NCHRP
SYNTHESIS 355

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Transportation Technology Transfer: Successes, Challenges, and Needs

A Synthesis of Highway Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration, U.S. Department of Transportation.

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FOREWORD

By Staff
Transportation
Research Board

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis presents information on the use of technology transfer practices in the highway transportation community. It is intended to assist transportation agencies and other transportation research organizations in expediting innovation to practice, thereby increasing safety, enhancing performance, and reducing costs. The report documents successful practices, discusses challenges encountered, and identifies the needs of those responsible for sponsoring, facilitating, and conducting technology transfer activities and processes. It incorporates practices within state departments of transportation and other programs such as Local and Tribal Assistance Programs' Technology Transfer Centers and the Resource Center and divisions offices of FHWA. Areas of interest include organizational structures, political and legal aspects affecting technology transfer, resources (financial, personnel, technology, facilities, and equipment), strategies and tools, and performance evaluation. Comparisons with practices from the private sector are included.

This synthesis included three primary sources of information: surveys, a literature review, and interviews.

Barbara T. Harder, B.T. Harder, Inc., Philadelphia, Pennsylvania, collected and synthesized the information and wrote the report, under the guidance of a panel of experts in the subject area. The members of the oversight panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

TRANSPORTATION TECHNOLOGY TRANSFER: SUCCESSES, CHALLENGES, AND NEEDS

SUMMARY

Technology transfer occurs with the application of every innovation; it is an unseen yet integral part of the transportation system. Because technology transfer enables innovations to realize their benefits, the topic is an important one to consider. Therefore, this synthesis reviews the technology transfer practices currently used within the highway transportation community. It documents successful practices, discusses challenges encountered, and puts forth needs to promote improvements for technology transfer activities and processes.

Technology transfer is defined as the activity leading to the adoption of a new-to-the-user product or procedure by any user or group of users. New-to-the-user means any improvement over existing technologies or processes and not only a recent invention or research result. Technology transfer includes research results implementation and product or process deployment. Activities leading to the adoption of innovations can include knowledge transfer, training and education, demonstrations and showcases, communications and marketing efforts, and technical assistance. In addition, in this transportation context, technology transfer includes the complex process of change, a comprehensive achievement dealing with cultural as well as technical issues.

Technology transfer for transportation applications emerged as a national issue and a recognized activity in the 1960s when highway agencies, through an AASHTO special committee, highlighted the time lag between completion of research and the adoption to practice of the results. FHWA shortly thereafter institutionalized its commitment to this topic by establishing a Technology Transfer Program and reorganizing to form an Office of Implementation. Local agencies were identified as requiring support in the application of highway technologies and, in 1982, started the Rural Technical Assistance Program, now known as the Local Technical Assistance Program (LTAP), and the Tribal Technical Assistance Program (TTAP) were created. Throughout these years, robust research programs, including those in California, Indiana, and Virginia, were engaging in technology transfer and making a concerted effort to get innovations into practice.

FHWA continued to emphasize the role technology transfer played in transportation by forming the Office of Technology Applications, which became the home for all of its technology transfer and implementation programs. With the advent of the Strategic Transportation Research Program (SHRP) products implementation efforts, AASHTO began a lead states program that used the expertise and experience in one state to foster the adoption of innovations from SHRP in other states. This AASHTO effort was the basis for the currently operating AASHTO Technology Implementation Group (TIG), which facilitates the adoption of new technologies by having states that are experienced in specific technologies share their knowledge and skills with other, interested states. TIG annually selects three technologies for its technology transfer efforts. FHWA also has continued to highlight the application of innovations through its Priority, Market-Ready Technologies, which are proven and applied technologies worthy of application nationwide.

For the past 40 years, state departments of transportation (DOTs) and their research units have been active participants in technology transfer through the application of their own

research programs' results. Every program and agency performs the essentials of technology transfer to varying degrees depending on the resources committed.

Paralleling the development of technology transfer in public-sector transportation was the explosion of technology transfer activities in the private sector. After much effort, the 1980s witnessed the passage of instrumental legislation beginning with the Stevenson–Wydler Technology Innovation Act (1980), which allowed federal laboratories to transfer results of research to state and local governments and, in particular, to the private sector. Other acts established Cooperative Research and Development Agreements and other mechanisms to facilitate the private sector's use of federal research products and enhanced opportunities for partnerships and other collaborative research and business development activities resulting from technology transfer.

Currently, commercialization is the most critical aspect of technology transfer in the private sector. Furthermore, commercialization is viewed as an important economic engine and as an essential element of competitive advantage. Commercialization is important whether the technology transfer occurs within an organization—most often value is placed on the technology according to its usefulness in the marketplace or whether the technology transfer is between private-sector companies—often some technology useful for the supply chain partners or between the private sector and federal public-sector research and development—where the literature shows some relevance to the context for technology transfer and implementation of research results for state DOTs. Because of this relevance, the private-sector experience with federally funded research or research and development done outside the organization is generally the context used for this synthesis when referring to private-sector involvement in technology transfer activities.

The private sector has, in effect, institutionalized its technology transfer and commercialization process activities. The academic research and federal or other laboratories are experts at getting their innovations noticed. Academic offices of technology transfer are common in this environment. Private industry eagerly anticipates commercialization opportunities from inside their own organizations or from other research organizations. Additionally, and most importantly, the private sector has established a strong link between those generating innovations and those seeking to bring them to market. There are myriad organizations filling the role of "transfer agent"—bringing both innovation generator and commercial enterprise together—with the ability to raise venture capital and other necessary resources for successful commercialization.

Currently, there are three common approaches of technology transfer in state DOTs: research-unit-led, operating-unit-led, and LTAP/TTAP-center-led approaches. Formal processes are found most frequently in the research units and the LTAPs and TTAPs. States are adopting some of the practices from the private sector, notably seeking out ready-to-use innovations for application in their own state. Some other issues addressed by academia and the private sector, such as licensing and patents, are now apparent and are beginning to be addressed or are on the near horizon for the states.

Characteristics of the state DOT technology transfer activities and LTAP/TTAP centers are summarized here. The information reported includes the most current information available at the time this synthesis was being assembled, generally from the year 2003.

- Close to one-half of the state DOT respondents and nearly 40% of the LTAP/TTAP survey respondents have 5 or fewer years of experience in technology transfer.
- State DOTs reported that, on average, they spend approximately 6.5% of total agency funds committed to research and research-related activities on technology transfer and implementation activities. This figure includes all types of funding; state, State Planning and Research (SP&R), other federal, and any other type of funding received for research and research-related activities.

- The 38 state DOTs providing information in the synthesis survey estimated that, on average, they spend approximately 9.3% of their Research Part II SP&R federal-aid funds on technology transfer and implementation activities. This figure is a component part of the previous bullet point's total expenditure figure.
- Both state DOTs and LTAP/TTAP centers showed substantially larger technology transfer program investment for respondents having 15 years or greater experience, as opposed to those respondents with 6 to 14 years experience and those with 5 years or less.
- Having a role assigned in the DOT for agency-wide coordination of technology transfer or implementation of research results showed a strong relationship to larger investment in technology transfer activities.
- Four of every five agencies having a group or person in an agency-wide coordinating role reported that more funding was necessary for technology transfer, whereas those state DOTs without such a coordinating function were somewhat equally divided in their assessment of whether they needed more funding or not.
- Organizations with a coordinating function tended to recognize the positive influence of senior management support more than did the state DOTs without such a person or group filling the coordinating role. State DOTs with technology transfer coordination also indicated a greater openness to including innovations into projects and were more accepting of management assistance as compared with their peers without a person or organization in the coordination role.
- The LTAP/TTAP center respondents have been operating for an average of nearly 20 years, with the California and Indiana DOT centers conducting organized technology transfer activities for 50 and 40 years, respectively.
- States routinely use a broad variety of communications vehicles and methods to convey the message of the innovation and their abilities to assist in technology transfer.
- The highway transportation community has three major technology transfer operating approaches. The approach for each can generally be described as either research-unit-led, operating-unit-led, or LTAP/TTAP-center-led. The two most common are those led by the research unit and the LTAP/TTAP centers.

Comparisons with the private sector were revealed as follows:

- The private sector consistently has organizations whose primary role it is to make the successful connection between the innovation generator and the innovation user. These may be venture capital firms, business incubator consortia, or other similar facilitator organizations. The public transportation sector does not have such roles clearly defined and in routine practice, with the exception of the transfer agents within the LTAP/TTAP centers.
- The private and public (other than transportation) sectors strongly endorse a well-supported national library system for information accessibility and availability, which is essential to technology transfer. Currently, transportation has no comprehensive coordinated system of libraries or a central national library providing full information services, including capabilities for archiving and preservation.
- In contrast to the private sector, the public sector may not be availing itself sufficiently of the research and foundational methodologies about technology diffusion and technology transfer developed in other scientific disciplines, such as the social and behavioral sciences.

Successful technology transfer occurs when the following factors are present:

- There is a push of technology into a user environment;
- A champion is associated with the research and technology transfer effort;
- Pilots and demonstrations allow hands-on learning;
- Senior management support attracts attention, leads by example, and gives guidance to the effort;
- Early involvement of the user allows early resolution of problems and prepares the user for fully embracing the innovation;

- There is a technology transfer or implementation plan to identify strategies and tactics;
- Qualified people are in lead roles;
- Partnerships leverage resources and attract the right participants;
- There is progress monitoring and committed funding;
- A focus area exists for technology transfer efforts;
- Emphasis is on marketing and communications; and
- Benefits of the technology meet users' needs.

Many of the elements of success in one project or for one organization can be a significant challenge for other projects or organizations. The challenges experienced by state DOTs include the following:

- Change and risk aversion issues;
- Time constraints;
- Staffing and workload;
- Structural and organizational issues;
- Commitment of the agency and of influential individuals;
- Weak outcomes of research, perceived and actual;
- Funding and costs;
- Communications and coordination;
- Measures of performance; and
- Implementation processes.

The challenges experienced by LTAP/TTAP centers include the following:

- Instructors and technical experts;
- Funding;
- Marketing, communications, and information availability;
- Change issues;
- Staffing and time;
- Materials and courses; and
- Measuring outcomes.

In the course of performing this study two categories of actions were noted. Technology transfer agents and their organizations tended to either encourage others to adopt or apply innovations that would benefit a potential user; in essence, "pushing" the technology out into the transportation community for it to be used. At other times it was noted that technologies or innovations were sought by organizations or their technology transfer agents to apply to specific problems or, in essence, pulling the technology into the agency for use.

The top three needs of state DOTs were: (1) more time to perform technology transfer, (2) additional funding, and (3) technology transfer training. State DOTs believe they could use training in the processes of technology transfer. LTAP/TTAP centers consider technology transfer training as one of their lowest ranked needs, most likely because the centers see these skills as existing strengths and do not place a priority on further enhancing these skills in place of addressing other more pressing needs.

The LTAP/TTAP centers consider additional funding the single most important need. The other needs cited by more than half of the LTAP/TTAP respondents are greater management support for technology transfer, more trained staff, greater access to technical expertise, and assistance for management and administrative responsibilities associated with technology transfer.

A number of state DOTs and LTAP/TTAP centers reported needs in the areas of management and administrative processes associated with making others aware of and encour-

aging others to use innovations. These are listed here in order of the rated need for each state DOT and LTAP/TTAP center:

- State DOTs
  - Implementation plans
  - Evaluation and assessment procedures
  - Executive briefing models.
- LTAP/TTAP centers
  - Evaluation and assessment procedures
  - Executive briefing models
  - Marketing plans.

For state DOTs, additional funding, added time for conducting technology transfer, and greater senior management support are the three most frequently mentioned areas of need when pulling promising technologies into the organization.

The LTAP/TTAP centers indicated more extensive contact with external-to-the-agency peers to determine candidate technologies, added time to perform technology transfer, and included methods or techniques to assist in making the process of technology transfer more efficient as the three most common needs cited in the survey responses.

CHAPTER ONE

INTRODUCTION

PURPOSE AND SCOPE

Technology transfer is a means to directly affect the rate and nature of innovation and improvements to the transportation system. Whether there is a new device to apply or a more effective manner of performing a task, technology transfer is an essential part of that innovation. Because of the integral role technology transfer plays in all areas of transportation, a synthesis of current practice is important for transportation practitioners and managers alike. This synthesis presents an overview of the technology transfer practices currently used within the highway transportation community. It is intended to assist in speeding innovation to practice, thus increasing safety, enhancing performance, and reducing costs. The synthesis documents successful practices, discusses challenges encountered, and identifies needs to promote improvements for technology transfer activities and processes.

The scope of the synthesis includes technology transfer practices within state departments of transportation (DOTs) and other programs or organizations such as the Local and Tribal Technical Assistance Programs' (LTAP/TTAP) Technology Transfer Centers and the Resource Center and division offices of FHWA. Technology transfer within the academic and private sectors is addressed to a lesser degree, and although there is substantial activity, most is focused on commercialization, an area not emphasized by state DOTs.

DEFINITIONS

A number of terms familiar to the transportation community are used in this document. Although many definitions for these terms may be acceptable, the following are used herein.

Adoption or application to practice—making a technology or innovation an organization's standard operating procedure or causing the technology or innovation to be used as the generally accepted means for accomplishing a specific task. Such action is an outcome of implementation of research results or technology transfer activities.

Deployment—systematic process of distributing an innovation for use. This term implies a relatively broad use, rather than pilot, demonstration, or incidental use of the innovation. A technology can be considered deployed when it is used multiple times within an organizational or group context, such as use resulting from a newly written specification.

Education and training—processes encompassing a variety of instructional methods to cause learning. For the most part, when using the terms education or training, this document implies formal or organized instructional opportunities for learning.

Implementation of research results—used in highway transportation and particularly by the research community to describe the various activities required to put an outcome of a research project into widespread use. This term is often used synonymously with technology transfer by those in research. The activities can span the entire duration of the research project and extend until the research result is adopted, for example, as part of a standard operating procedure. Implementation activities may be pilots or demonstrations, training, technical assistance, provision of needed resources, or any activity that fosters use of the research result.

Innovation—procedure, product, or method that is new to the adopting organization. The item may be a result of research or may be a new application of an existing improvement that has been used in another context or other organization.

Knowledge transfer—diverse activities causing the flow of knowledge from one person, group, or organization to another. Such knowledge transfer can be a systematic process to identify, capture, and share tacit knowledge to enable it to become explicit knowledge.

Technology—term used very broadly to include practices, products, processes, techniques, and tools.

Technology transfer—activities leading to the adoption of a new-to-the-user product or procedure by any user or group of users. New-to-the-user means any improvement over existing technologies or processes and not only a recent invention or research result. Technology transfer includes research results implementation and product or process deployment. Activities leading to the adoption of innovations can be knowledge transfer, training and education, demonstrations and showcases, communications and marketing efforts, technical assistance, and more (Wallace et al. 1998, pp. 2–3; Schmidt et al. 1984, p. 1). In addition, technology transfer in this transportation

context also includes the complex process of change, a comprehensive achievement dealing with cultural as well as technical issues.

LITERATURE AND DATA SOURCES

There were three major sources of data used to develop this synthesis: surveys, interviews, and a literature review. The most important of these sources was a survey that was sent to AASHTO Research Advisory Committee (RAC) members. A second very similar survey was sent to LTAP and TTAP Assistance Programs' centers. Completed surveys were received from 39 research units (38 states and one Canadian province) and 23 LTAP/TTAP centers. Data from the survey are generally expressed as the number of occurrences, percent of total responses, or as an average value of responses for the particular survey element. The surveys are included as Appendix A.

In total, there are 51 LTAP centers (50 states and Puerto Rico) and 7 TTAP centers. The response rate for the survey from LTAP/TTAP centers was 40%. More responses were desirable from the centers; however, the information received was from a representative sample of centers including 2 TTAP centers, 6 LTAP centers that have operations within the DOT, 23 LTAP centers funded by the DOT but operated by others, and 1 LTAP center that operates within the DOT as well as having others outside the agency operating the program. The response rate from the state DOTs was 75%, and one response was received from the Quebec Ministry of Transportation. A list of respondent organizations is included in Appendix B.

To augment data from these surveys, interviews were conducted with a number of research managers and LTAP/TTAP center directors. Those contributing to the synthesis are listed in Appendix B.

The survey for both the state DOTs and LTAP/TTAP centers included four focus areas. Initially, the questions centered on general information about the technology transfer and implementation activities carried out by the respondent's agency, including program size, structure, management, and funding. Three other focus areas, successes, challenges, and needs were included in the questioning. Respondents were asked to provide reasons for successes, to detail specific challenges to technology transfer or implementation of research results, and to discuss what was done to mitigate the challenges. The surveys also requested that respondents identify needs for improvements in technology transfer processes.

In addition to the formal surveys distributed, a short e-mail survey was sent to RAC members in conjunction with a related project, "Scoping Study for a Technology Transfer Toolbox" (Harder 2003a). This survey is included in Appendix A. The Technology Transfer Toolbox Scoping Study was done concurrently with this synthesis. Data from that study were available for this synthesis. The Technology Transfer Toolbox Scoping Study describes tools that are needed in the transportation community to facilitate the performance of technology transfer. The work done on that study provided information that was particularly relevant for the synthesis. Academic researchers, state DOT research managers, and FHWA resource center and division office staff involved with technology transfer were interviewed in the course of that study. Additionally, the TRB Committee on Technology Transfer and the FHWA Office of Professional Development, both sponsors of the Technology Transfer Toolbox Scoping Study, provided useful information for the synthesis.

To give a more complete picture of technology transfer in the transportation community, information about technology transfer processes in private organizations was reviewed for the synthesis. These reviews and the very large volume of published material on academic technology transfer provided a perspective of another aspect of technology transfer—patents, intellectual property ownership, and/or commercialization—perhaps precursors to future public-sector practices.

Government publications and business management literature provided substantial background information on the manner in which technology transfer is conducted in both the public and private sectors. EBSCOhost® and ProQuest® databases were the primary sources for business literature. The Transportation Research Information Services (TRIS) database and the TRB Library were particularly significant sources of information about transportation technology transfer activity both on the federal and state level. In addition, TLCat, the National Transportation Library Transportation Library Catalog (comprised of electronic document references), provided important references for this work. Because of the nature of technology transfer, much information is directly available on the World Wide Web. References and the bibliography note such availability.

Other sources of information were the state DOT research unit peer exchange meetings and a report based on 51 state DOT research unit's exchanges (50 states and the District of Columbia). The report, "Peer Exchange: A Value Added Program Management Tool" (Harder 2001), is a synthesis of the concepts, methods, and recommendations from research peers having participated in research, development, and technology peer exchanges throughout the United States. Implementation of research results, including the dissemination of research results, marketing, and communications are among the various topics considered by the peer exchanges.

In addition, the synthesis study project panel provided key information. The foundational strategies and perspectives on

users and their needs shared by the panel were central to the formation of this document.

ORGANIZATION

Chapter one of the synthesis provides the introduction to the topic, describes the purpose and scope of the project, defines important terms that are used in the study, identifies the primary sources of information used for this report and describes the content and organization of material in the document. Chapters two through six examine the various aspects of the practice of transportation technology transfer.

- Chapter two includes a general overview of the topic, establishing the fundamental issues related to technology transfer. The current context for technology transfer in highway transportation and in other public- and private-sector venues applicable to highway transportation are discussed.
- Chapter three details successful technology transfer practices and discusses their application, the context in which they were performed, and the ease of replication. The chapter also identifies factors affecting successful technology transfer and presents information on the evaluation of technology transfer practices.
- Chapter four addresses the challenges to technology transfer. A variety of barriers are discussed and, where applicable, solutions for overcoming the challenges are detailed.
- Chapter five describes the perceived needs of the suppliers and users of technology transfer processes.
- Chapter six details findings and conclusions from the study and identifies suggestions for future research.

CHAPTER TWO

TECHNOLOGY TRANSFER OVERVIEW AND APPLICATION

OVERVIEW AND BACKGROUND—HIGHWAY TECHNOLOGY TRANSFER

Technology transfer is a topic that has drawn the attention of innovators in the highway transportation community for more than 40 years. For all of this time, technology transfer has been closely identified with the implementation of research results. Documents describing what today is termed "technology transfer" were then primarily concerned with moving research findings into practice (Watkins 1974, p. 1). "In 1967, an American Association of State Highway Officials Special Committee on Utilization of Research (known as the Stevens Committee) noted that there was an undesirable and unnecessary time lag between the completion of research and the utilization of that research" (Hodgkins 1989, p. 3). The committee's findings led to substantive changes in the public sector highway arena. Among the changes was the reorganization of FHWA in 1970, which resulted in the creation of an Implementation Division, whose mission was to accelerate the utilization of research findings.

Reflecting the interest of the states, the FHWA work grew to include programs focusing on experimental projects, testing and evaluation, demonstrations, and implementation projects. All of these activities had technology transfer as their foundation. In 1973, FHWA established a Technology Transfer Program that positioned FHWA personnel in regional and division offices to provide assistance to the states (Burke 1984, p. 21). At this time, the state DOTs were actively working at transferring technology to enable use of innovations. The Michigan DOT regularly published a *Testing and Research Newsletter,* produced a *Research Laboratory Annual Report,* sponsored workshops to introduce new specifications, and capitalized on opportunities to meet with contractors to introduce new or experimental features. Arkansas issued newsletters, distributed its research documents, prepared presentations on its innovations, and circulated brief summaries of technical literature. The Virginia Research Council (now the Virginia Transportation Research Council) conducted an active technology transfer program, participating in FHWA programs and serving as an agency clearinghouse for technology transfer information, with the council director as the Technology Transfer Coordinator for the department. Libraries were important mechanisms for transferring technology and many states supported a library associated with their research offices (Burke 1984, pp. 22–28). Highway and transportation departments each addressed technology transfer and implementation of research results through varying processes from internal organizations such as Pennsylvania's Bureau of Bridge and Roadway Technology, charged with implementation of innovations, or external partnerships such as the Joint Transportation Research Program of the Indiana DOT (INDOT) and Purdue University.

There was a need for technology transfer of highway innovations for municipal governments as well. In 1982, the Rural Technical Assistance Program (RTAP) [now the Local Technical Assistance Program (LTAP) and the Tribal Technical Assistance Program (TTAP)] was created as a cooperative effort between FHWA and state DOTs. FHWA administered the RTAP activities. RTAP Technology Transfer Centers provided technical assistance to communities with a population of 50,000 or less. In subsequent years, through changes brought about by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), RTAP broadened its mission to serve larger communities, DOTs, and Native American tribal governments. FHWA continues to administer both LTAP and TTAP activities.

FHWA continued to strengthen its commitment to technology transfer, when in 1989 its Implementation Division became the Office of Technology Applications. This office housed the broad array of FHWA programs that encouraged adoption of innovations through technology transfer practices. Significant efforts were also occurring through AASHTO to transfer to highway users the research results and products produced by the Strategic Highway Research Program. The AASHTO Lead State program set a standard for transferring technology in state DOTs. States with expertise and experience with new technologies shared the knowledge and use of new technologies with other states not yet possessing the expertise or experience. Currently, FHWA is organized to provide expertise in close proximity to the users through the Resource Center and the division offices. In addition, program offices and the Turner–Fairbank Highway Research Center provide technical expertise for technology transfer to the state DOTs and others.

An important player in the current context is the TRB Committee on Technology Transfer. The committee is concerned with information exchange and research on the processes and methods for technology transfer. It assists TRB and other TRB committees by serving as an agent for technology transfer. The committee is an effective resource for networking among peers.

In addition to the LTAP/TTAP centers and their national LTAP organization, the LTAP Clearinghouse provides program support to LTAP. The American Public Works Association operates the clearinghouse through a contract with FHWA. The clearinghouse provides technical, publication, and program support for the LTAP/TTAP centers.

A number of other players have had a significant influence on transportation technology transfer. In 1970 Congress created the National Highway Institute, an FHWA organization that provides training, resource materials, and educational opportunities to the surface transportation community. At about the same time, TRB instituted TRIS. The TRIS database is the most comprehensive bibliographic resource for transportation information. Additionally, AASHTO, TRB, and other professional organizations such as ITE, ASCE, and ITS America have created forums for the exchange and transfer of information critical for applying innovation to transportation.

CURRENT CONTEXT—TECHNOLOGY TRANSFER IN HIGHWAY TRANSPORTATION

Today the transportation community benefits from the experiences of the past four decades that included creating a foundation for technology transfer and building on it. However, change is increasingly more rapid and technologies can be vastly more complex and sophisticated. The need still exists, and may be more acute, to transfer research results and other new, or new-to-the user, technologies into useful processes, products, and practices.

