final analysis, will make the difference in establishing technology transfer as a broadly supported and highly esteemed field of endeavor. My hypothesis is that this is necessary to obtain the major beneficial impacts that I feel technology-transfer efforts can provide. We need to keep these considerations (commitment, rewards, tailored knowledge, user involvement, public and media acceptance, and expectations) in mind as we proceed to emphasize and improve technology-transfer activities and programs.

## REFERENCE

1. A. B. Linhares. Directory of Federal Technology Transfer. Federal Coordinating Council for Science, Engineering, and Technology; National Science Foundation, Washington, DC, June 1977. NTIS: PB 285 896/7SL.