Two Primary Changes

Two changes that occurred in the past decades significantly influenced the current environment for technology transfer in highway transportation. Foremost, both the resources and expertise applied to technology transfer have increased dramatically. These increases come from greater amounts of legislated funds for research and related activities, including implementation of research results and LTAP/TTAP activities, and from the resources put forth through external partnerships—committing technical expertise, facilities, equipment, and in some cases additional funding. The second primary change is that there are more people involved in technology transfer, especially within state transportation departments, and they are more broadly distributed throughout the departments. In the past, those interested in technology transfer were most likely to be located in the research offices. Now, participants come from within operating divisions and regional or county offices of the agency, and also more frequently include senior managers who support the efforts. Moreover, others often involved are the partners in academia and the private sector, and FHWA or other federal-level organizations (Harder 2003b, pp. 9–12).

Another substantial change reflected in the current highway transportation community is the higher level of expertise for accomplishing the task of technology transfer. There is now a cadre of technology transfer and implementation experts available to close the gap between innovation and practice. Many of these professionals have acquired their expertise from involvement in LTAP/TTAP. Others, especially in state DOTs, have increased their knowledge through years of experience in fostering the application of research results.

In addition to those knowledgeable about technology transfer, other professional disciplines have been brought into the technology transfer process. Expertise in information services, organizational management including the forming of alliances and partnerships, and marketing and communications is being brought to bear on technology transfer and implementation of research results.

Additional Characteristics of the Current Environment

For the most part, technology transfer is now recognized as an important part of state research programs. However, recognition of the relationship between technology transfer and achieving agency goals is relatively recent. State DOT research units are continuing to develop this concept. Also, in general, the state research programs are using the term "implementation of research results" nearly synonymously with the term technology transfer. Such dual usage appears in this document as reflecting state DOT practice.

There is a general acknowledgement that specific resources are required for accomplishing technology transfer and implementation activities and that providing these resources facilitates the adoption and deployment of innovations. State DOTs are beginning to budget funds and human resources for technology transfer and implementation of research results. This is very different from past practices of relying on the operational environment to supply all resources for any implementation or technology transfer activity. Moreover, there is an awareness of the research units being the focus for expertise in technology transfer whether the innovation under consideration is a result of the program's research activities or from some other source.

Another characteristic of the current environment includes not only the more common practice of pushing technology out to users, but users seeking innovations and existing solutions to problems by pulling technology into the operational setting. Technology transfer no longer is solely the responsibility of the research group trying to get its results put into practice. Increasingly, operational units are lead participants in bringing innovations to transportation practice.

There is growing recognition that technology transfer now is both the practitioner's responsibility and the researcher's responsibility. The collaborative nature of technology transfer is becoming more accepted. In several states, cross-disciplinary

teams of practitioners, researchers, and technology transfer agents exist as formally structured mechanisms rather than as a hit-or-miss team-forming, ad hoc process.

Currently, technology transfer is a more planned and deliberate process than ever before. The planning of technology transfer activities and tracking and monitoring of performance are becoming necessary components of technology transfer and particularly of research results implementation.

Today virtually every state DOT uses some of the common tools for technology transfer. These include myriad communications processes from person-to-person venues to documents, reports, newsletters, brochures, and summaries to training, demonstrations, showcases, and the Internet. Information dissemination and its availability by means of the Internet is a remarkable phenomenon for technology transfer. Opportunities are increasing to create valuable resources such as user group communities and best practices collections.

The state of the practice of technology transfer also is becoming more strategic. States and FHWA understand that deployment of innovations can be a key to maximizing the value of transportation assets. Using technology transfer as a strategic tool to speed innovations into the transportation system is becoming an important management lever.

Although increased resources are being applied to technology transfer and with greater sophistication, there is much yet to be done. Within the state DOTs there are varying degrees of application of technology transfer practices. Inconsistencies abound and the change that technology transfer promotes may be difficult for even the most forward-thinking agencies. Successes follow on the heels of difficult and lengthy "not quite successes." Processes are not yet recognized as *best* practices and significant challenges still need resolution.

Profiles of Respondents from Surveys

To better understand the perspectives from the synthesis survey respondents, some general characteristics about the respondents are included in this section.

Table 1 contains a listing of the years of experience of respondents from the state DOT and LTAP/TTAP surveys. Within the DOTs, the distribution shows a sizeable group of individuals who are new to the technology transfer area within the past 5 years. It also shows that there is a very experienced group that has been involved with these activities, with an average tenure of more than 19 years. A key to maintaining a knowledge and skills level for technology transfer in state DOTs will be to encourage building on the basic experience of those relatively new to technology transfer activities and to retain the expertise of those who are in the middle experience level group (6 to 14 years). Retirements will occur among the most experienced group, and creating opportunities to share and document their expertise could contribute to a collection of successful practices for technology transfer and implementation of research results.

TABLE 1
RESPONDENT'S YEARS OF INVOLVEMENT AND AVERAGE TENURE—TECHNOLOGY TRANSFER/IMPLEMENTATION OF RESEARCH

Years of Involvement	State DOT		LTAP/TTAP	
	No.	Average Tenure (years)	No.	Average Tenure (years)
0–5	17	3.4	7	2.4
6–14	8	6.3	9	11.1
15 and over	13	19.3	6	17

Information from the responding LTAP/TTAP centers noted that they are better positioned to retain the current level of knowledge and skills for technology transfer. The distribution of years of experience has a balance of the new and the most experienced, with a strong group in the middle experience level group. Five of the seven LTAP/TTAP centers with respondents having 5 years or less experience are operated by state DOTs. This may be an indication of the generally high turnover rate in the state DOT-operated centers or that states are showing high levels of retirement in this area and efforts have recently been made to replace this talent.

Experience matters when considering program investment for technology transfer and implementation of research results. Both state DOTs and LTAP/TTAP centers showed substantially larger technology transfer program investment for respondents having 15 years or greater experience. For those state DOTs, the investment amount was more than three times that of respondents having 6 to 14 years experience and more than double the investment being made by those with experience of 5 years or less. LTAP/TTAP center technology transfer investments for the respondents with the most experience were nearly twice that of the respondents' programs with 6 to 14 years experience and greater than twice the investments of programs for those having experience of 5 years or less.

Respondents have carried out or conducted technology transfer in a variety of capacities. Thirty of 38 state DOTs, almost 80% of the respondents, were (or are) research managers, because they performed technology transfer or the implementation of research results activities (see Figure 1). Technology transfer or implementation duties were also done as these people worked in other areas of the department, such as other central or field offices. Most of the respondents' activities in technology transfer or implementation of research results was found in the research unit whether one was a researcher or research manager.

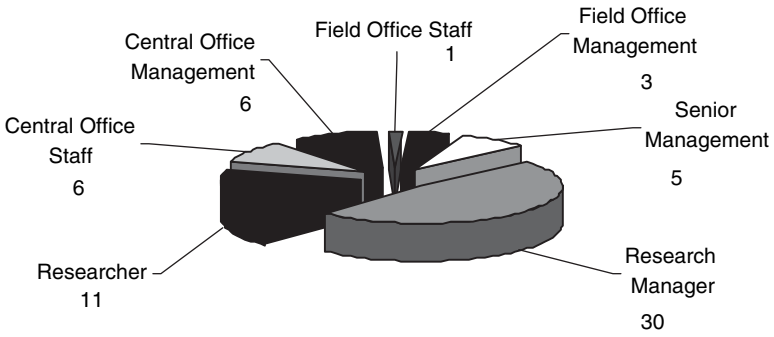

FIGURE 1 Respondent's role when carrying out technology transfer (state DOT). Thirty-eight respondents, multiple responses permitted.

Eight of the state DOT respondents were in agencies that operate an LTAP center. All eight had respondents that were researchers or in research management when performing technology transfer or implementation of research results. The survey results did not specifically identify the degree to which LTAP was associated with the research unit, but suggested that a direct connection existed among these states' research units and the technology transfer activities of the LTAP center.

Additionally, having a role assigned in the DOT for agency-wide coordination of technology transfer or implementation of research results showed a strong relationship to larger investment in technology transfer activities. For programs with a person or group assigned to coordinate the technology transfer activities the investment in technology transfer was 10 times that of agencies that had no such coordination. Eight DOTs indicated no coordinating function in their agencies. Certainly, if an agency commits resources to a coordinating function it might be expected that greater investment would occur; however, the difference of a factor of 10 is perhaps more dramatic than one might anticipate.

A brief analysis of all LTAP/TTAP centers shows that most of the centers are located in organizations apart from the state DOT that funds them. Approximately 25% of the LTAP centers are operated by state DOTs and 75% are operated by others. Outside of the state DOT, universities are the preferred choice for LTAP/TTAP operators, and all TTAP centers are operated by organizations other than the state DOT.

LTAP/TTAP center respondents had a somewhat different experience than the state DOT respondents (see Figure 2). Many of the LTAP and TTAP respondents had functioned in the role of technology transfer program manager or staff. They had not participated in technology transfer or imple-

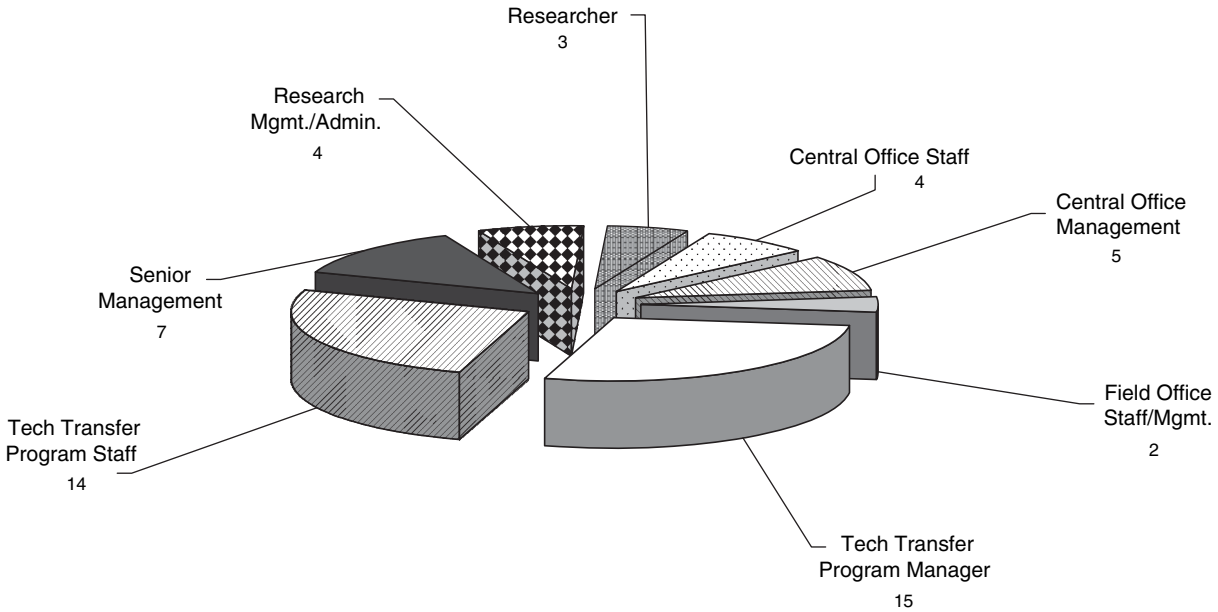

FIGURE 2 Respondent's role when carrying out technology transfer (LTAP/TTAP). Twenty-two respondents, multiple responses permitted.

mentation of research results through research activities or research management to the same extent as the state DOT respondents. Seventy-five percent of the LTAP/TTAP center respondents were from centers funded by a state DOT, but operated by others outside the agency—mostly by universities. Approximately one-third of the LTAP/TTAP centers respondents had experience in technology transfer as senior management. Nearly one-fourth had experience as central office management or research management. The diversity of roles at the LTAP/TTAP centers as they participate in technology transfer or implementation of research results may be from the wide reach that the centers use in attracting personnel to their programs.

For state DOTs there were a few noteworthy items that emerged from examining the agency-wide coordinating role and from determining whether it influenced any aspects of technology transfer. Four of every five agencies having a group or person in the coordinating role clearly reported that more funding was necessary for technology transfer, whereas those state DOTs without such a coordinating function were somewhat equally divided in their assessment of whether more funding was needed. Clearly, the coordinating function affects the perspective for funding needs. Other items to note are that the organizations with a coordinating function tended to recognize the positive influence of senior management support more than the state DOTs without such a person or group filling the coordinating role. The state DOTs with technology transfer coordination also indicated a greater openness to including innovations into projects and were more accepting of management assistance as compared with their peers without a person or organization in the coordination role.

Other general information about the respondents and their technology transfer operations includes the following:

- A majority of state DOT survey respondents (approximately 85%) were responsible for agency-wide coordination of technology transfer activities, and most of these were associated with the agency's research function.
- More than half of the research units in state DOTs share the responsibility of technology transfer with other units in the agency, one-quarter are solely responsible, and two respondents reported that no unit in their department was specifically assigned responsibility for technology transfer.
- The LTAP/TTAP centers that respondents represented have been operating for an average of nearly 20 years, with California DOT and INDOT centers having conducted organized technology transfer activities for 50 and 40 years, respectively.
- The LTAP/TTAP respondents' centers not including California's have annual budgets that average $375,000. If California's center is added, the average total budget is $495,000.
- All of the LTAP centers receive federal-aid LTAP funds. In addition, TTAP centers receive Bureau of Indian Affairs and tribal government funds. Approximately 35% of the LTAP/TTAP centers reported receiving university funds and 41% receive funds from local governments. Only 5% of the centers reported receiving funding from the private sector.

CURRENT CONTEXT—TECHNOLOGY TRANSFER IN OTHER VENUES APPLICABLE TO HIGHWAY TRANSPORTATION—PUBLIC AND PRIVATE SECTOR

There are several mechanisms in the public and private sectors that are relevant to transportation technology transfer practices. This section highlights a few of these mechanisms and relates them to their usefulness for the transportation community.

Technology Transfer and Commercialization in the Private Sector

The private sector has very different reasons for its interest in technology transfer, most based on the process of bringing a product to market; that is, commercialization. However, the origins of private-sector technology transfer and its subsequent maturing have application for public-sector highway transportation. Although private-sector companies bring about technology transfer within their own organizations and among private-sector partners, the most relevant private-sector technology transfer activities for this study are those between the private-sector and public-sector agencies. In particular, the private-sector technology transfer process, especially as it emerged with public-sector defense applications, provided a foundation for technology transfer practices within other areas in the public sector, including highway transportation.

As background, a short synopsis of the development of technology transfer in the private sector is included from *NCHRP Synthesis of Highway Practice 312: Facilitating Partnerships in Transportation Research* (Harder 2003b). This synopsis shows the rapid development of the mechanisms for partnerships, which increased the opportunities for technology transfer, facilitated technology transfer activities, and also fostered the development of technology transfer methodologies.

> During the late 1980s and 1990s, competitive advantage became one of the forces behind the collaboration of industry with its suppliers and within distribution channels. . . . Interests centered on decreasing the time for research and technology development as a means to speed products to the marketplace.
>
> Global competition began to pose a significant threat, particularly for science and technology applications. U.S. anti-trust laws were seen as too restrictive for meeting these broad economic challenges. Starting in 1980 federal laws were enacted beginning with the Stevenson–Wydler Technology Innovation Act, which 'required Federal laboratories to facilitate the transfer of Federally owned and originated technology to state and

local governments and to the private sector' (Science and Engineering Indicators 2000). Other legislation such as the National Cooperative Research Act (1984); the Federal Technology Transfer Act (1986), which created Cooperative Research and Development Agreements (CRADAs); and the National Cooperative Research and Production Act (1993) each enhanced the opportunities for partnerships, joint ventures, and other collaborative research and technology transfer activities between the public and private sectors.

See Appendix C for a descriptive list of related laws fostering cooperative relationships for technology transfer.

One result of the legislation in the 1980s (specifically, the Federal Technology Transfer Act of 1986) was the formal chartering of the Federal Laboratory Consortium for Technology Transfer (FLC), a nationwide network of federal laboratories that provides a forum to develop strategies and opportunities for linking the laboratory mission technologies and expertise with the marketplace. The FLC was organized in 1974 to promote and strengthen technology transfer nationwide. Today, more than 700 major federal laboratories and centers and their parent departments and agencies are FLC members. The Consortium creates an environment that adds value to and supports the technology transfer efforts of its members and potential partners. The FLC develops and tests transfer methods, addresses barriers to the process, provides training, highlights grass-roots transfer efforts, and emphasizes national initiatives where technology transfer has a role. For the public and private sector, the FLC brings laboratories together with potential users of government-developed technologies.

The objectives of the FLC include, among others (Federal Laboratory Consortium for Technology Transfer 2005):

- Enhancement of efforts that couple federal laboratories with American industry and small businesses to strengthen the nation's economic competitiveness;
- Collaboration with local, state, regional, and national organizations that promote technical cooperation; and
- Promotion of further development and adoption of effective methods for federal laboratory domestic technology transfer.

Interest in technology transfer in the private sector increased significantly as a result of these legislative solutions to foster competitive advantages for U.S. businesses. The laws made substantial progress in closing the gap between the university research community and the private-sector commercial community. There were strong incentives for universities to hold patents to their research products. Funds flowed into university research programs as partnerships for technology transfer grew. These partnerships were the primary vehicle for facilitating commercialization.

Technology transfer in the private sector has changed dramatically since the late 1980s. Commercialization has completely overshadowed other technology transfer activities. The rush to get products to market and to create profit for a company is paramount. The literature today points most decidedly at commercialization rather than other functions of technology transfer in which private-sector companies may be engaged. Companies transfer technology within their own organizations and with partners and other peer organizations; however, the commercialization activities far outweigh other technology transfer functions and in these processes there are particularly valuable lessons for the public sector seeking to enhance its methods and practices.

Commercialization has fostered a significant new infrastructure for technology transfer. "Concerned that it might be difficult for companies to locate promising technologies effectively in the complex government system, Congress created the National Technology Transfer Center (NTTC) in 1989. The NTTC works with [federal agencies such as the] National Aeronautics and Space Administration . . . Department of Defense, Environmental Protection Agency, and [others] to help identify promising technologies and match them with private-sector developers" (Allen 2004, p. 30). NTTC is a clear example of the support being given to foster commercialization.

Not only did a new means to identify innovations appear that augmented the private sector's efforts for commercializing innovations, but financial infrastructure developed as well. Venture capital firms and commercialization advisory organizations gained a strong foothold in the process of commercialization. These groups are experts at defining the usefulness of a technology and matching the technology generator with a commercialization organization. They also know where to get the money to fund the commercialization process and are very often the go-between or link between the university or developer and the business seeking innovations for the marketplace. Although NTTC provided a path for innovations that originated with federal funds, the process for commercialization of innovations from research laboratories is ofter similar for fully private-sector-funded efforts.

With a broader source of innovations and added financial capability, the researchers and developers also created a more stable working structure. In particular, research universities developed offices of technology transfer, which are well prepared to promote technologies suitable for commercialization that are produced by the universities. These offices are also equipped to deal with intellectual property and other legal hurdles, contracting and business arrangements, and they understand and use the laws designed to promote technology transfer. Additionally, there is pressure to increase such commercialization activities: "state lawmakers are sending public research universities a clear message: its time to begin commercializing your discoveries to promote local economic development" (Schmidt 2002, p. 1). Several states have made changes in laws that reduce or eliminate barriers that prevent collaboration between university faculty and private companies. Also, more than one-third of the

states' governors have requested additional funding for technology transfer efforts leading to economic development (Schmidt 2002, p. 1).

It is important to recap this type of private-sector experience to highlight some of the successful developments that may be used by the public-sector highway community. The private-sector experience has shown the need for infrastructure to help in identifying innovations, and to create financial and economic capability, as well as human resource capacity for facilitating technology transfer. Furthermore, the private sector found a means to effectively close the gap between those who have an innovation and those who can put the innovation to use. The structure the private sector developed is lacking, in full measure, in public-sector technology transfer efforts. The private sector now has highly experienced organizations (university offices of technology transfer) pushing the technologies out, and they have strong incentives for doing so. There are many companies ready to commercialize a new technology in hopes of it being the next success for its market. Also, the private sector consistently has organizations whose primary role it is to make the successful connection between the innovation generator and the innovation user.

In transportation, the innovation generators, whether they are the state DOTs, consultants, research institutes, or universities, generally do not have similar established offices (as with academia or the private sector) functioning with the sole responsibility to promote technology to be transferred. Moreover, the users of the technology to be transferred do not have the profit motive to lend the same type of immediacy to the activities. *TRB Special Report 256: Managing Technology Transfer, A Strategy for the Federal Highway Administration,* notes that "[U]nlike their private counterparts, public managers cannot look to the profitability of competitors as an indication of successful innovation . . ." (Jacobs and Weimer 1986, p. 139). However, the public-sector motivations for service excellence, wise stewardship of taxpayers' dollars, and transportation safety are even more worthy causes for commitment to technology transfer. Although the streamlined structure seen in the private sector may not yet exist in the highway transportation community, transportation does have a growing number of technology transfer agents. Many of these trained experts are dedicated to LTAP/TTAP activities, are located in the FHWA Resource Center, or are distributed throughout the state DOTs.

Stable Sources of Information

A second element that the private and public sectors have strongly endorsed for technology transfer is information accessibility and availability through a well-supported national library system. Several examples of such resources that are instrumental in advancing innovation are the National Agricultural Library (NAL) and the National Library of Medicine (NLM). Both NAL and NLM are legislatively mandated. NAL is chartered as a National Library, for public use, as well as the library for the Department of Agriculture. NLM serves the Department of Health and Human Services, National Institutes of Health. It is the world's largest library for health sciences and was designed to serve medical professionals. Since 1999 it has allowed public access to services such as its free Medline information system.

NAL and NLM prepare and distribute summaries of technical documents; provide reference services and document procurement; supply Internet accessibility to information experts; retain, preserve, and house unique documents and collections; and provide many other functions that are critical to technology transfer. For example, one of the objectives of NLM is to promote the use of computers and telecommunications by health professionals for purposes of improving access to biomedical information for health care delivery and medical research. Also, NAL states that it is to cooperate with and coordinate efforts toward development of a comprehensive agricultural library and information network and to coordinate the development of specialized subject information for its users.

The resources committed to these libraries, both human and financial, dwarf what transportation invests in its information access and availability. The existing information sources such as TRIS, the Research-in-Progress database, or TLCat, a catalog of the the holdings of many transportation libraries, do not approach the level of services that can be delivered by NAL or NLM. There is no full-service national library for transportation, and comprehensive national services for transportation information are not available, although these services are important to technology transfer (Harder and Tucker 2004, p. xi).

Technology Diffusion

Many of the private-sector technology transfer efforts have their roots in diffusion methods, and the private sector has made good use of the research in technology diffusion. Most research in this area originates in the social and behavioral sciences. Everett M. Rogers in his classic work, *Diffusion of Innovations,* describes diffusion as the process in which an innovation is communicated through certain channels over time among the members of a social system. He also states that diffusion is concerned with new ideas and includes social change. Rogers' four main elements are the innovation, communication channels, time, and a social system.

Mock et al. (1993), in *Moving R&D to the Marketplace: A Guidebook for Technology Transfer Managers,* discusses the diffusion process as developed by G.W. Hough. Hough's diffusion process includes the following elements:

- Current science and technology (is it possible?)
- Culture (is it allowed?)
- Market needs (economics—will it pay?)
- Social needs (is it wanted?)

From these elements come informing, innovating, and integrating processes. Outcomes of the processes are technical, geopolitical, economic, and social developments.

In contrast to the private sector, the public sector may not be availing itself sufficiently of the research and foundational methodologies about technology diffusion and technology transfer developed in other scientific disciplines, such as the social and behavioral sciences.

Transportation technology transfer and implementation of research results in large part have grown from the need to solve engineering problems. Technology transfer or implementation of research results in transportation has often been a collateral function of those having engineering responsibilities. Consequently, the same engineering expertise has traditionally been used to perform technology transfer. The expertise needed for technology transfer however can be quite different than what has been used in transportation. To its advantage, the public-sector transportation community's understanding of the unique expertise needed for technology transfer is growing. Of all the technology transfer activity that occurs in transportation, the LTAP/TTAP centers are most attuned to the diffusion models and change theory.

CHAPTER THREE

SUCCESSES

> In research we seek the truth and share it with others. Depending on how well we share, the people are served. The world changes, and the future opens up to us.
>
> (New Mexico Department of Transportation Research Bureau Brochure)

STRUCTURE AND ELEMENTS OF SUCCESSFUL TECHNOLOGY TRANSFER

The highway transportation community has three major technology transfer operating styles or approaches. The approach for each can generally be described as research-unit-led, operating-unit-led, and LTAP/TTAP-center-led. There is overlap in techniques and services; however, each of these three approaches addresses different needs for technology transfer.

The two most common approaches are those led by the research unit and the LTAP/TTAP centers. However, technology transfer is occurring in greater degrees within the state DOT operating divisions, especially through FHWA and organizations such as AASHTO, with its sponsored activities, committees, and technical peer groups.

The research-unit-led technology transfer is primarily comprised of facilitating the implementation of research results from its own program or successful research venues including FHWA, AASHTO, or others. For research results produced by its own program, research unit staffs provide or enlist the expertise, identify necessary resources, and work in partnership with operating units to do what is needed to put an innovation into practice. For programs that contract for research, research units have the added role of being a liaison between the external researcher and the operating unit user. For technologies or innovations originating outside the agency, the research unit will perform these same functions, but will also act as a magnet and filter to pull those innovations into the organization. The research unit will then act as a catalyst to get the operating units to adopt the innovation.

The LTAP/TTAP-center-led approach is based on the LTAP/TTAP mission: "foster a safe, efficient, environmentally sound transportation system by improving the skill and knowledge of local transportation providers through training, technical assistance, and technology transfer." Core services to clients provided by the centers are training programs, new and existing technology dissemination, personalized technical assistance, website information, and newsletters. The vision developed in the strategic plan for the program includes a focus on interactive relationships, information exchange, and the ability to enrich the knowledge base of the stakeholders (see: http://www.ltapt2.org/about/program.htm). There is an LTAP/TTAP center in all 50 states and in 7 regional areas for Native American governments. As a group, the LTAP/TTAP centers have the highest concentration of trained or experienced technology transfer professionals in the transportation community. The centers are typically very familiar with their constituencies. They pull into their operations the technologies or knowledge (innovations) suitable for transfer. They find the right packaging or develop it for the needs of their customers, and they use a broad array of tools and mechanisms to deliver the innovation. The centers are particularly experienced in communication and outreach activities, such as instructional activities by means of:

- Conferences and symposia,
- Training and short courses,
- Demonstrations,
- Technical assistance/communications, and
- Print and web-based publications and materials.

A detailed list of these activities was prepared for the TRB Committee on Technology Transfer and is contained in Appendix D. The style or approach used by the LTAP/TTAP centers is one of a central go-between—the transfer agent. Transfer agents, because of their expertise in identifying technologies and their thorough knowledge of their constituents, can link the technologies with the users.

The third approach, operating-unit-led, focuses on the technology transfer that is pulled into the organization by operating units or through the influence of senior management who have been exposed to an external technology push (e.g., a colleague or peer recommending adoption of a technology, an organizational endorsement of an innovation, or being enlisted to support an innovation and to be instrumental in the adoption and deployment decisions.) This technology transfer is more ad hoc; it occurs most frequently with professionals through communications among technical committees, peer person-to-person discussions, and other general word of mouth. The technology transfer happens when a viable innovation is brought to the attention of prospective users within these networks. Generally there is no assigned responsibility or defined position within operating units for

managing this type of technology transfer, although awareness of this function is growing. Although this approach is not as formal as the other two, it is very effective because it is uniquely user- and needs-driven. The technology would not be pulled into the operating unit unless it had a high potential for successful adoption.

To more effectively assist in the implementation of research results, research units are striving to be more integrated with the operations of their respective agencies. There is a shift in some of the state DOTs to work more closely with the research units when an operation-unit-led opportunity appears. This is a helpful trend, because it can provide more technology transfer expertise to the implementation effort and add some additional structure to that effort.

The following sections of this document primarily address the research-unit-led and LTAP/TTAP-center-led technology transfer activities. Where appropriate the operating-unit-led efforts will be addressed; however, the ad hoc nature of their technology transfer can make the processes difficult to record in any systematic manner.

FACTORS AFFECTING SUCCESSFUL TECHNOLOGY TRANSFER

The following factors all strongly correlate with successful technology transfer or implementation of research results. These factors were identified through a review of the literature, interviews, and particularly from the survey responses. The literature highlighted marketplace forces as being an influential factor for private-sector technology transfer. Although the technology marketing and technology push factor has its origins in the marketplace, it is included because of its applicability to public-sector practice.

The literature and the practice of the organizations and programs reviewed for this synthesis support the concept that use of any of these factors is a positive move toward success. Additionally, using multiple factors for each technology transfer or implementation project is better than using only one or two. The factors discussed are:

- Technology Push
- Champions
- Pilots Projects and Demonstrations
- Senior Management Support
- Early Involvement of Users
- Technology Transfer or Implementation Plan
- Qualified Technical Personnel in Lead Roles
- Partnerships
- Progress Monitoring and Committed Funding
- Focus Area for Technology Transfer Effort
- Marketing and Communications
- Benefits of the Technology—Meeting Users' Needs.

Technology Push

One significant factor affecting successful technology transfer is the push that technology exerts on prospective users. This technology push occurs often in the new product development area when vendors seek to sell an innovation to a state DOT or local government. States have formal processes for new product introductions and the assistance of the National Transportation Product Evaluation Program sponsored by AASHTO. However, there are other avenues for technology to be brought into an organization. One of the primary routes is through the AASHTO Technology Implementation Group (TIG). TIG is a combination of technology marketing by transportation experts within AASHTO and the push of the actual technologies—that is, the attractive or compelling benefits exhibited by the technologies are sufficient to gain notice by a prospective user organization. Very often TIG activities are operation-unit-led, because they involve technologies outside the results produced by the agency's research unit.

The following Technology Application Note on AASHTO TIG is an example of a mechanism that pushes technology out from one successful user to other potential users. Technology Application Notes are short narratives providing an illustrative example of the various factors that positively affect the success of technology transfer or implementation.

AASHTO TIG

AASHTO created TIG to identify high-payoff, ready-to-use technologies and to champion the use of the technologies throughout the country. The group works with the AASHTO Standing Committee on Research and the Research Advisory Committee to identify new technologies. Gary Hoffman, TIG Chair, Deputy Secretary of Pennsylvania DOT notes that: "One of the criteria is that at least one state has used the technology and is willing to champion it." TIG considers whether the technology meets a need or solves a problem in the transportation system, how effective the technology is, what costs are involved, and the ease of widespread implementation.

Once TIG has selected a technology for fast-track treatment, a lead state team develops and carries out a strategic plan for delivering the technology to users. Activities are tailored to each technology and may include the development of training programs and materials, as well as sending out teams to help agencies learn how to apply the technology (Schweppe 2003, p. 25).

The TIG process is relatively new and there are lessons being learned such as the critical role of the champion and the need for fully ready-to-implement technologies. TIG introduced three technologies each year from 2001 to 2003. Three of these technologies stand out as particularly successful for implementation in the states:

- Fiberglass-reinforced plastic (FRP) repair of overhead sign structures,
- Air void analyzer, and
- Prefabricated bridge elements and systems.

TIG originated from the successful AASHTO Strategic Highway Research Program (SHRP) Implementation Task Force, which instituted the lead state concept and successfully fostered implementation of SHRP products.

Some of the items that facilitate success for the TIG program are the success of the innovation in the original application,

> the credibility of the initial users who bring the success experience to the attention of peers, the willingness of the state DOT that proposes the innovation to spend time and resources to replicate the success alongside other state DOTs, the review of the innovation and acceptance by a national program sponsored by such a trusted organization as AASHTO, use of the network established within AASHTO to further communications about the innovation, and more. (See: http://www.aashtotig.org/tig/.)
>
> (K. Kobetsky, personal communication, Dec. 2, 2004.)

The technology transfer process for the AASHTO TIG is contained in Appendix E.

A second program influencing the successful transfer of technology is FHWA's Priority, Market-Ready Technologies and Innovations initiative. FHWA selected 20 technologies and also included 9 identified by AASHTO TIG as its Market-Ready Technologies. The criteria for selection of these technologies and innovations were:

- Do they support agency priorities, including strategic goals?
- Is there a user need and likelihood of implementation?
- Are they developed to the point of being truly market-ready, with tool(s) available for the field to market?
- Is expertise available to support deployment and implementation?

A list of the Priority, Market-Ready Technologies and Innovations is provided at: http://www.fhwa.dot.gov/rnt4u/pti.htm.

FHWA, through its Resource Center and division offices, is strongly promoting these technologies. Technical resources and guidance from FHWA are available to facilitate the technology transfer of these innovations to transportation agencies. This process of identifying market-ready technologies is new and still developing. Currently, not all of the technologies have been implemented and some may require additional development. As with TIG, this program is identifying promising technologies and partnering with states to produce a more streamlined and effective mechanism to introduce innovation to the highway system.

Marketing of technologies and the push of the technologies increase the opportunity for successful technology transfer. Marketing alone will not guarantee success; however, the information and knowledge it conveys assists a potential user in making the decisions necessary for determining whether a technology should be considered for adoption and deployment. The push of the technology—primarily its benefits—is an important booster of success. The benefits of the technology create added perseverance in those who perform technology transfer. Users will work harder at the technology transfer to realize the benefits. (See also the discussion in Benefits of the Technology—Meeting Users' Needs later in this chapter.)

Although marketing is important, there are two factors of success used by the TIG program and the FHWA Priority, Market-Ready Technologies initiative. For both of these technology transfer activities the technologies are screened and determined by peers to have a likelihood of successful implementation. Second, the vehicles that convey the technology, particularly evident in the TIG process, are tried and tested. That is, the process to get the technology transferred has been done successfully before. Both of these factors, peer-reviewed innovations and proven technology transfer vehicles, substantially enhance the opportunity for success.

Additional success factors were addressed by questions in the surveys conducted in conjunction with this synthesis. The responses highlighted a number of strategies and tactics that are considered factors influential in promoting success in technology transfer. Survey respondents were asked to identify successful techniques, practices, or processes that their organizations used for accomplishing technology transfer. The respondents were also asked to provide insight to successes based on a recent experience in technology transfer or implementation of research results (see Figures 3 and 4).

For each of these success factors rated by the state DOTs and LTAP/TTAP centers there is a section that discusses the factor and provides additional information about its

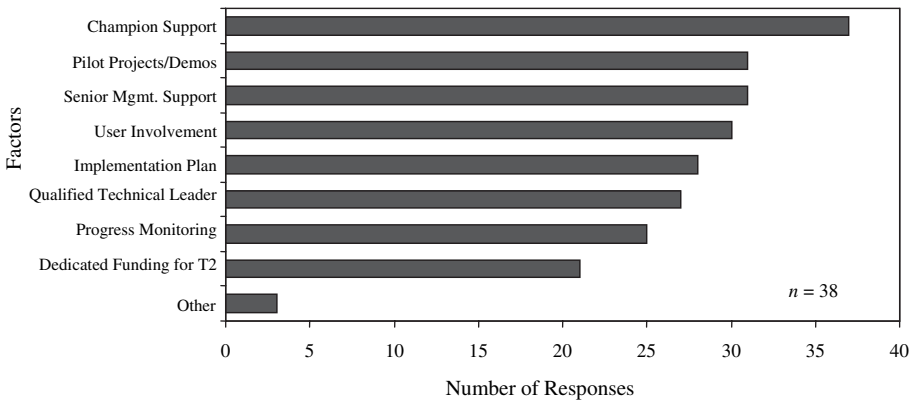

FIGURE 3 Success factors for technology transfer—State DOT. (Multiple responses were permitted.) T2 = technology transfer.

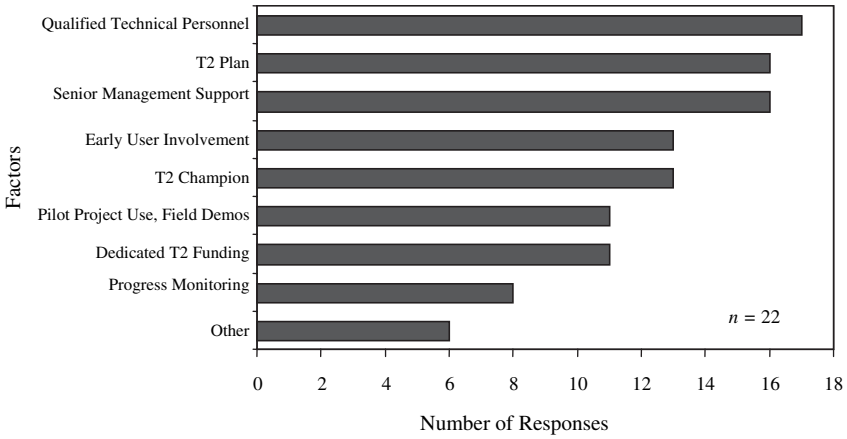

FIGURE 4 Success factors for technology transfer—LTAP/TTAP. (Multiple responses were permitted.) T2 = technology transfer.

characteristics. These discussions are contained later in this chapter. In addition, several of the state DOT respondents indicated that partnerships with other agencies was a success factor for their activities, as well as were benefits of the innovation and the flexibility of the technology transfer process to accommodate issues such as changes to the budget or staff losses during the project. The LTAP/TTAP respondents also mentioned that an adequate supply of materials (resources to perform the project) were a necessary success factor as were client endorsements of the technology, strong communications, and a venue conducive to learning. Because partnerships, communications, and benefits of the technology were identified as success factors in the literature and through the interviews and elsewhere in the survey responses, these factors are also discussed in this section.

Champions

> An empowered inventor is an invention's best advocate.
>
> (R.J. Goldman, "Technology Transfer Rehabilitation: A Personal Account" 2003, p. x)

For research-unit-led technology transfer, the most successful strategy or factor in a technology transfer situation was the presence of a champion. Champions were seen as critical participants in the successful outcome of the transfer. Champions were drawn from the practitioners, from management, and from within advisory committees. If champions had not been identified, respondents advised finding them and involving them directly in the project. Champions facilitate technology transfer in a number of ways. Survey respondents stated that:

- They (champions) would not give up until the project succeeded.
- The bureaus involved each had a champion that promoted and demonstrated the effectiveness of the equipment.
- Champions at the district level fostered user "ownership."
- The champion recognized future benefits.
- Champions provided needed impetus for introduction to change.
- Champions create a faster buy-in with management and workers.

On average, LTAP/TTAP centers considered the presence of champions a less important factor than did the state DOTs. Champions are recognized as facilitators for technology transfer, and 60% of respondents considered champions important to the success of the technology transfer. However, many of the examples of successful technology transfer projects reported by the centers rated other factors such as training, demonstrations, and workshops as more critical. (See also the discussion on Partnerships in this section for an example of an effective technology transfer champion.)

Pilots Projects and Demonstrations

Pilot projects and demonstrations are another factor for success and are considered a valuable addition to the strategies for facilitating technology transfer. More than 80% of respondents from the research units indicated that pilot projects and demonstrations were important success factors. LTAP/TTAP centers rely heavily on workshops, demonstrations, and pilot projects; however, they did not rate pilot projects and demonstrations as highly as the state DOTs. However, 50% of the LTAP/TTAP centers considered pilot projects and demonstrations a factor for success, which is also a strong endorsement. One center respondent summed up the importance of this factor by noting that, "People learn best by problem solving and hands-on applications."

The following Technology Application Note describes a program specifically designed to demonstrate products. It is an example of how important demonstrations are to the transfer of technology.

Florida LTAP Center
Product Demonstration Showcase, "Experience Technology"

Mission of the Product Demonstration Showcase (PDS) Program—Advance the implementation of roadway and bridge technology in the municipal arena by providing decision makers a total, start to finish, unbiased, real-time project experience of field-applied technologies and processes.

The PDS is an information exchange mechanism that can reduce or eliminate the financial, professional, and political risk public agencies face when committing hard-to-come-by funds implementing technology when little or no practical field experience exists. The process allows hands-on experiences for the participants who interact with knowledgeable peers and others experienced in the technology application.

Each PDS must include these five elements:

- A neutral sponsor (LTAP)
- A user agency host participant
- Industry/contractor/consultant participant
- In-use site visits, for real-time evaluations
- A complete live demonstration.

These elements are requirements for the PDS to occur. The LTAP Center acts as the facilitator, only when the other players agree to be active participants. Each PDS focuses on new or upgraded solutions to local road and bridge problems. Researchers, end users, and contractor/vendors all participate in the showcase information exchange process. Professional and elected decision makers gain practical, hands-on experience with new or upgraded products and services in a setting where the perception of bias has been eliminated. Prior to 2003 six showcases were conducted, such as a pavement management program implementation solution, a cost-effective solution for paving unpaved roads, and an asphalt pavement rejuvenation solution. In less than 3 years, nearly $250 million in local agency improvements and resulting impact occurred as a direct outcome of conducting the six showcases (Peaslee 2003).

Senior Management Support

Both research units and LTAP/TTAP centers considered the support of senior management a significant factor for success. When asked to explain why, responses provided some additional insight:

- Deputy Secretary previously served as the Director of Materials Research.
- Senior management has to make the investment decisions.
- Senior management mandated use of the innovation.
- Received support from the legislature.

From these responses, it is clear that decision makers are influential in the technology transfer process. They are uniquely different from the technology champion, although they may also endorse the innovation. They provide resources and guidance, and they lead by example. They are accountable for the outcomes and, in some cases, through personal experience, readily identify with the technology transfer process. Senior management support was ranked the third most influential for success of those factors ranked by both research units and LTAP/TTAP centers.

The following Technology Application Note on the Oregon DOT LTAP Center discusses the influence and impact of senior management on the success of technology transfer.

The Oregon LTAP Center used its Roads Scholar Program as an example of a successful technology transfer effort. The program is a structured training curriculum in highway construction, preservation, and maintenance technology leading to a skills level certificate for maintenance and operations employees. There was strong support from the Technology Transfer Steering Committee and the Association of Oregon Counties. Because of the lead and interest of these organizations' senior managers, many initial participants for the program were employees from the steering committee's organizations.

The training program enhanced skills of the employees, thus enabling them to be more effective in their respective work roles. The support of the senior managers drew attention to the program, provided additional program credibility for municipal governments not familiar with the training opportunity, and heightened the priority for organizations considering the training. Implementation of the training program occurred more rapidly because of the senior mangers' influence. Additionally, the success of the initial training built trust in the program and assisted in bringing others to the program. Other success factors noted were that champions appeared through the steering committee's involvement, a technology transfer plan was created, and that substantial benefits were anticipated as the result of other successful programs.

Early Involvement of Users

A tenet of research results implementation success is to involve the user early in the process of the research (Bikson et al. 1996). Participants in technology transfer include this factor in their practice whether it is transferring the results of research or an existing technology or innovation transfer. For both state DOT research units and LTAP/TTAP centers, this factor ranks fourth in importance, and is considered a factor for success by nearly 80% of respondents from state DOT research units and 60% from LTAP/TTAP centers.

As reported in the following Technology Application Note, the early involvement of bicycle advocates (users) was a primary success factor for the implementation of a safety device for Pennsylvania DOT (PennDOT) highways.

PennDOT—Bicycle-Friendly Shoulder Rumble Strips

Shoulder rumble strips reduce run-off-the road vehicle crashes on urban and rural freeways. Because of the potential for reductions of crashes, PennDOT considered installing shoulder rumble strips on non-freeway facilities. However, as shoulder rumble strip installations were extended to non-freeway facilities, bicyclists would encounter rumble strips more frequently. Understandably, bicyclists were concerned about maneuverability problems while traversing rumble strips. The strips are very uncomfortable to ride over and may cause loss of control of the bicycle.

The department's rumble strip configurations were evaluated for their potential to be bicycle friendly, yet still retain the alerting properties for drowsy/inattentive drivers in motor vehicles. Volunteer bicyclists were invited to participate in the study. They rode different types of bicycles over the rumble strip configurations at different speeds and at different angles. The bicyclists' perspectives were incorporated into the research

and were a significant contribution to the research findings. Implementing the research results and transferring the technology was facilitated through a primary success factor—involvement of the user early in the implementation process, in this case, directly in the research effort. The user involvement not only assisted in determining which rumble strip configuration was best for both types of roadway users, it provided credibility for PennDOT with its bicycle riding customers, and it reduced resistance from bicycle advocates to this roadway improvement.

Technology Transfer or Implementation Plan

As indicated in the survey results, research units and LTAP/TTAP centers consider having a plan for the conduct of the technology transfer or implementation activities an important factor for success. Nearly three-quarters of those responding to the surveys in both groups endorsed preparing a plan as a technique that enhances the likelihood of a positive outcome. Many state DOT research units are now requiring implementation plans at various stages of the research process. A number of states require an implementation plan as a deliverable product accompanying the research results. States also require implementation plans to initiate the process for funding implementation or technology transfer efforts associated with adoption of an innovation. Additionally, implementation plans become working documents that are used to guide the implementation process. For the most part the implementation plans are short and relatively easy to prepare. Many state DOTs indicated that ease of completing the plan was a primary factor. If the plan is easy to complete, it has a higher likelihood of being done. Committing to planning up front saves later problems that arise in the form of costs, delays, and rework. There is additional discussion on implementation plans in chapter five.

A well-constructed plan is an important success factor for implementation of research results and technology transfer. The Technology Application Note here provides an outline of the plan used by the Minnesota DOT (Mn/DOT) for the successful implementation of the many results of its research program.

Mn/DOT—Implementation Plan Outline

Mn/DOT has emphasized implementation of research results for many years. Its plan outline allows varying degrees of detail. Their Implementation Plan Outline is as follows:

1. Evaluate the results of the research
   a. Do the results solve the problem? If not, why?
   b. Are the results implementable? If not, why?
   c. Can implementation of the results yield benefits? If not, why?

2. Identify each task necessary for implementation and develop a step-by-step scenario describing the implementation process.
   a. Task description (What?)
   b. Task purpose (Why?)
   c. Task responsibility (Who?)
   d. Task resources and cost (How? How much?)
   e. Detailed schedule of tasks (When? Where?)

3. Develop a measuring system that will evaluate the benefits derived from implementing the research results. Whenever possible, express the benefits in terms of current Mn/DOT performance measures.
   a. Measure(s) description (What?)
   b. Measure(s) purpose (Why?)
   c. Measure(s) responsibility (Who?)
   d. Measure(s) resources and cost (How? How much?)
   e. Measure(s) schedule (When? Where?)

Accompanying this outline for an Implementation Plan is a Research Implementation Guide, which lists ten steps for implementation. The guide also explains the purpose of each step and asks clarifying questions to aid in documenting the appropriate strategies.

- Think about the end results
- Understand the environment
- Find the opportunity
- Know thy customers
- Involve the right players
- Explore the most appropriate tool
- Make strategic use of resources
- Bring in the experts
- Define, define
- Evaluate and celebrate.

A number of organizations use implementation or technology transfer planning aids. The FHWA RD&T Technology Facilities Action Plan is used to finalize action plans for the delivery of research products from the Turner–Fairbank Highway Research Center. The form is used by FHWA program offices as well as the researchers to foster more effective technology transfer. The Indiana DOT (INDOT) Research Project Implementation Plan is a one-page form that names the person(s) who will implement the innovation, identifies the items to be implemented, and requires details of resources needed for the implementation. The Kansas DOT implementation plan form requests an assessment of the implementation potential, asks for a description of the implementation strategies, and includes task scheduling and budget estimates. The PennDOT form particularly highlights communications actions to be taken and asks for identification of other actions that will further the implementation process. These implementation planning tools are contained in Appendix F.

LTAP/TTAP centers also emphasize the need for plans and consider planning essential for their technology transfer efforts. The centers use many different experts to conduct their activities. Additionally, the centers have a variety of venues as well as a wealth of types of transfer options. There are a host of details and planning is critical for the success of the transfer opportunity. Similarly, when the AASHTO TIG initiates a technology transfer in a state DOT an implementation plan is the primary guide for adopting the innovation.

Qualified Technical Personnel in Lead Roles

Top ranked among the success factors for LTAP/TTAP centers is qualified technical personnel in lead roles. Without technical expertise little transfer of knowledge and understanding of an innovation would occur. The existence of LTAP/TTAP centers is based on qualified technical staff or

contracted expertise. Without them, workshops, showcases, demonstrations, training, road shows, and technical assistance would not and could not take place. The credibility of LTAP/TTAP centers is based on the quality of the expertise and the ability to convey to the prospective user sufficient knowledge and information for decision making to affect change. The South Dakota LTAP Center considers as a primary success factor its "large body of knowledge . . . [its technology transfer] field staff have 150 years of experience." Other LTAP/TTAP centers clearly link success with "qualified instructors," "qualified people assigned [to] the lead role," and "a dedicated team of instructors/assistants who are available for technical assistance."

The research units and programs such as TIG have often identified the technical expertise in the researcher or through a lead state technical expert. They are already associated with the innovation. Furthermore, in the case of research results implementation, the users are brought into the research at an early stage, thus beginning the technology transfer process. The research units determined that such qualified technical capacity was an important success factor, although other factors such as champions, pilot programs and demonstrations, and senior management support had higher rankings in the synthesis survey.

The Technology Application Note that follows illustrates the value General Motors assigns to having well-qualified people in lead roles for technology transfer. This company specifically trains employees to be the lead as well as be a communication channel for facilitating technology transfer

Transferring Technology at General Motors

General Motors Research Laboratories (GMR) developed a program to facilitate transferring innovations generated by GMR to key corporate locations within the GM Corporation. Its primary methodology was to move critical technical expertise from research into other GM staff and operating units. The program focuses on transferring the capabilities of people rather than of products. Approximately 10% to 15% of GMR's newly hired engineers and scientists receive intensive training at the research laboratories with the knowledge that they will be transferred to an operating division. These entry-level employees (technology transfer engineers—TTEs) are provided with a complex and challenging assignment that is a collaborative project with an operating unit. The TTEs have a technical mentor within GMR and build expertise in a specific technical area. The transition of the TTE occurs after up to 18 months in the research unit. During the last 4 to 6 months of the project the TTE begins transitioning to the operating unit. To ease the transition, the TTE has office locations in the research unit and the operating unit and develops relationships with the new organization as well as continues ties to GMR. The TTE in time fully transitions to the operating unit and arrives at that position with viable research effort experience and the potential to lead future research efforts. The last element of the technology transfer process is that GMR maintains close contact with TTEs and uses them as a conduit through which it can channel its subsequent innovations. "TTEs become 'centers of technology' at the divisional unit and [share their expertise] through consulting or formal training [of others in the unit]." The TTEs also provide a direct link from the operating unit back to GMR, which allows the research unit to be more informed about operating needs and current activities (Ezzat et al. 1989).

Partnerships

As with qualified technical personnel, the participants in technology transfer are a factor for success. The team or partnership formed must have the right skills and abilities to positively affect the effort. For LTAP/TTAP centers, the participants with the highest average involvement are state DOT program/operations personnel, local or municipal experts, university educators or researchers, and state field office personnel.

In this Technology Application Note, the key to success was the selection of the various participants to form a partnership to facilitate technology transfer. This example also shows the benefits of a qualified person in a lead role, the value of a champion, and the assistance of identifiable benefits to facilitate technology transfer.

Northern Plains Tribal Technology Transfer Program
Gravel Road Maintenance and Heavy Equipment Maintenance Training

"We couldn't do this without our Tribal Government Partners"

The Northern Plains TTAP serves one of the largest land-based tribal reservations and is located in the north-central United States. The area is economically depressed, having at times an unemployment rate in excess of 80%. The TTAP Center, in conjunction with the Tribal Employment Rights Office and the Tribal transportation department, conducted a gravel road maintenance and heavy equipment maintenance training course and pilot project. The training efforts began with classroom work to enable the tribal participants to qualify for becoming certified flaggers and included the proper procedures for setting up work zones. The second step of classroom training prepared participants for passing commercial driver license testing and operating and maintaining heavy equipment. (Often heavy equipment operators are required to drive their equipment to the project site.) The classroom work positioned the participants for the field pilot, rebuilding a section of road in the reservation. Practical experience took over and the participants learned in the field how to stake out a road rebuilding project, protect themselves and motorists through appropriate work zone safety, ensure their safety in equipment operations and maintenance, and learn hands-on cost-effective and correct equipment maintenance procedures.

Several success factors are noteworthy in this experience. Foremost was the selection of the various participants for the program. Without the partnership between the TTAP Center and the tribal government, the program would not have succeeded. The tribal cooperation brought funds to the project, as well as solved one of the hurdles for the technology transfer effort, finding equipment for the pilot project. Additionally, the TTAP Center identified a technically qualified person to be the technical trainer, a former heavy equipment operator and a tribal member. The trainer established immediate credibility for the technology transfer project as well as being a champion for it. This champion allowed faster buy-in with the transportation director and the workers from the transportation office maintenance crew.

The overall project was very successful because it produced a section of rebuilt roadway, provided workers with marketable skills, and set a standard for safer equipment operations and maintenance within the Tribal Transportation Office.

"We always try to make sure what we do has relevance" (D. Trusty, personal communication, Sep. 2, 2004).

The research units also noted that the involvement of certain types of participants is associated with successful technology transfer efforts. The participants with the highest average rated involvement with the research units were their own office personnel, and personnel from headquarters program and operations and regional and district offices, along with outside research organizations. A partnership among these types of participants is a common occurrence for technology transfer.

Well-chosen participants for technology transfer in many cases are found in county and municipal governments. The Minnesota Local Road Research Board (LRRB) Technology Application Note is an example of having the right participants for the job of technology transfer.

Minnesota LRRB—Program Description

The Minnesota LRRB was established in 1959 and has operated as a means to involve the state's county and city officials in research and technology implementation efforts. The LRRB has sponsored more than 150 projects on topics dealing with materials and methods used in constructing and maintaining pavement, drainage systems and other utilities under the pavement, management of the roadside environment, and bridge construction and maintenance. Local engineers submit ideas to the LRRB that selects and approves proposals. Mn/DOT provides administrative support, and researchers from the DOT, universities, and consulting firms conduct the research. The LRRB is funded by state moneys specifically legislated for its research and technology transfer and implementation activities. The LRRB budget has grown from approximately $86,000 in 1960 to $2.3 million in 2004.

A key to the success of this program is the high level of involvement of the local officials in setting the agenda for research and the strong participation of these officials in implementing the results of the research. A notable function in the LRRB is its Research Implementation Committee (RIC). RIC makes information available and transfers research results into practical applications for local officials. RIC uses a variety of methods to reach engineers and others with new developments and innovations, such as videos, reports, pamphlets, seminars, workshops, field demonstrations, CD-ROMs, web systems, and on-site visits. Members of RIC are drawn from cities and counties, including county engineers, city directors of public works, and city engineers. Representatives from Mn/DOT research and state aid offices are also RIC members. In addition, individuals submitting a problem that is funded by the RIC may be asked to serve on the technical panel overseeing the conduct of the research. Special care is taken to involve potential local users to facilitate the implementation of the research results whether they serve on the RIC, guide research, or are involved with outreach efforts. In every aspect, the LRRB seeks to select the appropriate local participants for its activities.

The LRRB has been remarkably successful in transferring technology and implementing its research results. It uses a number of the success factors discussed in this chapter and, importantly, it uses well-chosen partners as a factor for its success.

The respondents to the survey provided a look at the types of participants that are involved in successful technology transfer or implementation of research efforts (see Figures 5 and 6). The respondents were asked what types of participants were involved in successful efforts. For state DOTs, the participants from the agency and a research organization were the most highly involved. For LTAP/TTAP a variety of participants were active, such as state DOT program and operations personnel, local experts, university researchers, and state maintenance personnel, among others. These survey results show what type of participation (each with an implied expertise) contributed to the success of the effort.

The survey results showed that there were four main participants in the state DOT process of technology transfer or implementation of research results: the research office personnel—often contributing the research administration and technology transfer expertise, the program or operations staff—often responsible for the change in specifications or policy that the innovation must include before being deployed, the field office staff that will be governing where the innovation will be put into practice, and the outside research organization that performed the research. A majority of the state

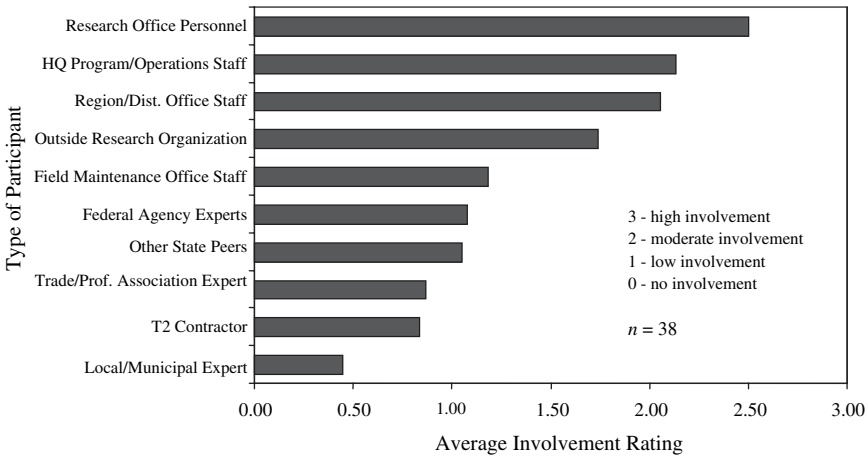

FIGURE 5 Average involvement of participants in successful technology transfer efforts—State DOT. (Multiple responses were permitted.) T2 = technology transfer.

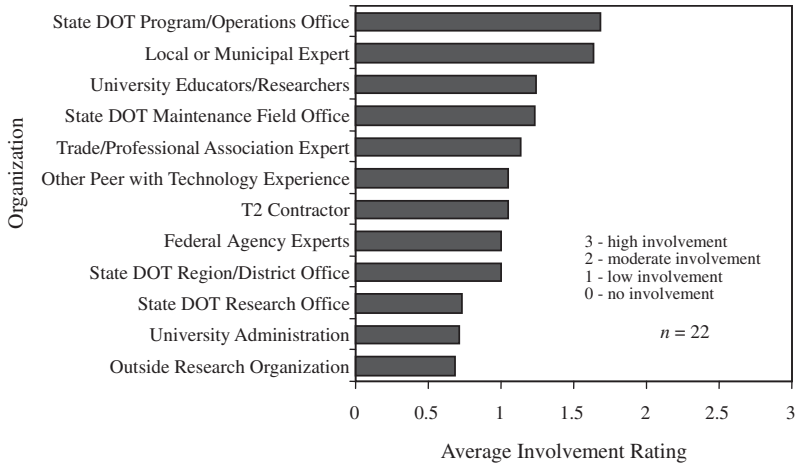

FIGURE 6 Average involvement of participants in successful technology transfer efforts—LTAP/TTAP. (Multiple responses were permitted.)
T2 = technology transfer.

research units conduct research through contracted research services, and the ranking of the participation of outside researchers confirms that practice. Others that were involved in technology transfer activities with the state DOTs participated at less involved levels owing to the nature of the specific project or, as with FHWA, their role would require less involvement considering that it is an oversight function.

The LTAP/TTAP centers however show the involvement of many types of participants, all at no more than moderate levels. The state DOT program or operations office and a local or municipal expert were most often involved in the technology transfer activities of the centers. Nearly all of the other participants for the technology transfer effort were chosen because of the unique skill that person could bring to the technology transfer activity. Additionally, the LTAP/TTAP centers often had a wide variety of individuals involved in the technology transfer activity, each contributing in some important aspect. The collaborative nature of the LTAP/TTAP centers' activities showed a more diverse group of participants, perhaps reflecting more of an outreach function than the technology transfer activities of the state DOTs.

For both groups, state DOTs and LTAP/TTAP centers, experts in technology transfer, contracted to perform services, had a relatively low involvement.

Progress Monitoring and Committed Funding

Progress monitoring and committed funding have influence on success; however, both research units and LTAP/TTAP centers considered them less important than most other factors. Only slightly more than one-third of the centers and approximately two-thirds of the research units believed that progress monitoring was a factor for success. The lower rating by the LTAP/TTAP centers may reflect the notion that the technology transfer activities may not be as long term as those facilitated by the state DOT research units. The requirement for progress tracking is somewhat less critical when sponsoring, for example, a one-time event. The implementation or technology transfer efforts of research units can extend from the inception of the research to several years beyond completion of the research as efforts proceed to put the innovation into practice. As discussed in chapter five, the informal survey on needs to the RAC showed that having a better process for technology transfer or implementation tracking and scheduling is desirable.

Partly owing to the long-term nature of the implementation or technology transfer, and considering the variety of deployment locations across a state DOT, there often is a separation of the research and its implementation efforts. It is common for research to be done in state DOTs without an adequate ongoing supply of funds for implementation. Some federal-aid State Planning & Research (SP&R) funds may be used for implementation and technology transfer; however, they are generally not sufficient to complete all of the work. Often funds are not committed until an innovation is ready to be deployed and, as with the LTAP/TTAP centers, the partner organizations share the cost of the technology transfer. Of the 38 state DOTs providing information in the synthesis survey, their best estimate was that on average they spend approximately 9.3% of their Research Part II, SP&R federal-aid funds on technology transfer and implementation activities. (This figure is a component part of the total expenditure figure for technology transfer and implementation activities discussed later.) Dedicated funding has traditionally been a primary booster for technology transfer activities (Bikson 1996). The past two federal transportation acts have increased research funding, and many states have committed a portion of these funds to implementation and technology transfer (Harder 2000). However, more needs to be done, and state

DOTs are finding other sources of funds to help accomplish technology transfer.

States are beginning to dedicate specific funds for implementation, and three states, Georgia, Minnesota, and Wyoming, reported having legislation that specifically funded technology transfer or implementation activities. Although these states have dedicated funding for technology transfer, there was no indicator in this brief review of funding that this commitment affected the amount of the funds for technology transfer and implementation of research results. Such legislated funding however does provide a stable funding source for ensuring that innovations are put into practice. South Dakota, Pennsylvania, Hawaii, and Kansas have committed the greatest percentages of their SP&R, Part II Research funds for implementation of research results or technology transfer (20%, 25%, 33%, and 75%, respectively). The state DOTs with respondents having 5 of fewer years of experience in technology transfer was the group that committed a greater percentage of their SP&R research moneys to technology transfer on the average than the other two groups. This group represented 34% of the respondents and 40% of the SP&R research moneys committed. The group with middle level experience (6 to 14 years) committed on average the least amount, and those with the greatest amount of experience (15 years or more) committed about the average of all respondents of their funds for technology transfer activities. Even with this average commitment to funding, the state DOT respondents having 15 or more years of experience had larger total program budgets from all types of funding including SP&R research funds. [The group with the most experience (15 or more years) in technology transfer was responsible for 62% of the total of all types of funding for research and research-related activities and represented 46% of all respondents.]

Approximately one-third of the respondents to the state DOT survey reported that they receive funds other than SP&R moneys from other department unit's federal-aid budgets, training course fees, other discretionary federal funds, state funds, and LTAP moneys. The state DOTs also reported that on average they spend approximately 6.5% of total agency funds committed to research and research-related activities on technology transfer and implementation activities. (Note that without California's large commitment to technology transfer through agency and other funds, in addition to Research Part II, SP&R moneys, the average total for respondents would drop to 5.3%.)

Of the LTAP/TTAP respondents, six centers indicated their states had legislation that provided funding to their programs. Four of these centers have program budgets of more than $450,000 and have the largest LTAP/TTAP program budgets of the respondents to this survey. Although other LTAP/TTAP centers that did not respond to the survey may have large budgets, it is important to consider that legislated funding is a catalyst for success; it contributes to stable, sustainable programs. The level of experience for LTAP/TTAP respondents does not suggest any correlation with the size of the program budget.

LTAP/TTAP centers reported that they receive funds from a variety of sources as well. All centers receive federal-aid LTAP program funds. In addition, the majority of the 22 LTAP/TTAP centers responding to the survey reported that they also receive funding from up to five other sources, including training fees, state funds, university funds, local funds, and private-sector funds. Often the funds, such as the SP&R research funds, require matches. The centers noted several additional sources of funding including the Bureau of Indian Affairs, tribal governments, and other federal agencies, such as the National Transportation Safety Administration. Table 2 shows the types of funding and the percent of respondents that receive moneys from these various sources.

Focus Area for Technology Transfer Effort

Respondents to the surveys for this synthesis were asked about the area of focus for a successful technology transfer or implementation project. Three areas were included in successful efforts; the most frequently cited for research units being knowledge transfer and for LTAP/TTAP centers training and education (see Table 3). There was no clear indication that any of these focus areas were a major success determinant, but that there was a focus to the project that tended to be a factor that promoted success. The concept of having a focus and a goal was beneficial for the projects.

Table 3 also shows that knowledge transfer is a primary focus of technology transfer and implementation of research results for both state DOTs and LTAP/TTAP centers. Both groups considered transferring knowledge a critical element of their activities. Furthermore, LTAP/TTAP centers consider training and education an even more important focus area for their programs.

Marketing and Communications

> Successful technology transfer programs depend on effectively segmenting user audiences, and tailoring strategies to those audiences and to different stages of the technology development process (*Special Report 256: Managing Technology Transfer: A Strategy for the Federal Highway Administration* 1999, p. 23).

Effective marketing and communications are key success factors of technology transfer. Every successful technology transfer activity in some manner involves the packaging or marketing of the innovation to suit the intended audience or user. Additionally, effective communications techniques are required to convey the knowledge and skills for users to promote change in their respective settings. INDOT noted that

TABLE 2
SOURCES OF FUNDING FOR LTAP/TTAP CENTERS

Source of Funding	Centers Receiving Such Funds (%)
Federal-aid/SP&R	100
Local	40.9
State	36.4
Training and other fees	31.8
University	22.7
Private sector	27.3

Notes: Multiple responses were permitted. SP&R = State Planning & Research.

TABLE 3
FOCUS OF TECHNOLOGY TRANSFER EFFORT

	Group	
Focus of Tech Transfer	Research Unit (%)	LTAP/TTAP (%)
Marketing	65.8	50
Knowledge transfer	92.1	81.8
Training and education	55.3	90.9

Notes: Percent of total responses. Multiple responses were permitted.

"a good marketing plan and public relations [communications] to every level in the agency and local entities" was required for a brine tank technology transfer effort. When the Kansas DOT required technology transfer of issues surrounding the long-term probability of grain-dependent shortline railroads, the principal investigator of the research publicized results of the project through a widely distributed news release. The DOT and the users gained a broader awareness of the project, which assisted in the implementation of the research results. Also, results were made available to the Kansas State Legislature and other interested parties to help provide support and funding for further work. Another example is the research that the Ohio DOT is conducting to understand how to market and communicate its research results. Although this project focused on communicating the benefits of research, the findings have also provided an opportunity for the research unit to apply these methods to the implementation and technology transfer process.

The following four Technology Application Notes show the value of marketing and communications for three state DOTs, Indiana, Washington State, and Ohio, and the 3M Company. Marketing and proper packaging of information streamlines the approval processes, professional communication tools assist in program effectiveness, and knowing the users and customers of the program is an important factor for facilitating technology transfer and implementation of research results.

Marketing and Technology Deployment Work Group

The Technology Deployment Work Group is a partnership among FHWA, Indiana Division; INDOT; Purdue University; and the Joint Transportation Research Program. This work group identifies technologies for promotion and adoption within INDOT. In the past 3 years, 13 technologies have been implemented through this work group including Spread Footings for Bridge Abutments, Galvanized Steel Diaphragms for Concrete Beams, and Environmental Management of Winter Salt Runoff Problems. Marketing is an integral element for the technology deployment. The group prepares a marketing plan for its technologies that are to be implemented and deployed throughout the state. These plans contain:

- Needs assessment
- Project and technology description
- Technology analysis
  - Technology background, profile, and analysis
  - Description of current practice in Indiana
  - Market profile and segments
  - Technology support
  - Cost–benefit evaluation
  - Suggested funding sources
- Short- and long-term goals and objectives for implementation
- Recommended implementation strategies and requirements
- Action items
- Partners, personnel, task responsibilities
- Success measures.

Once this marketing plan is done, the Technology Deployment Group uses it as the basis for its communications about the deployment or technology transfer efforts. A marketing plan was created for a project on Emergency Generators and Electronic Control Systems for Interstate Drinking Water Plants, Wastewater Treatment Plants, and Lift Stations. An executive briefing based on information developed in the marketing plan was prepared for the department's executive and senior management. On the strength of the briefing, the executive staff approved the project. Other promotion efforts distributed by the Technology Deployment Group are publications aimed at specific audiences, as well as business-card-size CDs (Pamplin and Arnold 2003; Pamplin 2004).

Washington State Department of Transportation (WSDOT) Communications Toolkit

The WSDOT has created a Communications Toolkit—available on the WSDOT intranet and containing virtually everything a WSDOT employee needs to know about communicating internally and externally. The toolkit contains information on:

- How to interact with the media, including press release guidance and examples, media kits, what to do when the media calls, interview guides, and more;
- Planning communications and strategies;
- Presentation guidelines and techniques;
- Writing strategies and sample letters; and
- Images for incorporating into communications vehicles.

The Communications Toolkit provides a consistent and professional approach to communicating within the DOT as well as with customers and stakeholders. The research unit in WSDOT is a beneficiary of this department-generated tool. This example shows that those performing technology transfer and implementation of research results have options to find excellent tools necessary for their activities without having to possess the expertise or create the tool. This is especially important when dealing with a discipline not commonly found in a research unit.

Ohio DOT (ODOT) Communication Strategies for State Transportation Programs

ODOT recently conducted a project to develop a strategic communications plan for its research office that supports ODOT's overall mission and goals, obtains feedback from selected ODOT constituents, and develops a communications template for use by other DOTs. The study was based on 12 comprehensive internal surveys and surveys of primary external constituents in academia, FHWA, contractors, county engineers associations, Ohio legislators, Ohio residents, and other state DOTs. The surveying purpose was to:

- Assess knowledge, attitudes, and behaviors regarding the ODOT Research Office.
- Develop recommendations to better inform and thereby better serve constituents.
- Discover communications mechanisms used nationwide.
- Increase awareness of research through efficient two-way communications (Knott 2004).

3M Company Communications and Internal Technology Transfer

The following Technology Application Note is based on a telephone interview with a 3M representative and an interview with Dr. Judith Benham, Technical Director of the 3M Packaging Systems Division, as reported in the University of Wisconsin–Madison School of Business Fall/Winter 2000 newsletter, *Manufacturing and Technology Matters.* 3M is committed to promoting excellent communications among its technical employees and has formal structures for facilitating such communications. One of its renowned functions is its Technology Forum, established in 1951 to "encourage free and active interchange of information and the cross-fertilization of ideas." (See http://www.3m.com/us/about3M/innovation/firsts.jhtml.)

Each technical employee is a member of the Technical Forum and is able to designate areas of interest for participation. The Technical Forum is organized into chapters similar to professional technical societies. Chapters can be established when a core of interested employees can be organized. Chapters meet on a regular basis and sponsor speakers and other technical knowledge events. Among the objectives of the Technical Forum is to foster communications among the variety of technical disciplines

In addition, communications among 3M technical employees also occurs through symposia conducted during the year, where researchers present papers or posters on their work. Furthermore, 3M conducts the Annual Event, which is an internal technical trade show. For example, up to one-half of a major division's knowledge workers participate annually. Individuals present new technologies in their respective area that may lead to new product opportunities. Technical employees from throughout 3M can wander among the booths, talk individually with the researchers involved in the technology, and discuss how the technology might be applied.

LTAP/TTAP centers possess considerable communications expertise. LTAP/TTAP centers consider communications to be a lifeline to their operations. The basis of technology transfer for these centers is to use some form of communications to deliver the message to the audience, whether it is a technical road show by a circuit rider, a training course for local maintenance employees, a video conference for state DOT employees, or a showcase for an area's transportation community. Refer to Appendix D for the various forms of communication and outreach mechanisms used by LTAP/TTAP centers.

Benefits of Technology—Meeting Users' Needs

In addition to the techniques and methods used to accomplish technology transfer, there is one essential success factor that should not be overlooked—the benefits of the technology to be transferred. Supplying what the user needs, when the user needs it, in a form that can be used, at a cost that is reasonable is a compelling success factor. Many of the survey respondents indicated that benefits of the innovation or the technology to be transferred were a significant success booster. They reported that:

- "The innovation was cost-effective."
- "The project involved cost savings and was an environmentally friendly solution to a common problem."
- "We saved money."
- "The project involved an accurate identification of needs."
- "This was a safety project that we expect will reduce accidents, which is a top priority of the DOT."
- "The project involved the bicycle community and demonstrated an effort to address concerns."

EVALUATING SUCCESSFUL TECHNOLOGY TRANSFER

Both state DOTs and LTAP/TTAP centers were asked whether they applied methods of performance measurement to the technology transfer projects. Questions regarding evaluation were asked about general practices and then about a specific technology transfer or implementation effort (see Table 4).

Both state DOTs and LTAP/TTAP centers use performance measures, but they were not seen as necessary criteria for success. If performance measures were used, however, they were considered a success factor. The respondents to the surveys also identified the types of performance measures that were used. The LTAP/TTAP centers used surveys, feedback forms from participants, follow-up visits for determining

TABLE 4
USE OF METHODS FOR MEASURING PERFORMANCE

Group	Used Measures for Performance—General Practice		Used Measures for Performance—Specific Successful Project	
State DOT	16 yes	20 no	18 yes	18 no
LTAP/TTAP	17 yes	5 no	13 yes	9 no

effectiveness, testing of skills acquired, and peer exchange. Approximately 60% of the LTAP/TTAP centers used the information for input to annual reports, accountability to senior management, and program justification. Other uses for the outcomes of the measures were to modify programs and manuals, as justification for more activities, and for various forms of information dissemination.

For the types of methods used for measuring performance, state DOTs mentioned measures such as the number of research findings implemented, tally of outcomes that result in change, quantification of savings, relationship of project to priority needs, and number of organizations that changed methods. The most frequently cited means for evaluation were benefit–cost and return-on-investment determinations for quantitative data and surveys for qualitative data. Only about 25% of the state DOT survey respondents used the information generated from measuring performance in their annual reports or for program justification. Approximately 35% of responding agencies used the information for accountability to senior management. (Note that only half of the respondents used measures for performance.) State DOTs also reported the information on their web pages and published it in research newsletters, received additional funds for programs, and, for specific projects, used the performance data for facilitating implementation.

State DOTs with a role defined to coordinate technology transfer tend to use or not use performance measures equally. However, when there is no coordinating function, there is a two times greater likelihood that the agency will not use performance measures for technology transfer and implementation of research results activities. Furthermore, the experience level of the respondent has little influence on whether performance measures are used.

According to the LTAP/TTAP respondents, performance measures were used at approximately the same rate whether the LTAP/TTAP center was operated by a state DOT or by others. Such measures were used about three times more frequently than not used.

REPLICATING SUCCESSFUL TECHNOLOGY TRANSFER

Of the successful technology transfer projects reported on in the LTAP/TTAP survey, respondents indicated that they were moderate to easy to replicate in another agency. This is an important factor for enhancing the content and increasing the number of technology transfer activities. Representative projects include:

- Statewide workshops;
- Training and technical assistance for the new *Highway Capacity Manual;*
- Summer intern program management;
- Product demonstration/showcase;
- Maintenance resource guides, training modules, and CD-ROM files developed, produced, and distributed nationally; and
- Roads Scholar Program.

LTAP/TTAP centers identified elements of their technology transfer projects that were either easy or difficult to replicate. Examples of those easiest to replicate are:

- Basic course design and curriculum,
- Classroom presentations,
- Convening stakeholders,
- Finding training locations,
- Core program of slides, and
- Setting up a program.

Whereas examples of those hardest to replicate include:

- Dedication and knowledge of lead team;
- Getting committed group willing to help;
- Private-sector involvement;
- Securing funding (about one-quarter of respondents highlighted this item);
- Field demonstration—owing to the need for equipment, operator, and good weather; and
- Interagency communications.

State DOTs were also asked if the successful project they reported on would be easy to replicate in another agency, with responses spanning the range from easiest to hardest with little consensus. The degree to which the technology transfer effort could be replicated had little relationship to the various technology transfer processes conducted during these efforts.

The state DOTs provided some insight to the elements that were easiest or hardest to replicate. Examples of the easiest to replicate are:

- Marketing efforts,
- Partnership with transportation association,
- Mechanics of the training process,
- Cooperation among DOT sections,
- Arranging the workshop,
- Having training manuals and modules available on DOT website, and
- Showing benefits through demonstration.

Whereas examples of the hardest to replicate include:

- Finding a champion;
- Staffing for technology transfer;
- Policy and legislative changes;
- Tailoring the system to a state's specific needs;
- Finding resources, expertise, time, and funds;
- Overcoming opposition of contractors; and
- Technical expertise to sustain production.

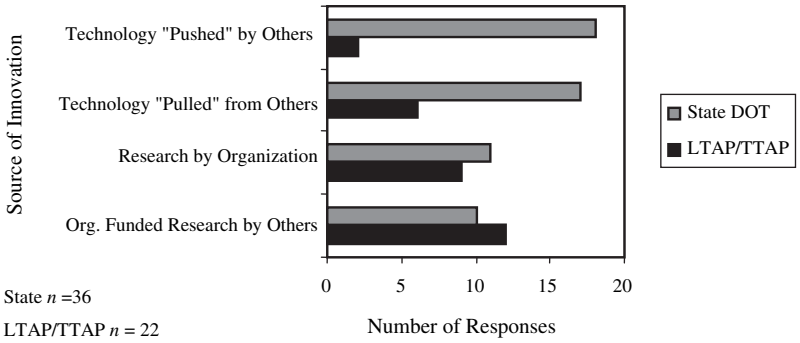

FIGURE 7 Comparison of source of technology—LTAP/TTAP and state DOTs. (Multiple responses were permitted.)

Reviewing these elements will prepare an individual who is considering incorporating the element in his or her own environment. The elements hardest to replicate were those that presented particular hurdles to some of the respondents.

SOURCE AND RESULTS OF SUCCESSFUL TECHNOLOGY TRANSFER EFFORTS

Knowing the source of the innovation and the results of its technology transfer or implementation efforts helps to gain a more complete understanding of successful projects. Note in Figure 7 that for the LTAP/TTAP centers the source of the majority of innovations comes from either (1) innovations being "pushed" by others; that is, others outside the center are providing influence and assistance in some form to have the technology transferred to the center for its use; or (2) technologies that are available from others and "pulled" into the center by its program personnel. There are considerably fewer technologies that originate as research funded by the LTAP/TTAP center organizations and fewer still from research performed by another organization. This is a reasonable picture of the operation of the LTAP/TTAP centers. Most do not perform research and most bring in technologies and innovations that have been recommended by credible sources or that are requested by a user organization. For the state DOTs, the source of the technologies is more frequently research performed by another organization (either another state DOT or a contractor to the state DOT that is implementing the research results) or by its own research unit. State DOTs are reaching out to locate technologies for implementation or getting technologies from others through AASHTO TIG, FHWA, and other organizations such as Indiana's Technology Deployment Group.

For LTAP centers that are operated by the state DOTs there was a small difference in the source of innovations. For the most part, the centers pulled in technology or used technology brought to their attention by others; however, these centers drew a greater number of innovations from the state research activities than the centers that are operated by others. This shows that some state DOTs are using the LTAP centers as outlets for deployment of their research products.

What happened as a result of the technology transfer efforts for the successful projects identified by the survey respondents? Figures 8 and 9 show the disposition of the

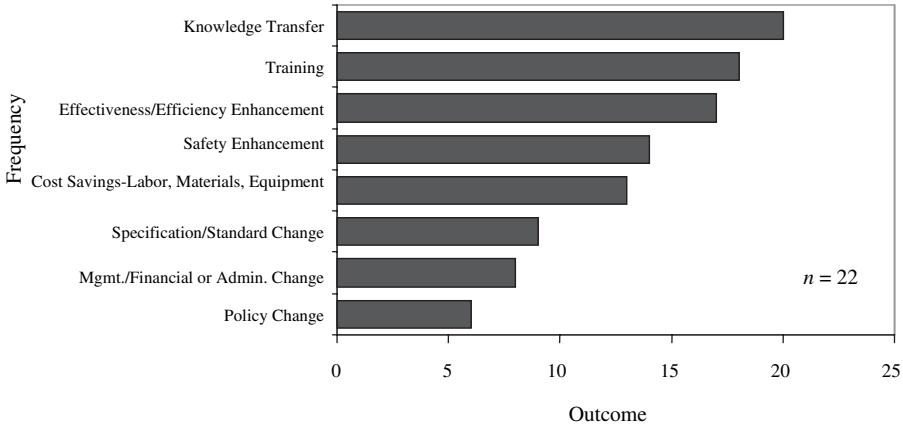

FIGURE 8 Result of the successful technology transfer—LTAP/TTAP. (Multiple responses were permitted.)

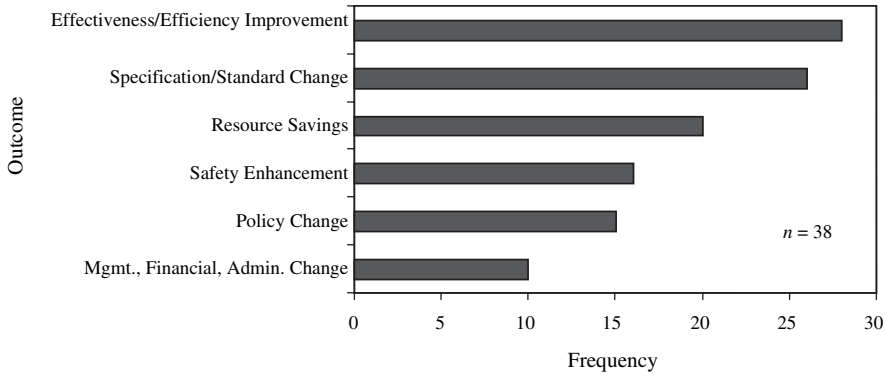

FIGURE 9 Result of successful technology transfer—State DOT. (Multiple responses were permitted.)

innovations, with respondents asked to identify the outcomes. LTAP/TTAP centers showed that their successful technology transfer activities corresponded with their mission and objectives—providing knowledge transfer, training, effectiveness, and efficiency enhancements. The top state DOT outcomes were effectiveness and efficiency enhancement, specifications or standard change, resource savings, and safety enhancements. These items also are common strategic goals of transportation organizations. A successful technology transfer project can be viewed as one that meets the strategic goals and objectives of the organization.

CHAPTER FOUR

CHALLENGES

BARRIERS IDENTIFIED IN PAST STUDIES

Challenges abound in the process of technology transfer or implementation of research results. Past studies have included the issue of impediments or barriers to successful technology transfer and a number of these challenges remain. The results from a few of these studies are included in this section. Each study provides a different perspective and helps to form a broad view of the challenges facing technology transfer participants.

TRB Special Report 256: Managing Technology Transfer: A Strategy for the Federal Highway Administration, notes that "a number of factors serve as impediments to innovation in the highway industry because they limit or prevent innovation and its potential benefits" (p. 33). *Special Report 256* presents an excellent summary of principal impediments to innovations in highway transportation that focus on the following categories:

- Technical—testing, demonstration, and standards setting issues.
- Procurement—disclosure, low-bid process, life-cycle costs, and specifications setting issues.
- Legal—design–build limitations, product liability and insurance costs, community involvement, and permit issues.
- Public sector and institutional—resistance to change, lack of incentives, limited capabilities, interest group resistance, effect of political patronage, employment practices and work rules, and technology mismatch issues.
- General—resources limitation issues.

The full summary table is in Appendix G.

In the comprehensive look at technology transfer provided in *Transportation Research Circular 488: Transportation Technology Transfer: A Primer on the State of Practice* (1998), the authors identify common challenges or barriers and also provide some guidance on overcoming these barriers. This study stated that, "Barriers restrict or constrain success" (p. 54). They may be self-imposed or the result of factors external to the technology transfer process. The barriers identified in the study have some overlap with TRB *Special Report 256,* considering the circular was a reference for the TRB work. However, the barriers discussion of the circular brings additional understanding to the topic of challenges. The barriers highlighted are:

- Institutional
  - Lack of resources—funding and people;
  - Lack of management support to implement new ideas;
  - Lack of an organizational infrastructure;
  - Inflexible regulations, incentives, and rewards; and
  - Resistance to risk taking and change.
- Technology supplier factors
  - Misunderstanding of receivers' needs,
  - Technology not suitable for the condition or environment, and
  - Technology not presented appropriately.
- Human/behavioral
  - Cultural clashes,
  - Language,
  - Lack of interest or perceived need, and
  - Poor attitudes from provider and recipient toward one another.

Overcoming these barriers can be difficult, but the circular provides the following advice:

- Motivation is caught, not taught—One person's excitement becomes contagious. When the whole staff, office, or agency is highly motivated, even institutional barriers are scaled, if not broken down.
- Empower people to become more open minded—If everyone in an organization is given the authority to think and, more significantly, act upon their thoughts, the organization will grow, both intellectually and productively.
- Be customer-oriented—Meet customer needs more effectively and strive for customer satisfaction.

In *NCHRP Report 382: Facilitating the Implementation of Research Findings: A Summary Report* (Bikson et al. 1996), the top barriers to implementation identified are grouped into the following four areas:

- Characteristics of research,
- Internal organizational context,
- External organizational context, and
- Implementation process.

For a listing of these barriers see Appendix G.

In a 1989 study, *NCHRP Synthesis 150: Technology Transfer in Selected Highway Agencies,* survey respondents were asked to describe their greatest difficulty in the transmission of information on new technology in the state. The responses are summarized as follows (Hodgkins 1989, p. 14):

- Problems with targeting audiences,
- Determining needed translations,
- Lack of resources,
- Availability of too much information,
- Lack of time on the part of potential users,
- Lack of an evaluation methodology,
- Inability to find appropriate personnel,
- Resistance to change by users,
- Communications, and
- Lack of participation by end user in identifying needs.

SURVEY RESPONDENTS—BARRIERS IDENTIFIED AND OVERCOMING THEM

In this synthesis survey, respondents were asked to identify the greatest challenges to accomplishing technology transfer in their organizations. They also were asked to describe what is being done to reduce or remove those challenges. The results of the survey revealed that some of the historical challenges have not been sufficiently addressed and still require attention. However, although barriers today may deal with similar root causes, they exist in more complex transportation systems and often with significantly more sophisticated technologies.

The broad categories of challenges identified by the survey respondents are listed here. Each category has a number of representative examples of the challenges as expressed by the survey respondents together with the corresponding actions taken to reduce or eliminate each challenge.

State DOTs provided these challenges and corresponding actions:

- Change and risk-aversion issues
  - Contractor resistance to change—Action: quarterly public meetings with the Associated General Contractors of America and suppliers to allow for questions and discussion.
  - Change acceptance—Action: persistence.
  - Resistance to change—Action: education and training, have an innovative champion, and capitalize on perspective of younger (less attached to tradition) or more open-minded staff.
  - Convincing industry of the reason for change—Action: work with industry associations to incorporate the changes into their sponsored training sessions.
  - Willingness to take risks by trying a new technology—Action: use new technologies on small pilot projects to reduce the risk.
  - Creating the incentives and motivations to change—Action: provide visible credit to individuals and divisions leading the effort.
- Time constraints
  - Lack of time for workload—Action: set up partnership with researchers to assist in technology transfer effort.
  - Limited staff and time—Action: try to create "just when needed" tools, databases, etc.
  - Time for experts to collaborate—Action: promote technology transfer organization and services.
- Staffing and workload issues
  - Lack of human resources—Action: create partnerships with associations and universities, outside contractors, and consultants.
  - Technology transfer must be done in addition to existing workload—Action: share success stories and show benefits to the agency.
  - Champion/technical expert needed to lead the effort—Action: work with division management to secure key staff involvement.
  - Staff turnover—Action: offer incentives.
- Structural and organizational issues
  - Lack unit with responsibility for implementation—Action: continue to rely on project monitors.
  - Organizational capacity, who should implement the innovations—Action: research unit will assume the lead role.
  - Changing priorities—Action: schedule regular briefings for Deputy Secretary and Chief Engineer.
  - Fragmentation of research roles—Action: new director is trying to show value of fully supported program to increase effectiveness.
- Commitment of the agency and influential individuals
  - Ensure that only the top projects the various offices want get funding—Action: there must be a link to the business plan and require executive approval.
  - Obtaining upper management support—Action: conduct research showcases, demonstrations, and other upper management visible activities—continue to create awareness.
  - Lack of interest from organizational personnel—Action: simplify the research management process.
- Weak outcomes of research, perceived and actual
  - Benefits of adoption not compelling—Action: focus on projects where benefits are absolute.
  - Benefits of adoption not understood—Action: emphasize knowledge sharing on benefits as well as change.
  - Untimely results—Action: continue effort to deliver timely results, focus on retaining project champions and be informed about potential technology leapfrogging.

  - Weak research—Action: ensure scope fits anticipated implementation; be willing to abandon weak results.
- Funding and costs
  - Insufficient funding—Action: avoid research with implementation costs exceeding management support, develop a business plan to inform and identify financial needs, diligently seek other sources, establish standing RAC responsible for functional area and budget.
  - Increased costs for technology transfer—Action: free up more SP&R funds, use fewer paper copies and circulating CDs, add website use.
  - Funding the implementation—Action: Research Advisory Board is more willing to fund more implementation of successful outcomes—success adds to future funding.
- Communications and coordination
  - Communications breakdowns—Action: awareness of potential is helpful, involvement of all participants on a scheduled basis, inform through multiple media formats.
  - Clear communications at all levels of the department—Action: tailor the message to the specific audience.
  - Ensure knowledge about research results is widespread throughout the organization—Action: provide easier access to final reports and other information by putting them on the department shared drive.
- Measures of performance
  - Tracking and measuring benefits and costs of research—Action: add tracking capabilities to database of research projects; develop comprehensive system for performance measures for time and labor.
  - Selecting baselines for benefit–cost comparisons—Action: identify deliverables early in the project.
- Implementation processes
  - Promote buy-in—Action: develop viable marketing strategy, marketing plan.
  - No plan or process for implementation of research results—Action: create a continuous process improvement study for recommended process and unit creation.
  - Lack of verification of implementation outcomes—Action: revise, formalize process, publicize results.
  - Lack of accurate technology transfer needs assessment—Action: involvement in exchanges, technology scanning, and participation in committees where needs will be discussed.

LTAP/TTAP centers have significant challenges as well. These centers experience some of the same challenges as state DOTs, although other challenges are uniquely present for this group of technology transfer professionals. Survey respondents identified the following challenges or barriers to technology transfer and also provided brief insights on how these challenges were overcome.

- Instructors and technical experts
  - Finding and securing trainers and technical experts who are credible, experienced, and good communicators—Action: use experts from other LTAP centers, continually recruit new instructors, advertise and focus on DOT and federal retirees, assist in training new trainees, and develop a portfolio of qualified instructors across the country within the LTAP network.
- Funding
  - Lack of stable funding or "lumpy" funding flow is a deterrent to smoothly running technology transfer efforts—Action: work with customers on master agreements, build up the technology transfer infrastructure to accommodate funding variances, direct request to legislature and DOT.
  - Insufficient funds—Action: leverage resources and collaborate with clients, barter, for example, space for technology transfer activity in exchange for free attendance; concentrate on highest customer priorities; officials do not attend technology transfer events—provide newsletter summaries; meet at conferences they already attend; share costs; involve users in fund appeals; demonstrate value of technology transfer efforts.
- Marketing, communications, and information
  - Making contact with decision makers—Action: become familiar with tribe's management structure; breakfast meetings with administrators and other upper management.
  - Create a "brand identity"—Action: add logo to documents, present overview of technology transfer program, circuit rider emphasis, exhibit at conferences.
  - Outreach to management—Action: target information and focus on senior management.
  - Information overload—Action: distribute only selected information and use DOT library as references source.
- Change
  - Resistance to change—Action: encourage participation, experiments, and more; drop if marginal results received; training.
- Staffing and time
  - Too much to do, too little staff—Action: 3-year rotation for workshops, spread out on a schedule.
  - DOT reluctant to participate in technology transfer activities owing to time commitments—Action: invite agencies in other states to participate.
  - No position vacancy for technology transfer—Action: combine the knowledge management and technology transfer efforts.
- Materials and courses
  - Developing courses—Action: use other technology transfer classes as models.
  - Up-to-date materials—Action: recognize library resources for uncopyrighted videos; update one course per year, prioritize, use web-based documents, provide

bibliographies; work with instructors before they update their materials.
  - Keeping program fresh—Action: attend national and annual meetings.
- Measure outcomes
  - Inability to measure outcomes—Action: learn from other LTAP/TTAP centers.
  - Performance measures for implementation—Action: national LTAP measures.

Unexpectedly, legal issues including patents and intellectual property ownership were not reported as primary challenges or barriers to technology transfer or implementation of research results on both surveys conducted for this study. Anecdotal information, however, describes patents and intellectual property as a problem area. In the survey responses, where these issues have arisen, states tended to have some precedent that allows this factor to be overcome without much remark. LTAP/TTAP centers are also inclined to focus their efforts on readily available techniques and processes and not spend scarce resources on technologies or innovations that may have some limitations on use. For further reference, *NCHRP Synthesis 312: Facilitating Partnerships in Transportation Research* contains a listing of the treatment of intellectual property by state DOTs for research and related activities (see Appendix E in that report, p. 75).

CHAPTER FIVE

NEEDS

There are highly effective and productive technology transfer activities throughout the nation, particularly in the public-sector transportation community—LTAP/TTAP centers and universities, state DOTs, and federal agencies. Many organizations have efficiently run programs and are well supported by their stakeholders and customers. However, although this may be so, many technology transfer or implementation activities have challenges to overcome.

The surveys asked respondents about their needs as they saw their organizations fulfilling two main roles: (1) that of pushing technology out of their unit to another unit or organization; for example, a research unit and its efforts to facilitate implementation of its research program's results or an LTAP/TTAP center's activities to transfer knowledge and skills to local government to improve, for example, its work zone safety practices; and (2) that of pulling technology in for use from other units or organizations external to the organization; for example, a state DOT research or operating unit that wants to apply a technology that is currently being used by another DOT or through AASHTO TIG or an LTAP/TTAP center that is seeking to find applicable innovations for its customers with particular needs.

The following sections discuss the needs encountered when state DOTs and the LTAP/TTAP centers fulfill the two roles of pushing technology out or pulling technology in.

PUSHING TECHNOLOGY OUT

The top three needs of state DOTs were: (1) more time to perform technology transfer, (2) additional funding, and (3) technology transfer training, as shown in Figure 10. More than half of the respondents indicated these three items as needs. Many states have fewer employees and increasingly larger workloads than previously. It is not surprising to see that the research managers need more time for technology transfer activities, because technology transfer is time intensive. It takes dedicated time of the best technical employees to perform technology transfer well. Although the state DOTs did not consider dedicated funding as the highest ranked element for success (see Figure 3), funding is still important and necessary. Thirty of 38 research units determined that additional funding was a need to be addressed. Another outcome of the survey is that the state DOTs believed that they could use training in the processes of technology transfer. Recalling that 17 of 38 respondents had been in their positions for 5 years or less, training in technology transfer could be a high-payoff activity. It is worth noting that LTAP/TTAP centers consider technology transfer training as one of their lower ranked needs. It is most probable that the LTAP/TTAP centers view these skills as existing strengths and do not place a priority on further enhancing these skills in place of addressing other needs. This is a result of their experience and excellence in this activity. State DOTs may be able to gain some insight into the conduct of technology transfer from the LTAP/TTAP centers.

Figure 11 shows that LTAP/TTAP centers consider additional funding the most important need. The centers also did not consider dedicated funding a high-rated success factor (see also Figure 3); however, as with the state DOTs, funding for LTAP/TTAP is a priority and ranks first among these needs. The other needs rated by more than half of the LTAP/TTAP respondents are greater management support for technology transfer, more trained staff, greater access to technical expertise, and assistance for management and administrative responsibilities associated with technology transfer. These needs support some of the challenges the LTAP/TTAP centers expressed about staffing (see chapter three). Such needs also show the difficulty centers have encountered in acquiring talent for their many and diverse activities.

For the state DOTs that indicated they could benefit by having assistance with those management and administrative responsibilities associated with technology transfer, a choice of five items was presented. Figure 12 provides the ranking of these items. All of the suggested items were accepted as viable approaches for assistance to the state DOTs. Note that implementation plans and evaluation or assessment procedures were the top two areas for assistance. Similarly, LTAP/TTAP centers were asked about the types of help they would like if they had indicated a need for management and administrative assistance for technology transfer.

Examining the experience levels and the needs for training provides additional insight for addressing how to build capacity and skill for technology transfer and implementation of research results. State DOT respondents with 5 years or less experience indicated by a two to one margin that they needed training for technology transfer. This group was less open to including new technology in projects and a majority

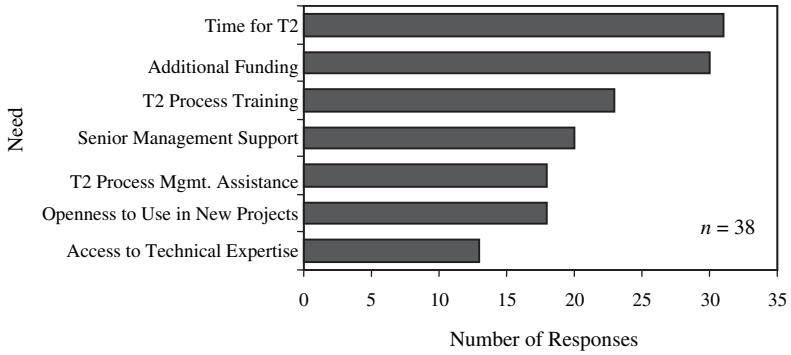

FIGURE 10 Needs—Pushing technology out—State DOTs. (Multiple responses were permitted.) T2 = technology transfer.

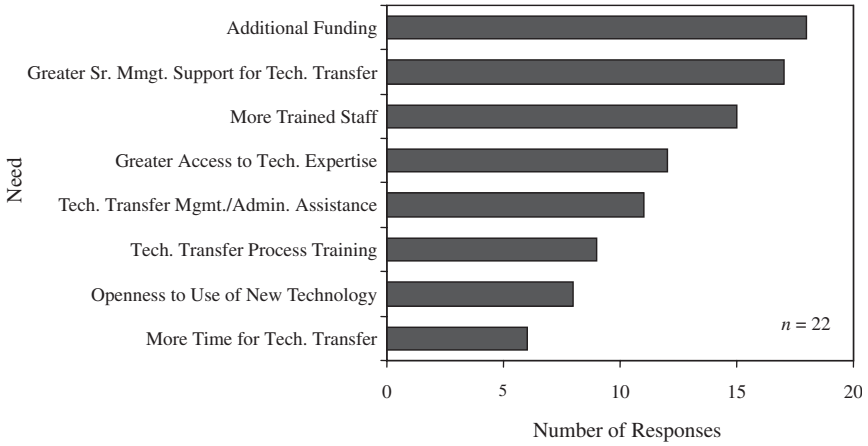

FIGURE 11 Needs—Pushing technology out—LTAP/TTAP centers. (Multiple responses were permitted.)

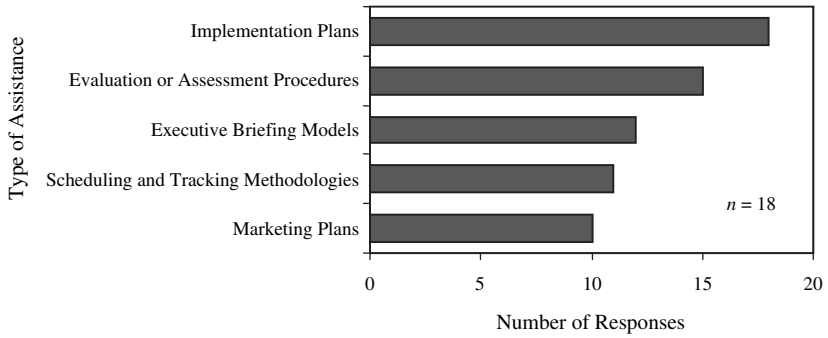

FIGURE 12 Type of helpful management assistance—State DOTs. Responses based on indication of need for management and administrative assistance from Figure 10. (Multiple responses were permitted.)

of the respondents in this group indicated that they did not need technology transfer management and/or administrative assistance.

State DOT respondents with 6 to 14 years of experience expressed different needs than those with less experience. Of these respondents, 63% determined that they did not need technology transfer training. They were very open to including new technologies in projects (75% of the respondents in this group), and were equally divided regarding the need for technology transfer administrative assistance. Those with the most experience (15 years and more) reported that they were nearly equally divided on needing technology transfer training and nearly 40% of this group was open to including new technologies in projects, and the same percentage reported that they did not need technology transfer management and/or administrative assistance.

Further review of all three of these different experience groups (less than 5, 6 to 14, and 15 or more years) shows that

a majority of the respondents indicated a need for more funding for technology transfer, all rather uniformly reported that they were not in need of greater access to technical expertise, all indicated a need for more time for conducting technology transfer, and all were nearly evenly divided regarding the need for additional support from senior management for their technology transfer projects. For the respondents who indicated a need for technology transfer management assistance, the different experience levels did not show any unique trends. In general, between 60% and 80% determined that they did not need the suggested technology transfer management strategies; for example, implementation plan assistance, marketing plan assistance, executive briefing models, scheduling tools, or evaluation assessment assistance. They also did not provide any alternatives when asked for other management strategies. The conclusions are that there is a sense of needing management and administrative assistance, but perhaps an inability to articulate what exactly that assistance should be.

As with LTAP/TTAP centers, each of the three experience level groups determined by a large majority that more funding is needed to perform technology transfer responsibilities. They also indicated by a substantial margin that it is desirable to have more time to perform technology transfer. Those with 5 or fewer years experience did not note such a wide margin (57% reported more time needed). Most LTAP/TTAP center respondents with 6 to 14 years of experience (78%) indicated that greater access to technical expertise was clearly needed. The other two groups, with less and more experience, had more reporting "no need," than those who reported "a need." Although there were a few exceptions, in general those with less than 5 years of experience did not show substantially different needs than the full community of LTAP/TTAP center respondents.

Program and project evaluation are very important needs in today's transportation environment. Figure 13 shows that evaluation and assessment procedures was the highest ranked type of management assistance cited by the respondent LTAP/TTAP centers. Having an accurate assessment of the value and contribution of technology transfer is certainly a desirable goal.

PULLING TECHNOLOGY IN

Not only do organizations push technology out, attempting to encourage the adoption of the technology by others, but many organizations also seek to bring in and apply proven technologies to their operations. State DOTs are in a unique position to take advantage of this methodology. Each of the 50 states has the opportunity to leverage its funds by finding best practices and innovations that have already been applied in a context similar to its own. As discussed earlier in this document, groups like the Technology Deployment Work Group in Indiana and the AASHTO TIG seek to identify technologies and innovations that are market ready and that can be applied to practice with relatively modest modifications.

State DOTs reported that additional funding, added time for conducting technology transfer, and greater senior management support for bringing in new technologies as the three most frequently mentioned areas of need when pulling promising technologies into the organization (see Figure 14). The LTAP/TTAP centers indicated that more extensive contact with external-to-the-agency peers to determine candidate technologies, added time to perform technology transfer, and methods or techniques to assist in making the process of technology transfer more efficient as their three most common needs (see Figure 15).

Assistance in pulling technology into the organization was addressed in an NCHRP effort completed in 2000. The results of the study were published as *NCHRP Report 442: Systems Approach to Evaluating Innovations for Integration into Highway Practice.* This report put forth guidelines designed to help state DOTs in:

- Researching and organizing information and data about a considered innovation,
- Screening and selecting innovations,
- Developing an evaluation plan, and
- Implementation planning.

The guidelines have a step-by-step procedure for evaluation approaches and a description of tools used during evaluation

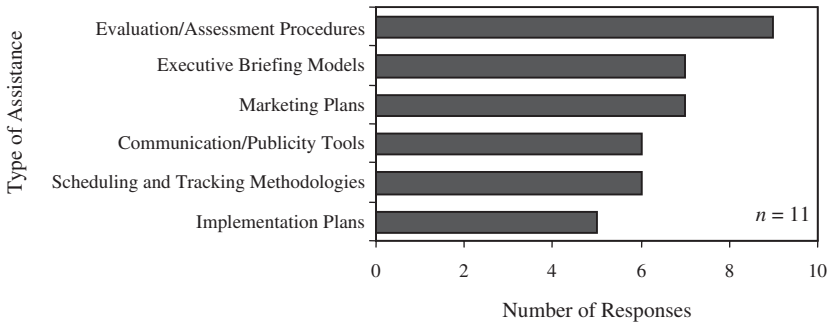

FIGURE 13 Type of helpful management assistance—LTAP/TTAP centers. Responses based on indication of need for management and administrative assistance from Figure 11. (Multiple responses were permitted.)

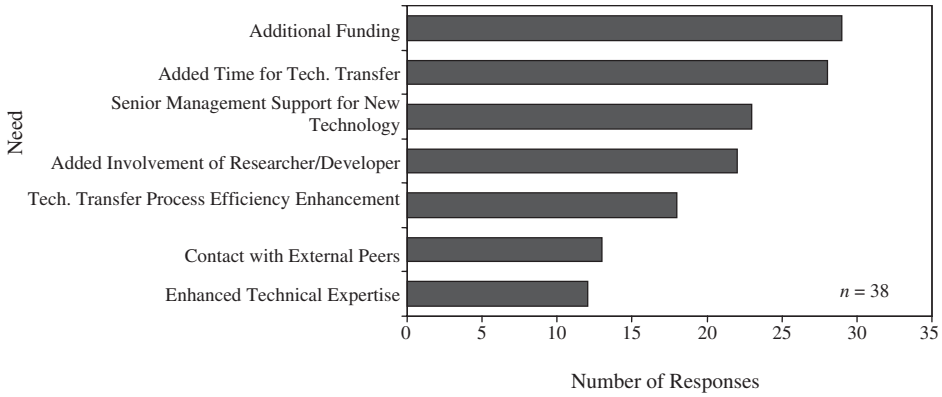

FIGURE 14 Needs—Pulling technology in—State DOTs. (Multiple responses were permitted.)

activities. The effects of applying the guidelines are increased efficiency of evaluation activities, higher probability of successful adoption, and improved communication and sharing of evaluation data among agencies (Worcester Polytechnic Institute 2000). The steps in the evaluation approach are:

- Screen the innovation,
- Address the evaluation implications,
- Identify the characteristics,
- Identify the effects of the innovation,
- Assess the fit of the innovation,
- Assess the feasibility of the innovation,
- Verify raised issues and develop evaluation criteria,
- Apply evaluation methods, and
- Plan for implementation.

The tools for evaluation are:

- Action plans;
- Cause-and-effect diagrams;
- Checklists;
- Cost–benefit analysis;
- Expert opinion;
- Group discussion and consensus;
- Influence diagrams;
- Scoring models;
- Sensitivity analysis; and
- Strength, weakness, opportunities, and threats analyses.

OTHER NEEDS IDENTIFIED

Other needs have been identified through a TRB Workshop, Optimizing the Dissemination and Implementation of Research Results, sponsored by the TRB Committees on Conduct of Research and Technology Transfer. The committees conducted the workshop in May 2003 and have since published an electronic document summarizing the workshop and 2003 mid-year committee meeting activities (http://www.trb.org/news/blurb_detail.asp?id=4439). The workshop topics included the following:

- New techniques and methods for sharing preliminary research findings,
- Efficient dissemination of published materials,

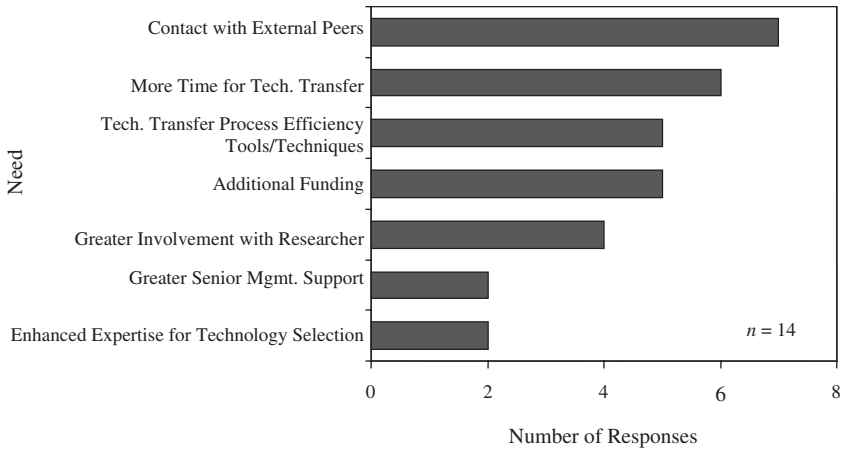

FIGURE 15 Needs—Pulling technology in—LTAP/TTAP. (Multiple responses were permitted.)

- Developing appropriate materials for the implementation of research results,
- Guidelines—dos and don'ts of implementation, and
- Identifying barriers to dissemination and implementation.

The priority action items—needs—that emerged from this workshop and subsequent meetings are listed here ("Optimizing the Dissemination and Implementation of Research Results" 2003):

- Conduct a study to document best practices for research implementation, including a benchmarking effort.
- Develop a guide to support implementation activities, including contract verbiage, implementation plans, reporting mechanisms, and training tools.
- Develop a framework and strategies for engaging end-users in all steps of the research process. Strategies should promote a dissemination mindset within researchers, sponsors, users, and technology transfer agents so that results will be communicated effectively to the various audiences.
- Encourage the use of incentives to promote implementation activity, including financial, travel, recognition, and others. Promote the use of SP&R funds to support these activities.
- Support adequate funding and long-term continuity for the National Transportation Library. Promote the recognition of the library as a key resource for research dissemination and implementation.

At the time of this writing, work was also being done on the further development of the Technology Transfer Toolbox. The effort is now moving from a broad scoping process to a preliminary design phase. This preliminary design will include a model of the implementation planning tools that will serve as a proof of concept (see also Appendix H).

CHAPTER SIX

FINDINGS, CONCLUSIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

Findings generated by the synthesis study are summarized here by topic beginning with the characteristics of the state departments of transportation (DOTs) and Local Technical Assistance Program and Tribal Technical Assistance Program (LTAP/TTAP) centers' programs.

- Close to half of the state DOT respondents and nearly 40% of the LTAP/TTAP survey respondents have 5 or fewer years experience in technology transfer.
- More than half of the research units in state DOTs share the responsibility of technology transfer with other units in the agency, one-quarter of the research units are solely responsible, and two respondents reported that no unit in their department was specifically assigned responsibility for technology transfer.
- State DOTs reported that on average they commit approximately 6.5% of total agency funds to research and research-related activities on technology transfer and implementation activities. This figure includes all types of funding; state, State Planning & Research (SP&R), other federal, and any other funding received for research and research-related activities. (Note that without California's substantial commitment to technology transfer using agency and other funds in addition to Research Part II, SP&R moneys, the average total for respondents would decrease to 5.3%.)
- Of the 38 state DOTs providing information in the synthesis survey, their best estimate was that on the average they spend approximately 9.3% of their Research Part II, SP&R federal-aid funds on technology transfer and implementation activities. This figure is a component part of the previous bullet point's total expenditure figure.
- Survey responses from the LTAP/TTAP centers reported that they have been operating for an average of nearly 20 years, with California DOT and Indiana DOT centers having conducted organized technology transfer activities for 50 and 40 years, respectively.
- Responding LTAP/TTAP centers have annual budgets totaling, on average, $375,000, and including California, $495,000. Nearly all of the centers reported receiving federal-aid funds (one center reported state-only funds). Two TTAP centers received Bureau of Indian Affairs and tribal government funds as well. Approximately 35% of the centers reported receiving university funds and 41% receive funds from local governments. Only 5% of the centers reported receiving funding from the private sector.
- Both state DOTs and LTAP/TTAP centers showed substantially larger technology transfer program investments for respondents having 15 or more years of experience. For state DOTs, the investment amount was more than three times that of respondents having 6 to 14 years experience and more than double the investments being made by those with experience of 5 years or less. LTAP/TTAP center technology transfer investments for the respondents with the most experience were nearly twice that of the respondents' programs with 6 to 14 years experience and greater than twice the investments of programs for those having experience of 5 years or less.
- Four of every five agencies having a group or person in an agency-wide coordinating role reported that more funding was necessary for technology transfer, whereas those state DOTs without such a coordinating function were somewhat equally divided in their assessment of whether or not they needed more funding.
- Organizations with a coordinating function tended to recognize the positive influence of senior management support more than did the state DOTs without such a person or group filling the coordinating role. State DOTs with technology transfer coordination also indicated a greater openness to including innovations into projects and were more accepting of management assistance when compared with their peers without a person or organization in the coordination role.
- Having a role assigned in the DOT for agency-wide coordination of technology transfer or implementation of research results showed a strong relationship to larger investment in technology transfer activities. For programs with a person or group assigned to coordinate the technology transfer activities the investment in technology transfer was 10 times that of agencies that had no such coordination.
- States routinely use a broad array of communications vehicles and methods to convey the message of the innovation and their abilities to assist in technology transfer.

Technology transfer and implementation applications as compared with the private sector were revealed as follows.

- The private sector consistently has organizations whose primary role it is to make the successful connection between the innovation generator and the innovation

user. These may be venture capital firms, business development consortia, or other similar facilitator organizations. The public transportation sector does not have such roles clearly defined and in routine practice, with the exception of the transfer agents within the LTAP/TTAP centers.
- The private and public (other than transportation) sectors strongly endorse a well-supported national library system for information accessibility and availability, which is essential to technology transfer. Currently, transportation has no comprehensive coordinated system of libraries or a national library providing full information services, including capabilities for archiving and preservation.
- In contrast with the private sector, the public sector may not be availing itself sufficiently of the research and foundational methodologies about technology diffusion and technology transfer developed in other scientific disciplines, such as social and behavioral sciences.

The structure for technology transfer and implementation of research results is as follows:

- The highway transportation community has three major technology transfer operating approaches; research-unit-led, operating-unit-led, and LTAP/TTAP-center-led. The two most common approaches are those led by the research unit and the LTAP/TTAP centers.
- Considering the different missions of the two primary structured approaches, there is only modest linking of the expertise contained in the LTAP/TTAP centers and the technology transfer or implementation needs internal to the DOT.

Successful technology transfer occurs when the following factors are present:

- There is the push of technology into a user environment.
- A champion is associated with the research and technology transfer effort.
- Pilot projects and demonstrations allow hands-on learning.
- Senior management support attracts attention, leads by example, and gives guidance to the effort.
- Early involvement of the user allows early resolution of problems and prepares the user for fully embracing the innovation.
- There exists a technology transfer or implementation plan to identify strategies and tactics.
- Qualified people are placed in lead roles.
- Partnerships leverage resources and attract the right participants.
- There is progress monitoring and committed funding.
- There exists a focus area for technology transfer efforts.
- There is emphasis on marketing and communications.
- Benefits of the technology meet users' needs.

These factors all correlate with successful efforts. The literature and the practice of the organizations and programs reviewed for this synthesis support the notion that the use of any of these factors is a positive move toward success. Using multiple factors for each technology transfer or implementation project is better than using only one or two.

Many of the elements of success in one project or for one organization can be a significant challenge for other projects or organizations. The challenges experienced by the state DOTs are concerned with:

- Change and risk-aversion issues;
- Time constraints;
- Staffing and workload;
- Structural and organizational issues;
- Commitment of the agency and of influential individuals;
- Weak outcomes of research, perceived and actual;
- Funding and costs;
- Communications and coordination;
- Measures of performance; and
- Implementation processes.

Whereas the challenges experienced by the LTAP/TTAP centers deal with:

- Instructors and technical experts;
- Funding;
- Marketing, communications, and information availability;
- Change issues;
- Staffing and time;
- Materials and courses; and
- Measuring outcomes.

Legal issues, including patents and property ownership, were not reported in the survey responses as primary challenges or barriers to technology transfer or implementation of research results. Where these issues have arisen, states frequently have some precedent that allows this to be overcome without much discussion. LTAP/TTAP centers also tend to focus their efforts on readily available techniques and processes and not spend scarce resources on technologies or innovations that may have some limitations on use.

Keying from challenges reported in this document and other sources, state DOTs and LTAP/TTAP centers have recognized various needs that can be addressed.

- For pushing technology out to others

The top three needs of state DOTs were more time to perform technology transfer, additional funding, and technology transfer training, with more than half of the respondents citing these three items.

The state DOTs believe they could use training in the processes of technology transfer. Recalling that 17 of 38 respondents were in their positions 5 years or less, training in the

processes of technology transfer could be a high-payoff activity. It is noteworthy that LTAP/TTAP centers consider technology transfer training as one of their lower ranked needs. It is most probable that the LTAP/TTAP centers see these skills as existing strengths and do not place a priority on further enhancing these skills in place of addressing other more pressing needs. State DOTs may be able to gain some insight into the processes for technology transfer from the LTAP/TTAP centers.

The LTAP/TTAP centers consider additional funding as the most important need. The other needs there were rated by more than half of the LTAP/TTAP respondents are greater management support for technology transfer, more trained staff, greater access to technical expertise, and assistance for management and administrative responsibilities associated with technology transfer. These needs identify some of the challenges that LTAP/TTAP centers expressed about staffing, and they also show the difficulties that centers have encountered in acquiring talent for their many and diverse activities.

A number of state DOTs and LTAP/TTAP centers reported needs in the areas of management and administrative processes associated with technology transfer. For LTAP/TTAP centers these are evaluation and assessment procedures, executive briefing models, and marketing plans. For state DOTs these are implementation plans, evaluation and assessment procedures, and executive briefing models.

- For pulling technology into the organization

State DOTs reported that additional funding, added time for conducting technology transfer, and greater senior management support as the three most frequently mentioned areas of need when pulling promising technologies into the organization. Whereas LTAP/TTAP centers indicated that more extensive contact with external-to-the-agency peers to determine candidate technologies, added time to perform technology transfer, and methods or techniques to assist in making the process of technology transfer more efficient as their three most common needs.

The following are suggestions for further research.

- The barriers to technology transfer and implementation of research results that are associated with patents and intellectual property ownership are not clear. There was no focus on these issues within the survey responses, perhaps indicating few problems. However, some respondents' organizations are effectively dealing with intellectual property ownership rights, although anecdotal information suggests barriers still exist. More in-depth questioning of state DOTs and the LTAP/TTAP centers is required to determine the causes and solutions to these barriers, if they do present substantial hurdles. The indication given by the literature is that when such barriers arise, considerable effort is required to overcome them. Investigating the processes used by public-sector transportation organizations and the relationship of these processes to facilitating technology transfer could be productive. Additional work on this topic could yield valuable information.
- Further research to investigate the staffing, time, and other resources required for optimal efforts in technology transfer and implementation of research results would be helpful to those now struggling with finding the resources required to conduct these activities.
- In the future, it will be important for public-sector transportation organizations to be skilled in the commercialization of research products. Currently, trends in the public sector are moving toward the private-sector commercialization model.
- Further investigations into the applicability of skills developed by LTAP/TTAP centers for use by the research and operating units of state DOTs in their technology transfer or implementation of research results efforts could yield highly beneficial results. Opportunities for cross-functional exchange of talent should be considered.
- There appears to be great potential for the methodologies on diffusion developed in other disciplines to have useful application in public-sector transportation practice. Research into how such diffusion theory can be applied to public-sector transportation would contribute to application of innovations to transportation.
- Research is needed in which technology transfer strategies and technologies are best matched to various situations and circumstances.

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APPENDIX A

Surveys

Surveys included:

- State DOT Survey
- LTAP/TTAP Survey
- Technology Transfer Toolbox Scoping Study: AASHTO Research Advisory Committee Short Survey

TECHNOLOGY TRANSFER SUCCESSES, CHALLENGES, AND NEEDS
NCHRP PROJECT 20-5, SYNTHESIS TOPIC 35-12
STATE DOT SURVEY
PLEASE RETURN COMPLETED SURVEY BY APRIL 16, 2004

PURPOSE OF THE SYNTHESIS AND THE SURVEY

The *purpose of the synthesis* is three-fold. It will:

- Provide information on the successful technology transfer practices currently in use by state departments of transportation and other transportation research organizations dealing with technology transfer in the public sector highway arena.
- Characterize and discuss the challenges to effective and successful technology transfer.
- Identify the needs of those responsible for sponsoring, facilitating, and conducting technology transfer activities.

The *purpose of the survey* is to gather basic information about these three areas of interest in technology transfer to form findings for the synthesis. Information you provide will also help determine whether your agency or organization may be a candidate for a featured spot in the synthesis via case studies of technology transfer experiences or highlights of technology transfer practice.

TERMINOLOGY

Technology transfer includes, but is not limited to, information dissemination, deployment, training, and research results implementation.

Technologies are broadly defined to include practices, products, processes, or techniques.

Innovations are technologies that are new to the organization or agency regardless of how long they have been in existence or where else they have been applied.

Implementation of research results describes the various activities required to put an outcome of a research project into widespread use. The activities can span the entire duration of the research project and extend until the research result is adopted, for example, as part of a standard operating procedure.

Adoption occurs when a technology or innovation becomes an organization's standard operating procedure or when the technology or innovation is used as the generally accepted means for accomplishing a specific purpose.

DOCUMENTATION

We would appreciate electronic attachments that document or illustrate key points that you reference in your survey responses. If you have materials that are not available in electronic format, please mail them to us so we have the opportunity to include them in this synthesis and so that others can use them in their technology transfer efforts.

SUBMIT COMPLETED SURVEY AND SUPPORTING MATERIALS TO:

Barbara T. Harder		
B. T. Harder, Inc.	Telephone:	215-735-2482
1626 Pine Street	Fax:	215-735-9586
Philadelphia, PA 19103	E-mail:	btharder@sprintmail.com

Please contact Barbara directly if you have questions.

Alternate contact:

Robert Benke	Telephone:	763-493-5373
Synthesis co-principal investigator	E-mail:	bob@straussmgmt.com

THANK YOU FOR YOUR RESPONSES—PLEASE RETURN THE COMPLETED SURVEY AND SUPPORTING MATERIALS BY APRIL 16, 2004

RESPONDING AGENCY OR ORGANIZATION INFORMATION

We'd like to have people who are responsible for technology transfer and/or implementation of innovations or research results provide input to this survey. If there are a variety of people involved please provide an opportunity for all to give input so the survey will present a full picture of what your organization does. The individual(s) may be in the research office or in operation or program offices where the innovations will be used. Let us know who participated in completing this survey.

Agency/Company: _____

Address: _____

_____

City: _____ State: _____ Zip: _____

Questionnaire Completed by: _____

Current Position/Title: _____

Date: _____ E-mail: _____

Telephone: _____ Fax: _____

Agency/Company Contact (if different from above): _____

Telephone: _____ E-mail: _____

Others providing input to this survey.

Name: _____ Position/Title: _____

Name: _____ Position/Title: _____

Name: _____ Position/Title: _____

Name: _____ Position/Title: _____

Name: _____ Position/Title: _____

THANK YOU IN ADVANCE FOR YOUR HELP AND COOPERATION WITH THIS IMPORTANT PROJECT

PLEASE RETURN YOUR COMPLETED SURVEY AND SUPPORTING MATERIALS AS SOON AS POSSIBLE
To: btharder@sprintmail.com

Barbara T. Harder
B. T. Harder, Inc., 1626 Pine Street, Philadelphia, PA 19103

GENERAL

We'd like to know some general information about you and how your agency handles technology transfer and implementation of research results.

1. How long have you been involved with technology transfer or implementation of research results? _____ years
   In what capacity have you accomplished this technology transfer or implementation of research results? (Check all that apply.)
   - ☐ Senior management
   - ☐ Research office management or administration
   - ☐ Researcher
   - ☐ Central office program or project staff
   - ☐ Central office project or program management
   - ☐ Field office program or project staff
   - ☐ Field office program or project management

2. ☐ My agency has a *person* responsible for agency-wide coordination or management of technology transfer or implementation of research results. (If no, skip to question 3.)
   - ☐ I am that individual
   - ☐ Another person is that individual _____ Name _____

   Title _____ Name of group or office _____

3. ☐ My agency has a *group or office* responsible for agency-wide technology transfer or implementation as one of or its primary function. (If no, skip to question 4.)
   - ☐ It is my group or office
   - ☐ Same as group or office identified in above question

   _____ Name of other group or office

4. What units in your agency are responsible for technology transfer and implementation of research results? (Check all that apply.)
   - ☐ Operating units are primarily responsible
   - ☐ Operating units share the responsibility with other units within agency, such as _____

     _____
   - ☐ Research unit is primarily responsible
   - ☐ Research unit shares the responsibility with other units within the agency, such as _____

     _____
   - ☐ Agency has a specific unit other than research, primarily responsible for technology transfer and/or implementation: unit name _____
   - ☐ No unit is specifically assigned responsibility for technology transfer and/or implementation

5. Does your agency operate or provide funding for others to operate a federal-aid funded Local Technical Assistance Program (LTAP) technology transfer center?
   - ☐ Operate center
   - ☐ Fund a center operated by others

6. What are the top three (or more) most successful techniques, practices, or processes that your agency uses for accomplishing technology transfer or implementation of research results? (We use the word successful to mean that the intended results are achieved. The items we are looking for can relate to administrative duties, communication techniques, field practices, and more.) Please specify the item and briefly describe it; include at least three.

   1. _____

      _____

   2. _____

      _____

   3. _____

      _____

4. _____
_____

5. _____
_____

7. Does your agency apply methods for measuring performance for technology transfer or implementation activities?
Yes ☐ No ☐

If yes, what are they? (For example, benefit/cost, return-on-investment, other quantitative or qualitative measures.)
_____
_____

8. How do you use the results of these measures of performance? (Check all that apply.)
☐ Annual report input
☐ Accountability to senior management
☐ Program justification
☐ Other, please describe: _____

TECHNOLOGY TRANSFER SUCCESSES

We would like to understand how your agency accomplishes technology transfer and/or implementation of research results. Please identify a successful experience and answer questions 9 through 24 about this successful experience.

9. Please provide a short description of the technology transfer or implementation success.
_____
_____
_____

10. What is the area of focus for the technology transfer? (Check all that apply.)
☐ Marketing focus (making another party aware of the benefits to using a technology so an informed decision about potential application of the technology can be made)
☐ Knowledge transfer focus (getting another party knowledgeable about a technology through a presentation, showcase, demonstration)
☐ Training or education focus (workshop, seminar, course)
☐ Other area of focus, please describe: _____

11. Which of these following characteristics apply to the successful experience? (Check all that apply.)
☐ Senior management support of the effort
☐ Champions to promote the technology transfer or implementation activity
☐ Plan developed for the conduct of the technology transfer or implementation activities
☐ Progress monitoring of the technology transfer or implementation activities
☐ Dedicated funding for the technology transfer or implementation activities
☐ Use of a pilot project, field demonstrations, and other hands-on field testing
☐ Early and continuous involvement of users
☐ Fully qualified technical personnel assigned a lead role in the technology transfer or implementation effort
☐ Other, please describe: _____

12. What were the top three reasons or factors why this experience was successful and why did they work?
1. _____
_____
Why? _____
_____
_____

2. _____
_____
Why? _____
_____
3. _____
_____
Why? _____
_____
_____

13. Which of the following were involved with this success? Please indicate the degree of involvement:
3—high involvement, 2—moderate involvement, 1—low involvement, 0—no involvement
_____ Research office personnel
_____ Headquarters program or operations office personnel
_____ Region or district office personnel
_____ Field maintenance office personnel
_____ Outside research organization involved with producing the technology
_____ Contracted organization brought on board to assist in technology transfer
_____ Federal agency expertise (e.g., FHWA division or region staff)
_____ Other state peer experienced in the technology
_____ Trade or professional association expert
_____ Local or municipal expert
_____ Other, please describe: _____

14. From the above list, which participant(s) lead the successful technology transfer activities? _____
_____

15. What was the source of the funding for the technology transfer or implementation? _____
_____

16. What was the source of the facilities and/or equipment supplied for the technology transfer to take place? _____
_____
Or ☐ not applicable

17. What was the source of the materials supplied for the technology transfer to take place? _____
_____
Or ☐ not applicable

18. What office or organization supplied the technical expertise in the technology transfer process? _____
_____

19. Was other specialized expertise (e.g., legal, policy, administrative) required in the process of the technology transfer or implementation?
Yes ☐ No ☐

If yes, please describe what that was: _____

20. What was the result of the technology transfer or implementation effort? (Check all that apply.)
☐ Policy change
☐ Specification or operating standards change
☐ Change in management, financial, or administrative practices
☐ Cost savings (labor, material, equipment)
☐ Safety enhancement
☐ Enhancements in effectiveness or efficiencies in current practice
☐ Other, please describe: _____

21. What was the source of the technology that was transferred or implemented?
    - ☐ A result of research performed by my agency
    - ☐ A result of research performed by others and funded by my agency
    - ☐ A technology my agency sought from others outside the agency and brought into the agency to use
    - ☐ A technology others outside the agency (e.g., FHWA, vendors, AASHTO, other states) encouraged my agency to use

22. Was any effectiveness assessment or performance evaluation done on the technology transfer or implementation process?
    Yes ☐ No ☐

    If yes, what type of assessment or evaluation was done? (For example, benefit/cost, return-on-investment, other quantitative or qualitative measures.) _____
    _____

    If yes, what did you do with the results? _____
    _____

23. What were the three most difficult hurdles or barriers to the technology transfer or implementation that were encountered and how were they overcome?

    1. _____
    _____
    How overcome? _____
    _____
    2. _____
    _____
    How overcome? _____
    _____
    3. _____
    _____
    How overcome? _____
    _____

24. How easy would this technology transfer or implementation activity be to replicate in another agency (use rating scale of 10, easiest to 1, most difficult). _____ rating.

    What elements of the activities would be easiest to replicate in another agency? _____
    _____
    _____

    What elements of the activities would be most difficult to replicate in another agency? _____
    _____
    _____

If you have another example you would like to share with us, please copy survey questions 9–24 and send us your responses about that experience.

GENERAL CHALLENGES

The following questions are about your agency's general experiences with technology transfer or implementation of research results.

Challenges to technology transfer and implementation activities often occur. They may be related to cultural differences; operational, legal, organizational, political differences; or economically related such as resource constraints.

25. In general what are the five greatest challenges (non-project-specific) to accomplishing technology transfer in your agency or organization?
    1. _____
    _____
    _____
    2. _____
    _____
    _____
    3. _____
    _____
    _____
    4. _____
    _____
    _____
    5. _____
    _____
    _____

26. What, if anything, is being done to reduce or remove these challenges?
    Challenge 1. _____
    _____
    Challenge 2. _____
    _____
    Challenge 3. _____
    _____
    Challenge 4. _____
    _____
    Challenge 5. _____
    _____

NEEDS

The following questions are about your agency's general experiences with technology transfer or implementation of research results.

27. For those in your agency who have the responsibility for making technologies available for others to use—those "pushing technology out to others," what would help to make these efforts more effective? (Check all that apply.)
    - ☐ Additional funding
    - ☐ Greater access to technical expertise
    - ☐ More time to perform technology transfer
    - ☐ Greater senior management support for technology transfer activities
    - ☐ Training in the process of technology transfer
    - ☐ More openness to including new technologies in new projects
    - ☐ Assistance for management and administrative responsibilities associated with technology transfer
    - ☐ Other, please describe: _____

28. If you indicated that management and administrative assistance would be helpful, what type of assistance is needed?
    - ☐ Implementation plans
    - ☐ Marketing plans
    - ☐ Executive briefing models
    - ☐ Scheduling and tracking methodologies
    - ☐ Evaluation or assessment procedures
    - ☐ Other, please describe: _____

29. For those in your agency who want to implement new technology or innovations into the area of highway practice for which they are responsible—"pulling technology into their work," what would help make these efforts more effective? (Check all that apply.)
    - ☐ Additional funding
    - ☐ Enhanced expertise for technology selection
    - ☐ More extensive contacts with external-to-the-agency peers to determine candidate technologies
    - ☐ More time to perform technology transfer
    - ☐ Greater senior management support for bringing in new technologies
    - ☐ Greater involvement with the researchers or developers of the innovation
    - ☐ Methods or techniques to assist in making the process of technology transfer more efficient
    - ☐ Other, please describe: _____

30. If you indicated methods or techniques to assist in making the process of technology transfer more efficient, what would they be? _____

FUNDING

31. How many dollars does your agency or organization commit to research and research-related activities—all activities, organization wide? $_____ Please include federal-aid funds, state funds, state matching funds for federal-aid moneys, funds from other outside sources, and funds committed to NCHRP, pooled-fund projects, and support of TRB. Please do not include the agency's general training funds.

32. Does this figure include technology transfer and implementation activities funding?
    Yes ☐ No ☐

For questions 33 and 34, if a dollar amount is not available, please provide your best estimate of a percentage of the research funding; for example, 10%, for every $10 spent on research, approximately $1 is spent on technology transfer and/or implementation.

33. How many dollars does your agency or organization commit to technology transfer and implementation activities? $_____

34. What percentage of the federal-aid State Planning and Research Program funds are committed to technology transfer and implementation? _____ percent

35. Does your state have legislation that provides funding for technology transfer or implementation activities?
    Yes ☐ No ☐

36. Are there any other program moneys being spent on or *dedicated* to funding technology transfer or implementation activities?
    Yes ☐ No ☐ If yes, how much $ _____

    If yes, what is the source of this funding and describe any special conditions governing its use
    _____
    _____

THANK YOU FOR PARTICIPATING IN THIS SYNTHESIS STUDY

Please return the completed survey and supporting materials to
Barbara T. Harder by APRIL 16, 2004
btharder@sprintmail.com
or
Barbara T. Harder
Principal
B. T. Harder, Inc.
1626 Pine Street
Philadelphia, PA 19103
or Fax: 215-735-9586

TECHNOLOGY TRANSFER SUCCESSES, CHALLENGES, AND NEEDS
NCHRP PROJECT 20-5, SYNTHESIS TOPIC 35-12
LTAP/TTAP SURVEY
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TERMINOLOGY

Technology transfer includes, but is not limited to, information dissemination, deployment, training, and research results implementation.

Technologies are broadly defined to include practices, products, processes, or techniques.

Innovations are technologies that are new to the organization or agency regardless of how long they have been in existence or where else they have been applied.

Implementation of research results describes the various activities required to put an outcome of a research project into widespread use. The activities can span the entire duration of the research project and extend until the research result is adopted, for example, as part of a standard operating procedure.

Adoption occurs when a technology or innovation becomes an organization's standard operating procedure or when the technology or innovation is used as the generally accepted means for accomplishing a specific purpose.

DOCUMENTATION

We would appreciate electronic attachments that document or illustrate key points that you reference in your survey responses. If you have materials that are not available in electronic format, please mail them to us so we have the opportunity to include them in this synthesis and so that others can use them in their technology transfer efforts.

SUBMIT COMPLETED SURVEY AND SUPPORTING MATERIALS TO:

Barbara T. Harder
B. T. Harder, Inc.
1626 Pine Street
Philadelphia, PA 19103

Telephone: 215-735-2482
Fax: 215-735-9586
E-mail: btharder@sprintmail.com

Please contact Barbara directly if you have questions.

Alternate contact:

Robert Benke
Synthesis co-principal investigator

Telephone: 763-493-5373
E-mail: bob@straussmgmt.com

THANK YOU FOR YOUR RESPONSES—PLEASE RETURN THE COMPLETED SURVEY AND SUPPORTING MATERIALS BY APRIL 16, 2004

RESPONDING AGENCY OR ORGANIZATION INFORMATION

We'd like to have people who are responsible for technology transfer and/or implementation of innovations or research results provide input to this survey. If there are a variety of people involved please provide an opportunity for all to give input so the survey will present a full picture of what your organization does. Let us know who participated in completing this survey.

Agency/Company: _____

Address: _____

_____

City: _____ State: _____ Zip: _____

Questionnaire Completed by: _____

Current Position/Title: _____

Date: _____ E-mail: _____

Telephone: _____ Fax: _____

Agency/Company Contact (if different from above): _____

Telephone: _____ E-mail: _____

Others providing input to this survey.

Name: _____ Position/Title: _____

Name: _____ Position/Title: _____

Name: _____ Position/Title: _____

Name: _____ Position/Title: _____

Name: _____ Position/Title: _____

THANK YOU IN ADVANCE FOR YOUR HELP AND COOPERATION WITH THIS IMPORTANT PROJECT

PLEASE RETURN YOUR COMPLETED SURVEY AND SUPPORTING MATERIALS BY APRIL 16, 2004
To: btharder@sprintmail.com

Barbara T. Harder
B. T. Harder, Inc., 1626 Pine Street, Philadelphia, PA 19103

GENERAL

We'd like to know some general information about you and how your organization/agency handles technology transfer and/or implementation of research results.

1. How long have you been involved with technology transfer? _____ years?

2. In what capacity have you accomplished this technology transfer? (Check all that apply.)
   - ☐ Senior management
   - ☐ Research office management or administration
   - ☐ Researcher
   - ☐ Central office program or project staff
   - ☐ Central office project or program management
   - ☐ Field office program or project staff
   - ☐ Field office program or project management
   - ☐ Technology transfer program manager
   - ☐ Technology transfer program staff

3. Which of the following best characterizes your organization/agency?
   - ☐ State DOT and operate an LTAP/TTAP center
   - ☐ University and operate an LTAP/TTAP center
   - ☐ Other program management institution that operates an LTAP/TTAP center

4. How long has your Center been operating? _____ years

5. What is your Center's total annual budget for 2004? _____ dollars

6. What is the source of the funds for your program? Please also give an estimate of the percentage of funds for each source.
   - ☐ Federal-aid funds from state or federal DOT _____ percent
   - ☐ University funds _____ percent
   - ☐ Local/municipal funds _____ percent
   - ☐ Private sector funds _____ percent
   - ☐ Other source, please describe _____

   Are there any special conditions for the use of any of these funds? Please describe:
   _____

7. Does your state have legislation that provides funding for technology transfer that is available to your program?
   Yes ☐ No ☐

8. What are the top three (or more) most successful techniques, practices, or processes that your organization/agency uses for accomplishing technology transfer? (We use the word successful to mean that the intended results are achieved. The items we are looking for can relate to administrative duties, communication techniques, field practices, and more.) Please specify the item and briefly describe it; include at least three.
   1. _____
   _____
   2. _____
   _____
   3. _____
   _____
   4. _____
   _____
   5. _____
   _____

9. Does your organization/agency apply methods for measuring performance for technology transfer?
   Yes ☐ No ☐

   If yes, what are they? (For example, benefit/cost, return-on-investment, other quantitative or qualitative measures.)
   _____
   _____

10. How do you use the results of these measures of performance? (Check all that apply.)
    - ☐ Annual report input
    - ☐ Accountability to senior management
    - ☐ Program justification
    - ☐ Other, please describe: _____
      _____

TECHNOLOGY TRANSFER SUCCESSES

We would like to understand how your organization/agency accomplishes technology transfer. Please identify a successful experience and answer questions 11 through 26 about this successful experience.

11. Please provide a short description of the technology transfer success.
    _____
    _____
    _____

12. What is the area of focus for the technology transfer (Check all that apply.)
    - ☐ Marketing focus (making another party aware of the benefits to using a technology so an informed decision about potential application of the technology can be made)
    - ☐ Knowledge transfer focus (getting another party knowledgeable about a technology through a presentation, showcase, demonstration)
    - ☐ Training or education focus (workshop, seminar, course)
    - ☐ Other area of focus, please describe: _____

13. Which of these following characteristics apply to the successful experience? (Check all that apply.)
    - ☐ Senior management support of the effort
    - ☐ Champions to promote the technology transfer activity
    - ☐ Plan developed for the conduct of the technology transfer
    - ☐ Progress monitoring of the technology transfer
    - ☐ Dedicated funding for the technology transfer
    - ☐ Use of a pilot project, field demonstrations, and other hands-on field testing
    - ☐ Early and continuous involvement of users/stakeholders
    - ☐ Fully qualified technical personnel assigned a lead role in the technology transfer effort
    - ☐ Other, please describe: _____

14. What were the top three reasons or factors why this experience was successful and why did they work?
    1. _____
       _____
       Why? _____
       _____
       _____
    2. _____
       _____
       Why? _____
       _____
       _____
       _____

3. _____
_____
Why? _____
_____
_____
_____

15. Which of the following were involved with this success? Please indicate the degree of involvement:
3—high involvement, 2—moderate involvement, 1—low involvement, 0—no involvement
_____ State DOT research office personnel
_____ State DOT program or operations office personnel
_____ Region or district office personnel
_____ Field maintenance office personnel
_____ Outside research organization involved with producing the technology
_____ Contracted organization brought on board to assist in technology transfer
_____ Federal agency expertise (e.g., FHWA division or regional staff)
_____ Other peer experienced in the technology
_____ Trade or professional association expert
_____ Local or municipal expert
_____ University administrative personnel
_____ University educators/researchers
_____ Other, please describe: _____

16. From the above list, which participant(s) lead the successful technology transfer activities? _____
_____

17. What was the source of the funding for the technology transfer? _____
_____

18. What was the source of the facilities and/or equipment supplied for the technology transfer to take place? _____
_____
Or ☐ not applicable

19. What was the source of the materials supplied for the technology transfer to take place? _____
_____
Or ☐ not applicable

20. What organization/agency supplied the technical expertise in the technology transfer process? _____
_____

21. Was other specialized expertise (e.g., legal, policy, administrative) required in the process of the technology transfer or implementation?
Yes ☐ No ☐

If yes, please describe what that was: _____
_____

22. What was the result of the technology transfer? (Check all that apply.)
☐ Knowledge transfer
☐ Training
☐ Policy change
☐ Specification or operating standards change
☐ Change in management, financial, or administrative practices
☐ Cost savings (labor, material, equipment)
☐ Safety enhancement
☐ Enhancements in effectiveness or efficiencies in current practice
☐ Other, please describe: _____

23. What was the source of the technology that was transferred?
    - ☐ A result of research performed by my organization/agency
    - ☐ A result of research performed by others and funded by my organization/agency
    - ☐ A technology my organization/agency sought from others
    - ☐ A technology others outside the organization/agency (e.g., FHWA, vendors, AASHTO, other states) encouraged my organization/agency to foster its use

24. Was any effectiveness assessment or performance evaluation done on the technology transfer process?
    Yes ☐ No ☐

    If yes, what type of assessment or evaluation was done? (For example, benefit/cost, return-on-investment, other quantitative or qualitative measures.)_____
    _____

    If yes, what did you do with the results? _____
    _____

25. What were the three most difficult hurdles or barriers to the technology transfer that were encountered and how were they overcome?
    1. _____
    _____
    How overcome? _____
    _____
    2. _____
    _____
    How overcome? _____
    _____
    3. _____
    _____
    How overcome? _____
    _____

26. How easy would this technology transfer activity be to replicate in another organization/agency (use rating scale of 10, easiest to 1, most difficult). _____ rating.

    What elements of the activities would be easiest to replicate in another organization/agency?
    _____
    _____

    What elements of the activities would be most difficult to replicate in another organization/agency?
    _____
    _____

If you have another example you would like to share with us, please copy survey questions 11–26 and send us your responses about that experience.

GENERAL CHALLENGES

The following questions are about your organization's/agency's general experiences with technology transfer.

Challenges to technology transfer often occur. They may be related to cultural differences; operational, legal, organizational, political differences; or economically related such as resource constraints.

27. In general what are the five greatest challenges (non-project-specific) to accomplishing technology transfer in your organization/agency?
    1. _____
    _____
    _____

2. _____
_____
_____
3. _____
_____
_____
4. _____
_____
_____
5. _____
_____
_____

28. What, if anything, is being done to reduce or remove these challenges?
    Challenge 1. _____
    _____
    Challenge 2. _____
    _____
    Challenge 3. _____
    _____
    Challenge 4. _____
    _____
    Challenge 5. _____
    _____

NEEDS

The following questions are about your organization/agency's general experiences with technology transfer.

29. For those in your organization/agency who have the responsibility for making technologies available for others to use—those "pushing technology out to others," what would help to make these efforts more effective? (Check all that apply.)
    - ☐ Additional funding
    - ☐ Greater access to technical expertise
    - ☐ More time to perform technology transfer
    - ☐ Greater senior management support for technology transfer activities
    - ☐ Training in the process of technology transfer
    - ☐ More openness to including new technologies in new projects
    - ☐ Assistance for management and administrative responsibilities associated with technology transfer
    - ☐ More trained staff
    - ☐ Other, please describe: _____

30. If you indicated that management and administrative assistance would be helpful, what type of assistance is needed? (If this does not apply, please go to question 31.)
    - ☐ Implementation plans
    - ☐ Marketing plans
    - ☐ Executive briefing models
    - ☐ Scheduling and tracking methodologies
    - ☐ Evaluation or assessment procedures
    - ☐ Communication and publicity tools
    - ☐ Other, please describe: _____

31. If your organization/agency uses the technology transferred and wants to implement new technology or innovations into the area of highway practice for which they are responsible—"pulling technology into their work," what would help make these efforts more effective? (Check all that apply.)
    - ☐ Does not apply to my agency
    - ☐ Additional funding

- ☐ Enhanced expertise for technology selection
- ☐ More extensive contacts with external-to-the-agency peers to determine candidate technologies
- ☐ More time to perform technology transfer
- ☐ Greater senior management support for bringing in new technologies
- ☐ Greater involvement with the researchers or developers of the innovation
- ☐ Methods or techniques to assist in making the process of technology transfer more efficient
- ☐ Other, please describe: _____

32. If you indicated methods or techniques to assist in making the process of technology transfer more efficient, what would they be? _____
_____

FUNDING

33. Does your state have legislation that provides funding for technology transfer or implementation activities?
Yes ☐ No ☐

34. Other than federal-aid funding of LTAP/TTAP centers, are there any other programs or sources of funds available to your center *dedicated* to funding technology transfer or implementation activities?
Yes ☐ No ☐

If yes, what is the source of this funding and describe any special conditions governing its use:
_____

THANK YOU AGAIN FOR PARTICIPATING IN THIS SYNTHESIS STUDY

Please return the completed survey and supporting materials to
Barbara T. Harder by April 16, 2004 to
btharder@sprintmail.com
or
Barbara T. Harder
Principal
B. T. Harder, Inc.
1626 Pine Street
Philadelphia, PA 19103
or
Fax: 215-735-9586

TECHNOLOGY TRANSFER TOOLBOX SCOPING STUDY
AASHTO RESEARCH ADVISORY COMMITTEE SHORT SURVEY

A copy of the survey and the results of the survey are below. The ranking of the preference is included for the first question and the number of responses for each item is included for the second question. Nearly half of the respondents indicated their willingness to discuss the T^2 Toolbox.

To: RAC Members

From: Barbara T. Harder
215-735-2482
btharder@sprintmail.com

Subject: Your help regarding effective implementation and technology transfer tools

I've been asked by the TRB committees on Technology Transfer and Conduct of Research along with the FHWA to prepare a scope for a Technology Transfer Toolbox. In that light, I'm asking a number of groups including the TRB committees and TRB state representatives (those other than RAC members), FHWA field personnel, and others for input. The committees want this toolbox to be a useful mechanism to assist those responsible for implementation of research results.

Often people performing research results implementation in state DOTs are not always technology transfer or implementation specialists and therefore may benefit by having a resource that will guide them through some of the basic processes needed for enhancing their implementation efforts. The goal is to get technology transferred and methods, processes, and products put into practice more effectively.

If there was a step-by-step guide for processes that would be of assistance, which of the following would be useful? Please number the items, 1 being most useful, 2 next most useful, to 6, least useful of the list.

_____ A template that maps out an implementation plan
_____ A project management process to schedule and monitor technology transfer activities and implementation actions
_____ Communications and publicity action plans
_____ Marketing/promotion plan development for new technologies
_____ Resource estimator for implementation and deployment activities
_____ Technology transfer and implementation effectiveness assessment
Other: _____

What is the most effective mechanism to use for the toolbox? Please consider the various people that might be using this tool: people from your office, from the operational offices, and from field offices. **Please check one only.**

_____ Workbook (with reproducible forms), hardcopy only
_____ Workbook accompanied by a CD (generates plans and hardcopy) that can be used on a PC or installed on an agency's intranet
_____ DVD (generates plans and hardcopy) that can be used on a PC or installed on an agency's intranet
_____ Web-based, requiring access to the Internet
Other: _____

_____ Would you be willing to talk about this toolbox concept with me?
Name: _____
E-mail: _____
Telephone number: _____

Thank you very much. Please return this by December 19 to btharder@sprintmail.com

APPENDIX B

Survey Respondents and Conducted Interviews

Surveys were received from the following state departments of transportation and Canadian ministries of transportation:

Arizona
Arkansas
California
Colorado
Connecticut
Florida
Georgia
Hawaii
Illinois
Indiana
Iowa
Kansas
Louisiana
Maine
Maryland
Michigan
Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New York
Ohio
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Texas
Utah
Virginia
Washington
West Virginia
Wisconsin
Wyoming
Canadian province: Quebec

Surveys were received from the following Local and Tribal Technical Assistance Program Technology Transfer Centers:

Arkansas*
California
Colorado**
Connecticut
Delaware
Florida
Georgia*
Illinois*
Indiana
Maine*
Michigan
Minnesota
Nebraska
Nevada
New Hampshire
Northern Plains**
Oregon*
South Carolina
South Dakota***
Vermont
Virginia*
Washington*
Wisconsin

*LTAP center operated by state DOT. **Tribal Technology Transfer Center. ***Operates LTAP Center and funds operations by others.

Interviews and Discussions With State Departments of Transportation (DOTs) and Tribal Technology Assistance Program (TTAP) Center

Michael Bonini and William Pogash, Pennsylvania DOT
Ken Kobetsky, AASHTO
Wes Lum, California DOT
Richard McReynolds, Kansas DOT
Leni Oman, Washington State DOT
Dennis Trusty, Northern Plains TTAP

Data collected from the Technology Transfer Toolbox Scoping Study (Harder 2004) was used in this synthesis. A short survey on implementation needs was sent to AASHTO Research Advisory Committee (RAC) members. (Similar questions were included in the synthesis surveys.) Thirty-two RAC members and one Canadian province responded. E-mails and telephone discussion follow-up were conducted with approximately one-quarter of the Technology Transfer Toolbox survey respondents. In addition to interviews with state DOT research managers, the following FHWA and University researchers were also interviewed:

Federal Highway Representatives

Resource Centers

- Thay Bishop, Finance Technical Service Team Leader, Atlanta, GA
- Pat Hasson, Safety and Highway Design Technical Service Team Leader, Olympia Fields, IL
- Peter Osborne, Hydraulics and Geotechnical Service Team Leader, Baltimore, MD
- Susanna Reck, Technology Deployment Specialist, Lakewood, CO

Division Offices

- David Pamplin, Quality, Research and Technology Deployment Team, Indiana
- Mary Stringfellow, Technology Management Systems Engineer, Louisiana

University Representatives (including Technology Transfer Professionals)

- John A. Anderson, Education Resource Group, Dixon University
- Jason Bitner, Program Manager, Midwestern Regional University Transportation Center
- John B. Metcalf, Professor, Civil & Environmental Engineering, Louisiana State University
- Sue McNeil, Director, Professor, Urban Transportation Center, University of Illinois
- Wilfrid A. Nixon, Professor of Civil Engineering, University of Iowa
- Gib Peaslee, Program Outreach Coordinator, Florida LTAP Center, University of Florida
- Ed Stellfox, Maryland Technology Transfer Center Director, University of Maryland

APPENDIX C

Principal Federal Legislation Related to Cooperative Technology Transfer

Since 1980, a series of laws have been enacted to promote federal and civilian partnerships and to facilitate the transfer of technology between sectors. Among the most notable pieces of legislation have been the following:

- **Stevenson–Wydler Technology Innovation Act (1980).** Required federal laboratories to facilitate the transfer of federally owned and originated technology to state and local governments and to the private sector.
- **Bayh–Dole University and Small Business Patent Act (1980).** Permitted government grantees and contractors to retain title to federally funded inventions and encouraged universities to license inventions to industry. The act is designed to foster interactions between academia and the business community.
- **Small Business Innovation Development Act (1982).** Established the Small Business Innovation Research (SBIR) Program within the major federal R&D agencies to increase government funding of research with commercialization potential within small high technology companies.
- **National Cooperative Research Act (1984).** Encouraged U.S. firms to collaborate on generic, precompetitive research by establishing a rule of reason for evaluating the antitrust implications of research joint ventures. The act was amended in 1993 by the National Cooperative Research and Production Act, which let companies collaborate on production as well as research activities.
- **Federal Technology Transfer Act (1986).** Amended the Stevenson–Wydler Technology Innovation Act to authorize Cooperative Research and Development Agreements between federal laboratories and other entities, including state agencies.
- **Omnibus Trade and Competitiveness Act (1988).** Established the Competitiveness Policy Council to develop recommendations for national strategies and specific policies to enhance industrial competitiveness. The act created the Advanced Technology Program and the Manufacturing Technology Centers within National Institute of Standards and Technology to help U.S. companies become more competitive.
- **National Competitiveness Technology Transfer Act (1989).** Amended the Stevenson–Wydler Act to allow government-owned, contractor-operated laboratories to enter into cooperative R&D agreements.
- **National Cooperative Research and Production Act (1993).** Relaxed restrictions on cooperative production activities, enabling research joint venture participants to work together in the application of technologies they jointly acquire.

Science & Engineering Indicators 2000, Chapter 2, U.S. and International Research and Development: Funds and Alliances, National Science Foundation, Washington, D.C., 20036 [Online]. Available: http://www.nsf.gov/sbe/srs/seind00/start.htm.

APPENDIX D

List of Communication Outreach and Marketing Tools

September 2003

C. Marti, Center for Transportation Studies, U of MN; P. Leas, Consultant

Instructional Activities

- Interactive workshops and training (exercises/case examples/scenarios)
- Lecture
- Computer-assisted learning (web-based, CD-ROM, live on-line)
- Self-instruction workbooks
- On-the-job training/apprenticeships/job shadowing
- Coaching/mentoring
- Loaned personnel
- Video-taped courses and interactive video

Conferences and Symposia

- Key expert discussion seminar
- Symposium (focused on single topic)
- Conference (broad topic areas)
- Meeting presentations
- Electronic teleconferencing

Demonstrations

- Product demonstration
- Exhibits/trade shows
- Equipment rodeos
- Simulations

Technical Assistance/Communications

- On-site, traveling assistance (circuit programs)
- Hotline Q & A assistance
- Internet networks (Listservs, instant messaging, chat-rooms, e-mail)
- Telephone conferencing
- Key-expert knowledge management systems
- Networking
- Cooperative “twinning” partnerships

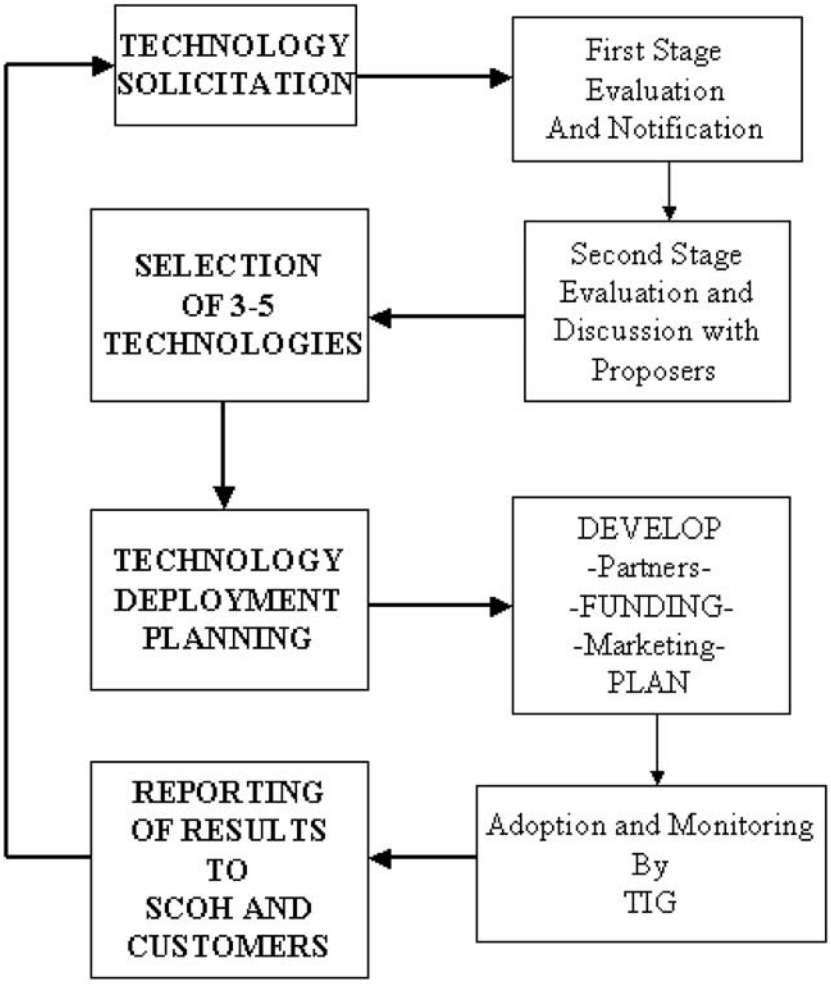
Print and Web-Based Publications and Materials

- Web pages and links
- Brochures
- Newsletters/articles
- Best practice manuals/helpful guides/fact sheets
- Posters
- Guidelines/specifications
- Press release/media kits
- Reports/papers/research syntheses
- Job aids and resources (flow charts/checklists)
- Promotional items

APPENDIX E

AASHTO Technology Implementation Group Technology Transfer Process

Technology Deployment Process: Concept View



APPENDIX F

Implementation Plan Forms

Items included:

- FHWA Turner–Fairbank Highway Research Center, RD&T Technology Facilitation Action Plan
- Indiana DOT Research Project Implementation Plan
- Kansas DOT Research Project Implementation Plan
- Pennsylvania DOT, Bureau of Planning and Research, Research Division, Implementation Evaluation Form

RD&T Technology Facilitation Action Plan

The following provides a framework for items to be included in technology facilitation action plan. The items should be developed in coordination with appropriate Headquarters contact. This framework can than be used to finalize the action plan for delivery of research products.

PRODUCT *Describe product and its use*

Description of Product

.....

Intended User

.....

Distribution methods

.....

Alternative Formats

.....

Delivery Date

PROGRAM/PRODUCT SUPPORT *List contact information for subject matter experts or resource team*

Headquarters Contact(s)

.....

Resource Center Contact(s)

.....

Division Office Contact(s)

.....

Other Contact(s)

OUTREACH ***Describe opportunities or planned external outreach***

Conference Presentations (ITE, AASHTO, TRB, etc)

Publications (ITE, Public Roads, Transporter, etc.)

Other Outreach Activities

TRAINING ***Describe formal training, briefings or workshop developed or needed***

Materials Needed

Instructor Requirements

Schedule of Training/Workshop/Briefing

Intended Audience

Alternative Formats

SCHEDULE OF ACTIVITIES ***List critical dates and deadlines for Technology Deployment (e.g., when to submit abstracts or articles, whom to contact, when to enlist implementation champions)***

PROGRAM INTEGRATION ***Should include discussion of transfer of program activities to appropriate Headquarters Unit***

Headquarters Contact

Research Contact – research will continue in a support role for many technical areas

Follow-up Activities – some products may create additional program integration activities. (For example has research product resulted in item that should be incorporated in MUTCD.)

INDOT Research Project Implementation Plan

Date: _____

Research Project Number: _____

Project Title: _____

Principal Investigator: (PI): _____ Project Administrator (PA): _____

Note: If more than one implementor recommended, please fill in the information on each implementor's implementation items:

Name of Implementor: _____

Items (Research Results) to be implemented:

Help of resources needed for implementation (e.g., help from PI, funding, equipment, etc.):

Name of Implementor: _____

Items (Research Results) to be implemented:

Help of resources needed for implementation (e.g., help from PI, funding, equipment, etc.):

Name of Implementor: _____

Items (Research Results) to be implemented:

Help of resources needed for implementation (e.g., help from PI, funding, equipment, etc.):

Signatures of SAC members: _____

_____

Please send a copy of this form to the INDOT Research Division and FHWA with the final report.

KDOT RESEARCH PROJECT IMPLEMENTATION PLAN

DESCRIPTION OF PROJECT: _____

RESEARCH STUDY NO.: _____

TITLE: _____

PRINCIPAL INVESTIGATOR: _____

PROJECT MONITOR: _____ AREA PANEL LEADER: _____

CONTRACTING AGENCY: _____

STUDY COST: _____

SUMMARY OF RESEARCH FINDINGS: Enough detail should be given to provide a basic understanding of the project without necessitating reading the final report.

_____

_____

_____

_____

_____

IMPLEMENTATION POTENTIAL: Explain how the research study solved the problem, specify the types of changes being recommended and describe the expected benefits of implementation. Determine if implementation is warranted or further research or development is needed.

_____

_____

_____

_____

_____

IMPLEMENTATION STRATEGIES: The goals and scope of implementation, any potential problems or constraints, and the tools needed to achieve implementation; include any approvals required.

_____

_____

_____

_____

_____

TASK SCHEDULING: Describe tasks and assign responsibilities to functional areas and a time schedule for completion of activities.

BUDGET ESTIMATING: Detail the expected costs of implementation as well as the anticipated benefit saving from implementation.

Prepared by: _____
K-TRAN Project Monitor

Approved by: _____
K-TRAN Area Panel Leader

Bureau of Planning and Research
Research Division

Implementation Evaluation Form

To be completed by the Technical Advisor and Program Manager

PENNDOT Research Project Title:		
PENNDOT Research Contract Number:		
Technical Advisor:	Phone Number:	Email:
Program Manager:	Phone Number:	Email:
Project Background – Why Did PennDOT Conduct This Research?		
Project Findings:		
Project Recommendations:		

Please choose the appropriate Communication action(s) from the following:

- ☐ Final Report Distribution (standard)
- ☐ IDEAs Have Consequences (standard)
- ☐ Research Web Site Feature (standard)
- ☐ Research Newsletter Article/Partner Newsletter Article _____
- ☐ *TR News* Article (Research Pays Off)
- ☐ PowerPoint Presentation to Engineering Districts
- ☐ PowerPoint Presentation to County Maintenance Managers (MEDP)
- ☐ PowerPoint Presentation to Technical Experts (Bridge Engineers, etc.)_____
- ☐ PowerPoint Presentation at Conference (specify which)_____
- ☐ Technology Transfer (LTAP, Transportation University, other)_____
- ☐ Research Implementation Workshop
- ☐ Additional Research
- ☐ Outlook Today Message
- ☐ Highlight on PennDOT Website
- ☐ Project Covered by Attorney/Client Provisions – **Stop Here**

What Core Group of PennDOT Officials Need To Be Aware of This Research?
Why Have You Identified This Group?
Does this project's final product(s) require a change to current business? ☐ Yes ☐ No Does this project's final product(s) present an opportunity for a major business process improvement? ☐ Yes ☐ No

If "yes" to either question, please proceed.

From the following, please choose as many actions as applicable. ☐ Additional Research (to support major business process improvement) ☐ Pilot ☐ Training Required ☐ Policy Development ☐ New Specification Development ☐ Equipment Purchase ☐ Expert Assistance Required ☐ Funding Required
Please describe the specific tasks and activities associated with this implementation effort.

Total Estimated Cost: $ Estimated List of Expenditures:	List the performance measures that should be used to determine the success of the project's implementation.

Please stop here. Thank you!

Staff Use Only:

Highest Technical Expert Recommendation: ☐ Would you recommend that this project be included in the Implementation program? ☐ Would other states be interested in this project (Pooled Fund Program)?	
Research Implementation Manager Recommendation: ☐ Candidate included in Implementation program ("A") ☐ Candidate prioritized as a "B" listed project ☐ No further action for this project ("C" candidate)	☐ Implementation Program Budget ☐ Research Program Budget ☐ Transportation Pooled Fund Budget
Comments:	

If you need assistance, [contact name, email, and email address]

APPENDIX G

Impediments to Innovation in Highway Transportation

Principal Impediments to Innovations in Highway Transportation
Excerpted from *TRB Special Report 256: Managing Technology Transfer—A Strategy for the Federal Highway Administration* (1999)

Principal Impediments to Innovations in Highway Transportation		
Impediment Category	Type	Description
Technical	Testing and demonstration	New technologies need to be tested and demonstrated thoroughly before public agencies will accept them in competition with other, well-established technologies.
	Standards	Standards-setting groups that offer a safeguard against unexpected failure are often slow and deliberate and can delay implementation of innovative solutions.
	Testing to failure	Long-term testing is difficult and expensive and can preclude innovative solutions that are large and/or expensive.
Procurement	Disclosure rules	Public-sector disclosure rules can prevent the use (and advantages) of a proprietary design or process.
	Low-bid contracts	Such contract awards do not account for future operating and maintenance costs and can result in higher total costs.
	Life-cycle costs	Making awards based on life-cycle costs is difficult; adequate information on such costs may not be available.
	Specifications	Public agencies rely on design or method specifications. This can discourage innovative techniques and products that could be considered if performance specifications were used.
Legal	Design–build limitations	Requiring that separate firms provide design and construction dampens the potential for innovation.
	Product liability and insurance costs	The potential for product liability tort claims, high insurance costs, and prospects for litigation discourage both the development and application of new techniques and products.
	Community participation	Technical choices are open to such intense public scrutiny that officials avoid controversy by relying on engineering design standards that simply repeat previous practice.
	Permit process	Federal, state, and local permit processes are needed to protect public health and safety, but can preempt consideration of innovative solutions.
Public Sector and Institutional	Resistance to change	The natural tendency to resist change and the conservative nature of public-sector organizations institutionalize this resistance.
	Lack of institutional incentives	Highway agency engineers have little incentive to examine new or innovative technologies to solve familiar problems.
	Limited agency capabilities	Highway agencies with limited technical capabilities may be unable to maintain complex new technology.
	Interest group resistance	Many organizations and interest groups committed to preserving the status quo act as a check on innovation.
	Effect of political patronage	Political patronage can dilute agency technical competence, further reducing the incentive for innovation.

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Principal Impediments to Innovations in Highway Transportation		
Impediment Category	Type	Description
Public Sector and Institutional	Employment practices and work rules	Employment practices and compensation can restrict the ability of public agencies to hire personnel needed to implement and maintain new technologies.
	Technology mismatch	There are possible mismatches between technologies employed today and those needed to meet future demand, as well as possible mismatches between existing and future job skill.
General	Limited resources	Resources for R&D in the public sector are limited; the size and complexity of the market limit interest in infrastructure problems.

Factors that Impede Implementation of Research Findings Excerpted from *NCHRP Report 382: Facilitating the Implementation of Research Findings: A Summary Report* (1996)

Factors Pertaining to the Characteristics of Research Results

- Allocation of patents, etc., unsettled
- Research output does not fit work procedures
- Research output not sufficiently tested
- Mismatch between research and user needs

Factors Pertaining to the Organizational Context

Internal organizational context

- Inadequate travel budget
- No local precedents
- Political involvement of managers
- Skill obsolescence
- Discomfort with change
- Inadequate resources
- Inflexible contract specifications
- Legal liability
- Organizational inertia
- Risk aversion

External organizational context

- Hi-tech government support bias
- Dispersed funding authority
- Private–public tensions
- No local precedent
- Contractor investment risk
- Research-user culture gaps
- Unclear national objectives

Factors Pertaining to the Implementation Process

- Researchers not market-oriented
- Unknown information source
- Costliness
- One-way dissemination
- Poor quality/relevance filters
- User successes unpublicized

APPENDIX H

Technology Transfer Toolbox Scoping Study Executive Summary

Federal Highway Administration,
Office of Professional Development and
Office of Research, Development and Technology and
Transportation Research Board, Technology Transfer Committee

The Need

Annually hundreds of millions of dollars are invested by state, federal, and university researchers to produce innovations and improvements to the transportation system. However, the benefits of these investments are dependent upon the ability to deploy and implement the results of research—the innovations, technologies, new methods, and procedures. Coupled with this responsibility to put into practice what has been learned, there is a substantial need for effective and continuous sharing of best practices and new information among the transportation community. These factors point to a more basic need; that of creating and enhancing mechanisms to enable technology transfer, which is the term used for all the activities leading to the adoption of a new-to-the-user product or procedure as an accepted operating practice.

This scoping study describes a Technology Transfer Toolbox—basic principles and concepts developed into tools to assist those engaged in implementation of innovations or technology transfer. These tools will be designed for use by researchers, research administration staff, and program, operations, and field staff, from the public or private sectors or academia. Ultimately the objective of the study is to make transportation innovations more readily available and usable through the use of effective tools and to inform sponsors of the value of developing these tools to more quickly realize the benefits of technology transfer activities.

The Users

The largest group of potential users of the Toolbox is unfamiliar with technology transfer or implementation of research results and does not regularly perform these duties. They are expected to know what to do when they are faced with shepherding the promotion or adoption of an innovation in a specific technical discipline. These people can be field and operation staff, researchers, or others involved with the process of research. It will be this group that benefits the most by having the tools to assist them as they accomplish the necessary technology transfer tasks. Another group in the transportation community, which could be served by the Toolbox, is made up of those who are knowledgeable about or involved in effective technology transfer or implementation of research results. While the Toolbox could assist this group, it will be designed primarily for the inexperienced user.

Users will be drawn from a variety of organizations and responsibilities within transportation. Individual users will come from (1) local government and state departments of transportation: the research unit office technical and administrative staff and those that oversee the application of innovations into the operating environment, including field or district/region personnel; (2) FHWA division offices and others in its regional centers and research and program areas; (3) technology transfer professionals, including National Local Technical Assistance Program and Tribal Technical Assistance Program Centers; (4) universities including researchers and in particular students who will have the opportunity to prepare for their careers by learning to use these essential tools; and (5) private sector researchers and organizations or associations dealing with promoting the use of new technologies and innovations for transportation.

Two Phases of Development

There are two phases of development of the Toolbox. Both phases lead to creating a primary technology transfer resource for the transportation research and technology community. The first phase of development will create an interactive CD-based system with accompanying hardcopy that can be used on a personal computer or installed on an intranet (if available) within the user's organization. The second phase of the system would advance this CD-based system to an interactive web-based system accessible through commonly available Internet browsers. The two-stage approach came about because those

providing input to this study realized that there are many in the transportation community that still do not have full access to the Internet.

The preferences determined for the Toolbox are based on input from federal and state department of transportation personnel and university researchers including technology transfer professionals. The Toolbox will be interactive, providing prompts and suggestions for information input and will include some internal-to-the-system intelligent decision making. Professionally formatted reports will be produced from the tools as needed.

The Tools

Just like a home contractor's toolbox that contains specialized tools for specific tasks, the Technology Transfer Toolbox will contain a set of tools each designed to perform a given task associated with technology transfer or implementation. There will be four primary tools in the Toolbox, which include a Marketing (Promotion) Plan Tool, Implementation Plan Tool, Executive Briefing Development Tool, and a Scheduling and Tracking for Technology Transfer and Implementation Activities Tool. Each of the tools also will include an internal assessment module that allows the user to examine the effectiveness of the performance generated by its activities. Examples of the Marketing (Promotion) Plan Tool and Implementation Plan Tool are given to demonstrate the interactive nature of the Toolbox and provide a vision of the capabilities such a system could provide.

What Next

Now is the time to develop the Toolbox. There is a large base of support within the transportation community for more effective implementation of innovative practices to advance the transportation system. The state departments of transportation can particularly benefit from the Toolbox and because of this, a recommended vehicle for developing the Toolbox is the State Planning and Research supported Pooled Fund Program. The Toolbox will require resources to realize the contribution it could generate.

Initial estimates of cost for producing the CD version of the Toolbox with four primary tools—Marketing Plan, Implementation Plan, Executive Briefing, and Scheduling and Tracking will be $850,000. This amount will include the technical and administrative costs including supporting the policy, technical oversight committees, and project management directing the development of all four tools. The figures also include developing both phases of the tools, the CD version and then the web-based system and include a development effort of 24 months. Funding for this effort may come from a number of sources. The state departments of transportation contribute to the pooled fund activities as well as other organizations such as FHWA, AASHTO, and university transportation centers.

This expense is an investment in the transportation system. Consider that without an implementation plan or a marketing strategy, labor, equipment, materials, and other physical costs could and do rapidly multiply. Additionally, without the forward looking tools to prevent delays, unseen liability, or technical barriers, costs for any one project that had difficulty with implementing the innovation could reach the amount that for example one state department of transportation would contribute to development of the Toolbox, or that one organization may put forward as its support. Furthermore, innovations may not be implemented or the technology may not be transferred because there was no plan or tool to facilitate it. The consequences of not having the benefits of such innovations present an even stronger reason to move forward with this Toolbox.
The immediate next steps to bring the concept to reality are:

- Establish cornerstone sponsorship—key sponsors to launch and expand the Toolbox sponsorship
- Determine project governance and implementation participants
  - Advisory board—strategic oversight and sponsorship
  - Technical Advisory Panels—advise and shape the development of the tools
  - Project management—manage the development and consultant teams
- Select vehicle/structure for project performance
- Secure project development funding
- Develop request for proposal and proceed with consultant selection

The Technology Transfer Toolbox presents a set of tools that will multiply the benefits of the current efforts to enhance the transportation system. These tools need to be in the hands of practitioners to produce efficiencies and create more value for the existing and future transportation assets.

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation