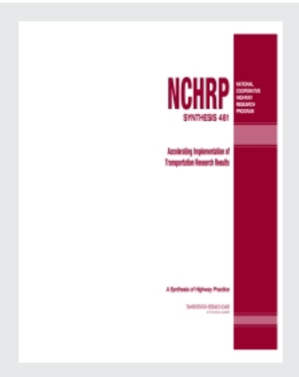

Accelerating Implementation of Transportation Research Results

DETAILS

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NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

Accelerating Implementation of Transportation Research Results

A Synthesis of Highway Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSPORTATION RESEARCH BOARD 2014 EXECUTIVE COMMITTEE*

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* Membership as of August 2014.

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NCHRP SYNTHESIS 461

Accelerating Implementation of Transportation Research Results

A Synthesis of Highway Practice

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TRANSPORTATION RESEARCH BOARD

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communication and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NOTE: The Transportation Research Board of the National Academies, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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NOTICE

The project that is the subject of this report was a part of the National Cooperative Highway Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

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 of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

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FOREWORD

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

By Jon M. Williams
Program Director
Transportation Research Board

This synthesis examines implementation practices used by public-sector nontransportation agencies, nonprofits, and academia to accelerate practical application of research results. The emphasis is on practices that might be useful for transportation agencies to create more responsive research programs. A series of implementation case examples and practices are presented.

Information for this study was gathered through a comprehensive literature review of U.S. and selected international sources. Agency websites were searched and interviews were conducted with key individuals at case example agencies.

Barbara Harder, B.T. Harder Inc., Philadelphia, Pennsylvania, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable with 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

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

ACCELERATING IMPLEMENTATION OF TRANSPORTATION RESEARCH RESULTS

SUMMARY

This synthesis examines the processes used by public-sector nontransportation agencies and others (nonprofits, academia) for accelerating implementation of research results. The report identifies factors and actions that can be applied to further advance implementation processes and accelerate the implementation of research results for transportation applications.

Although there have been many successes in implementing important processes and products in transportation applications, there is room for improvement in every aspect of implementation—the time, the methods and procedures, the types and availability of resources, the innovation climate and culture, the organizational leadership, and more.

A comprehensive literature review of U.S. and some international sources was conducted to establish background information on the range of practices that have been, and are now being, pursued regarding implementation of research results within the private sector and public-sector agencies. Information was gathered from the websites of government and academic and nonprofit organizations as well as through telephone interviewing of research scientists and implementation experts. The study report includes a listing of websites and a bibliography providing sources for further investigation and reading.

Key factors that affect the implementation of research results are identified. A majority of key factors affecting the use, timing, and ease of implementation will be familiar to the highway community. Many organizations have implementation activities that are being done at some level or by pockets of research managers in the highway arena. The synthesis provides a group of factors that are used by government, the private sector, academia, and nonprofit user associations. Factors discussed are applicable across the broad perspective of technology and research results implementation and can be effective regardless of the context in which they occur. The key factors affecting implementation success in contexts other than the transportation community are summarized here.

No one activity in the examined broad array of implementation processes stands out as being the ultimate solution—the must-do action—to accelerate implementation of research results. Rather it is generally a combination of approaches and strategies that foster success and speed the implementing organization's realization of benefit. Using more strategies to produce greater acceptance and using innovations are considered more beneficial than using only a few strategies. Additionally, few if any organizations experiencing success in speeding research results to practice can definitively identify what specific strategy or process is attributable to that success, or the amount of acceleration experienced. Furthermore, many organizations, while successful at increasing implementation over time, consider any added strategies as beneficial to increasing the rate of implementation.

Contexts vary for accelerating the application of research results. Public-sector, academic, and private-sector organizations are different frameworks in which application to

practice is generated or occurs. While timing, resources, and other external factors vary, many of the processes used are applicable across the various contexts.

Availability of resources and implementation infrastructure maturity and are critical factors that foster and speed implementation success. Organizational resources of adequate funding, expertise—both technical and of implementation professionals—and time to accomplish the implementation are essential. Furthermore, organizations that have mature infrastructures—processes, organizational structure, and cultures that create acceptance of change in practice—continue to show success in being able to effectively and efficiently apply research results.

Incentives to do a more effective job of implementation often work to foster and speed application of research results. Recognition of the results and benefits of change in practice are useful means to bring attention to the process of implementation and to encourage more implementation activity.

Although many processes benefit from using well-crafted effectiveness measures, few, if any, measurement systems for speeding implementation were found in the literature.

To illustrate the importance of these factors and to provide examples of implementation strategies that could serve as models for transportation practice, a series of implementation case examples and practice descriptions are discussed. These are:

- Network of Implementation Experts—National Implementation Research Network (NIRN)—an example of the types of resources available for implementation assistance within the medical clinical community. The mission of NIRN is to close the gap between science and service by improving the science and practice of implementation in relation to evidence-based programs and practices.
- Global Implementation Conference—Hosting such a conference shows the value of creating a unique venue to encourage advancement of the science and practice of implementation. Such venues promote sharing of best practices, provide education and training for the implementation sciences, and foster research to further expertise and practice.
- Manufacturing Extension Partnerships (MEP), National Institutes of Standards and Technology—MEP shows a significant commitment by the federal government to nurture and foster innovation, and particularly to accelerate the application of technology in manufacturing through strong partnership activity. This example shows a structure that creates partnerships that foster the development of products available to private-sector business through technology acceleration support, and examples of a framework to provide technical support to organizations seeking to accelerate the use of technology to advance practice.
- Research Project Synopses, Joint Fire Science Program (JFSP)—This discussion shows the benefit JFSP received as it created and now uses research project synopses and manager opinion articles to convey critical research findings to busy program and senior managers within the forest fire safety community.
- Partnership Intermediaries—Resources Committed to Implementation Processes—Partnership Intermediary Agreements (PIAs) allow research programs to add targeted expertise to the job of implementation through specific partnership arrangements. PIAs were created through legislation for use by federal laboratories and can serve as a model for agreements by others not in the federal laboratory community.
- Well-Defined and Documented Implementation Processes—Manager's Guide, Desk Reference, Policies and Procedures, and Implementation Guide—Various agencies are excellent examples of how implementation processes can be documented in a practical and rational fashion.

- Research, Document, and Share Successful Implementation Strategies—Accelerating Innovation at Hewlett-Packard—This discussion shows the process used by a private-sector organization to speed its products to market. It shows the importance of considering the technology characteristics, the newness of the market, the degree of innovation represented, as well as the necessity to benefit from lessons learned and the importance of directly addressing innovation barriers and enablers. What is particularly noteworthy is that Hewlett-Packard performed research to gain new knowledge and understanding of its research implementation processes.
- Technology Readiness Levels (TRLs)—TRLs are a standard readiness scale used to determine the maturity of a technology or innovation. This scale helps an organization consider innovations and research results application through a systematic process that advances with the level of readiness. The process fosters acceleration of implementation by addressing problems and finding solutions to prevent downstream delays.
- Entrepreneur-in-Residence Programs—The Entrepreneur-in-Residence Program is an initiative that aims to commercialize viable technologies by placing venture capital firms or those with funding in a position to work directly with academic partners or others developing innovations. This program models how the addition of entrepreneurial talent, with the purpose of creating a market or use for a research finding, can make a significant impact on the speed of application to practice.
- Innovation Inducement Prizes—These are designed to attain scientific and technical goals not yet reached, to encourage fostering of innovation, and particularly to create motivation to excel in implementation best practices.
- Evidence-Based Practice Scholars Program—This program is an example of how the medical clinical community highlighted the importance of developing expertise in implementation science to increase the likelihood and speed of the application of proven research results to practice.
- Training for Implementation—Coupled with other strategies such as a strong implementation infrastructure, this discussion shows the advantages of building capacity in the organization to sufficiently address the tasks of implementation.
- Organizational Implementation Policy—This practice description discusses the need for and benefits of developing a workable organizational policy that clearly articulates the vision and goals for implementation of research results to benefit operational practice. The discussion provides an example policy created by the National Weather Service.
- Research Transition Teams (RTTs)—RTTs are formalized teams created to facilitate rapid transition from research to application of results in the operational setting. The teams are comprised of research and technical experts as well as implementation experts and address technical, organizational, administrative, and other barriers or enablers.

In summary, there are effective strategies being used by other domains that can increase the potential for accelerating the adoption of research results in transportation. Many of the tactics being used by other domains are also used, to some degree, within the transportation community. However, these accelerator tactics will be significantly more effective if an overall systematic approach to implementation exists. This approach includes (1) a sustainable infrastructure of experienced talent, (2) sufficient resources operating in an organizational setting, and (3) a leadership priority on implementation. Such an integrated approach will enable greater opportunity to realize benefits from research and to accelerate the use of research results and innovations in transportation practice.

CHAPTER ONE

INTRODUCTION

PURPOSE AND SCOPE

Better-faster-safer-with-less-impact-to-the-traveling-public—the oft-heard expression is putting significant pressure on highway professionals whether they are facility owners, researchers, or industry entrepreneurs. How to be more effective and efficient with current resources perhaps has never been more of a challenge and an opportunity. It is certain that the status quo will not serve our nation well and will not sufficiently address current and future highway transportation needs. It is also certain that innovations in the highway industry have provided remarkable solutions that vigorously respond to the better, faster, safer, and greener unwritten mandate (Harder 2010).

> HIGH VALUE RESEARCH: Cross-median crashes are 3 times more likely to cause fatalities than any other freeway accident, according to research conducted through the North Carolina Department of Transportation (NCDOT). As a result of these findings, the agency pioneered the use of cable median barriers to prevent a car from entering opposing traffic lanes. From 1999 to 2005, NCDOT estimates that more than 95 cross-median crashes were prevented using this new technology, saving more than 145 lives. (AASHTO 2009)

Yet there is a choice that confronts the highway community, in particular facility owners throughout the nation: either buy one's way out of current problems (mostly impractical) or find a better way to accomplish the work to be done through innovative processes, methods, technologies, and products—that is, through applying the results of research. Indeed, research results are the primary source of the successful innovations adopted by the highway community. Implementing research results such as cable median barriers is just one example that proves the value and necessity of getting innovations into practice.

In this current "better-faster" environment, the question arises, how can the transportation community accelerate the implementation of research findings to realize more benefits more expeditiously? This question is not new, but it has new urgency.

AASHTO studies show successful processes for implementation of research results in the transportation context, such as *NCHRP Report 382: Facilitating the Implementation of Research Findings: A Summary Report* (1996); *NCHRP Synthesis 355: Transportation Technology Transfer: Successes, Challenges, and Needs* (2005); *NCHRP Synthesis 150: Technology Transfer in Selected Highway Agencies* (1989), and as far back as *NCHRP Synthesis 23: Getting Research Findings into Practice* (1974). These and other efforts show avenues for success; yet can these techniques, methods, and processes be enhanced or augmented to accelerate the implementation process?

A variety of public-sector agencies, in addition to those in transportation, are charged with applying research results to practice. The Federal Technology Transfer Act of 1986 (P.L. 99-502) made technology transfer of research results by federal laboratories a responsibility of the labs and chartered the Federal Laboratory Consortium for Technology Transfer—highlighting the need and responsibility of labs to integrate the products of federal research into the U.S. economy. Laboratories from the U.S. Departments of Defense, Energy, and Agriculture, the National Institutes of Health, and the many others in the consortium subscribe to the mission of linking laboratory technology and expertise with use in the marketplace (Federal Laboratory Consortium for Technology Transfer 2011). In addition, nonprofit and academic partnership organizations such as the National Implementation Research Network include implementation of research findings as a core mission element. Likewise, many private-sector companies are dependent on the research and development and customer use (application to practice) of products that generate profit, literally enabling the companies' existences.

> The mission of the National Implementation Research Network (NIRN) is to contribute to the best practices and science of implementation, organization change, and system reinvention to improve outcomes across the spectrum of human services. (NIRN 2014)

Considering this activity in other domains, are there successful techniques, methods, and systems for implementation that could be used in the public-sector transportation community? Also, are there practices in these domains that might enable a more effective implementation process that realizes the benefits of research more rapidly? The expectation is that there are implementation strategies that could be transferred to transportation applications to assist in accelerating current implementation activities. At this time, however, there has been no concerted effort to find out what successful practices being applied in other disciplines and industries might enable the transportation community to accelerate the application of its research results into transportation practice.

This synthesis examines implementation practices used primarily by public-sector agencies with a primary focus not on transportation and then a variety of nonprofit, academic, and private-sector organizations. The goal of the study is to identify successful practices that have potential for use in the transportation sector, and when used help accelerate practical application of research results. The likelihood of these identified practices speeding up implementation processes in transportation is based on, among a number of factors, the success they have had in their existing contexts and the degree to which they can streamline or enhance current transportation processes. Speeding up implementation of research results may also be accomplished by adding more practices to the transportation professional's available options, whether these practices are new to the transportation context or focus additional attention to current, but underused, practices. Having additional options to get results used may enable implementation to occur successfully where efforts in the past have languished. These types of options have been considered in the identification of the strategies presented.

Although there have been many successes in implementing important research results—both products and processes—in transportation applications, there is room for improvement in every aspect of implementation. The time it takes to realize benefits can be measured in multiples of years; the processes are considered by many as lacking in transparency and thus thwart replicability; and the skills to get the research results into widespread practice frequently must be accompanied by a healthy dose of perseverance. Improvements in the procedures, the types and availability of resources including expertise, the innovation culture, the organizational leadership, and more can make a difference.

> Accelerating the use of research results enables research to be more relevant to transportation practice.

In summary, adding to and fine tuning the implementation practices already in use by others so that benefits accrue more rapidly is a primary means to create more responsive transportation research programs. Furthermore, enhancing research implementation practices, in particular accelerating them, will increase the relevance of research and continue to promote research as the provider of solutions to the most pressing transportation problems.

DEFINITIONS

A number of terms commonly used within the transportation community deal with implementation. This report will use those terms in the course of discussion, and may also refer to terms in other industry domains that have equivalent or similar meanings. A number of the terms familiar to transportation research managers are provided in *NCHRP Synthesis 355: Transportation Technology Transfer: Successes, Challenges, and Needs* (2005). For the purposes of this report, definitions from NCHRP Synthesis 355 are included herein. These are followed by additional definitions used in other industries.

Definitions from *NCHRP Synthesis 355*

Deployment: The systematic process of distributing an innovation for use. This term implies a relatively broad use, rather than 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: The processes encompassing a variety of instructional methods to cause learning. For the most part, when using the terms "education" and "training," this document implies formal or organized instructional opportunities for learning.

Knowledge transfer: The 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.

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. Often this term is 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 demonstrations, training, technical assistance, provision of needed resources, or any activity that fosters use of the research result.

Innovation: A 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.

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

Technology transfer: The 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. 1988, pp. 2–3; Schmitt et al. 1985, 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.

Other Definitions

Technology transition. The U.S. Department of Defense's primary term to describe the movement of research and development to the use of technology in military applications. The process can occur between a government R&D organization for use in a specific system, or an industry can enable use of technology in a government application (U.S. DoD 2003, p. 1-1). Technology transition is a comprehensive and broad term used for all processes, including technology transfer.

Technology insertion. The Department of Defense's term for the cycle of a product from program ideas and design to the user evaluation of the product.

Research to Practice (*RintoP*). The term often used in the medical community to represent the full process of adoption of research results into clinical settings. Many of the meanings for this term are directly similar to the common use of the word "implementation" in the highway research community.

Implementation research. A term used in the behavioral health community to describe the efforts at closing the gap between science and service by improving the science and practice of implementation in relation to evidence-based programs and practices (National Implementation Research Network).

Innovation implementation. Innovation implementation is the transition period during which targeted organizational members ideally become increasingly skillful, consistent, and committed in their use of an innovation. Implementation is the critical gateway between the decision to adopt the innovation and the routine use of the innovation (Klein and Sorra 1996, p. 1057).

Implementation strategy: The report uses this term to describe any of the myriad techniques, methods, processes, and tools used to do the work of implementation. Strategies may include planning tools, information development and provision, coaching, technical assistance, training and education, demonstrations, networking and fostering of partnerships and collaborations, capital development, and much more.

Dissemination of research: Terminology used by certain segments of the health and human services community with a meaning similar to the use of "implementation of research findings" in the highway community. The reference to dissemination focuses on "disburse throughout" the user context.

The Federal Laboratory Consortium for Technology Transfer (FLC) occupies an important position as a leader and a resource for federal agencies regarding technology transfer. The FLC website describes the organization as "the nationwide network of federal laboratories that provides the forum to develop strategies and opportunities for linking laboratory mission technologies and expertise with the marketplace." FLC defines the technology transfer it accomplishes as "the process by which existing knowledge, facilities, or capabilities developed under federal research and development (R&D) funding are utilized to fulfill public and private needs." Additionally, it defines technology transfer in a general context as "the process by which technology or knowledge developed in one place or for one purpose is applied and used in another" (FLC 2008). The FLC definition of technology transfer is sufficiently broad to encompass the activities described in the transportation community as "implementation of research results." In their definition and for the purposes of this synthesis when discussing FLC-based processes, technology transfer is treated as an overarching term that includes the variety of activities leading to sharing and use.

The previous definitions are in concert with the definitions that Everett M. Rogers uses in his classic work, *Diffusion of Innovations* (Rogers 2003) and others on the nature of technology transfer (Rogers 2002):

- Adoption—a decision to use an innovation (Rogers 2003, p. 417).
- Implementation—putting an innovation to use (Rogers 2003, p. 417).
- Technology transfer—a communications process through which the results of scientific research are put into use; often including implementation activities (Rogers 2003, p. 323).

It is easy to understand the often confusing meanings when references to implementing, adopting, disseminating, transferring technology, and more abound. Each has an aspect of the core element, use of the innovation.

Implementation Process Flow

In *Diffusion of Innovations* Rogers provides a process flow for innovation that shows implementation actions as an organization moves from identifying a problem to finding the solution to incorporating that solution as standard operating procedure. Rogers's findings are accepted as best practice and serve as a foundation for many who have examined the

TABLE 1
FIVE STAGES OF THE INNOVATION PROCESS IN ORGANIZATIONS

→ THE INNOVATION PROCESS IN AN ORGANZATION →				
		Decision		
I. INITIATION →		II. IMPLEMENTATION →		
#1	**#2**	**#3**	**#4**	**#5**
AGENDA-SETTING	MATCHING	REDEFINING/ RESTRUCTURING	CLARIFYING	ROUTINIZING
General organizational problems that may create a perceived need for innovation.	Finding a problem from the organization's agenda with an innovation.	The innovation is modified and re-invented to fit the organization and organizational structures are altered.	The relationship between the organization and the innovation is defined more clearly.	The innovation becomes an ongoing element in the organization's activities, and loses its identity.

Source: Rogers 2003.

topic of innovation implementation. This synthesis addresses opportunities that transportation practitioners and organizations have to accelerate the implementation processes, as shown in Table 1. Rogers describes implementation as "consisting of all of the events, actions, and decisions involved in putting an innovation to use" (Rogers 2003, p. 421).

LITERATURE REVIEW AND DATA SOURCES

A comprehensive literature review of U.S. and some international sources was conducted to establish background information on the range of practices that have been, and are now being, pursued regarding implementing research results within the private sector, academia, and public-sector agencies. Because of the differences in terminology used by various domains, the literature review cast a broad net to examine concepts associated with implementation of research results, but that use different labels. Key terms such as application to practice, technology deployment, innovation diffusion, technology transfer (in context used by federal laboratories or, for example, the U.S. Department of Agriculture), technology commercialization, and technology transition (as used within the U.S. Department of Defense), were used.

A number of resources were accessed, including the Transportation Research International Documentation database and business, government, management, science, technology, medicine, and social sciences databases, including ProQuest® and EBSCOHost® services. Online access to journals through the Industrial Research Institute, Wiley's journal services, *Harvard Business Review*, and others were used. A substantial amount of literature and information was accessible through the World Wide Web. Manuals of practice, regulations, research reports, program descriptions, project discussions, and more are provided on websites of organizations and agencies promoting use of their respective innovations or technologies. Because the web is easily accessible, many organizations are including detailed information whereas just a few years ago, this information would have been available only through a visit to the organization or a comprehensive interview.

There is abundant and, perhaps better termed, overwhelming amounts of information available on the World Wide Web regarding technology commercialization and the activities leading to the realization of profits from the use of technology. Many of the activities and practices in the private sector do not have direct use in the public sector; however, there are overarching principles that can be tailored to the public sector processes and thus some of these types or literature sources were valuable.

Owing to the vast amounts of relevant information written on the many facets of implementation, the study report includes some websites and a bibliography providing sources for further investigation and reading.

Further reading on the topic of technology transfer and implementation in general can be found in the literature review prepared in conjunction with NCHRP Project 20-93, Development of a Guide for Transportation Technology Transfer (Hood et al. 2012). The document can be downloaded from the NCHRP project web page at http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3185.

Interviews of representatives from nontransportation government entities, academia, and the private sector were conducted in the course of this synthesis effort. This method of communication with research managers and implementation experts was a substantially more productive means to gather informative and relevant responses than a survey instrument, which is the typical means of data gathering used for such synthesis studies. Early on in the planning for the information and data gathering it was also determined that those who possess the desired information were individuals within agencies that may not have similar titles or similarly defined responsibilities, making the distribution of a survey very difficult.

Furthermore, giving more validity to interviewing in this effort, many of the individuals possessing the most relevant information are very relationship oriented and particularly willing to talk and discuss the issues.

Candidate organizations for interviews were determined through a literature search, panel contact recommendations, and networking. The original plan for conducting interviews was two-tiered. The initial tier was to be a screening call to determine general information regarding implementation processes at the organization and to identify the correct person to discuss the processes at a detailed level, the second-tier interview. This initial call was not usually necessary. Organization websites, for example, that of The National Implementation Research Network, or the U.S. Department of Agriculture (USDA) Agricultural Research Service, which also includes online access to the National Agricultural Library, are so well populated with information that some interviews would only have been asking for what was available online. Furthermore, people associated with implementation tasks are often very willing to make themselves known. Commercialization offices, technology transfer managers at the federal laboratories, and others were relatively easy to identify through contact information given on websites.

One unanticipated change in the interview process was the lack of access to private-sector implementation, new product development, commercialization, and other related process information from company representatives. Activities in the private sector dealing with what in this study is being broadly termed implementation often occur at the later stages of product development. Therefore the processes were considered proprietary or trade secrets and not publicly discussed. However, the Industrial Research Institute's *Research—Technology Management* journal and others such as the *MIT Sloan Management Review* provide articles using more generalized descriptions of processes and successes in the private sector.

The interview protocols developed for the project are included in Appendix A.

REPORT ORGANIZATION

Chapter one of the synthesis gives an introduction to the topic of acceleration of implementation of research results and describes the scope of the project. The chapter also includes discussion of the primary information sources used and the extensive literature search that produced a wide variety of details about implementation efforts. Findings from the literature were augmented by information received through interviews with research scientists and individuals involved with implementation responsibilities. Chapters two through five present the factors and strategies of implementation currently in practice by others outside of the transportation community and identify the applicability for use in transportation.

- Chapter two provides a discussion on the factors that affect the timing and ease of implementation of research results.
- Chapter three gives a variety of case examples and descriptions that illustrate strategies and practices seen as contributing to accelerating implementation within various public-sector, private-sector, and academic organizations.
- Chapter four discusses the perceived degree of ease to replicate and transfer the practices and strategies found to have potential to accelerate implementation of research results in transportation applications.
- Chapter five summarizes the key findings of the synthesis project, including observations on how the material in the report can be used to accelerate implementation practices used within the transportation community.

CHAPTER TWO

FACTORS AFFECTING THE USE, TIMING, AND EASE OF IMPLEMENTATION

INTRODUCTION

This chapter provides a discussion on the factors that affect the timing and ease of implementation of research results. Some factors exist independently, but many are dependent on a variety of other factors in the implementation process and in the deployment environment. There is little information that links factors to promote success, but by observation a number of factors are present in any one implementation activity. Factors are identified and their contribution to the timing and ease of implementation are provided.

Some of the factors are more comprehensive than others and will, therefore, have the potential to make a greater contribution to improvements in implementation efforts. Some key factors affecting the use, timing, and ease of implementation will be familiar to the highway community. These factors have established a foothold in highway transportation practice but may not have been significantly exploited or supported. Thus, some organizations have implementation activities that are being done at some level or by pockets of research managers in the highway arena, but are not common practice, or are not routinely applied.

The following discussion gives a synthesis of factors used by government, the private sector, academia, and nonprofit user associations. Interestingly, factors apply across the broad perspective of technology implementation work and usually regardless of the context in which it occurred. The factors are not listed in priority order.

KEY FACTORS

No one activity in the examined broad array of implementation processes stands out as being the ultimate solution—the must-do action—to accelerate use of research results or innovations. Little definitive work has been done to determine a set of reliably successful activities across contexts or domains that uniquely accelerates implementation. The literature and interviews identified a variety of strategies for implementation of research results, technologies, or innovations, but there was no consensus about a set of best actions for accelerating results use, even within programs or agencies that have a focus on implementation or technology transfer.

> Whether at the institutional or programmatic level, whether stated or implied, and regardless of the degree of experience, typically the implementation goals are to foster and speed the practical application of research results or innovations to practice.

Nevertheless, the need to accelerate implementation of research results is recognized or at least strongly implied in *all* domains examined. The Joint Fire Science Program, a federal multiagency partnership [Departments of Agriculture (Forest Service) and Interior, and the U.S. Geological Survey] clearly expresses the concept: "getting new science and technology into use quickly is the key to the success of an applied science program" (Barbour 2007, p. 5). The Agency for Healthcare Research Quality (AHRQ) initiative, Translating Research into Practice, "seeks to accelerate the impact of research on patient care to improve clinical outcomes and enhance cost effectiveness and efficiency" (Carpenter et al. 2015, p. 83).

The goal of accelerating implementation of research results is generally intended, but measurement of whether the strategies have had an effect on the speed of implementation or what is a best practice for increasing speed across industries and agencies is still a work in progress. For some organizations, a focus on accelerating implementation of research results is relatively new, happening over approximately the past decade. While still making progress, organizations are at different stages in the process of accelerating the use of research results. Some organizations articulate goals and the need for activities *promoting* adoption and implementation of research results, with the unstated goal of *accelerating* the use of research results. Many organizations are at the stage that if they are promoting implementation activities, they are therefore, by definition, accelerating implementation. Even if these organizations are not directly stating the need for more rapid use of research results, they are applying a variety of endorsed strategies, and acceleration occurs, and occurs more often and more rapidly, than if the strategies were not applied. As mentioned in the above paragraph, other organizations are further along and are vigorously pursuing speeding up the use of research results and other innovations. They have created programs or infrastructures to foster accelerating the use of research results.

However, for both these situations, at the earlier stages of activity or having identified a systematic approach, there is little consensus about which processes are most successful.

Contexts vary: The concept of accelerating research results to practice is relative depending on the context in which the implementation takes place. Yet regardless of the context, even for vastly different applications, the mission of "faster," that is, reducing the time it takes to get a product into use, is critical. For the military, a 20-year project that employs implementation strategies that allow technology transition to occur in 10 years is considered as achieving remarkable productivity. For the private sector, Hewlett-Packard's ability to introduce a new printer, having progressed from design to market in 4 months rather than 9 months, is considered essential for product leadership and competitive advantage. With such differing contexts, the job of determining what general strategy or practice was key to accelerating the pace of the implementation process is very difficult to isolate. Also, depending on the implementation context, strategies that are key elements of the implementation process in one assignment may be of significantly lesser importance in another. There are a variety of contexts that promote implementation success.

In the course of this effort, the most frequent implementation interactions generally occurred within three contexts. Figure 1 shows implementation of research results from one government organization to another. The implementation occurs between various levels of government agencies—most often federal to federal and federal to state and local, rather than from state to federal, for example. There are some variations, such as implementation of U.S. Department of Defense (DoD) technologies, flowing from a government laboratory to a private-sector contractor to a branch of the military, yet the integration of contractor and military branch is for the most part constructed to be seamless and the process is essentially government to government.

FIGURE 1 Implementation activities: one government organization to another.

Figure 2 describes the any two-party or often three-party implementation context: government to private sector, government to academia, academia to private sector, and other variations such as government and academia partnering to accomplish implementation of research results in the private sector. Because of the research-oriented nature of the academic setting, activity generally flows out of the research university to affect implementation by government or the private sector.

FIGURE 2 Implementation activities between and among government, academia, and the private sector.

Figure 3 shows the context wherein government, academia, and the private sector work together to accomplish implementation of research results into a specific user community—such as the public or a professional community serving a specific segment of the public. Often an example of this context is found in efforts for implementation of research results into communities dealing with medical clinical practices and behavioral health.

FIGURE 3 Implementation activities from government, academia, and the private sector are often in partnership with the public sector.

More is often better: The literature and descriptions of implementation practice always discuss multiple techniques, strategies, or actions, coupled together or performed in concert. One of the factors that affect implementation and its timing is the use of a variety of options deemed appropriate for the specific task at hand. In a discussion of military processes, in *Accelerating Technology Transition: Bridging* *the Valley of Death for Materials and Processes in Defense Systems*, the National Academies panels concluded, "there is no single strategy that, if implemented, will accelerate the insertion of new technologies into either commercial or military systems. Instead, it is more likely that the omission of a key element of the many needed will guarantee failure" (National Materials Advisory Board and Board on Manufacturing and Engineering Design 2004, p. 3). While this quote refers to the whole product cycle, the same is true for a subset of the process. Because each context varies, there was no overarching guidance regarding which items were considered fatal if omitted. In general, the more attention and strategies that are used to foster implementation of research results, the more potential there is for success.

Infrastructure maturity: Maturity of the implementation practice in a context is a significant factor that affects timing and ease of the processes to produce results. Medical research has been looking at implementation research for more than 20 years, making an effort to get evidence-based results into patient care practices (Grol and Jones 2000). DoD has developed a highly structured process for technology transition that includes detailed instructions and considerations to enable DoD research products and technology to be used by its partners and customers (U.S. Department of Defense 2005). In both of these cases and others such as the USDA and the Federal Laboratory Consortium for Technology Transfer, there are well-developed infrastructures supporting implementation activities. Because these industries or domains have been studying the use and results of implementation efforts, they are further advanced in providing systematic approaches to the business of implementation. They have published documentation, references, and guidance for those who participate; they more clearly recognize the value and importance of implementation activities; and they are more experienced at performing the implementation tasks.

Implementation resources: Without exception, in all contexts, if implementation of research results was to be done, there were resources committed to its achievement. Resources are categorized into three primary areas: funding, expertise, and the time to accomplish the stated responsibilities.

> Implementation is time consuming, expensive, and, at least initially, a drag on performance. Effective innovation implementation often requires hefty investments of time and money in technology start-up, training, user support, monitoring, meetings, and evaluation. (Klein and Knight 2005)

Funding is essential, and in many of the discussions on implementation it was a foundational concept—that if the implementation was to occur, it would require financial support. Rogers, in his discussion on the nature of technology transfer—defined as the application of information to use, encompassing implementation—points out that the success of the USDA agricultural extension work was based on adequate funding. The efforts to get research results into use were *roughly equal to that of the investment in the research* (author's emphasis) (Rogers 2002).

Every implementation activity requires some degree of funding, whether the strategy used is a demonstration project, development of marketing and communications materials or planning tools, education and training opportunities, incentives that fostered performance, or other types of methods. In fact, Klein and Knight state that "[i]mplementation is, of course, not cheap. It takes money to offer extensive training, to provide ongoing user support, to launch a communications campaign explaining the merits of the innovation, and to relax performance standards while employees learn to use the innovation." (Klein and Knight 2005, p. 245) Additionally, Klein et al. (2001) found that financial resource availability was a significant predictor of the overall quality of an organization's implementation policies and practices and thus, indirectly, a predictor of the organization's implementation effectiveness. Certainly there is thinking that funding can address barriers that slow implementation progress. Recently, the National Science Foundation (NSF) initiated a program of investment to accelerate innovation research (AIR 2011), which includes specific support toward developing proofs of concept and technology translation plans and for getting the academic work into the marketplace. More than $9 million was awarded to 22 academic research institutions.

> Resources, whether in the form of time, money, equipment, or materials must be available for the new process, product, service, or strategy to be implemented. (Desouza et al. 2009)

Organizations that have more experience in the process of implementation also are more aware of the funding required for implementation efforts. These organizations are better prepared to commit funding to getting the research results into practice, or into the marketplace to be available for use. The financial support of university technology commercialization offices is an example of the acknowledgement of necessary funding to foster the ultimate use of research results. The advantage for these academic settings is the potential to recoup expenses through licensing and other fees associated with use and commercialization.

Conscious of the necessary financial commitments to implementing innovations, government and private-sector organizations alike often have rigorous processes to winnow out potential failures and push forward promising products or processes from research efforts. This is particularly important in the new development process within private-sector research and development efforts (Canez et al. 2007). NSF and the U.S. Department of Health and Human Services, AHRQ both have provided substantial project funding that incorporates the costs of research results to practice efforts. As a note, programs and organizations, for example, FLC, that have reliable implementation funding resources tended to spend some of that money on telling potential users of their success: this acknowledges the excellent work done as well as serves as a marketing tool for research products. FLC annually publishes *Technology for Today*, highlighting the successes of federal laboratories.

The **2011 California DOT Peer Exchange** team members determined the following traits are characteristic of people who motivate others to accelerate the adoption of innovations:

- Have strong marketing and communication skills.
- Are able to plan and run effective, efficient meetings.
- Are good brokers of information and resources.
- Are strong negotiators.
- Have persistence, passion, and drive.
- Have people skills.
- Understand the technical aspects of a project, but can also create and implement a successful marketing plan.
- Serve as a conduit between technology experts and all others—including stakeholders within the organization, potential adopters of innovation, and the public.
- Are able to recognize gatekeepers and what drives them to accept or reject change.
- Are trustworthy and credible; have strong personal working relationships.
- Are empowered to work across organizational lines and are in a position that offers access to many different levels of the organization.
- Are comfortable working within chaos—have public relations skills.
- Are able to think outside the box (understand there is more than one way to get from A to B).

(California DOT)

Knowledgeable and experienced people are a high-impact factor affecting the time and ease of implementation activities. Expertise for accomplishing the tasks associated with implementation is particularly valuable, whether the expertise lies in the organization pushing the technology out to users or in the organization pulling the technology in to effect change. Additionally, such expertise may reside in the organization, or participate from outside but be associated with the organization in some role such as through participation by nonprofit industry or user associations, consultants, or via various private-sector business incubator organizations. Importantly, this expertise must be talent that is targeted to support implementation efforts.

The kinds of individuals regarded as successful in the work of implementation activities bring to the job highly developed interpersonal skills for relationship building; they are consummate users and builders of networks and make links and connections within their domains; and they are experts at forming partnerships and collaborations, at marketing, and with other tasks that include getting people involved in the implementation. Kanter states, "[I]nnovations need connectors—people who know how to find partners in the mainstream business or the outside world" (Kanter 2006, executive summary). One individual interviewed gave the sage reminder that implementation is essentially a "people business"; that is, skillful people do the work of implementation. It is necessary to emphasize that carving out implementation duties from the responsibilities of scientists at the laboratory or research facility, or relying on the project administrators or even business process people on the commercial side of an organization was not seen as sufficiently effective in making a positive impact on time and ease of implementation. In a synopsis of a study of more than 30 U.S. and European companies discussing five stages of successful innovation (including commercialization, diffusion, and implementation), one chief executive officer stated, "We learned a simple thing: researchers and idea creators do not appreciate the nuances of marketing and commercialization. … In the past we tried to get the researchers involved in the commercialization aspects of the business. … The end result was pain and more pain" (Mariello 2007, p. 9). This observation does not mean that researchers' expertise is not important in the implementation of research results, but it points to efficiencies gained (including speed of the process) through placing the necessary talent for research and, similarly, the necessary talent for implementation. Technical expertise of the researcher can convey the technical content of the research, yet this technical knowledge is not the sole basis on which an organization makes the decision to adopt and implement an innovation. Both types of talent are essential; positive impact comes from having the right expertise or combination of expertise to do the job.

Expertise to accomplish implementation of innovations also includes a specific role, that of the champion. Champions are an essential element of implementation, and Everett Rogers describes a champion as "a charismatic individual who throws his or her support behind an innovation, thus overcoming the indifference or resistance that the new idea may provoke." (Rogers 2003, p. 414) Rogers goes on to discuss other research that has shown innovation champions may be powerful individuals in an organization, or they may be lower-level individuals who possess the ability to coordinate the actions of others. [See Chapter 10 of his classic work, *Diffusion of Innovations*, for a discussion of the importance of champions and a description of their roles in health care, student activism, city government, and a variety of other contexts (Rogers 2003, p. 414–417)].

Allowing time for implementation is fundamental. On the surface this factor may appear counterproductive to the goal of accelerating the pace of implementation results. Yet, in conjunction with the provision of expertise, individuals performing implementation responsibilities must have the time to do the job. This means that implementation experts, whether in-house or hired, require a formal, recognized responsibility for implementation that gives the authority to work on implementation as a primary task. Often in the transportation arena, implementation tasks are assigned as "collateral" duties, only to be accomplished after the main responsibilities are accomplished. In understaffed organizations, the implementation tasks may not be done because of the heavy primary responsibility workloads.

The business literature emphasizes the important contribution of new product development expertise, the partnership with the marketing arm of the organization, or other areas that work together in the various roles to speed a product to market. Each has specific responsibilities to contribute to the job, and each has committed time to do it.

Additionally, time to do the job also implies the necessity for implementation expertise to be committed to the longer-term nature of implementation. Implementation experts in the medical field acknowledge, "RintoP [research into practice] processes should be conceptualized as being a long-term effort. One isolated workshop or training course is not expected to have much impact" (Aagaard-Hansen and Olsen 2009, p. 381). Rosabeth Moss Kanter, a noted business author, writes, "MIT researchers have found that for R&D team members to be truly productive, they have to have been on board for at least two years. At one point Pillsbury realized that the average length of time the company took to go from new product development to successful commercialization was 24 to 26 months, but the average length of time people spent on the product teams was 18 months. No wonder the company was falling behind on innovation. … Product teams also include those performing implementation responsibilities" (Kanter 2006, p. 8).

Culture or climate that fosters innovation: Business, government, and academia discuss the need for an authorizing environment in which to promote and apply results of research. A senior product development professional describes the elements of an innovative culture as being: "**CREATIVE**: **C**ustomer-focused, **R**isk-tolerant, **E**ntrepreneurial, **A**ligned with strategy, **T**echnology and scientific excellence, **I**nnovative, **V**irtual organizations (or creative collaboration), **E**xecution (or) **E**xcellence in project management" (Newman 2009). Additionally, using the term "climate," Klein and Sorra define the environment that can facilitate or impede implementation, as one where there is "a shared perception among intended users of an innovation, of the extent to which an organization's implementation policies and practices encourage, cultivate, and reward innovation use." An empowered staff, a supportive management, a fail-fast/win-strong environment, and the host of other cultural elements that foster motivation to pursue change and benefit from it, continue to be an elusive but important aspect of whether research results languish or are expeditiously implemented.

State departments of transportation (DOTs) are becoming more aware of the value of creating a culture that fosters innovation and in turn is more risk tolerant. The trade-off is being willing to accept more risk for the higher return of the innovation. More needs to be done to bring about organizational change, yet progress is being made. The California DOT 2011 Peer Exchange report, "Implementing Research Results, Characteristics of Organizations and Skill Sets of Individuals Successful at Accelerating Adoption of Innovation," includes perspectives on creating innovative cultures that are also more supportive of risk (California DOT 2011). Louisiana and Utah departments are particularly noteworthy for seeking to advance the culture of innovation. In a news video on AASHTO Transportation TV, Utah chief executive John Njord shows an example of the accomplishments of an innovative culture: the I-15 CORE project using accelerated bridge construction among other innovations. The culture of innovation is an intentional strategy to enhance delivery of transportation products departmentwide. Moreover, communication and marketing of innovative activities bring further credibility for the department (AASHTO Transportation TV 2011).

Complex process: One of the understated factors is that for practitioners and research managers alike, implementation is a surprisingly complex process. Well-written documentation on the implementation process, regulations, and strategies has been produced by DoD, USDA, and others such as FLC (DoD 2005; USDA 2000; FLC 2008). Also, the National Implementation Research Network prepared a synthesis of the literature published for the behavioral health community to "describe the current state of the science in implementation and identify what it will take to transmit innovative programs and practices to mental health, social services, [and more]" (Fixsen et al. 2005, p. vi). Anecdotal evidence from interviews conducted for this current study confirms the complexity of implementation efforts and promotes guidance and best practices sharing as enablers of more effective and efficient implementation of research results.

Boundary spanning: Interventions that span the gap between researcher and user contexts are being promoted by a variety of organizations. Most notable of these activities in the public sector are Partnership Intermediary Agreements

(PIAs) that provide a formalized role for an intermediary player between the institutions producing the research results (who have implementation and technology transfer functions) and the user community. PIAs supply expertise and other resources to reduce barriers in the process of implementation and to speed the use of results of federal laboratory research (USDA 2009, p. 5). Likewise, the gap between academic research and commercialization of research products is being filled by specialized talent that steps in to facilitate a more effective transition from researcher to developer and market. The goal of such boundary spanning is to promote collaboration between researcher and user and to produce outcomes that the individual domains could not produce as effectively without such intentional connection.

> A boundary spanner provides openness across the boundaries of an organization by facilitating an information exchange that alerts the system to new developments, both problems and solutions. (Rogers 2003)

An additional aspect of the value of boundary-spanning activities is to further the ability to properly prioritize research needs. A tenet of implementation is to "always address a genuine need" (Bikson et al. 1996, p. 15), and a key to prioritizing needs is providing excellent communication and closing the gaps that can exist among the sponsor, the researcher (or prospective researcher), and the user community. Furthermore, credible champions fulfill boundary-spanning roles. Champions know the technical aspects of the need or the solution and can also communicate well among all the participants. Boundary-spanning activities can promote more effective understanding of the need and supply a better understanding of the use of the research result, thus ultimately playing a role in speeding the application of the result to practice. The outcome of using boundary-spanning practices is to foster better interaction and engagement among all parties involved in the research activity, especially implementation.

Incentives: Many in the business of implementation know that incentives are helpful to foster motivation for change in desired behavior. Incentives assist the organization in achieving its strategic priorities, and can be helpful when those priorities are focused on accelerating the use of research results. This type of tool is used in the public and private sectors as well as in academia, and it is accomplished through a host of vehicles. In particular, incentives are not necessarily financial rewards, although for those seeking to commercialize research results, financial rewards to the institution or the researchers and developers can be part of the practices that lead to fostering the use of innovations. Regardless of the form of the incentive, a key is tapping into what makes people excited about their work and motivates them to work more effectively at achieving success aligned with the organizational goals (Rumpel and Medcof 2006). Among many outcomes of using incentives, such rewards are an indication of management support for exemplary performance and serve to recognize the individual in a public manner. Incentives are often an integral part of an organization's culture that enables an entrepreneurial atmosphere in which to foster use of innovations. Incentives must be carefully crafted to promote desired results yet also be designed to fall within legal and regulatory limits. Incentives should be considered by organizations seeking to accelerate the application of research results as a strategic priority.

Effectiveness measures: The factors discussed in this chapter affect the rate of implementation of research results, but there is little, if any, definitive work that examines the effectiveness of the practices used. In health, defense, and other domains, there is considerable awareness of the need for research into what methods are most successful, what impact the application of a specific practice yields, the cumulative effect of application of multiple practices to an implementation effort, and more. Studies, including by Rogers (2003) and Fixsen (2005), conclude that information dissemination *alone* is an ineffective implementation tool (yet is a common practice), and Fixsen further states that training *by itself* in human services contexts is not sufficiently effective. Such studies discuss what does not work well; however, no replicable, quantitative measures of effectiveness of direct application of strategies, methods, or tools for implementation are evident in the literature reviewed for this synthesis. Much of the difficulty of finding effectiveness of practices is the result of the "wide variation in methodology, measures, and use of terminology across studies [that] limits interpretation and prevents meta-analysis with regard to dissemination-diffusion and implementation studies" (Fixsen et al. 2008, p. 1).

Additionally, as noted in the recent study of the landscape for technology transfer within the federal laboratories, there is no quantitative information on metrics to oversee and assess effectiveness of technology transfer methods or strategies. In general, effectiveness is seen more as a subjective determination of success. It is measured not by how well individual strategies or methods perform and to what degree, but through assessment of whether the total implementation was accomplished successfully and how many incidences of such successes occurred. For example, measurement occurs as identified by greater engagement/performance of patients or users in the clinical and behavioral health fields, the use of research products in domains such as energy and defense, or the number of products commercialized by the academic community.

Best practices: In many cases, the application of a practice successfully used by others is often considered best practice—the practice worked and accomplished the determined goal. Essentially, the term "best practice" can mean that it was successful, without substantive benchmarking to determine whether the practice was indeed "best." With that caveat, use of best practices is universally endorsed by every domain and in every context within the literature addressing implementation. Some domains are more advanced than others in identifying genuinely best practices. The clinical and behavioral health fields, as has been discussed in this chapter, have done comprehensive work on identifying practices and have documented them for implementation guidance and training (Fixsen et al. 2005). Private-sector organizations seek to apply practices with high potential for producing timely and cost-effective results. Using best practices in every stage of the new product development cycle, including implementation, is another example of the dependence on and use of adopting others' strategies that work.

Certainly the attractiveness of using best practices is to capitalize on the opportunity to reduce risk of failure for the implementing organization—applying practices that worked in a similar context has potential for similar success; to speed the implementation process along because hurdles that slowed the use of the research result have been addressed or strategies have been identified to circumvent them; and to reduce cost by preventing duplication of effort though not having to develop the successful implementation process.

In summary, the factors discussed present the foundation for actions to accelerate the implementation of transportation research results. The following chapter provides examples of how these factors are incorporated into the process of implementation in various contexts.

CHAPTER THREE

CASE EXAMPLES AND PRACTICE DESCRIPTIONS

To him who devotes his life to science, nothing can give more happiness than increasing the number of discoveries, but his cup of joy is full when the results of his studies immediately find practical applications. (Louis Pasteur)

This chapter provides a variety of case examples and practice descriptions that build on the factors discussed in the chapter two. The examples are illustrations of strategies and activities seen as contributing to accelerating implementation within various public-sector, private-sector, and academic organizations. These case examples or descriptions were selected (1) as models that picture how other domains succeed in effective and efficient implementation of innovations, and (2) because they may be applicable within transportation contexts. Furthermore, these examples are presented to prompt transportation professionals to consider how these strategies and approaches can speed the use of research findings by

- Enhancing expertise to perform implementation,
- Providing support to those responsible for accomplishing implementation,
- Demonstrating the value of well-defined processes based on research, and
- Providing systematic approaches to implementation that will be foundational to developing a strong implementation infrastructure.

Implementation case examples and practice descriptions included in this chapter are

- Network of Implementation Experts—National Implementation Research Network
- Global Implementation Conference
- Manufacturing Extension Partnerships, National Institutes of Standards and Technology
- Research Project Synopses, Joint Fire Science Program
- Partnership Intermediaries—Resources Committed to Implementation Processes
- Well-Defined and Documented Implementation Processes—Manager's Guide, Desk Reference, Policies and Procedures, and Implementation Guide
- Research, Document, and Share Successful Implementation Strategies—Accelerating Innovation at Hewlett–Packard
- Technology Readiness Levels
- Entrepreneur-in-Residence Programs
- Innovation Inducement Prizes
- Evidence-Based Practice Scholars Program
- Training for Implementation
- Organizational Implementation Policy
- Research Transition Teams.

NETWORK OF IMPLEMENTATION EXPERTS—NATIONAL IMPLEMENTATION RESEARCH NETWORK

The National Implementation Research Network (NIRN) is an example of the type of resources that can be available for implementation assistance for the transportation community. NIRN is located at the FPG Child Development Institute of the University of North Carolina, Chapel Hill. It is staffed by implementation and technical assistance academicians and scientists.

Material in this discussion is excerpted from the NIRN website: http://nirn.fpg.unc.edu/. The purposes of NIRN are to

1. Advance the science of implementation across domains (e.g., mental health, substance abuse, education, juvenile justice) by
   - Conducting implementation research and evaluation and
   - Developing and updating syntheses of relevant implementation research and practice descriptions.
2. Inform the transformation of human services by
   - Developing practical implementation frameworks to guide the transformation of behavioral health services and
   - Providing technical assistance to governments, communities, foundations, and individual agencies that are implementing evidence-based programs and practices.

National Implementation Research Network
The mission of NIRN is to close the gap between science and service by improving the science and practice of implementation in relation to evidence-based programs and practices. (NIRN)

3. Ensure that the voices and experiences of diverse communities and consumers influence and guide implementation efforts by
   - Supporting a network to impact implementation agendas as they relate to consumer and family issues, diversity, access, and effectiveness and
   - Collaborating with diverse communities that wish to develop an evidence base for a promising practice.

The National Implementation Research Network can help states, communities, and provider organizations develop locally sustainable solutions to many problems faced by human service planners, managers, and practitioners. NIRN's practical and effective strategies and processes are based on more than 35 years of experience developing and implementing evidence-based programs, reviews of the implementation evaluation literature, and ongoing reviews of effective implementation practices from the perspectives of purveyors, implementers, policy makers, and researchers.

> The most important aspect of this implementation network is the commitment from the clinical community to dedicate expertise to create implementation content.

It is not difficult to insert wording related to transportation to get the idea of how helpful such a resource would be to transportation research managers and those seeking to implement research results. The most important aspect of this implementation network is the commitment from the clinical medical community to dedicate the expertise to create the implementation content provided through the network. The network is not only a means to connect or link clinical professionals, it provides substantive content on implementation strategies and practices. It is a "go-to" place to receive guidance to accelerate use of practices.

One of the most informative items on the NIRN website was produced in 2005 by NIRN. The document, "Implementation Research: A Synthesis of the Literature," provides detailed material on the existing research and practice for implementation in clinical settings. The study reviewed more than 1,000 documents in agriculture, business, child welfare, engineering, health, juvenile justice, manufacturing, medicine, mental health, nursing, and social services (Fixsen et al. 2005, p. vi).

Implementation is defined as "a specified set of activities designed to put into practice an activity or program of known dimensions" (Fixsen et al. 2005, p. 5). Moreover, at the outset of this work, it is acknowledged that careful and thoughtful activity is required to actually accomplish implementation as described by these three degrees of implementation:

> *Paper implementation* means putting into place new policies and procedures. … It is clear that paperwork in file cabinets plus manuals on shelves do not equal putting innovations into practice with benefits to consumers.
>
> *Process implementation* means putting new operating procedures in place to conduct training workshops, provide supervision, change information reporting forms, and so on. … It is clear that the trappings of evidence-based practices and programs plus lip service do not equal putting innovations into practice with benefits to consumers.
>
> *Performance implementation* means putting procedures and processes in place in such a way that the identified functional components of change are used with good effect for consumers. It appears that implementation that produces actual benefits to consumers, organizations, and systems requires more careful and thoughtful efforts [than addressing policy and procedures]. (Fixsen et al. 2005, p. 6)

The implementation synthesis identifies six stages of implementation that are seen in practice within the context of the authors' work:

1. Exploration and Adoption—the first step, thinking about options and making a decision to implement

2. Program Installation—putting into place the structures and resources to accomplish the implementation

3. Initial Implementation—early use of the new practices, requiring change and commitment to use of something new

4. Full Operation—experienced change, learning the new way of doing things is integrated into practitioner and organizational and community practice

5. Innovation—evaluation of practice over a sufficient time to determine if the new practice is beneficial to users

6. Sustainability—ensuring long-term survival and continued effectiveness.

Detailing the implementation process in this manner shows some of the complexity of the process and provides a framework in which to consider how implementation of transportation research findings can be addressed. These stages may be present in transportation applications; however, there is little support to acknowledge and marshal the resources and expertise required to successfully accomplish each stage.

Other items in the document include guidance for the clinical community on the core implementation components: Practitioner Selection—who is qualified to carry out the new practice; Pre-Service and In-Service Training—practitioners need to learn the new way of doing things; Consultation and Coaching—guidance for individual change, especially during initial implementation; Staff Evaluation—assessment of use and outcomes by practitioners; Facilitative Administrative Supports—leadership and organizational support; and Systems Interventions—ensuring the continued financial, organizational, and human resources required to support the innovation (Fixsen et al. 2005, chapter 4).

The implementation synthesis provides an example of using the core implementation components taken from manufacturing: Consultation and Coaching—Toyota adopted a new just-in-time manufacturing process that caused a comprehensive reorganization of the production units. To assist in implementation of the new system, the Toyota Supplier and Support Center (TSSC) provided consulting and implementation support free of charge to Toyota manufacturing production sites that have committed to implementing the new manufacturing process. TSSC analyzed plant capacity, prescribed the best implementation strategy with adaptations for local context, directly observed and analyzed workers on the production line and for the supply chain, identified key aspects at the operation level, assisted in plant redesign for industrial engineering efficiencies, and more. The TSSC staff spent about 1 week per month for 3 years observing performance, reviewing progress, answering questions, and assigning new tasks until full implementation was achieved (Fixsen et al. 2005, p. 13). The effort and expertise required to ensure successful implementation was not trivial; it was substantially greater than what is traditionally committed by transportation organizations for implementing major changes in practice.

Although the content of the implementation synthesis is particularly informative, it is also important to recognize the fact that the document was produced—that the research-to-practice and clinical communities supported the effort to do an in-depth comprehensive examination of current practice. The work was accomplished with funding from a nonprofit partner, the William T. Grant Foundation (http://www.wtgrantfoundation.org), that has an interest in applying research results to policies and practice to affect youth. This implementation case example shows the critical assistance that partners can give to furthering successful implementation.

The research performed to produce the NIRN implementation synthesis has also spawned additional activity for implementation science. One such activity is the Global Implementation Conference sponsored in part by NIRN.

GLOBAL IMPLEMENTATION CONFERENCE

The evidence-based practice (EBP) community conducted its first Biennial Global Implementation Conference (GIC) in August 2011 with 750 scientists, practitioners, and policy makers gathered to address the variety of topics dealing with implementing research results to practice. A 2013 conference was also planned. (Material is excerpted from the GIC 2013 conference website, http://www.implementationconference.org/.)

Specific goals for the inaugural conference included the following:

- Gather participants from a variety of disciplines, domains, and countries to share ideas and research around implementation science, practice, and policy.
- Form practice groups based on participants' implementation-related roles—researchers, purveyors, practitioners, policy makers, and organization leaders—to exchange knowledge and best practices.
- Integrate knowledge across practice groups to create a common language, framework, and measures to guide implementation policy, practice, and research.
- Set the stage for discussion and activities within and across practice groups for continued collaboration beyond the 3-day conference.

Lessons learned from literature were the foundation for the conference agenda. GIC did the following:

- Focused on the practice and science of implementation, rather than on specific evidence-based practices or other interventions.
- Addressed universal aspects of implementation, organization change, and system transformation that have the potential to benefit all human services.
- Spotlighted issues related to the improvement of implementation practices in order to promote better implementation science and policy.
- Emphasized the interplay among implementation, organization change, and system transformation.

Plenary sessions addressed

- Frameworks to Integrate Implementation Science, Practice, and Policy
- Cross-Disciplinary Integration of Research, Practice, and Policy
- Integration of Implementation Research, Practice, and Policy across Human Services
- The Future of Implementation Science, Practice, and Policy.

An important aspect of this conference is the focus on sharing successful practices—those that fostered the implementation of research results—thus helping to accelerate the implementation of innovations in the practitioner community. For example, the Norwegian Center for Child Behavioral Development presented its findings on large-scale implementation of empirically supported programs after 10 years of integrating research, policy, and practice. "The work presented results of activities to strengthen competence in the specialist treatment services for young children with conduct problems" (Ogden et al. 2011, p. 2). This study showed that the work done to implement research findings on services to enhance multisystemic therapy (MST) and parent management training (PMT) more than doubled therapist adherence to defined practice in Norwegian MST teams. Additionally, with PMT processes implemented in more than 50 municipalities, 383 PMT therapists trained more than 850 practitioners—families, parents, schools—to use innovations from research findings to improve effectiveness in intervention.

Noting that the EBP implementation community is more developed than the implementation community within transportation, this type of conference presents a future opportunity to gather all players serving a role in transportation implementation. As in EBP, those involved are researchers, developers, practitioners, policy makers, and leaders—each group representing participants in the continuum of the implementation process. Such a transportation implementation conference could accomplish many of the same goals as GIC. Furthermore, the sharing of best practices, coordination among the various interests with the implementation process, and providing a forum to present recent progress will enable more effective and efficient—including accelerated—implementation of research results.

MANUFACTURING EXTENSION PARTNERSHIPS, NATIONAL INSTITUTES OF STANDARDS AND TECHNOLOGY

The U.S. Department of Commerce's response to the need for more and faster innovation by the manufacturing sector has been the Manufacturing Extension Partnership (MEP), a more than 20-year-old program, sponsored by the National Institute of Standards and Technology (NIST). MEP represents a significant commitment by federal government to nurture and foster innovation, and particularly to accelerate the application of technology in manufacturing through strong partnership activity (see Figure 4). MEP is a model of involving federal expertise to speed the application of technology into a business sector. There are two potential applications for such a model in transportation: (1) as it currently operates in manufacturing—to create a partnership that fosters the development of products available to private-sector transportation business through technology acceleration support, which MEP can do, but does not focus on transportation specifically; and (2) as it may operate within the public sector—to form a framework to provide technical support to public-sector agencies seeking to accelerate the use of technology to advance transportation practice.

The program has focused on technology acceleration during approximately the past 5 years, as shown in Figure 5.

FIGURE 4 Manufacturing Extension Partnership Strategy (Kilmer 2013, p. 13).

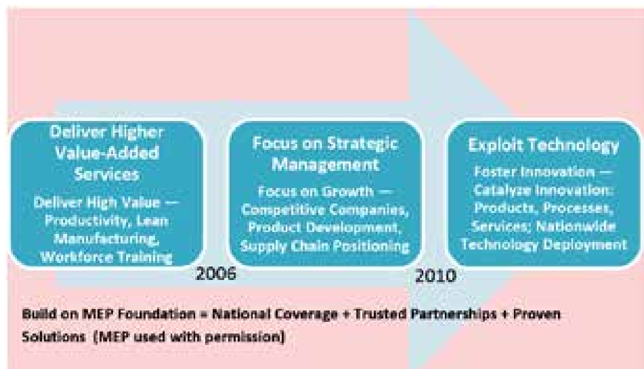

FIGURE 5 Manufacturing Extension Partnership Program Evolution (Kilmer 2011, p. 15).

The NIST Hollings Manufacturing Extension Partnership describes the program as follows:

Manufacturing Extension Partnership

The National Institute of Standards and Technology's Hollings Manufacturing Extension Partnership (MEP) works with small and mid-sized U.S. manufacturers to help them create and retain jobs, increase profits, and save time and money. The nationwide network provides a variety of services, from innovation strategies to process improvements to green manufacturing. MEP also works with partners at the state and federal levels on programs that put manufacturers in position to develop new customers, expand into new markets, and create new products.

MEP field staff has over 1,300 technical experts—located in every state—serving as trusted business advisors, focused on solving manufacturers' challenges and identifying opportunities for growth. As a program of the U.S. Department of Commerce, MEP offers its clients a wealth of unique and effective resources centered on five critical areas: technology acceleration, supplier development, sustainability, workforce and continuous improvement.

Innovation is at the core of what MEP does. Manufacturers that accelerate innovation are far more successful and realize greater opportunities to participate in the global economy. By placing innovations developed through research at federal laboratories, educational institutions and corporations directly in the hands of U.S. manufacturers, MEP serves an essential role sustaining and growing America's manufacturing base. The program assists manufacturers to achieving new sales, leading to higher tax receipts and new sustainable jobs in the high paying advanced manufacturing sector.

As a public/private partnership, MEP delivers a high return on investment to taxpayers. For every one dollar of federal investment, the MEP generates $32 in new sales growth. This translates into $3.6 billion in new sales annually. For every $1,570 of federal investment, MEP creates or retains one manufacturing job. (NIST-MEP)

Figure 6 shows the vital bridge and continuing support that MEP provides as it connects the research community seeking to transfer technology from laboratories to the manufacturing industry. As with other technology acceleration efforts, the MEP model supplies technical expertise that augments the skills and knowledge of the partner organization. MEP's role is clearly to assist in diffusion and adoption of technologies within industry.

An example of the MEP effort that shows the potential for accelerating technology into the marketplace is the experience of 3C Cattle Feeders. The company developed state-of-the-art cattle feeders that are efficient, effective, and economical, meeting high standards of commercial livestock owners. For the past 30 years, 3C Cattle Feeders' products earned a sterling reputation among the agricultural community for their quality and design elements. With changes in the industry, the company owner sought a way to once again distance himself from the field, retain his market share, and grow his business. For help, he turned to the Oklahoma Manufacturing Alliance, a NIST MEP network affiliate. One situation that was addressed was the problem of wild hogs and other animals scavenging food from traditional feeders. Though it was a common problem, livestock owners had learned to live with the situation. The feeders developed are completely enclosed, which prevents feed from falling on the truck bed, and include exclusive features such as sight holes and digital counters. The Oklahoma Manufacturing Alliance worked with the Oklahoma State University New Product Development Center, one of the Alliance's programs. Initial designs were promising and helped secure a Small Business Innovation Research grant. Those funds were used to perfect the design and create a marketing plan for the high-tech feeder. Now in production, initial sales of the feeders are encouraging and have boosted the company's potential future sales. A snapshot of the results of the effort are development of a new product, a $500,000 increase in sales, and creation of three new jobs (MEP-Client Successes n.d.).

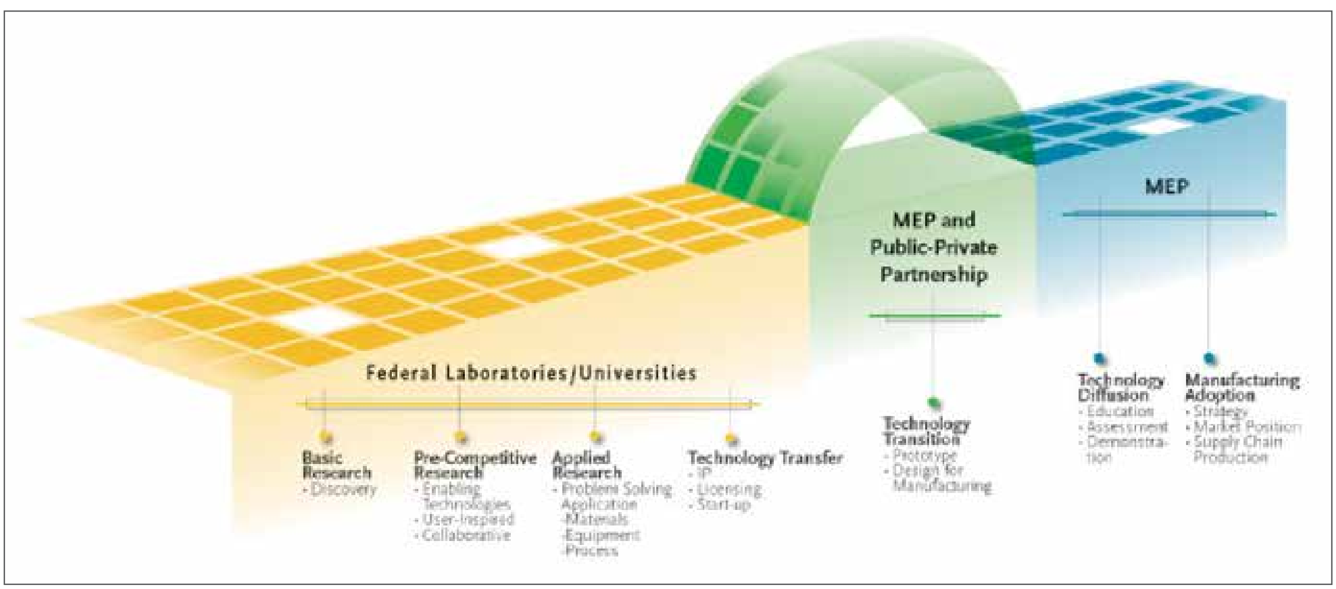

FIGURE 6 Manufacturing Extension Partnership Technology Acceleration Framework (NIST-MEP) (Kilmer 2013, p. 14).

RESEARCH PROJECT SYNOPSES, JOINT FIRE SCIENCE PROGRAM

(*Synopses*) *of research findings and targeted delivery to managers are essential components of the program.* (Fire Science website)

The Joint Fire Science Program (JFSP) is an interagency research, development, and applications partnership created in 1998. It is funded by the Departments of Agriculture and Interior and is managed through an oversight board consisting of five representatives from the Forest Service and a representative from each of the five following agencies: Bureaus of Land Management and Indian Affairs, Fish and Wildlife Service, Park Service, and U.S. Geological Survey.

From the beginning of its work, JFSP conducted a vital and aggressive applied research effort, and between 1998 and 2005, it committed more than $100 million to more than 300 research projects dealing with fire science and other fire-related topics. JFSP realizes that "getting new science and technology into use quickly is the key to the success of an applied science program" (Barbour 2007, p.5). The program also realized that it had "been so successful in developing new data and information that it [was] a challenge to assimilate it [the new knowledge] in its entirety" (Barbour 2007, p. 6).

Having the host of research project results by 2007, JFSP needed to determine how to do a better job than it had been of disseminating its research findings. JFSP conducted a study to develop a proof of concept whereby scientists and users could connect and engage more effectively. This two-way interchange was designed to enhance knowledge transfer—particularly data and information from the research findings—between the two groups. As part of this effort, JFSP examined the use and effectiveness of research study synopses by "program managers and/or line officers that have very limited time to invest in acquiring technical information, but tend to control budget and program priorities, which in turn affect the rate of adoption or science delivery by members of their staffs" (Barbour 2007, p. 20).

In the course of the study, JFSP prepared 138 synopses of research project reports through the efforts of researchers, managers, and a technical writer. The products of their efforts were designed to be easy-to-read, informative, concise summaries, and attractive to busy officials and practitioners. Information was categorized by themes, organized according to topical descriptions of importance; for example, firefighting, fuels and fuel reduction, fire behavior, and physical effects/erosion. JFSP posted synopses on its website and received feedback from users. Synopses written by people in technical responsibilities the same as the users were more effective and better received than those written by research scientists.

As a response to feedback, in FY 2007, the JFSP board of directors formalized the publication of Fire Science Briefs—research report synopses—some with opinions of research results by managers for managers in a several-page "Manager's Viewpoints" addenda to the brief. As an example, a February 2009 Fire Science Brief states the Manager's Viewpoints is "an opinion written by a fire or land manager based on information in a JFSP final report and other supporting documents. This is our way of helping managers interpret science findings. If readers have differing viewpoints, we encourage further dialog through additional opinions. … Our intent is to start conversations about what works and what doesn't" (JFSP Fire Science Brief 2009, p. 11).

Conclusions from the 2007 study by Barbour used in this discussion note that the synopses were well received and are part of the foundation of the program's efforts to effectively disseminate the results of research among the forest fire safety community. Furthermore, of the 140 research project synopses listed on the JFSP website, about 40 contain Manager's Viewpoints discussions (http://www.firescience.gov). Dissemination is addressing managers/decision makers as well as practitioner/user needs.

As the program continues, additional research synopses have been posted. JFSP continues its research activity and focuses on application of research results. Its May 2011 investment strategy commits 25% of its funding to Science and Delivery and Adoption (JFSP Investment Strategy 2011, p. 1).

As in the fire science community, busy transportation practitioners and managers would benefit from professional synopses and cogent, enlightened opinion—for some, the existence of synopses would further the understanding of the research results and foster accelerated implementation.

PARTNERSHIP INTERMEDIARIES—RESOURCES COMMITTED TO IMPLEMENTATION PROCESSES

Partnership intermediaries are a relatively new strategy being used by a number of federal government agencies to assist them in getting more research results applied and getting them applied more expeditiously. For example, DoD and the USDA Agricultural Research Service are creating networks of private-sector organizations to help with implementation (USDA 2009 and T2Bridge online n.d.). Material for this discussion is excerpted from both references.

The vehicle used to formalize the relationship between a federal government agency and the organization doing implementation tasks is a Partnership Intermediary Agreement (PIA). These agreements are allowing research programs to add targeted expertise to the job of implementation through partnership arrangements.

ARS PIA Fosters Use of Innovation

Within the first 18 months of creating the ATIP, the Maryland Technology Development Corporation (TEDCO), the founding ATIP Partner and seven ATIP Affiliates were established; five with some funds provided by TEDCO. One of these affiliates, a Maryland start-up business (CrispTek), licensed an ARS technology developed at the Southern Regional Research Center, received funding from TEDCO, and made its first sale within 8 months. This process was initiated through an entrepreneurship program affiliated with TEDCO, and demonstrated the value these complementary business assets can bring in accelerating adoption of research outcomes by companies vetted by ATIP Partners. (ATIP-ARS 2010, p. 2).

The Agricultural Research Service (ARS) initiated the Agricultural Technology Innovation Partnership (ATIP) program to facilitate the adoption of ARS research outcomes by private-sector companies for commercial production of goods and services. PIAs are with technology-based economic development entities and are strategically chosen by geographic region and for their ability to serve small businesses by providing assets complementary to ARS research and innovation capacities. A strategic network of six to eight PIAs across the United States would increase opportunities for businesses—through the intermediary—to gain access to the 2,100 scientists conducting research at more than 100 ARS locations and strengthen partnerships with current university researchers. Intermediaries facilitate business development and competitiveness by helping ARS identify companies to license ARS innovations. They also assist small businesses whose research needs can be matched to the expertise of ARS scientists conducting research addressing high-priority agricultural issues. Businesses identified and assisted by the intermediary—who subsequently partner with ARS through licensing or establishing a Cooperative Research and Development Agreement (CRADA)—are designated as ATIP affiliates.

A similar description of a partnership intermediary is found with an authorized DoD intermediary, T2Bridge, sponsored through funding from the Air Force Research Laboratory. T2Bridge is one of a handful of partnership intermediaries located throughout the country to serve the needs of DoD. The website describing the services this PIA provides states:

> **T2Bridge™** is a technology acceleration program designed to solve defense needs through development, transfer, transition, and commercialization of defense sponsored innovation. The program connects private sector businesses and researchers in the southeast United States with Department of Defense (DoD) technologies, research capabilities, funding opportunities, development partners, and procurement needs. A primary program objective is to match a DoD need with an innovative solution and to facilitate the development and transition of the solution into DoD.
>
> - T2Bridge provides assistance at various stages throughout the research, development, and transition cycle. The following are examples of where T2Bridge can add value to technology development and transition:
>   - Finding new product opportunities in the portfolio of defense created technologies,
>   - Facilitating cooperative research and development with defense labs,
>   - Identifying research funding opportunities,
>   - Obtaining funds for creation of new technologies,
>   - Creating partnerships between small and large businesses, and
>   - Helping companies through the transition of defense sponsored innovation back to DoD.

The noteworthy item about partnership intermediaries is that the federal government agencies realize more must be done to facilitate implementation of research results. By instituting a network of PIAs, the agencies are augmenting the technology transfer and commercialization services performed through the Federal Laboratory Consortium for Technology Transfer (FLC). PIAs work with the federal labs to move innovations from late-stage development to acquisition. PIAs are filling a gap that still exists between the federal laboratories' research results and getting these results into practice. The current economic times make the job of implementation even more difficult for the federal labs, and by many accounts they struggle with the mission of commercializing innovative products coming out of the labs. PIAs bring to the table agile organizations with precise implementation expertise. PIAs are funded to do implementation services whereas, for example, federal labs have little funds for marketing of a research result. Federal labs may initially perceive PIAs as "doing their job," but many are now seeing how partnership intermediaries are fostering more innovations through creating more CRADAs, bringing more players to the table, and accelerating the implementation process.

A further initiative is being considered that will bring together the various partnership intermediaries from the federal agencies now having PIAs in operation. A national network of PIAs would bring in intermediary companies working with USDA, Department of Homeland Security, National Institutes of Health, and Department of Energy (DOE).

An important aspect of the example of PIAs is that it can serve as a model for creating standard arrangements that form an infrastructure of organizations specifically tasked with fostering use and impacting the speed of use of innovations developed by research laboratories. Work done by the federal laboratories also has prompted model agreements in use by federal agencies that address the scope of the intermediary organization's responsibility, the treatment of intellectual property, and other necessary contractual items. Such PIAs could be created at the state or regional level to foster the development, adoption, and implementation of innovations in transportation.

WELL-DEFINED AND DOCUMENTED IMPLEMENTATION PROCESSES—MANAGER'S GUIDE, DESK REFERENCE, POLICIES AND PROCEDURES, AND IMPLEMENTATION GUIDE

A number of federal agencies have excelled at documenting processes for implementation or implementation-related activities.

- The Department of Defense produces the *Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment* (DoD 2005) to detail the process and procedures for DoD transition/implementation responsibilities. Planning for the transition activities in every aspect of the process with the requirement for accountability including timelines and responsibilities are included.
- The Federal Laboratory Consortium for Technology Transfer publishes its *FLC Technology Transfer Desk Reference, A Comprehensive Guide to Technology Transfer,* detailing the activities federal labs perform in conjunction with moving federally funded research and development to practice (FLC 2011b).
- ARS publishes *Policies and Procedures*, which describes policies, procedures, and responsibilities for technology transfer (USDA 2000).
- NASA produced the NASA eEducation Research and Development Guide that begins the process of discussing the necessary steps to receive outcomes from the implementation of science, technology, engineering, and mathematics education (Laughlin 2007).
- The National Oceanic and Atmospheric Administration (NOAA) created its *Policy on Transition of Research to Application* (NOAA 2008).

The model these agencies provide is helpful to the transportation community in that it shows that implementation processes can be documented in a practical and rational fashion. Just as state department of transportation research organizations have produced a research program manual, manuals documenting the processes required to accomplish implementation of research results can be prepared. Guidance from the available federal agency manuals can be helpful in determining the types of implementation instruction required, the scope of the implementation practices identified, and the level of detail necessary.

Just creating a document, however, does not fully satisfy the needs of successful implementation. Resources, supportive management, innovation culture, and other factors must augment clearly defined implementation documentation. Such documentation is only a start, but importantly, it is a start of the process of institutionalizing implementation practices, so that in the future such processes become the standard. Of course, a caution is also important: such processes are to facilitate implementation, not to develop barriers to implementation that focus on non-implementation-critical activities.

Elements contained in DoD's *Manager's Guide* include the following:

- Environment for Technology Transition—including definitions, goals, decision support systems descriptions, acquisition and financial systems, and players—government and industry.
- Technology Transition Planning and Tools—including planning government-to-government transitions, tools for industry-to-government transition, and transition planning tools.
- Programs That Facilitate Technology Transition—including discussions of and guidance for participation in 13 demonstration, technology transition initiatives, and acquisition programs.
- Challenges and Considerations—including technology transition, cultural barriers, and knowledge management.
- Appendices contain resource information, websites, success stories, and planning guidance.

The elements of DoD's *Manager's Guide* are designed for the military establishment, yet they show the variety and comprehensiveness of available guidance. Developing guidance documents for transportation implementation procedures is an achievable task. Such manuals are, however, part of a larger effort to foster the acceleration of implementing research findings. Recall that federal agencies are not solely relying on the activities generated by guidance manuals but often bring in targeted expertise to the implementation process, as evidenced by establishing Partnership Intermediary Agreements. The transportation community can learn from the other federal agencies and make a leap in process improvement. Rather than only taking the model of documenting processes, coupling the defined processes with the expertise to do the implementation work through mechanisms functioning like partnership intermediaries would be a significantly more effective approach.

RESEARCH, DOCUMENT, AND SHARE SUCCESSFUL IMPLEMENTATION STRATEGIES—ACCELERATING INNOVATION AT HEWLETT-PACKARD

This Hewlett-Packard case study was prepared for *Research-Technology Management* (RTM), the journal of the Industrial Research Institute (IRI). IRI describes its organization as "a non-profit association of more than 200 leading industrial and service organizations having a common interest in effective management of innovation." This case study description is excerpted from the referenced article in the RTM journal (Rivas and Gobeli 2005).

NOAA Policy on Transition of Research to Application

Transition Plan: A management document, which should be updated as appropriate, identifying the comprehensive activities necessary to transfer a research result to applications. This document should be used for planning purposes as well as to ensure that the project is being executed per the terms and conditions of the Plan. The Transition Plan shall:

a. clearly define the requirements of the end-result of the transition of research to applications;

b. define data collection requirements and procedures in sufficient detail to enable the applications organization to understand and meet, as appropriate, the data requirements of the research organization and other users;

c. document technical performance and cost-effectiveness parameters to be met prior to the operational implementation or information service delivery;

d. justify the transition from the research to applications and document how the benefits outweigh the costs;

e. identify the amount and source of funds needed to cover the costs associated with the transition, as necessary, including relevant requirements for equipment, upgrades, staff training, and maintenance of redundant application capabilities during the transition period;

f. outline how the applications organization will address the evolving needs of the research organization, partners, and users after the transition, as appropriate; and

g. for testbeds and other similar development systems/projects, the transition plan is a compilation of numerous individual project components whose net result is a significant improvement or advancement in NOAA capability justified, in general, using the elements defined above. (NOAA 2008)

The case study discusses enablers and barriers to innovation as well as lessons learned regarding accelerating the process of innovation. The purpose of highlighting this case study in this synthesis is to show the type of research results that are presented in the private sector to foster improvements in innovation; in this case, improvements to the time to market for an innovative inkjet product. The case study clearly demonstrates the type of research being conducted to improve processes for innovation delivery. This then serves as an example of the type of research studies that could be available in the transportation research management community, which would foster improvements for implementation activities. When there is robust research on the processes related to implementation, there will be opportunities for continued advancement in the ability of scientists, transportation research managers, and practitioners to accelerate implementation of research results.

The work of this case study provides a view into what aspects within the research functions at Hewlett-Packard would accelerate the rate of innovation for the Technology Development Operation—the micromachining and semiconductor R&D section of the inkjet enterprise. The goal of the research was to determine how to excel at innovation and commercialization—to speed the results of research to market.

Figure 7 shows the model used within Hewlett-Packard to display the attributes that are considered as inputs to the study of accelerating innovation for the inkjet printing market, the factors or resources available within the company that were used to analyze potential technology offerings, and the results of the analysis—the enablers and barriers and lessons learned about advancing Hewlett-Packard inkjet technology. The analysis allowed the company to clearly understand what will help further speed their inkjet product technologies to the marketplace.

FIGURE 7 Research model for identifying enablers, barriers, and lessons learned (Rivas and Gobeli 2005, p. 33).

For its technologies, attributes of the market included items such as how new the product was to the market (for domestic and global markets), how new it was to Hewlett-Packard, whether the technology was innovative or incremental, the competitive position of the technology, and more. In the course of the analysis, the capabilities of the organization such as the checkpoint processes were examined—the decision-making methods along the course of the project; the integration team—technical experts who select technologies and oversee spanning the transition from concept to product development; the influence of senior management; the culture of risk taking, decision making, and communication; as well as the infrastructure, such as, resources, equipment, and organizational support.

These enablers and barriers are excellent facts to understand about the potential successful commercialization or market acceptance of the technologies. Analysis on this level for the products that are to be used in the highway industry by facility owners would give remarkable insight into the ease of implementing innovations. The top five enablers and barriers identified are listed in Table 2.

Hewlett-Packard also learned lessons from this effort: barriers are more project specific; enablers relate to the overall program efforts; identify and consider the lessons learned by the study team involved with the technology; and manage the innovation improvement process. A standard process to identify and address enablers, barriers, and lessons learned would be the framework that substantially contributes to accelerating technology into the marketplace.

TECHNOLOGY READINESS LEVELS

In 1979, NASA created a seven-level standard readiness scale to determine the maturity of its technologies. In the 1990s, two more levels were added, and today the nine-level technology readiness scale continues to be used in a broad array of industry applications. Although highway transportation's missions may not have as large of dollar as NASA's space program or Boeing's 787 aircraft, there are specific lessons to be learned by the use of well-proven standards in the application of new technologies.

A particularly notable aspect of using technology readiness levels for the research, development, and implementation of innovations is the necessary systematic perspective, beginning from the concept or idea through to the successful operational experience. This systematic perspective fosters a comprehensive view with the understanding that the research will be forwarded to development and then application. Because of the necessary work committed to each of the nine steps in the process, barriers and hurdles to eventual implementation are addressed along the course of the project. The work within each level when accomplished brings the work of the next level, which includes its various requirements to

TABLE 2
HEWLETT-PACKARD ACCELERATING TECHNOLOGY INNOVATION TOP 5 ENABLERS AND BARRIERS

Top 5 Enablers and Recommendations for Action	
Enabler	Recommendation
1. Skilled people	Continue to stress the importance of individuals increasing their skills. Recruit individuals for new technologies when there are no in-house candidates.
2. Helping culture (People are helpful)	Promote and reward a culture of helping and sharing. Actively create and support networks within the organization. Older programs do not report helping culture as being critical, but new programs might benefit most here.
3. Management support	Continue strong management support for all programs, especially fundamental programs.
4. People working together	Create teams with a wide breadth of skills.
5. Checkpoints provide discipline/focus	Use checkpoints to drive focus and decision making. Communicate checkpoint decisions widely.
Top 5 Barriers and Recommendations for Action	
Barrier	Recommendation
1. Not enough resources	Analyze bottlenecks, best done with cross-functional teams to review key learning cycle barriers. Flexibility in programs to address new issues that arise from new market and technology information. Enable organization to deploy resources faster.
2. Hard to run experiments on production equipment	Related to level of innovation, fundamental innovations experience this the most; exploratory research recommends early investment in required equipment, reducing bureaucracy for experiments.
3. Lacking capable equipment	Invest in flexible research tools and invest early in tools for fundamental programs.
4. Market planning	Market planning is related to market newness of an innovation. Quickly identify marketing resources, strategy, and value on new innovations to HP and the world.
5. Multisite project	Multisite projects add communication complexity. If a cross-site project cannot be avoided, establish strong communication links and develop clear roles and responsibilities.

Source: Rivas and Gobeli (2005) (IRI used with permission).

Definition of Technology Readiness Levels
NASA

TRL 1 Basic principles observed and reported: Transition from scientific research to applied research. Essential characteristics and behaviors of systems and architectures; Descriptive tools are mathematical formulations or algorithms.

TRL 2 Technology concept and/or application formulated: Applied research. Theory and scientific principles are focused on specific application area to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.

TRL 3 Analytical and experimental critical function and/or characteristic proof-of-concept: Proof of concept validation. Active Research and Development (R&D) is initiated with analytical and laboratory studies; Demonstration of technical feasibility using breadboard or brassboard implementations that are exercised with representative data.

TRL 4 Component/subsystem validation in laboratory environment: Standalone prototyping implementation and test; Integration of technology elements; Experiments with full-scale problems or data sets.

TRL 5 System/subsystem/component validation in relevant environment: Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.

TRL 6 System/subsystem model or prototyping demonstration in a relevant end-to-end environment (ground or space): Prototyping implementations on full-scale realistic problems; Partially integrated with existing systems; Limited documentation available. Engineering feasibility fully demonstrated in actual system application.

TRL 7 System prototyping demonstration in an operational environment (ground or space): System prototyping demonstration in operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test. Well integrated with collateral and ancillary systems; Limited documentation available.

TRL 8 Actual system completed and "mission qualified" through test and demonstration in an operational environment (ground or space): End of system development; Fully integrated with operational hardware and software systems. Most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and Validation (V&V) completed.

TRL 9 Actual system "mission proven" through successful mission operations (ground or space): Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed; Successful operational experience; Sustaining engineering support in place.

be completed before progressing. Because of continued use, the technology readiness level strategy is sufficiently familiar to those working on technology projects for NASA or DoD, for example, and these agencies' researchers, developers, and technology professionals know that the process steps must occur to successfully implement the technology.

It is important to note the full spectrum of players involved in advancing through the technology readiness levels. Applied researchers work closely with development experts, and their work is closely integrated with those in the relevant environment (users). There is continual awareness of the application of the technology and of what is needed for its operation and maintenance, including user competency. Importantly, this process shows the role of development expertise in the implementation process. The readiness levels show there is a smooth and expected handoff from research to development to the users. Progressing to the next level ensures that barriers to implementation are addressed, enabling more effective and efficient implementation of the technology. The system perspective allows researchers and implementers to anticipate and correct choke points or barriers that slow the implementation as well as fosters actions to enable positive conditions that speed the implementation process.

Missile Defense Agency Hardware Maturity Checklists for Technology Readiness Levels 6–9

TRL 6: System/Subsystem Model or Prototype Demonstration in a Relevant Environment. Representative model or prototype system, which is well beyond the breadboard tested for level 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness; examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.

Hardware Maturity Criteria: (each must be identified as "Met," "Not Met," or "N/A" with supporting documentation)

1. Materials, process, design, and integration methods have been employed. *Provide documentation of process, design, and integration methodology compliance with MDA Quality Assurance Plan.*
2. Scaling issues that remain are identified and supporting analysis is complete. *Provide description of issues and resolution.*
3. Production demonstrations are complete. Production issues have been identified and major ones have been resolved. *Provide documentation of data, issues, and resolutions.*
4. Some associated "Beta" version software is available.
5. Most pre-production hardware is available. *Provide documentation of identified shortfalls to end user(s) and/or testing organization.*
6. Draft production planning has been reviewed by end user and developer. *Update integration cost estimate and update integration schedule with end user(s).*
7. Draft design drawings are nearly complete.
8. Integration demonstrations have been completed, including cross technology issue measurement and performance characteristic validations. *Verification report compiled and reviewed by system engineer and testing organization.*
9. Have begun to establish an interface control process. *Provide process documentation to system engineer for review.*
10. Collection of actual maintainability, reliability, and supportability data has been started. *Provide RAM data to system engineer.*
11. Representative model or prototype is successfully tested in a high-fidelity laboratory or simulated operational environment. *Provide performance estimate and verification of capability enhancement with data collected.*
12. Hardware technology "system" specification is complete. *Submit hardware technology "system" specification for approval.*
13. Technology Transition Agreement (TTA) has been updated to reflect data in items 1 through 4, 7 through 9, 11 and 12. TTA has been coordinated and approved by end user Deputy(ies) and [others].

TRL 7: System Prototype Demonstration in an Operational Environment. Prototype near or at planned operational system. Represents a major step up from level 6, requiring the demonstration of an actual system prototype in an operational environment. Examples include testing the prototype in a test bed aircraft.

Hardware Maturity Criteria: (each must be identified as "Met," "Not Met," or "N/A" with supporting documentation)

1. Materials, processes, methods, and design techniques have been identified and are moderately developed and verified.
2. Scaling is complete.
3. Production planning is complete.
4. Pre-production hardware and software is available in limited quantities.
5. Draft design drawings are complete.
6. Maintainability, reliability, and supportability data growth is above 60% of total needed data.
7. Hardware technology "system" prototype successfully tested in a field environment.

TRL 8: Actual System Completed and Qualified Through Test and Demonstration. Technology has been proven to work in its final form and under expected conditions. In almost all cases, this level represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.

Hardware Maturity Criteria: (each must be identified as "Met," "Not Met," or "N/A" with supporting documentation)

1. Interface control process has been completed and final architecture diagrams have been submitted.
2. Maintainability, reliability, and supportability data collection has been completed.
3. Hardware technology successfully completes developmental test and evaluation.
4. Hardware technology has been proven to work in its final form and under expected conditions.

TRL 9: Actual System Proven Through Successful Mission Operation. Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

Hardware Maturity Criteria: (each must be identified as "Met," "Not Met," or "N/A" with supporting documentation)

1. Hardware technology successfully completes operational test and evaluation.
2. Training Plan has been implemented.
3. Supportability Plan has been implemented.
4. Program Protection Plan has been implemented.
5. Safety/Adverse effects issues have been identified and mitigated.
6. Operational Concept has been implemented successfully. (Missile Defense Agency)

The Missile Defense Agency (MDA) created a maturity checklist that adapts the technology readiness level (TRL) strategy for its specific use as it advances applied research results to practical use. The checklist is a customized application of the nine readiness levels. It provides a tailored definition of the maturity level as well as hardware maturity criteria for each level. The various criteria also have with a check box for "Met" with appropriate background information for verification, "Not Met" providing a status and an estimate when the criteria will be met, and "N/A" with supporting documentation. Furthermore, MDA also describes the certification authority sign-off so that accountability for achieving each level is identified at the beginning of the process. The following are entries for TRLs 6–9 definitions and criteria as examples of how this type of process can become an implementation methodology.

ENTREPRENEUR-IN-RESIDENCE PROGRAMS

A primary concept for entrepreneur-in-residence (EIR) programs is to assist in commercializing viable technologies by pairing a research institution with venture capital firms. The intent is to assist in the start-up of a new venture by providing a means to bridge the gap, the "valley of death," in commercialization efforts and enable technologies to be ready for the market more quickly and efficiently. The valley occurs after the research is completed and the researcher considers the technology ready for the market. Yet there can be huge potential for a disconnect between what a scientist considers a viable market product and what the market will actually embrace. EIR programs assist researchers and research sponsor organizations in developing business plans and strategies for their products and in capitalizing on opportunities by introducing them to innovative business funding and venture capitalists.

Federal government, academia, and the private sector all conduct successful EIR programs. Some federal programs have modified the concept of spanning the "valley of death" and rather than bettering the position a product has for successful commercialization, these programs span the gap between the program's innovative services and the use of the services by stakeholders and customers. Another variation on the EIR basic strategy is one taken by a number of academic institutions with strong EIR programs. The University of California Los Angeles instituted an EIR program in April 2013 to provide experienced entrepreneurs' counsel to UCLA scientists and inventors. These entrepreneurs have knowledge of marketplace requirements and will be a resource for new business start-up strategies for innovations developed by university scientists.

An example of the potential for EIR success is the program in place at High Tech Rochester sponsored by the New York State Energy Research & Development Authority (NYSERDA). Although this program is based on promoting energy innovation, it is funded through the authority for the benefit of New York State, and it is not a DOE partnership effort. The Rochester EIR program began in 2004, and it has more than 45 entrepreneurs available for assistance. The program is a model of how executive-level advice can enable early-stage companies to more effectively accomplish, among many areas, resource management, operations planning, and, most important, technology development, enabling the viable products to enter the marketplace more quickly. For example, an EIR was instrumental in providing advice to a start-up that developed a software platform associated with networking of electronic devices. The start-up was acquired by a company that will get the technology into the marketplace. The experienced entrepreneurial mentor made the difference in the speed with which this product was available to users (NYSERDA 2013).

$15 Million Award Will Fund Three 'Idea Incubators' to Bring Commercial Success to Clean-Energy Ideas

The New York State Energy Research and Development Authority (NYSERDA) will invest $5 million each in seed money over a period of five years in Columbia University, the Polytechnic Institute of New York University, and High Tech Rochester. Cost sharing will be required as part of the agreements. The three centers are expected to operate on their own after NYSERDA funding ends. Centers will link business experts and early-stage investors with scientists making new discoveries. The new entities — "idea incubators" for very-early-stage entrepreneurs — will fill a gap between the maturing of an idea in a research environment and the creation of a business. (NYSERDA 2013)

The Entrepreneurs-in-Residence (EIR) model … brought together professionals with diverse talents from inside and outside government to work together as a team on outcome-oriented solutions within a short and focused time frame. (USCIS 2013)

In addition, the U.S. Citizen and Immigration Service (USCIS) formally launched its Entrepreneurs in Residence initiative in February 2012. USCIS reports "that based on work accomplished the past year the EIR program has been a great success. By leveraging talent from the private sector and empowering government employees in an unprecedented way, the EIR initiative has proven to be an effective model to focus and address a critical challenge faced by government…. In the coming months, USCIS intends to expand the EIR concept to a broader range of industries that it serves, including performing arts, health care, and information technology." USCIS had the unique opportunity to foster entrepreneurs coming into the United States through the USCIS entrepreneur-in-residence program—a win-win for USCIS.

USCIS recruited both start-up experts from the private sector, using the Department of Homeland Security's Loaned Executive Program, and internal immigration experts from across the agency. Working within the framework of current immigration law, the team set out with the overarching goal of optimizing existing visa categories used by entrepreneurs to provide pathways that are clear, consistent, and aligned with business realities.

The EIR team worked collaboratively to develop the most effective solutions for USCIS. For each of its three main goals, the team produced a range of signature deliverables, making valuable contributions to the mission of the service. The three areas in which practical solutions were developed are

- Produced clear public materials to help entrepreneurs understand which visa categories are most appropriate for their particular circumstance.
- Equipped USCIS's workforce with tools to better adjudicate cases in today's complex and rapidly evolving business environment.
- Streamlined USCIS's policies and practices to better reflect the realities faced by foreign entrepreneurs and start-up businesses. (Excerpts from USCIS website)

The first Entrepreneurs-in-Residence program at CDRH [conducted from October 2011 to April 2012] brought in 20 outside FDA representatives—from industry, academia, venture capital, and research—to work with CDRH staff and management to rapidly develop and test the Innovation Pathway 2.0, a streamlined regulatory pathway intended for innovative medical devices with significant public health impact.

Fifteen EIR members participated on the strategic team, serving as a sounding board as other EIR members worked to build Innovation Pathway 2.0. The strategic team provided vision and focus during the development phase of the Innovation Pathway, including the review of policies, business processes and tools helpful in bringing innovative and safe new products to the U.S. market. (CDRH)

Other government agencies are using the EIR structure to find solutions to particularly challenging needs. The U.S. Food and Drug Administration's Center for Devices and Radiological Health (CRDH) conducts an EIR program that is

> "a time-limited recruitment of world-class entrepreneurs and innovators to join highly-qualified internal government employees in the development of solutions in areas that impact innovation. The EIR goal is to deliver transformational change by combining the best internal and external talent applying the principles of lean engineering in rapidly testing, validating and scaling new approaches. EIR Programs at Centers for Devices and Radiological Health (CDRH) currently last six months.

> … CDRH looks forward to continuing the program in order to cultivate new ideas and fresh perspectives that will advance [its] vision to provide patients in the U.S. with access to high-quality, safe, and effective medical devices of public health importance first in the world" (CDRH n.d.).

After a successful initial experience, CDRH launched the EIR Program Two (October 2012 to April 2013), addressing areas that have the potential to better support a more robust environment for medical device innovation by (1) streamlining clinical trials; (2) streamlining FDA approval to reimbursement; and (3) striking the right balance between pre- and post-market requirements. The teams assess the current landscape, identify problems and their underlying drivers, and develop potential solutions (CDRH n.d.)

The NYSERDA, USCIS, and CDRH programs are only a few examples of the many seen in the private sector. In 2011, Dell Computers launched a pilot EIR program to foster opportunities for entrepreneurs to turn their solutions into a marketable reality. Dell's EIR plays a part in identification, assessment, and potential adoption of new business and technology solutions for small to medium-sized businesses, and while shepherding the pilot she will be developing her next business venture and being Dell's EIR (Dell n.d.).

Regardless of the type of EIR program created, a common purpose across the various domains and sectors is engaging entrepreneurs and research sponsors or originators of an innovation so the new practice or technology is brought to market or applied more readily and efficiently.

INNOVATION INDUCEMENT PRIZES

"Prizes such as the Nobel prizes and the U.S. National Medal of Science or the National Medal of Technology [and Innovation], reward past accomplishments and do not have a specific or technological goal. These have been called 'recognition prizes.' Other prizes called 'innovation inducement prizes,' are designed to attain scientific and technical goals not yet reached. ... Objectives of these prizes include both technological and nontechnological goals:

- Identify new or unorthodox ideas or approaches to particular challenges;
- Demonstrate the feasibility or potential of particular technologies;
- Promote development and diffusion of specific technologies;
- Address intractable or neglected societal challengers; and
- Educate the public about the excitement and usefulness of research and innovation." (Stine 2009, p. 1).

"In FY 2006 Science, State, Justice, Commerce, and Related Agencies Appropriations Act (Public Law 109-108) directed the National Science Foundation (NSF) to use available funds for 'innovation inducement prizes'" (Committee on the Design of an NSF Innovation Prize 2007). As a first step in the process, the NSF commissioned a study by the National Academies to propose a plan, evaluate goals, and address issues of design and administration for such a prize mechanism. From this work a variety of innovation inducement prizes are now offered through NSF. Additionally, The America COMPETES Act, December 2010, gives federal agencies a legal mechanism to award prizes to stimulate innovation. Recent studies of the concept of incentivizing innovation conclude that such tools provide, among other things, a means to gain greater market awareness of technology as well as a means to encourage accelerated implementation of targeted technologies (Brunt et al. 2011; Kay 2011). Now with the 2010 legislation further encouraging innovation inducement prizes, more activity is occurring. The website http://Challenges.gov, hosted by the U.S. General Services Administration, provides a view into some of the more recent inducement prize challenge efforts. The U.S. Department of Transportation is currently sponsoring a few small science and technology challenge competitions. These are a modest initial entry into what has proven to be a successful mechanism, particularly on a larger scale for other technical domains.

In "Managing Innovation Prizes in Government," Kay (2011) discusses the structure of innovation prizes and challenges in designing a prize competition, and then provides implementation guidance for those deciding whether such inducements are applicable in their contexts. The following is taken from Kay.

According to Kay (2011), the structure of innovation inducement prizes can vary depending on the competition. Yet, in general, participants are asked to solve pre-specified technical challenges or meet targets by a given deadline. Prizes can be "first-to-achieve," "best-in-class," or "winner-takes-all" as defined by the program. Prize competitions can be individuals or teams and can originate from the private sector (companies, entrepreneurs) and academia. Flexibility resides in the identification of goals for the competition, the criteria for selection of prize topics, and the program administration.

Important to this synthesis, Kay notes, "Properly designed prizes may accelerate the speed of technology development, incentivize creativity that leads to new inventions, promote the introduction, application, and diffusion of existing technologies, stimulate performance improvements, and bring on new forms of R&D organization."

For approximately the past 8 to 10 years, DoD, DOE, and NASA have been conducting innovation inducement challenges and competitions. Each of these programs was established through legislation (prior to the America COMPETES Act) that, in general, allows the DoD Secretary to conduct the program, award cash prizes, and set criteria for the completion.

GENERIC EXAMPLES OF APPLICATIONS OF PRIZES TO TECHNOLOGY DEVELOPMENT-RELATED GOALS

- Explore new, experimental technologies that imply high-risk R&D
- Explore new innovative approaches to break critical technological barriers
- Incentivize the development of cheaper or better-performing solutions based on existing technologies
- **Accelerate the application, diffusion, and commercial development of technologies**
- Raise public or industry awareness and change beliefs about science and technology topics linked to the agency's mission.

(Kay 2011)

Using a $2 million innovation inducement final prize, the "DARPA Robotic Challenge" (DRC) will focus on developing robots that can operate in rough terrain and austere conditions, using aids (vehicles and hand tools) commonly available in populated areas. Specifically, DARPA wants to prove that the following capabilities can be accomplished:

1. Compatibility with environments engineered for humans (even if they are degraded).

2. Ability to use a diverse assortment of tools engineered for humans (from screwdrivers to vehicles).

3. Ability to be supervised by humans who have had little to no robotics training.

Success in the DRC would mark a significant leap forward for the field of robotics. The entire robotics industry would be strengthened by raising the bar for robotic hardware, software, and sensors. Additional benefits include increasing the speed of advancements in robotics, growing international cooperation in the field of robotics, and attracting new innovators to the field. The challenge events include a virtual challenge in June 2013, a robotics trial in December 2013, and the challenge finals in December 2014 (DARPA n.d.).

Two million dollars is a substantial prize that could produce breakthrough technologies and innovations to contribute to the Defense Advanced Research Products Agency's (DARPA's) mission. As with other inducement competitions, the intention of the DARPA prize is to spur the creation of an innovative solution rather than rewarding a final product that has been commercialized and is now institutionalized in practice.

DARPA also uses challenge prizes to meet time commitments for deployment. "The DARPA Grand Challenge competitions in 2004 and 2005 made significant strides toward a day when autonomous robotic vehicles will perform hazardous tasks on the battlefield that today put America's fighting force in harm's way…. The DARPA Urban Challenge continued the acceleration of autonomous ground vehicle technology, making possible deployment on the battlefield within the timelines established by Congress" (Stine 2009, p. 10). Accelerating the deployment of technology is only one of the benefits of the challenge prizes. DARPA also reports the forming of new alliances of cross-discipline teams and bringing into the research arena new, energetic talent from nontraditional sources—all providing fresh insights to problem solving and generating a more robust research and a strengthened commercial community. Furthermore, DARPA's as well as others' experiences of innovation inducement prizes shows that the researchers, scientists, and entrepreneurs are motivated by the marketing potential brought about by winning the prize and often contribute more than the cash value of the prize. In fact, a Brookings Institute study notes, "Prizes … offer the potential for allowing government to establish a goal without being prescriptive as to how that goal should be met; can stimulate philanthropic and private sector investment that is greater than the cash value of the prize and attract teams with fresh ideas who might not otherwise do business with the federal government" (Kalil 2006).

As with the DARPA example, the highway community could benefit from innovation inducement prizes that not only focus on developing needed technology and research expertise, but that base awards on acceleration of deployment of the technology. The model presented is federal, yet it can be mirrored on a state level where there is a push for identifying innovative solutions to spur advancements through development of highway transportation technology. Furthermore, investigation into states cooperatively sponsoring such prizes through federal aid-funding may prove productive.

EVIDENCE-BASED PRACTICE SCHOLARS PROGRAM

The Evidence-Based Practice Scholars Program conducted at the Menninger Clinic, a leader in psychiatric and behavioral health care, is a response to findings within the medical community that "[t]here is a need for strategies aimed at improving the translation of research to practice in order to improve patient outcomes" and that while "[s]ignificant resources have been committed to health care research; the lag between the reporting of research and the implementation of research findings is between 15 and 20 years" (Mahoney 2009, p. 356). Clearly research findings—evidence of successful treatment—needed to be applied more expeditiously.

EVIDENCE-BASED PRACTICE

The term evidence-based practice (EBP) is used to describe the application of research and other forms of clinically relevant information to practice. (Mahoney 2009)

The movement for EBP for nursing in the medical community began with the recognition that nursing professionals needed to be using the best available research results—research evidence of successful treatment strategies and best practices. Further acknowledgments within the medical community stated that many in the nursing profession lacked the skills and understanding to apply research to practice, even with the emphasis on EBP in nursing school curricula. Therefore as Mahoney describes, the Menninger Clinic developed a scholars program where "scholars focus on identifying a critical practice issue and proposing a new or updated policy or guideline based on the best evidence" (Mahoney 2009, p. 359). The scholars program was developed in-house by the clinic's director of nursing practice and research. Program details are taken from Mahoney (2009).

Criteria for scholars:

- Intellectual curiosity
- Commitment to professional excellence
- Leadership
- Strong work ethic
- Letters of recommendation and personal essay detailing use of EBP within work context.

Scholars' acceptance is a management-recognized responsibility and assignments from the program are included in performance appraisals. Coursework includes 6 full work days and requires a final project presentation to peers and management. Nurses receive educational leave to attend classes and supervisors champion the scholars. Having completed the program, scholars may serve as mentors for others going through the program.

EPB five-step process:

- Asking the burning question
- Collecting the best relevant evidence (research findings)
- Critically appraising the evidence (research findings)
- Integrating the research evidence with one's clinical expertise, patient preferences, and values in making practice decisions or change
- Evaluating the practice change.

Scholars' projects impact the operational environment of the clinic. The goals of the program are not only to train nursing professionals to use research results and develop a project that pilots a changed practice, but to change the decision-making process, transform the culture, and create a best practice environment more attuned to incorporating EBP as a standard. Eighteen scholars completed the program in its first 2 years. Research results are being put into practice at a rate not heretofore experienced resulting from the scholars' projects, and a trained cadre of nurses now fosters EBP in their operational spheres.

The highway community has no similar opportunity to focus on enhancing skills leading to accelerating the potential for implementing innovations. The value of such a program to the highway community is that this type of activity not only provides skills and knowledge enhancement but spurs implementation of a specific project important to the organization. The added competencies are gained through project-specific work in line with work responsibilities.

Training for more effective implementation of highway materials is just one such example. Partnerships with the private sector are an avenue that could reap significant benefits for highway training venues. The highway construction industry could be a partner that provides skills-building expertise as well as enhances competencies for more rapid and effective materials use.

TRAINING FOR IMPLEMENTATION

If we keep on doing what we have been doing, we are going to keep on getting what we have been getting. (Anonymous)

The scholars program is only one example of building expertise to more effectively put innovations into practice in an operational setting. Whether the implementation activities are considered increasing research into practice, fostering technology transition, or enhancing technology transfer of innovations from federal laboratories, training plays an essential role when partnered with other strategies to accelerate implementation of research findings. Literature confirms that training alone is not sufficient to make a significant difference in accelerating the use of innovations (Rogers 2003; Fixsen et al. 2005). Yet when training is part of a systematic and multifaceted approach to implementation, it is a high-payoff tool for streamlining the implementation processes and thus accelerating availability of innovations to practice.

The Federal Laboratory Consortium for Technology Transfer (FLC) actively promotes training and education. It offers a variety of training opportunities in conjunction with its many other implementation and technology transfer education and initiatives. Scientists and those involved in making innovations more readily and quickly available to the marketplace are the primary audience for training. Use of the term "technology transfer" by federal laboratories is broadly directed at commercialization and avenues for application of innovations to practice. As described by the *FLC* *for Technology Transfer Annual Report to Congress 2008*, the Technology Transfer and Education Program includes

- *Technology Transfer Fundamentals Training*—Designed to introduce newcomers to the technology transfer (T2) field or as a refresher for T2 veterans, the day-long Fundamentals Training course provide(s) a basic foundation in the background, concepts, and practical knowledge required to transfer federally funded technologies from the laboratory to the marketplace. The course feature(s) an in-depth workshop on Cooperative Research and Development Agreements (CRADAs), other transfer mechanisms, how to manage a federal technology transfer office, and an introduction to intellectual property issues.
- *Technology Transfer Intermediate Training*—Designed for T2 professionals with a basic foundation in technology transfer, this day-long, intermediate-level course feature(s) two interactive workshops on developing and commercializing innovative technologies. The Workshop on Commercialization of Innovative Technology focus(es) on how researchers, scientists, and technology entrepreneurs can interest investors and other business backers in their ideas and show(s) how they can increase the odds of bringing innovative ideas from "laboratory to life." The Licensing and Negotiations Workshop focused on how to develop an effective license and how to successfully negotiate a license agreement.
- *Technology Transfer Advanced Training Workshop*—This day-long workshop focus(es) on several issues important to technology transfer leaders and managers, including how technology transfer adds value to laboratories and agencies, metrics that enable a laboratory or agency to quantify the economic and mission-related impacts of technology transfer, interface issues for laboratories when dealing with startup companies, entrepreneurial programs sponsored by federal laboratories, and how federal agencies can utilize the licensing of trademarks to further their technology transfer mission.
- *Technology Transfer Video Training Program*—[This program] enables FLC members and other technology transfer professionals to participate in FLC training activities at the time and place that best fit their needs. (FLC 2008; see also FLC 2011a)

These training courses are supplemented by a number of important reference publications including the *FLC Technology Transfer Desk Reference: A Comprehensive Introduction to Technology Transfer* (2011b), and the *Green Book, Federal Technology Transfer Legislation and Policy* (2013), which includes policy guidance for decision makers and practitioners.

Although public agencies do not focus on the commercialization of technologies, the message is clear: the FLC is a model that shows training is a vital part of getting people better equipped to effectively implement innovations. The FLC committed the resources to create the Training and Education Program and offers its courses in a variety of venues, including its annual national meeting. For the highway community, such training could be a successful practice for those involved in implementation of innovations. With the commitment of resources through collaborative efforts, coursework could be developed, and training could be provided for varying levels of experience. The FLC training could be given in conjunction with national meetings as well as in standard scheduled offerings.

The health care community also is active in training to produce the types of strategies and tools that will assist in implementation activities. The sponsored training opportunities frequently require the student to identify an implementation study that will be part of the training, and it may form the foundation for a longer-term mentoring opportunity for the student.

National Institutes of Health (NIH): NIH Training Institute for Dissemination and Implementation Research in Health. The first training institute was held in August 2011 as an effort to help close the gap between knowledge and practice and specifically to address how health care providers can more consistently disseminate and implement research results. The institute was a joint effort sponsored by the NIH Office of Behavioral and Social Sciences Research, working with the National Cancer Institute and the National Institute of Mental Health. The five-day training institute focuses on expanding the capacity for research that is specifically oriented to accelerating an innovative treatment strategy to practice. The 2011 institute was comprised of plenary sessions featuring experts on implementation and dissemination, discussing the science and the practice; technical sessions discussing practice; individual project development sessions; individual project roundtable discussions; and case study workshops. The institutes are designed to have attendees work on practical problems in their specific contexts. The 2011 institute was so well received that another institute was held in 2012.

In addition, a number of training and educational programs offered in the medical community are longer-term opportunities that include a research grant to develop an implementation plan, strategy, and program for practical application of a treatment needing more consistent use by practitioners. One of these is offered by the National Institute of Mental Health/Veterans Affairs Implementation Research Institute fellows participate in a 2-year program that includes a week of on-site training and ongoing mentoring, pilot project funding for a mentored implementation study, and travel funds to visit a funded implementation research project and to attend the NIH Conference on the Science of Dissemination and Implementation.

The goal of these health care community training and educational opportunities is to substantially change the nature of practice, by determining the best practices for implementation as well as for dissemination of the best practices—what works and what does not in implementation of the practice and in the dissemination of the practice to the full medical community.

The Interactive Systems Framework for Dissemination and Implementation is an approach also used within the medical community that stresses the capacity of the organization and individuals to accommodate and perform implementation. Central to using this framework is training—building and supporting the capacity that enables the implementation to be accomplished. The framework is based on work done by Wandersman et al. (2008), who acknowledge that "understanding capacity is central to addressing the gap between research and practice."

This framework was used to examine the potential for a more effective system of school mental health services after Hurricane Katrina because of schools' unique role in the community and the particular vulnerability of youth survivors of disasters (Taylor 2012). The community as well as the educational system required the knowledge, skills, and tools to create an effective system to provide interventions for post-trauma occurrences. On a variety of levels, training and technical assistance—for example, coaching, retraining, materials—were key strategies that could enable and accelerate implementation of viable programs. Training was needed at the organizational level to create innovative, effective programs, as well as at the individual level to model and implement practice changes. Training was an integral part of the systematic framework for changing how a difficult community problem was approached. Yet, while training was integral, it was not seen as a sole implementation accelerator. It played a role along with city community policy, professional resources, a social infrastructure with recognized need for change, and other implementation activities.

ORGANIZATIONAL IMPLEMENTATION POLICY

A particularly influential enabler for implementation is a senior management committed to accelerating the use of innovations and a well-crafted policy to communicate to, and guide the organization in, its implementation and technology transfer activities (Bikson et al. 1996; Kanter 2006). The Energy Policy Act of 2005 created the position of DOE technology transfer coordinator. Yet technology transfer had not been a sufficiently primary focus of DOE and the position was not filled with a full-time dedicated staff person—indicating a lack of management commitment and resources to the task of speeding innovation to practice. In 2011, the newly appointed Secretary of Energy clearly communicated his challenge to DOE regarding his support of increasing the use of DOE research findings through technology transfer, by creating a technology transfer policy and selecting a well-qualified professional to fill the coordinator post.

The Technology Transfer Coordinator's charge is "to increase the rate of tech transfer" (Innovation June/July 2011). Moreover, the new Technology Transfer Coordinator confirms that having an agency head fully committed to accelerating the use of research products in operational settings is a means to replicate successful practices conducted in one research program/facility to many others. The Secretary's goal is, by applying the resources of expertise in a leadership position, to reduce "red tape" in the process of getting research findings out of the laboratory through its agreements that give more advantages to small businesses, a memorandum of understanding with DoD to position that agency as a first adopter, and other similar program options.

> **INCREASE SUCCESSES**
>
> The traditional outcome-driven role for tech transfer remains strong, but there is a considerable pressure to increase the number of successes in order to maximize better the return on the federal R&D investment… It is time to create an infrastructure that reduces costs by providing easy access to information and resources, and encourages industry stakeholders to work with federal laboratories and universities… using cooperative models that can accelerate [the use of] technology. (Blaustein 2010/2011)

As an example of the focus on getting research findings out of the laboratory and reducing the red tape that goes along with it, Moughon's article titled "How Tech Transfer Is Supposed to Work," recounts the following: The National Renewables Energy Laboratory (NREL), the DOE laboratory focused exclusively on renewable energy and energy efficiency research and development, is actively promoting the use of the bacterium Zymomonas mobilis (Zymo). "Zymo is poised to change production of biofuels as we know it. From food waste to grass clippings to any feedstock with good levels of cellulose and hemicellulose, Zymo and a little water can turn them into bioethanol. … NREL is offering [Zymo] widely, with straightforward license terms designed to get the bacterium into extensive use." NREL has also assisted in removing barriers for users through completing the Microbial Commercial Activity Notice for the Environmental Protection Agency, which substantially reduces costs and effort for licensees. Zymo is licensed to producers and manufacturers as well as to a company that markets a home fueling station. The head of NREL views technology transfer—the process by which innovative research findings are effectively put into

NATIONAL WEATHER SERVICE POLICY DIRECTIVE 80-8 MARCH 29, 2010
SCIENCE AND TECHNOLOGY TRANSITION OF INNOVATION AND RESEARCH TO OPERATIONS

1. This policy describes the authorities, roles, and responsibilities of National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) associated with the transition of research and innovations to operations (R2O). NWS must invest in a process, staffing, and infrastructure that support transitioning results of innovation and research into NWS enterprise operations in a cost-effective manner.
2. Transition is the transfer of research or innovation projects from one financial management center (FMC), conducting research or innovation, to another FMC providing operations and maintenance (O&M) of the transitioned project. The policy applies to NWS R2O activities with other NOAA line offices (or other external research organizations)….NWS will maximize the application of NOAA sponsored research, NWS innovations, and capitalize on non-NOAA research for operations. NWS will:

   a. Establish processes for identifying valid needs and opportunities, and transitioning research and innovation results to operations;

   b. Maintain an operations environment capable of transitioning proven research and innovation results into operations while continuing to maintain reliable cost effective services for users;

   c. Implement and manage processes that identify new opportunities and needs for research and innovation, develop project plans, formulate budgets, report status information, and create test and evaluation procedures, and effectively transition to operations.

2.1 The policy requires an effective and efficient pathway from research to operations including strategic partnerships and effective collaboration between the research and operational communities.

3. This directive establishes the following NWS roles, and responsibilities:

3.1 The Director of the Office of Science and Technology (OST) serves as the NWS research to operations Line Office Transition Manager (LOTM). The LOTM also serves as the manager of NWS field, regional, national center, and headquarters innovation to enterprise operations transition activities. Under this authority the OST Director is responsible for:

a. Ensuring Policy on Transition of Research to Application is implemented. The LOTM assesses and approves NOAA research projects for transition to NWS enterprise operations;
b. Enhancing relationships with NOAA research organizations, including identifying research thrusts in support of NWS needs and fostering the interactive feedback process between operational capabilities and researchers;
c. Overseeing the NWS R2O transition portfolio, including those in recognized test beds, by tracking project performance, addressing issues, identifying research incubation projects ready for transition to NWS enterprise operations, and risks that endanger transition success;
d. Establishing criteria for test beds and other transition projects that includes setting priorities based on tactical and strategic needs identified in the NOAA Annual Guidance Memorandum, NOAA and NWS Strategic Plans, the NWS Science and Technology Roadmap, and other scientific review processes;
e. Tracking and providing reports to NWS leadership on the status of the transition portfolio including any issues related to resource gaps, schedule modifications, and changes in priorities;
f. Instituting transition "best-practices" including test bed activities, operational testing, research activities performed on operational platforms, and common information technology architecture (e.g. software & hardware compatibility);
g. Ensuring all training requirements for the transition to operations are submitted to the Office of Climate, Water, and Weather Services;
h. Ensuring that all potential licensing, intellectual property rights, distribution, and agreement issues associated with technology transfer are properly addressed.

3.2 The NWS Meteorological Development Laboratory's Research and Innovation Transition Team supports the LOTM and assists working teams in facilitating transition of research and innovation projects into NWS operations.

3.3 The NWS regional Innovation Advisory Board assesses field office innovation and recommends to the LOTM innovation projects for transition to national operations.

3.4 The NWS Chief Financial Officer ensures NWS corporate budget planning supports the approved transition portfolio.

3.5 Program managers will participate with the LOTM and transition team in planning for transition activities.

3.6 The NWS field offices, and the National Centers for Environmental Prediction, the NWS Regional Headquarters, and other NWS Headquarters Offices are responsible for leading, conducting, staffing, and managing individual transition projects and associated activities. They are responsible for identifying and validating program gaps and research needs in collaboration with the LOTM [and others].

4. The NWS will measure effectiveness of innovation and research to operations transition.

(http://www.nws.noaa.gov/directives/080/pd08008a.pdf)

use—as a completion of research and development, and the means to bridge the gap between lab and user.

Fostering this type of technology has its roots in the newly adopted policy being used at DOE. The guiding principles in the 2011 DOE's secretarial policy statement (U.S. DOE 2011) include

- *Commitment* to ensure robust activities that result in commercialization and deployment.
- *Empowerment* of innovators to be directly involved in the technology transfer activities.
- *Fairness* in opportunity within the private sector domestically and globally.
- *Facilitation* of expeditious technology development and deployment for partners.
- *Visibility* through promoting access to capabilities and intellectual property and by accelerating the maturation and commercialization of new technologies arising at the facilities.
- *Leverage* of DOE's resources through partnerships to demonstrably benefit the United States.
- *Impact* through identification and measurement of outcomes that are effective indicators of success and impact that show widespread deployment of technologies developed by DOE.
- *Predictability* along with streamlined processes and appropriate flexibility in applying the policy.
- *Cooperation* in sharing best practices and lessons learned in order to further technology transfer, to foster collaboration among partners, and to maximize administrative flexibility in items such as minimizing cycle times and eliminating and avoiding unnecessary barriers.

It is not difficult to consider a policy for implementation within the highway community as having many similar guiding principles. It may be more challenging to foster full commitment by transportation leaders to such a policy. Yet with the similar conditions of needing to accelerate the use of innovations to solve problems and the pressures of needing to show benefit for investments, senior management commitment to such policy for transportation may be advantageous.

A policy for implementation of innovations should not be overly complex. The most critical factor is to have a clearly worded, workable policy that provides guidance and structure for implementation practices. The National Oceanic and Atmospheric Administration, National Weather Service *Policy on Science and Technology Transition of Innovation and Research to Operations* is such an example. The majority of the main body of that policy is included as an example of the language that can be created for useful organizational guidance.

The National Weather Service policy also included a glossary of less than a dozen terms used in the document. Included are several definitions as follows:

- Innovation Project: NWS Regional efforts to improve NWS Operations based on localized needs that could be expanded to national capability. An innovation project includes the collective set of activities necessary to transfer one or a collection of NWS innovative results developed or initiated by NWS field, regional, or headquarters staff, to national operational status.
- Incubation Project: Exploratory research or innovation project addressing one or more objectives of NOAA 5-year research plan and/or NWS requirements.
- Transition Project: Incubation project deemed mature, scientifically valid, and technically ready for implementation into NWS Operations. This includes the collective set of activities necessary to transfer one or a collection of research results to operational status or to an information service between NOAA Line Offices or between separate and distinct organizations within NWS.

RESEARCH TRANSITION TEAMS

Research Transition Teams (RTTs) are used by a variety of federal agencies such as the National Weather Service as identified in the research and innovation transition policy described above.

NWS Research and Innovation Transition Teams (RITTs) are charged to

- Provide staff for the transition manager's office, and identify and prioritize projects for transition
- Establish a "help-desk" center that reduces the burden on project managers and innovators by streamlining bureaucracy (not duplicating it); establish customer "checklists for success"
- Coach personnel through prescribed administrative procedures
- Oversee and arrange formal work agreements
- Ensure appropriate coordination with NWS and the NOAA processes
- Maintain awareness of research and innovations with enterprise potential
- Connect field innovators and NOAA research labs to synchronize efforts
- Identify funding/resource vehicles
- Identify promising projects for the Office of Science and Technology seed funding
- Track RITT performance and resolve issues and concerns (RITT Charter n.d.).

National Weather Service Research and Innovation Transition Team Vision

A team dedicated to facilitating rapid transition of research and innovation into NWS operations proactively, efficiently, and effectively.

NOAA Policy on Transition to Operations

Transition Project Team: A group of individuals, representing the research and applications communities, who support the transition project lead and are assigned the responsibility to execute the project per the terms and conditions of the agreed-upon Transition Plan.

The NWS has active RITTs for a variety of projects and communicates progress on selected teams' efforts in a monthly forum. The RITT Forum showcases potential transition projects and provides an opportunity for a transition team member—subject matter expert—to present project information. Attendees at the forum, virtual or in person, discuss the project's implications for NWS operation. Projects such as Hurricane Forecast Improvement Project, Local Climate Analysis Tool Updating, and other technical efforts are effectively communicated across disciplines, providing a broader knowledge base to NWS as well as providing the opportunity to gather feedback on project outcomes.

Research Transition Teams

"[T]he research transition teams, the teams that we have between FAA and NASA, are held up as a model for how we do agency collaborations and share knowledge. It is generally considered a best practice [for knowledge management] in the federal government." Susan Minor, Integration and Management Office Deputy Director for the Aeronautics Research Mission Directorate NASA

NASA and FAA have been using the transition team concept to implement innovations with the Next Generation Air Transportation System (NextGen). These agencies recognize that implementing research results and innovations is a process that requires a team approach, and that team must be staffed with experienced professionals in the tasks necessary for implementation. Team members must also be well qualified technically and have technical credibility with the researcher and user communities. The goal of establishing the teams was to ensure that the research and development for NextGen was identified, conducted, and effectively transitioned to the user agencies. The objectives for the teams were to create a formal venue for researchers and implementers to collaborate throughout the NextGen effort, and to ensure that research results were fully utilized and implementable to accomplish NextGen improvements.

RTTs were established to match four primary elements within the NextGen project framework. These RTTs were aligned with strategically important topics for user organizations that facilitated the implementation planning and processes. Initially a NASA-FAA collaboration workshop defined the scope objective, timelines, and methods for the RTT activities. A major role for FAA was to provide operational unit personnel that could describe barriers to implementation and issues requiring resolution to assist in investment decisions. NASA provided researchers and details of research plans and anticipated products for implementation (Scardina, JPDO 2011).

An example of the work of one of the RTTs provides insight to the type of work accomplished by these teams. The team was a technically competent group of researchers and user professionals that worked through significant technical challenges that would have prevented or slowed implementation of research findings and innovations. The team solved technical problems that would influence implementation and developed a process for technology transfer

The NASA/FAA Integrated Arrival/Departure/Surface Research Transition Team, one of several teams charged with coordinating the transition of NASA research products to FAA in support of NextGen, is currently coordinating the transition of four NASA research products: Precision Departure Release Capability, Spot and Runway Departure Advisor, Integrated Surface Management and Flight Deck, and Airport Runway Management. FAA participants at the meeting [September 11-12, 2012] represented NextGen organizations responsible for technology development, prototyping, and specifying and procuring automation systems. FAA personnel provided updates on NextGen technology development and prototyping as well as new FAA processes for transitioning Ideas to Implementation. NASA researchers and managers supporting the Airspace Systems Program participated and provided updates on the four research products along with demonstrations at Ames' Future Flight Central and the Airport and Terminal Area Simulator. (NASA Aviation Systems Division News 2012)

that incorporated developing prototype/proof-of-concept models, demonstrations, and pilot example projects.

All of the implementation strategies and methods discussed in this chapter point toward accelerating implementation of research findings in one way or another. As a given, the goal of any implementation action is to get the research into practice — always pushing time constraints. Because of the variability of each implementation effort and the complex processes used for the implementation of research results, no attempt was made to rank the efficacy of individual strategies. Across all contexts or industries it was not possible to determine which strategies used had the highest impact on implementation success, but it was possible to highlight strategies and practices that might bring benefits to the transportation community.

CHAPTER FOUR

REPLICATION AND TRANSFERABILITY OF IMPLEMENTATION STRATEGIES AND PRACTICES

This chapter provides a discussion on replicating and transferring the strategies or practices found to have potential to accelerate implementation of research results in transportation applications.

TRANSFERABILITY OF THE ENVIRONMENT TO AID ACCELERATION OF IMPLEMENTATION

It is good news that the strategies and practices used by others in government and the private sector or academia discussed herein make sense for and can be applied to public-sector transportation practice. Even so, some aspects of whether a particular strategy or practice is used create challenges for replication to transportation applications. As seen in the earlier chapters of this document, *accelerating* implementation involves creating and applying systemwide processes, often bringing in talent not currently within a transportation organization, requiring cultural changes for accepting risk and promoting innovation, or other broad organization-wide activity. To date, transportation organizations are to varying degrees fostering implementation of innovations and research results. Yet an environment predisposed to fostering application of innovations is what can make a remarkable difference in innovations' rate of adoption. Such environments include commitment to a systems perspective, capacity of the organization to adopt innovations including providing adequate financial resources and expertise, as well as commitment to an organizational structure that enables and facilitates the interaction of the participants in innovations to positively affect the organization. Creating the environment for innovation is a significant challenge for transferring the case examples and practices to transportation organizations. Overcoming the challenges presented by the environment must be addressed with intentional effort.

Systems Perspective

The case example and practice descriptions show a number of strategies, methods, and techniques that bear consideration for advancement in the highway transportation community. Advancing one or two of these methods can bring about changes and provide a means to accelerate the implementation of transportation research results. However, a consideration for the transportation community might be to change from ad hoc implementation to systematic implementation built on a solid infrastructure supporting the various elemental building blocks of expertise, funding, time, and other items. Taking a systems perspective that incorporates a variety of the case example concepts may provide a better opportunity to create a sustainable process for acceleration of innovations and research results for highway applications.

Consider the manner in which many highway research results are currently implemented. Champions for the research and administrative expertise are combined with some funding on a project-by-project basis to push implementation along. Implementation efforts in these highway transportation environments often do not have sufficient professional technical and implementation expertise and often lack resources needed to work the problem. Implementation, therefore, advances by fits and starts. Often, implementation does not gather sufficient momentum to sustain its activities. Adding a technique here or there depending on what resources can be had—perhaps by using funds from other nonrecurring, underspent areas—is unreliable and unpredictable at best. Such an ad hoc approach has not produced the desired impact, which has been recognized as long ago as 1984 when John Burke noted in *NCHRP Synthesis 113: Administration of Research, Development, and Implementation Activities in Highway Agencies*, "most … departments currently approach the incorporation of new research findings in practice on an informal basis."

Creating an implementation infrastructure, resourcing it effectively with talented technical and implementation experts that are given responsibility and time to do implementation, and providing dedicated funding will substantially change the way implementation is currently handled in most highway contexts. The transportation community has an option: to recognize the need for and establish sustainable implementation programs that will accelerate implementation of research results or to continue the current manner that is cumbersome and variable and produces only incremental change. Creating this systems perspective will take substantial effort, yet it is replicable in every highway transportation context.

A systems approach is beginning to be addressed by a variety of highway transportation organizations. One example of this approach, which is yet in the early stages of development, is FHWA's State Transportation Innovation Council (STIC) initiative. FHWA is encouraging formation of councils that will "provide leadership for the Every Day Counts initiative in each state. The division administrator for each State and his or her equivalent at the state DOT will lead the councils, which will consist of a diverse representation of local stakeholders. The councils will provide leadership to the individual initiative teams, ensure deployment of the selected initiatives, and monitor performance" (McAbee 2012). The STIC initiative is a systematic approach to accelerating technology and innovation deployment and shortening project delivery through directing specific attention to a focused group of market-ready technologies and getting them into widespread use (EDC n.d.). This effort is large scale and proposes to bring together the multitude of partners that participate in providing the transportation infrastructure at the state level. Executives from the state DOT and the FHWA division office provide leadership; working groups are committed to accelerating the implementation and deployment of the various Every Day Counts (EDC) technologies and innovations selected by the STIC; and performance is being monitored to show the progress of the EDC activities. As noted in the previous paragraph, replicating a systematic approach such as STIC's can be and is being done, but it is requiring substantial effort and resources—leadership, expertise and technical assistance, communication, training, as well as the vetted, proven technologies. Additionally, at the state level, a few DOTs are using a systems approach to accelerate the speed of implementation as well as to increase the number of innovations implemented. The Pennsylvania Department of Transportation created a well-organized and -resourced STIC, and built a Research and Innovation Implementation System to more effectively facilitate the use of innovative tools and methods—particular outcomes of the system are greater efficiency, effectiveness, safety, and cost savings (Bonini et al. 2011).

Expertise

For transportation departments, the addition of expertise, for the job of implementation, is generally a very difficult undertaking. The decrease in transportation budgets and, often, limits on personnel numbers are a huge hurdle for an agency attempting to add implementation professionals. Furthermore, the need for technically qualified personnel for creating research transition teams, for example, can require transferring technical experts from program offices to implementation offices. Such reorganization of technical expertise is scarcely any easier than adding new staff. Although there is such difficulty, the job of implementation must be resourced by qualified, experienced professionals. This may be the most difficult aspect of replicating any of the strategies discussed in the case studies or practice descriptions for an existing highway transportation organization.

An alternative to adding permanent staff for an organization that has difficulty increasing employee numbers is purchasing the expertise. Such contracting would be through longer-term arrangements with organizations that can create a sustainable implementation infrastructure within the organization. This approach also can create the opportunity to build organizational capacity for implementation. As the organization learns and the culture becomes more predisposed to the need for intentional and systematic implementation, recognition of the need for committed expertise will occur, and adding such staff will be less of a hurdle. An essential element of this approach is to create a longer-term commitment to outside staffing so that growth can occur.

A number of state transportation departments, such as Louisiana, Iowa, and Ohio, have designated implementation staff committed to fostering and increasing the effectiveness of implementation activities. Other state DOTs such as Pennsylvania and New Jersey contract for research and technology implementation expertise. Identifying the appropriate expertise is essential, and when that talent is found, reorienting existing funding to support the expertise is the remaining hurdle. State planning and research (SP&R) federal-aid research funding includes implementation activities that may be of assistance.

Financial Resources

Replicating items discussed in this synthesis involves another area of difficulty for many organizations: either (1) redistributing financial resources from other department organizational missions to implementation activities, or (2) identifying new sources of sustainable revenue to fund implementation. Senior management implements organizational priorities, and financial resources for implementation activities will need to be committed by decision makers. With all the examples in this synthesis, management decisions were made to provide adequate financial resources for implementation activities. Similar decisions will be required by any organization that desires to accelerate implementation efforts. A current example—on a national scale—of commitment to funding, as well as providing expertise, for implementation are Strategic Highway Research Program 2 (SHRP2) research and implementation activities. The Three-Year SHRP2 Concept Implementation Plan includes a budget of $75 million (Steudle 2012). The SHRP2 program identified implementation as a critical element of the program and specifically provided funding to enable and speed the implementation and deployment of SHRP2 innovations. In addition to the funds committed through FHWA, current transportation legislation, Moving Ahead for Progress in the 21st Century, specifies support for implementation funding through commitment of a percentage of SP&R moneys—agreed by AASHTO leadership to be 4%. For other organizations such as the New York State Energy Research and Development Authority, they developed an entrepreneur-in-residence program modeled after others that were mandated—carving out the resources for enhancing implementation from operating funds; they understood the priority for assistance in getting technology implemented.

Organization Structural Change

Having (1) a systems perspective, (2) appropriate talent, and (3) adequate financial resources, a transportation organization may also require some degree of organizational change to enable implementation personnel be effective in their implementation activities. Such changes may require creating teams or recruiting personnel focused on the job of implementation—located within the research unit or in the program/operations or field office. In a discussion with a former state research manager, placing the implementation experts with the operational staff was seen as a beneficial strategy to speed implementation because the constant exposure of the implementation experts with the operational issues at hand facilitated faster uptake of innovations and research results. Another state DOT is committed to getting implementation-aware research administrative staff in field offices for significant amounts of time to enable better communication with the research unit and to develop strong networks with field personnel. If the first three challenges are met—having a systems perspective with necessary expertise and resources—the ability to form working groups or teams and accommodate the teams in an effective organizational structure can be done within transportation organizations.

TRANSFERABILITY OF THE STRATEGIES AND PRACTICES

Information on transferability to transportation users of the identified strategies and practices discussed in this synthesis are presented here and include a listing of potential users of the type of implementation accelerator strategy or practice; comments on the potential for use of the strategy and the ease of its transferability to application within the transportation sector; and notes describing necessary actions or resources required to support the transfer.

Network of Implementation Experts

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Network of Implementation Experts	• Research Program Managers • Implementation Staff • Program and Field Units	Informal networks exist now; providing structure and standards are important.	Difficult because of the need for maintenance of the resources and an institution or organization to host the activity	Network of experts must be identified and maintained. Can be a collaboratively supported community of practice. A "home base" to house the community will be necessary.

A network of implementation experts is directly transferable to transportation practice based on the examples given in clinical medical practice. The National Implementation Research Network is an exemplary model (http://nirn.fpg.unc.edu/). The desire to be better informed and to share knowledge about one's expertise is the basis for formation of and participation in user groups or communities of practice. Furthermore, developing working relationships with and having a platform for collaboration among one's peers is often a place for furthering the state of the art. A structured, viable network of practicing implementation experts within transportation can be accomplished.

Those working in transportation research and technology have the beginnings of such types of a network in the AASHTO Research Advisory Committee (RAC) task force structure (see RAC website, http://research.transportation.org/Pages/RACTaskForces.aspx). Additionally, transportation professionals are knowledgeable about the FHWA Resource Center and communities of practice applications sponsored by FHWA. These examples of networking expertise and knowledge show a high potential for developing a network of implementation experts within transportation. However, the ease of transferability poses a significant hurdle—that of sponsorship and hosting a "home," as well as some amount of staff support to maintain and enhance the network. A lesser challenge, yet one that must be met, is identifying the appropriate champion to provide contagious vision and passion to develop the network. Hosting and supporting an implementation network of experts could be designed as a collaboratively funded initiative.

Implementation Conference

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
(Global) Implementation Conference	Wide community of users: • Sponsors and Stakeholders • Researchers • Research Program Managers • Implementation Staff • Program and Field Units • Private Sector Technology and Innovation Firms • Academic Technology Offices	Conduct conferences on a periodic basis; in-person interaction is highly valuable; lack of public-sector travel funding can be a barrier; must be endorsed by transportation leadership.	Transportation community has sufficient models for creating conference venues. May start regionally or domestically and broaden by modal area or geography.	Identification of influential lead organization to host and promote conference is necessary.

The valuable exchange of information experienced by in-person, on-site interactions is recognized as one of the primary outcomes of the Global Implementation Conference. The website for the 2013 conference states: "The mission of the Global Implementation Conference is to gather implementation stakeholders to promote collaboration, exchange information about advances in implementation science, practice, and policy, and define key directions for the advancement of the implementation field" (http://globalimplementation.org/gic).

Conducting a global conference is not a new experience for transportation professionals, and transferring this strategy to the transportation sector is an easy conceptual leap. Such a conference requires broad-based and influential sponsorship and hosting by a nationally recognized organization—organizations that exist in the transportation community. Potential for use of the strategy depends on the ability of the transportation community leadership to endorse, promote, and provide talent and resources for its success. Linking the concept of accelerating implementation of research results and innovation in transportation organizations with the need for more innovative culture in those organizations may be an avenue to creating the needed endorsement and support. Travel to on-site meetings is difficult at best for many state DOTs and others in transportation; a new conference will be difficult to fit into already crowed schedules; and reaching the level of critical mass of participation that will foster future sustainability will take time.

Manufacturing Extension Partnerships Model

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Manufacturing Extension Partnerships Model	• Sponsors and Stakeholders • Researchers • Research Program Managers • Program and Field Units • Private Sector Technology and Innovation Firms • Academic Technology Offices	Presents opportunity for greater private-sector innovation to be available for public-sector transportation applications.	Model created by NIST has application for transportation technology innovation and development.	Creation of a government-supported partnership to advance private-sector transportation innovations and a framework to include public-sector agency involvement.

Creating a manufacturing-extension-partnership-like program that focuses specifically on fostering transportation innovations could be revolutionary for accelerating implementation of innovations into transportation practice. This strategy is a large undertaking and most likely only achievable through federal initiative or legislation. However, creating a systematic approach, a unique entity with the primary mission of fostering and supporting transportation innovation, could be the generator of more, and more relevant, applicable solutions for transportation needs. Greater availability of relevant innovations can create a technology push for innovation use in both the private and public sectors.

The NIST partnership model is a conceptual framework that could be transferred from manufacturing assistance to transportation where it would promote more relevant, cost-effective, applicable transportation innovations. A new transportation extension partnership program, working in partnership with public-sector agencies to supply demonstration and test locations, could provide added credibility to such a program. Creating the program, defining the program services and operational considerations, and other organizational processes and policies would be difficult. The use of the program, once created with broad transportation-sector input and adequate resources, could approach the success of the MEP.

The outcome of creating such a program is the production of more applicable, credible, useful transportation innovations that will be implemented more effectively and efficiently. The investment is large and the return potential is equally large.

Research Project Synopses

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Research Project Synopses	• Wide community of users: • Sponsors and Stake • holders • Researchers • Research Managers • Implementation Staff • Program and Field Units • Public	Common refrain within transportation: the need for technically accurate, informative, and concise research project results documentation.	This practice is already in use by some in transportation, but there are no standards or guidance and little incentive to commit resources to create them.	Research sponsors to provide resources for synopses development. Collaboration in the transportation community to create standards and expectations for such synopses.

As is important for fire management practitioners discussed earlier in this synthesis, producing clear, concise, informative research project results synopses is a welcome activity for research management and transportation practitioners. The Joint Fire Science Program began with a project to examine research efforts and produce synopses on an initial set of projects. The concept was well accepted and synopses became standard practice. Implementing the initiative began with a substantive pilot effort. Developing a standard practice throughout the transportation research community as an expectation of research performance would enable more effective technology transfer and speed the implementation of research results into practice.

Similar to the Joint Fire Science Program, research sponsors have a role in institutionalizing research results synopses for the transportation community at large. Sponsors can collaborate to determine standards for elements, content, and quality of synopses and can also identify channels for distribution and exchange among research results users and stakeholders. Sponsors must also be willing to commit the expertise and resources to developing the synopses as well as disseminating the information. The concept of standard transportation research results synopses is easily envisioned, yet it will take a concerted effort by research sponsor organizations to adopt this concept as standard practice.

Partnership Intermediaries

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Partnership Intermediaries	• Research Managers • Implementation Staff • Program and Field Units • Private Sector Technology and Innovation Firms • Academic Technology Offices	Provides implementation expertise for public-sector agencies in which staff hiring is difficult; brings additional experience and talent on an as-needed basis.	Bringing in such talent is already being done by some organizations; recognition of when such talent is needed and support of the concept is needed by others.	Leadership in endorsing the use of partnership intermediaries is necessary; model contracting and processes guidance will be helpful.

The use of intermediaries in disciplines other than transportation addresses the gaps and differences among various research partners, sponsors, and user organizations working on large research programs. Adapting the partnership intermediary concept to transportation is an easy transition. Partnership intermediaries are the cadre of experts available to enhance the effectiveness of research partnership activities, independent of discipline. Whenever multiple participants are involved in research and the implementation of research results, opportunities exist to ensure a consistent and seamless flow of activity from research to implementation and full deployment of innovations. Many state DOTs do not have the available expertise to ensure that the gaps between researcher and user, and research product and application context, are adequately addressed, mitigated, and closed. Partnership Intermediary Agreements (PIAs) are currently being used successfully in other domains and existing policies and procedures can be customized to transportation application. The ARS, DoD (Air Force Research Laboratory), and other federal laboratories have documentation that could be used to guide transportation uses. Creation of model guidance, including contracts and policy and procedures, is a relatively low-cost solution to help organizations adopt this implementation accelerator strategy.

Well-Defined and Documented Implementation Processes

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Well-Defined and Documented Implementation Processes	• Researchers • Research Program Managers • Implementation Staff • Program and Field Units	Processes must be tailored to the organizational context to increase relevance and usability; some such processes are currently in use.	Implementation processes are documented to some degree in many research programs; refining and enhancing what can be done is easily transferrable.	Development of implementation model documentation that can be customized for implementation professionals.

Well-defined and documented implementation practices are an insurance against knowledge loss as well as an instrument to train newcomers to the job of implementation. In addition, such documentation provides the solid base of effective practices on which all implementation efforts will be accomplished. The DoD, Federal Laboratory Consortium, NASA, and NOAA all show the importance of consistent, well-written, and expert documentation. Similarly, transportation research sponsors and stakeholders can set an expectation for quality and excellence through collaboratively developing model implementation processes, including implementation policies, implementation plans that give guidance on the requirements of timelines and responsibilities, desk reference manuals, and other documentation.

Research program management process guidance has been developed for such items as research program manuals (NCHRP 20-38), performance measures (NCHRP 20-63B), and communicating the value of research results (*NCHRP Report 610 2009*). Producing research and implementation guidance is a successful practice for transportation and good models of accomplishment are available. More needs to be done, and one project in progress is NCHRP Project 20-89, "Intellectual Property Management Guide for State Departments of Transportation." The intent of this research project is to produce a guidance document to enhance the effectiveness of research and technology management and the implementation of innovations. Results of this work are not yet available, so there is no basis at this stage of the research to determine how intellectual property issues may affect the implementation speed of innovations.

There is excellent potential for the use of such documented tools to assist implementation professionals in performing their jobs better. With greater expertise and using best practices, implementation of research results will be streamlined and more efficiently applied. The applicability of the strategy to transportation research programs is high and the barriers to create tools are low.

Research, Document, and Share Successful Implementation Strategies

Strategy	Potential Users	Potential for Use	Ease of Transfer-ability	Resources to Support Transfer
Research, Document, and Share Successful Implementation Strategies	• Research Managers • Implementation Staff • Program and Field Units	Little research is done on transportation implementation; communicating successful research findings on implementation strategy will fill a knowledge gap.	Research on implementation practice and strategy is a low priority for many transportation research programs, but general research methods and activities are well established.	Leadership to increase priority on need for and value of knowledge about practice of implementation; expertise and financial resources to perform the research and communicate it well.

Little research is being done on transportation research management processes, including advancement of the state-of-the-art for transportation research results implementation. In contrast, the private sector exhibits a clear effort to better understand the intricacies of implementation and other research management processes through effective research. As with creating a model to assist in defining and documenting current implementation practices discussed above, results of research that provide more effective strategies and new knowledge on implementation practice will be well received by research sponsors, manager, implementers, and users.

The potential use of such a strategy has substantial barriers owing to the lack of value placed on new knowledge for more effective implementation. Yet with a push for more innovative culture within transportation organizations, there is opportunity to raise the priority for creating new and better implementation methods and processes. Such research results will enable the organizations to implement practices that foster the innovative culture more readily and rapidly. Intentional effort must also be made to ensure that research on implementation is funded. There are many competing topics for scarce research dollars and a continuing focus and championing of research on implementation practice will have to be done.

Technology Readiness Levels

Technology readiness levels are a means to more effectively assess a technology's status for application. The potential for using information related to technology readiness is high; research sponsors and users alike seek data that enable more effective decision making to streamline implementation of research results. TRL information has a specific use. A technology that reaches a level indicates a current status of the level examined, it does not provide the potential for successfully reaching higher levels. Yet TRLs properly used can provide information to assist in advancing a technology toward implementation.

Strategy	Potential Users	Potential for Use	Ease of Transfer-ability	Resources to Support Transfer
Technology Readiness Levels	• Researchers • Research Program Managers • Implementation Staff • Program and Field Units	Providing an aid to determine potential for implementation will be well received because it increases the likelihood of success.	Technology maturity/readiness levels must be tailored for the appropriate types of transportation research outcomes; examination of maturity level tools such as TRLs for highway technology application is in progress.	Research and development to produce applicable TRLs, and guidance for their use for transportation research technology outcomes.

For this practice to be transferred to transportation research and technology applications, development work and customization of the readiness levels must be done. FHWA has begun this process by conducting a project to determine the applicability of technology maturity tools such as the NASA TRL concepts for selected highway research activities such as the Exploratory Advanced Research Program. Additional development will be necessary to customize this concept to the applied research activities sponsored by state DOTs, academia, and others in transportation. As a working model for transportations is made available, marketing of the value of the practice and champions for its use will be required. These are low barriers to implementation, especially considering that the process is created to streamline implementation and enable more efficient means to accomplish implementation.

Entrepreneur-in-Residence Programs

The EIR concept for the public-sector transportation research community has several potential applications. EIRs within transportation can be involved at the pre-competitive stage of research activity, working with public-sector research sponsors to better define the types of products needed by industry and transportation facility owners. The EIR can be more attuned to the research results available and can then work to develop a marketable product outside the relationship with the research sponsor. Additionally, public-sector transportation researcher sponsors are becoming more sophisticated in how they address ownership of intellectual property, thus fostering more opportunities for commercialization of innovations through licensing and other similar arrangements. As with FDA's Center for Devices and Radiological Health, EIRs working with public sector–funded research could effectively add value to the research results and be involved in commercializing a product for use in transportation applications.

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Entrepreneur-in-Residence Programs	• Sponsors and Stakeholders • Research Program Managers • Implementation Staff • Program and Field Units • Private Sector Technology and Innovation Firms • Academic Technology Offices	High potential for use; brings together uniquely targeted expert entrepreneurial talent with researchers and users to work collaboratively on reaching new solutions; will create new programs and businesses based on innovative research results.	Many variations of the EIR concept shows transfer has low barriers; programs for public-sector transportation organizations can be modeled on public-sector experience in other domains.	Availability of entrepreneurs with technical expertise; resources, people, and funds, to create an EIR program including model terms and conditions of the entrepreneur's scope and responsibility; academic partners may be available for collaboration.

EIRs also provide a means to add to the technology pipeline with innovations for transportation practice, by assisting the research sponsors to back innovations with a higher degree of relevance to the users. A higher degree of relevance will provide a greater likelihood for a marketable product; a more marketable product will accelerate its availability for application. EIRs are an effective means to more closely involve entrepreneurial talent in the transportation community and to make use of the private sector's profit motive to accelerate the use of innovations.

Creating an EIR program for a public-sector transportation organization will require expertise and perspective not traditionally found in existing DOTs or other similar organizations. Many existing programs have EIRs that are not permanent staff, but agree to serve in the position for a finite time frame. Contracting for such talent rather than adding a permanent position may be a solution for many transportation agencies with strict hiring limitations. Additionally, developing an EIR program may be a means for more effective collaboration with an existing research university partner. Such collaboration could advance sponsored research results and innovations enabling them to be better positioned for the marketplace, and thus having potential for more rapid application to transportation practice.

Innovation Inducement Prizes

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Innovation Inducement Prizes	• Sponsors and Stakeholders • Researchers • Research Program Managers • Implementation Staff	Positive action with few downsides; provides new incentive to find new solutions to long-standing or difficult problems. Gives recognition to researchers and technical experts.	Infrastructure and legal authority must exist to allow cash prize awards. MAP-21 authorizes USDOT Secretary to award cash prizes to stimulate innovation. Sponsor(s) for awards required. Counterintuitive process for transportation community.	Well-respected sponsor(s) willing to organize and manage program; technical experts to provide program credibility; compelling prize amounts.

The transportation community makes significant efforts to recognize excellent performance and accomplishment among its many participating organizations. For example, AASHTO, TRB, and ASCE, Transportation and Development Institute (ASCE, T&DI) regularly make awards that give due recognition to outstanding people and for exemplary contributions to transportation. Some of these awards focus on research-related accomplishments such as the awards given at the TRB Annual Meeting. The function of all of these awards is to recognize a job well done. Prizes for excellence are characteristically recognized and prizes in general have high acceptance within the transportation community.

Inducement prizes are used to award scientific and technical goals to be accomplished; the prizes stimulate finding better solutions to problems, promote innovative means to meet challenges, and build support for addressing pressing needs. Awarding a prize ahead of having a viable and applied result is counterintuitive for the transportation community. Yet, for organizations that want to break existing barriers to long-standing or particularly difficult challenges, those that have not been answered through traditional research problem selection processes, a program to induce and reward viable solutions has significant potential. There are many organizations in transportation willing to foster innovation and looking for better solutions. Inducement prizes are successful in various public-sector domains, and models from these domains exist. There is expertise familiar with prize programs currently within transportation and a credible, respected inducement prize program for transportation can be created. In particular, inducement prizes in transportation can be designed specifically to foster speeding implementation of innovations to practice.

Cash prizes awarded by public-sector transportation organizations must be backed by legal authority. Precedence for awarding cash prizes is contained in the current transportation act, Moving Ahead for Progress in the 21st Century Act (MAP-21). The FHWA summary of the act's highway provision states, "MAP-21 provides new authority for the Secretary to use up to one percent of funds authorized for research and education for a program to competitively award cash prizes to stimulate innovation that has the potential for application to the national transportation system." An inducement prize for fostering acceleration of research results and innovations to practice may be an excellent candidate for a prize program.

Other members of the transportation community can also consider promoting inducement prizes. Private-sector organizations may have a less complex process to create a prize program without the requirements of public-sector authority requirements. Moreover, the private sector can collaborate to create programs using professional and trade associations, such as ASCE's T&DI. In addition to nationwide programs, more narrowly scoped innovation inducement prize programs can be fostered that address a geographic/regional area, a specific technical topic, or a single organization.

A credible sponsor is required with the financial resources and expertise to develop and manage the program. In particular the prize sponsor must have the technical resources available, from within or from the transportation community, to determine the viability of contending prize proposals.

Evidence-Based Practice Scholars Program and Training for Implementation

Training and educational focus are integral elements in the medical community culture. When the Menninger Clinic moved to evidence-based practice, a scholars program met the needs to quickly and effectively forward new policy implementation. Work to develop the program was necessary, but the acceptance of education as important assisted the implementation. Likewise in transportation, educational and training programs are a well-respected tool to increase organizational capacity—transportation organizations endorse the value of creating more knowledgeable and capable employees. Given the support for training, it would seem like an easy transfer of these types of knowledge-building tools to be effective in and attractive to transportation organizations. However, many transportation organizations have little funding or expertise to commit to training for skills to do tasks considered non–mission critical or collateral to primary responsibilities. Furthermore, creating a scholars program or implementation training curricula most likely only will be considered a priority within organizations that have or are seeking a culture supporting innovation. Because of these organizational constraints, scholars programs and training for implementation have high use potential in some organizations—those fostering innovative processes and cultures—and will have little or no relevance to others—those not yet recognizing the value in building professional capacity to affect the speed of implementation activities. Even so, the perception of the need to build knowledge and skills for implementation is growing among public transportation organizations, as evidenced by more implementation positions being created in state DOT research management units over the past 5 years or more.

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Evidence-Based Practice Scholars Program	• Research Program Managers • Implementation Staff • Program/ Operations Units	High potential for use; scholars work to solve pressing problems in their own environment; produces evidence-based results that are implemented; promotes culture change.	Program conducted in user/ practitioner environment similar to transportation experience; program goals and objectives fill similar need occurring in transportation.	Leadership endorsement within an organization; expertise, funding, and operational sites; program development, scholar and project identification and selection.
Training for Implementation	• Research Program Managers • Implementation Staff • Program/ Operations Units	For organizations seeking change to more innovative culture and operations, high potential for use; for those not yet aware of value of implementation expertise, less interest.	Training is more effective when part of overall systematic, multifaceted approach to implementation (e.g., policy, process documentation, receptive organizational culture).	Desirable to have mature implementation infrastructure in which training supports goals and objectives of accelerating use of innovations; requires curricula and course development, trainers, and funding to support activity.

Currently, the highway community has nothing similar to the EBP program discussed earlier, which focuses on enhancing skills leading to accelerating the potential for implementing innovations. The value to the highway community is that these training activities not only provide skills and knowledge enhancements, but they spur implementation of a specific project of importance to the organization. Professional capacity is built through project-specific work that also contributes significant accomplishments in assigned responsibilities.

In the fall of 2012, the Transportation Research Board announced a new effort titled, "Ahead of the Curve, Mastering the Management of Transportation Research and Innovation." This initiative is a scholars/training program designed to enhance research and innovation management skills, raise the stature of transportation research and innovation managers, and ensure high-quality research programs contribute to meeting transportation goals (Norman 2012). The initiative is in the scoping stage, and basic implementation practices are a likely candidate for a course of study.

Other than the TRB initiative, in order to further enhance skills, courses to create acceleration of implementation and thus speed innovations to practice must be developed. Excellent instructors and supportive services for problem solving—for example, technical assistance—also must be part of program development. Nationwide programs or programs for a single organization can be created. If nationwide, a credible transportation community leader organization would be appropriate to take on the role of championing scholars programs or training for implementation. However, a national program is not always necessary. An individual organization can contribute to speeding the use of research results and innovations by developing its own professional capacity through education and training.

Partnerships with the private sector are an avenue that could reap significant benefits for highway training venues. For example, the highway construction industry could be a partner that provides skills-building expertise as well as enhances competencies for more rapid and effective materials use.

It is important to add that feedback from training programs discussed in this synthesis note that sole training courses to increase application of innovations to practice is not sufficient as an implementation accelerator. A systematic approach building an implementation infrastructure including policy, guidance, training, mentoring, and more were necessary to fully change practice and create a new standard of operation.

Organizational Implementation Policy

A clear policy that fosters a culture and creates the operational environment to encourage and support implementation practice is an important step for any organization. Organizations such as DOE, mentioned earlier in this synthesis, benefit by having workable guidance and goals for technology transfer and application to practice of innovation. With clear policy, the whole of the organization can work toward the expressed goals. Developing policy for organizational processes is common in transportation organizations. Writing an implementation policy to speed the adoption and application of innovations is a task that can be done, given expertise to craft the language.

Strategy	Potential Users	Potential for Use	Ease of Transferability	Resources to Support Transfer
Organizational Implementation Policy	• Sponsors and Stakeholders • Research Program Managers • Implementation Staff • Program and Field Units • Private Sector Technology and Innovation Firms • Academic Technology Offices	Policy guides and formalized operational practice; organizations willing to change practice and culture to accelerate innovation will readily consider effective policy.	Writing policy is a known activity—can be done; commitment to substantive content and executing the policy takes champions, leadership, and culture change; primarily a top-down process.	Organizational leadership to create a culture that endorses, encourages, and provides resources for implementation is critical.

However, putting the policy into practice is a more challenging task. The potential for use of an implementation policy and the ability to have this policy become standard operating practice relies heavily on the organizational leadership, as also seen within DOE (U.S. DOE 2011). If leadership fully supports, champions, and encourages the intent as well as the stated content of the policy, there is a substantially greater potential for successful use of the policy. Creating and following a well-designed policy will affect the culture of the organization—enabling strategies for accelerating implementation of research results and other innovations to be a more readily accepted occurrence. Furthermore, leadership also has a role in ensuring that the culture of the organization is accepting of the processes required to foster and accelerate implementation, including providing the freedom to fail when a well-researched, well-planned process or viable innovation does not realize the anticipated benefits.

Organizations with a mature infrastructure for implementation that is not formalized by a stated policy can benefit by a more serious treatment of their implementation process. Creating implementation policy brings into concert the operational practice with leadership's endorsement and guidance.

Research Transition Teams

Strategy	Potential Users	Potential for Use	Ease of Transfer-ability	Resources to Support Transfer
Research Transition Teams	• Sponsors and Stakeholders • Research Program Managers • Implementation Staff • Program/ Operations Units • Private Sector Technology and Innovation Firms • Academic Technology Offices	High potential for use when two or more organizations are involved with creating the research result and applying the result into practice; useful for large and complex research project results that require significant change in practice.	Requires collaboration between organizations and recognition of the need for spanning the gap that exists between researcher and user.	Participating organizations to assign well-qualified experts for team composition; RTT members must have authority to overcome implementation barriers and expertise to contribute innovative solutions; funding to support the activities of the RTT.

Research Transition Teams, used by the National Weather Service or NASA-FAA, demonstrate a strategy for collaboration, communication, and fostering implementation effectiveness between the research sponsor and the practitioner organization that will apply the innovation. The objective of RTTs is to have available to the implementation work a team of experts that has authority and capability to overcome challenges or barriers traditionally encountered when implementing a research result or innovation that was created or developed by one organization and that is to be applied within another organization. This situation often occurs in the transportation community; a research organization conducts the research and the products of the research are applied in a research sponsor organization. The two organizations are often an academic or private-sector research partner and a government agency but also can be two different organizations within one larger entity.

RTT members are highly skilled and knowledgeable about the anticipated deliverables, the fiscal, legal, and other aspects of the research result, and the user environment. Additionally, the team is comprised of members from all organizations participating in the research as well as the implementation and use of the innovation. RTTs in transportation can serve as an oversight group to plan and evaluate the implementation progress and its effectiveness, to be a collaborative resource for overcoming implementation barriers, and to be a voice to champion the application of the innovation to practice. Importantly team members must have the authority from their respective organizations to provide effective and efficient solutions to span the gap that exists between researcher and user. This type of collaborative working group can be particularly effective for implementation of research results that require significant change in operational practice and creating cultural change.

Not all the strategies discussed in this document are entirely new to transportation research and technology managers. As noted, a number of the strategies are already being used to some degree by transportation research managers and those performing implementation of research results. For example, a few state departments of transportation currently have an implementation procedures manual. However, the advantage that DoD or USDA has is a long track record of experience and a mature infrastructure that ensures sustainable activities.

In summary, replicating what others outside the highway transportation community are now accomplishing may be difficult for some transportation organizations, and for others a matter of building on an existing foundation. A number of programs and organizations in the highway community are already addressing some of the concepts and strategies presented herein. For example, the FHWA Highways for Life program is approaching implementation with a systematic perspective that combines highway technical and implementation expertise with some degree of implementation funding integrated into unique teams that accomplish implementation. SHRP2 is building implementation effectiveness through its commitment to well-designed processes for application to practice. Some state department of transportation programs are focusing on implementation of research results and committing to creating cultures in which to foster accelerating innovation. Additionally, the Local/Tribal Technical Assistance Program has been operating for nearly 30 years and has had the opportunity to develop a solid infrastructure that helps sustain value for technology transfer and implementation-related activities.

These programs and other programs and practices examined in this study have personnel, fiscal, operational, leadership, and cultural costs associated with their success. Likewise, any transportation organization's efforts aimed at accelerating implementation will incur costs of the activities. There is a very clear trade-off. Achieving greater and faster change in practice resulting from implementing research results and other innovations requires commitment to change and the ability to adequately support and resource that change.

CHAPTER FIVE

CONCLUSIONS AND OBSERVATIONS FOR GOING FORWARD

This chapter provides a summary of the key findings of the synthesis project, including considerations for how the material in the report can be used to accelerate implementation of research results within the transportation community.

SUMMARY OF CURRENT STATE OF PRACTICE

In general, those outside the transportation domain, such as federal government agencies—for example, U.S. Department of Agriculture, U.S. Department of Defense, National Institutes of Health, Food and Drug Administration, U.S. Citizen and Immigration Service—are further advanced in the process of implementing research results than is the transportation community. In addition, the private sector and academic commercialization offices are aggressively seeking improvements in implementation strategies to meet market challenges. These for-profit organizations are using the adoption of innovation as a primary tool for competitive advantage. However, many in these contexts, whether public or private, domestic or international, regularly confess that their organization is not performing well enough in this area and that more must be done. The overarching perspective is one of striving for greater effectiveness and efficiencies to yield greater benefits from implementation of the results of research.

Although more could be done, even by those organizations experiencing success in this area, there are practices identified in this study that could be transferred to the highway transportation community, especially for those in the public sector. The strategies and practices discussed in this synthesis for the most part can be applied effectively to transportation settings. As discussed in chapter four, however, the application of those strategies and methods may present challenges to some in the public-sector transportation community, because of the extent of change required, the leadership necessary to promote change, and the resources to accomplish those changes. It is certainly more difficult to change an organization's strategic approach and its priorities for resource utilization and to incorporate these changes into the operations, than it is to institute tactical changes to existing operations.

The literature and interviews revealed that organizations outside the transportation sector apply many of the same tactics for applying research results to practice as do those working to implement transportation research results and innovations. There is a significant difference between other organizations studied and the transportation context when examining the strategic perspectives, expertise and financial resources committed, and the willingness of the organization to create a structure to accommodate implementation activities.

The extent and maturity of the infrastructure supporting implementation is a significant factor in realizing benefits of research by these organizations and their partners. Many organizations reviewed for this synthesis have well-defined and documented processes and have solid longer-term approaches such as partnership intermediaries, transition teams, and other strategies that add people-intensive expertise to the structure to close the gap that slows or prevents implementation success. All have defined and provided financial support to carry out implementation work and accomplish this through organizational structures to accommodate the work necessary to remove or lessen the gap between research results and their use. The organizations also have created a culture of pushing forward the innovation to the marketplace or to the user and consider the application of the innovation an integrated element of the research activities.

Clear Trade-Off

There is a very clear trade-off. To achieve greater and faster change in practice resulting from implementing research results and other innovations requires commitment to change and the ability to adequately support and resource that change.

The transportation community is experiencing ad hoc commitment to implementation and is receiving varying degrees of success. Some programs are making progress in accelerating or sustaining implementation success. The Strategic Highway Research Program 2 is building a foundation for strong and faster implementation to practice. The FHWA Highways for Life program is achieving acceleration of implementation, compared with traditional processes, through its strong priority for and its commitment to resourcing implementation. The Local/Tribal Technical Assistance Program continues also to foster transfer of technology to transportation practitioners. Yet many other programs are still struggling to increase the rate at which their organization applies research results and innovations. As with organizations examined in this synthesis, there are strategies that can be used to increase the likelihood of realizing the benefits and speeding the practical application of research results and innovations.

KEY FACTORS THAT CAN ACCELERATE THE TIMING OR EASE IMPLEMENTATION OF SUCCESS

Key factors affect implementation of research results within an organization. Each of these factors has a role for advancing implementation and accelerating the implementation of research results. They are all applicable in the transportation context. The factors identified and discussed are as follows.

No one activity in the examined broad array of implementation processes stands out as being the ultimate solution—the must-do action—to accelerate implementation of research results. Rather it is generally a combination of approaches and strategies that foster success and speed the implementing organization's realization of benefits. Using more strategies to produce greater acceptance and using innovations are considered more beneficial than using only a few strategies. Additionally, few, if any, organizations experiencing success in speeding research results to practice can definitively identify what specific strategy or process is attributable to that success, or the amount of acceleration experienced. Furthermore, many organizations, while successful at increasing implementation over time, consider any added strategies as beneficial to increasing the rate of implementation.

Contexts vary for accelerating the application of research results. Public-sector, academic, and private-sector organizations are different frameworks in which application to practice is generated or occurs. Timing, resources, and other external factors vary, yet many of the processes used are applicable across the various contexts.

Resource availability and implementation infrastructure maturity are critical factors that foster and speed implementation success. Organizational resources of adequate funding, expertise—both technical and of implementation professionals—and time to accomplish the implementation are essential. Furthermore, organizations that have mature infrastructures—processes, organizational structure, and cultures that create acceptance of change in practice—continue to show success in being able to effectively and efficiently apply research results.

Incentives to do a more effective job of implementation often work to foster and speed application of research results. Recognition of the results and benefits of change in practice are useful means to bring attention to the process of implementation and to encourage more implementation activity.

Although many processes benefit from using well-crafted effectiveness measures, few, if any, measurement systems for speeding implementation were found in the literature.

All of the implementation strategies examined in this synthesis point toward accelerating implementation of research findings in one way or another. As a given, the goal of any implementation action is to get the research into practice—always pushing time constraints. Because of the variability of each implementation effort and the complex processes used for implementation of research results, there was no attempt made to rank the efficacy of individual strategies. Across all contexts or industries it was not possible to determine which strategies used had the highest impact on implementation success, but it was possible to identify practices that might be of benefit to the transportation community.

SUMMARY OF CASE EXAMPLES AND PRACTICE DESCRIPTIONS

Implementation case examples and practice descriptions included in this chapter are:

- Network of Implementation Experts—National Implementation Research Network (NIRN)—An example of the types of resources available for implementation assistance within the medical clinical community. The mission of NIRN is to close the gap between science and service by improving the science and practice of implementation in relation to evidence-based programs and practices.
- Global Implementation Conference—Hosting such a conference shows the value of creating a unique venue to encourage advancement of the science and practice of implementation. Such venues promote sharing of best practices, provide education and training for the implementation sciences, and foster research to advance practice.
- Manufacturing Extension Partnerships (MEP), National Institutes of Standards and Technology (NIST)—MEP shows a significant commitment by the federal government to nurture and foster innovation, and particularly to accelerate the application of technology in manufacturing through strong partnership activity. This example shows a structure that creates partnerships that foster the development of products available to private-sector business through technology acceleration support, and examples of a framework to provide technical support to organizations seeking to accelerate the use of technology to advance practice.

- Research Project Synopses, Joint Fire Science Program (JFSP)—This discussion shows the benefit JFSP received as it created and now uses research project synopses and manager opinion articles to convey critical research findings to busy program and senior managers within the forest fire safety community.
- Partnership Intermediaries—Resources Committed to Implementation Processes—Partnership Intermediary Agreements (PIAs) allow research programs to add targeted expertise to the job of implementation through specific partnership arrangements. PIAs were created through legislation for use by federal laboratories and can serve as a model for agreements by others not in the federal laboratory community.
- Well-Defined and Documented Implementation Processes—Manager's Guide, Desk Reference, Policies and Procedures, and Implementation Guide—Various agencies are excellent examples of how implementation processes can be documented in a practical and rational fashion.
- Research, Document, and Share Successful Implementation Strategies—Accelerating Innovation at Hewlett-Packard—This discussion shows the process used by a private-sector organization to speed its products to market. It shows the importance of considering the technology characteristics, the newness of the market, the degree of innovation represented, as well as the necessity to benefit from lessons learned and the importance of directly addressing innovation barriers and enablers.
- Technology Readiness Levels (TRLs)—TRLs are a standard readiness scale used to determine the maturity of a technology or innovation. This scale helps an organization consider innovations and research results application through a systematic process that advances with the level of readiness. The process fosters acceleration of implementation by addressing problems and finding solutions to prevent downstream delays.
- Entrepreneur-in-Residence Programs—The Entrepreneur-in-Residence Program is an initiative that aims to commercialize viable technologies by placing venture capital firms or those with funding in a position to work directly with academic partners or others developing innovations. This program models how the addition of entrepreneurial talent, with the purpose of creating a market or using a research finding, can make a significant impact on the speed of application to practice.
- Innovation Inducement Prizes—These are designed to attain scientific and technical goals not yet reached, to encourage fostering of innovation, and particularly to create motivation to excel in implementation best practices.
- Evidence-Based Practice Scholars Program—This program is an example of how the medical clinical community highlighted the importance of developing expertise in implementation science to increase the likelihood and speed of the application of proven research results to practice.
- Training for Implementation—Coupled with other strategies such as a strong implementation infrastructure, this discussion shows the advantages of building capacity in the organization to sufficiently address the tasks of implementation.
- Organizational Implementation Policy—This practice description discusses the need for and benefits of developing a workable organizational policy that clearly articulates the vision and goals for implementation of research results to benefit operational practice. The discussion provides an example policy created by the National Weather Service.
- Research Transition Teams (RTTs)—RTTs are formalized teams created to facilitate rapid transition from research to application of results in the operational setting. The teams are comprised of research and technical experts as well as implementation experts and address technical, organizational, administrative, and other barriers or enablers that may affect the ability to implement the project's research results.

OBSERVATIONS FOR GOING FORWARD

Based on the work of organizations examined in the course of this study, there are a number of observations that may apply to transportation contexts.

The transportation community will benefit through building an implementation infrastructure for transportation. For significant progress in accelerating the implementation of research findings, state department of transportation (DOT) programs and other public-sector research efforts will be able to move from ad hoc implementation activities to a systematic approach. With a systematic approach, there is greater likelihood of creating value through streamlining and expediting future implementation efforts.

In building the implementation infrastructure for transportation, it will be necessary for the transportation community to get experienced talent to perform the implementation. This may be accomplished by bringing such expertise into transportation, and by building capacity within organizations. Organizations studied in this project added implementation expertise to the ranks of assigned scientists and project administrators to accomplish effective and expeditious implementation. One area that has not been investigated is which organizational structure is most effective or which elements of the infrastructure would produce the most positive result to spur use of research results. Further work in this area could produce guidance for research sponsors such as DOTs to better accomplish implementation tasks.

A significant aspect of other domains is the amount of research being done on the science and practice of implementation. The literature has many accounts of successful implementation experiences in, for example, the medical, defense, and agriculture fields. Even in the private sector, where detailed implementation strategies are not publicly available, stories of success abound and analysis of the success is often the subject of business school case studies and research management journal articles. There is not a critical mass of such implementation success stories available to the broad transportation community. It will be beneficial for the transportation community to have research findings and best implementation practice materials available as do these other domains. Furthermore, many of the success stories are written in language that will not intimidate decision makers. In business applications for adopting change, Kanter (2006) writes, "To establish the foundation for successful reception of an innovation, groups must be able to present the radical so it can be understood in familiar terms and to cushion disruptive innovations with assurances that the disruption will be manageable."

Many of the strategies and practices described as accelerators of implementation in other domains require development of tactical tools to be effective for implementation of transportation research results and innovations. Some of these tactical tools are model policies, contracts and agreements, boundary-spanning activity guidance, reference guides, and evaluation procedures. If such tools were made available, the strategies for speeding innovations to practice could be implemented with greater confidence and more quickly.

Similar to developing tactical tools for administrative processes is the need for development of comprehensive and in-depth training programs and curricula to better equip those responsible for implementing research results and innovations. A variety of levels and types of training can be useful, from gaining general knowledge regarding implementation practices to hands-on project-oriented implementation pilots that show the potential for and begin organizational change.

In addition to training and educational opportunities to build capacity for implementation practice, there is no definitive resource for the practice of transportation implementation. Creating a transportation center of excellence, having associated with it the best expertise, best practice guidance for the conduct of implementation, and an existing knowledge base, would be useful to promote more effective use of research results.

Investigating risk associated with the implementation of transportation research results is a topic that could produce valuable findings for the transportation community. There is little in the literature that provides guidance to sponsors of transportation research on assessing the legal and financial exposure of implementing an innovation, comparative costs of various solutions, or future threats and impacts.

A question that has yet to be given a definitive answer for the transportation research community is, "How is research implementation success measured?" Considerable work has been done to equip research managers with guidance to develop research performance measures. Certainly a measure of research performance is the effectiveness or success of the implementation effort. More work in this area that would produce qualitative and particularly quantitative measurement for implementation success would be welcome.

In summary, there are effective strategies being used by other domains that can increase the potential for accelerating the adoption of research results in transportation. Many of the tactics being used by other domains are also used, to some degree, within the transportation community. However, the overall strategy of developing a systematic approach to implementation that includes a sustainable infrastructure of experienced talent and sufficient resources operating in an organizational setting that places a priority on implementation will be the approach that can make a significant impact. Such an integrated approach will enable greater opportunity to realize benefits from research and to accelerate the use of research results and innovations in transportation practice.

REFERENCES

Aagaard-Hansen, J. and A. Olsen, "Research into Practice: A Comprehensive Approach," *Development in Practice*, Vol. 19, No. 3, 2009, pp. 381–385.

AASHTO Standing Committee on Research, Research Advisory Committee, "Research Makes the Difference 2009: State DOTs, Transportation Innovations," AASHTO, Washington, D.C. [Online]. Available: http://research.transportation.org/Documents/Task%20Forces/Value%20of%20Research%20Task%20Force/NCHRPBrochureWEB2009.pdf [accessed May 8, 2013].

AASHTO Transportation TV, "Innovation in Motion, Utah DOT's I-15 Core Project," AASHTO, Washington, D.C., updated Jan. 2011 [Online]. Available: http://www.transportationtv.org/Pages/default.aspx?VideoId=231 [accessed Apr. 30, 2013].

AIR, "New NSF Investment to Accelerate Innovation Research, National Science Foundation," Washington, D.C., July 26, 2011 [Online]. Available: http://www.nsf.gov/news/news_summ.jsp?cntn_id=121182&WT.mc_id=USNSF_56&WT.mc_ev=click [accessed Apr. 30, 2013].

ATIP-ARS, "A Plain Language Overview: The ARS Agricultural Technology Innovation Partnership Program," Jan. 9, 2010 [Online]. Available: http://www.edacademy.org/wp-content/uploads/2010/11/Plain%20Language%20Overview%20of%20Agricultural%20Technology%20Innovation%20Partnership%20_ATIP_%20Program%20of%20ARS%20ver01%2009.pdf [accessed Apr. 29, 2013].

Barbour, J., "Accelerating Adoption of Fire Science and Related Research," Joint Fire Science Program, Project # 05-S-07, 2007 [Online]. Available: http://www.firescience.gov/projects/05-S-07/project/05-S-07_final_report.pdf [accessed Oct. 15, 2011].

Bikson, T.K., S.A. Law, M. Markovich, and B.T. Harder, *NCHRP Report 382*: *Facilitating the Implementation of Research Findings: A Summary Report,* Transportation Research Board, National Research Council, Washington, D.C., 1996, 24 pp.

Blaustein, R.S., "A New Role for Technology Transfer?" *Innovation*, Dec. 2010/Jan. 2011 [Online]. Available: http://www.innovation-america.org/new-role-technology-transfer [accessed Apr. 30, 2013].

Bonini, M., B. Fields, R. Vance, B. Harder, M. Treisbach, and L. Bankert, "How to Build a System to Implement Research and Innovation: Lessons Learned in Pennsylvania," *Transportation Research Record: Journal of the Transportation Research Board, No. 2211*, Transportation Research Board of the National Academies, Washington, D.C., 2011.

Brunt, L., J. Learner, and T. Nicolas, "Inducement Prizes and Innovation," Harvard Business School Working Paper 11-118, Dec. 5, 2011 [Online]. Available: http://www.hbs.edu/research/pdf/11-118.pdf [accessed Apr. 29, 2013].

Burke, J., *NCHRP Synthesis 113: Administration of Research, Development, and Implementation Activities in Highway Agencies*, Transportation Research Board of the National Academies, Washington, D.C., 1984, 49 pp.

California Department of Transportation (California DOT), "Implementing Research Results, Characteristics of Organizations and Skill Sets of Individuals Successful at Accelerating Adoption of Innovation," Peer Exchange Report, Mar. 16–18, 2011 [Online]. Available: http://www.dot.ca.gov/newtech/docs/finalreport_2010_peer_exchange.pdf [accessed Apr. 30, 2013].

Carpenter, D., V. Nieva, T. Albaghal, and J. Sorra, *Development of a Planning Tool to Guide Research Dissemination, Advances in Patient Safety: From Research to Implementation*, Vol. 4, Agency for Healthcare and Research Quality, Rockville, Md., 2005, p. 83–91 [Online]. Available: http://www.ahrq.gov/professionals/quality-patient-safety/patient-safety-resources/resources/advances-in-patient-safety/vol4/Carpenter.pdf [accessed Apr. 30, 2013].

Canez, L., L. Puig, R. Quintero, and M. Garfias, "Linking Technology Acquisition to a Gated NPD Process," *Research-Technology Management*, Vol. 50, No. 4, 2007, pp. 49–55.

Center for Devices and Radiological Health (CDRH), Entrepreneur in Residence Program, U.S. Food and Drug Administration, U.S. Department of Health and Human Services, Washington, D.C., n.d. [Online]. Available: http://www.fda.gov/AboutFDA/CentersOffices/OfficeofMedicalProductsandTobacco/CDRH/CDRHInnovation/InnovationPathway/ucm286138.htm [accessed May 8, 2013].

Committee on the Design of an NSF *Innovation Prize, Innovation Inducement Prizes at the National Science Foundation*, National Academies Press, Washington, D.C., 2007.

DARPA Robotics Challenge, 2013–2014 [Online]. Available: http://theroboticschallenge.org/aboutprogram.aspx [accessed May 10, 2013].

Dell, Entrepreneur in Residence, n.d. [Online]. Available: http://en.community.dell.com/dell-blogs/direct2dell/b/

direct2dell/archive/2011/09/08/dell-announces-first-entrepreneur-in-residence.aspx and http://eir.dell.com/about/eir/ [accessed Apr. 30, 2013].

Desouza, K., C. Dombrowski, Y. Awazu, P. Baloh, S. Papagari, S. Jha, and J. Kim, "Crafting Organizational Innovation Processes," *Innovation: Management, Policy & Practice*, Vol. 11, No. 1, Apr. 2009, pp. 6–33.

EDC (Every Day Counts), Federal Highway Administration, Washington, D.C., n.d. [Online]. Available: http://www.fhwa.dot.gov/everydaycounts/about/ [accessed Oct. 23, 2012].

Federal Laboratory Consortium for Technology Transfer (FLC), Annual Report to Congress, 2008 [Online]. Available: http://www.federallabs.org/pdf/2008_FLC_Annual_Report.pdf [accessed Oct. 15, 2011].

Federal Laboratory Consortium for Technology Transfer (FLC), 2011 Annual Report to the President and Congress, 2011a [Online]. Available: http://www.federallabs.org/pdf/2011_Annual-Report.pdf [accessed Apr. 26, 2013].

Federal Laboratory Consortium for Technology Transfer (FLC), *FLC Technology Transfer Desk Reference: A Comprehensive Introduction to Technology Transfer*, FLC, Cherry Hill, N.J., 2011b [Online]. Available: http://www.federallabs.org/pdf/T2_Desk_Reference.pdf [accessed Apr. 30, 2013].

Federal Laboratory Consortium for Technology Transfer (FLC), The Green Book, Federal Technology Transfer Legislation and Policy, Fifth Edition, 2013. [Online]. Available http://globals.federallabs.org/pdf/FLC_Legislation_and_Policy.pdf [accessed May 16, 2014].

Federal Technology Transfer Act of 1986, P.L. 99-502 [Online]. Available: http://history.nih.gov/research/downloads/PL99-502.pdf [accessed Oct. 15, 2011].

Fixsen, D., S. Naoom, K. Blase, R. Friedman, and F. Wallace, "Implementation Research: A Synthesis of the Literature," University of South Florida, Tampa, 2005.

Fixsen, D., P. Panzano, S. Naoom, and K. Blase, "Measures of Implementation Components of the National Implementation Research Network Frameworks," National Implementation Research Network, Chapel Hill, N.C., 2008.

Global Implementation Conference, Washington, D.C., Aug. 2011 [Online]. Available: http://www.implementation-conference.org/ [accessed May 9, 2013].

Grol, R. and R. Jones, "Twenty Years of Implementation Research," *Family Practice*, Vol. 17, Suppl. 1, 2000, pp. S32–S35.

Harder, B.T., "Overcoming Barriers That Inhibit the Adoption of Proprietary Products," working paper, Research & Technology Coordinating Committee, Transportation Research Board of the National Academies, Washington D.C., Feb. 2010.

Hood, M., S. Thompson, R. Vance, M. Renz, B. Harder, J. Toole, and S. Hunter, "Development of a Guide for Transportation Technology Transfer," Technical Memorandum #1, Transportation Research Board of the National Academies, Washington D.C., Nov. 2012.

Innovation, "DOE's Chu on Tech Transfer," June/July 2011 [Online]. Available: http://www.innovation-america.org/does-chu-tech-transfer [accessed Apr. 26, 2013].

JFSP (Joint Fire Science Program), Fire Science Brief and Manager's Viewpoint, "ArcFuels: Integrating Wildfire Models and Risk Analysis into Landscape Fuels Management," Issue 43, Feb. 2009 [Online]. Available: http://www.firescience.gov/projects/briefs/03-4-1-04_FSBrief43.pdf [accessed Apr. 19, 2013].

JFSP Investment Strategy, May 31, 2011 [Online]. Available: http://www.firescience.gov/documents/JFSP_Investment_Strategy_Summary.pdf [accessed Feb. 15, 2013].

JPDO (Joint Planning and Development Office), "Flow Based Trajectory Management Research Transition Team Final Report," Washington, D.C., July 14, 2011 [Online]. Available: http://www.jpdo.gov/library/20110712_JPDO_Paper_FBTM_Result_v1.4.pdf [accessed Apr. 26, 2013].

Kalil, T., "Prizes for Technological Innovation," The Brookings Institute, Dec. 2006 [Online]. Available: http://www.brookings.edu/research/papers/2006/12/healthcare-kalil [accessed Apr. 30, 2013].

Kanter, R., "Innovation: The Classic Traps," *Harvard Business Review*, Vol. 85, No. 11, 2006, 9 pp.

Kay, L., "Managing Innovation Prizes in Government, IBM Center for the Business of Government," 2011 [Online]. Available: http://www.businessofgovernment.org/sites/default/files/Managing%20Innovation%20Prizes%20in%20Government.pdf [accessed Apr. 29, 2013].

Kilmer, R.D., "The Hollings Manufacturing Extension Partnership—The Network Effect," National Institute of Standards and Technology, Gaithersburg, Md., 2011 [Online]. Available: http://www.hawaii.edu/offices/op/innovation/kilmer.pdf [accessed Apr. 29, 2013].

Kilmer, R.D., "The Evolution of MEP: The New Strategy," National Institute of Standards and Technology, Gaithersburg, Md., Feb. 2013 [Online]. Available: http://www.nist.gov/director/vcat/upload/MEP-Program-Perspective.pdf [accessed Aug. 25, 2014].

Klein, K.J., A.B. Conn, and J.S. Sorra, "Implementing Computerized Technology: An Organizational Analysis," *Journal of Applied Psychology*, Vol. 86, 2001, pp. 811–824.

Klein, K.J. and A.P. Knight, "Innovation Implementation, Overcoming the Challenge," *Current Directions in Psychological Science*, Vol. 14, No. 5, Oct. 2005, pp. 243–246.

Klein, K. and J.S. Sorra, "The Challenge of Innovation Implementation," *Academy of Management Review*, Vol. 21, No. 4, 1996, pp. 1055–1080.

Laughlin, D., "NASA eEducation Research and Development Guide," NASA Learning Technologies, Washington, D.C., 2007.

Mahoney, J., "Evidence-based Practice and Research Scholars Programs: Supporting Excellence in Psychiatric Nursing," *Bulletin of the Menninger Clinic*, Vol. 73, No. 4, 2009, pp. 355–371.

"MAP-21, Moving Ahead for Progress in the 21st Century, A Summary of Highway Provisions," Federal Highway Administration, Washington, D.C., 2012 [Online]. Available: http://www.fhwa.dot.gov/map21/summaryinfo.cfm [accessed Apr. 29, 2013].

Mariello, A., "The Five States of Successful Innovation," *MIT Sloan Management Review*, Vol. 40, No. 3, 2007, pp. 8–9.

McAbee, W., "Every Day Counts," *Public Roads*, Vol. 75, No. 2, Jan.–Feb. 2012 [Online]. Available: http://www.fhwa.dot.gov/publications/publicroads/12janfeb/01.cfm [accessed May 10, 2013].

MEP-Client Successes, NIST Hollings Manufacturing Extension, n.d. [Online]. Available: http://ws680.nist.gov/mepmeis/SearchSS.aspx?ID=2943 [accessed Apr. 26, 2013].

Missile Defense Agency, MDA Hardware Maturity Checklists for Technology Readiness Levels, Mar. 24, 2003 [Online]. Available: http://mdatechnology.net/pdf/trl_checklist.pdf [accessed Apr. 30, 2013].

Moughon, L., "How Tech Transfer Is Supposed to Work," *Innovation*, June/July 2011 [Online]. Available: http://www.innovation-america.org/how-tech-transfer-supposed-work [accessed Apr. 29, 2013].

NIRN (National Implementation Research Network), home page, 2011 [Online] Available: http://nirn.fpg.unc.edu/ [accessed Apr. 29, 2013].

NASA Aviation Systems Division News, September 20, 2012 [Online]. Available: http://www.aviationsystemsdivision.arc.nasa.gov/news/highlights/af_highlights_20120920.shtml [accessed June 18, 2014].

National Institute of Standards and Technology (NIST)–Manufacturing Extension Partnerships (MEP), Hollings Manufacturing Extension Partnership [Online]. Available: http://www.nist.gov/mep/about.cfm [accessed Apr. 29, 2013].

National Oceanic and Atmospheric Administration (NOAA), Policy on Transition of Research to Application, issued July 31, 2008, NOAA, Washington, D.C. [Online]. Available: http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_216/216-105.pdf [accessed Apr. 29, 2013].

National Weather Service Policy Directive 80-8, "Transition of Innovation and Research to Operations," Silver Spring, Md., Mar. 29, 2010 [Online]. Available: http://www.nws.noaa.gov/directives/080/pd08008a.pdf [accessed Apr. 30, 2013].

Newman, J., "Building a Creative High-Performance R&D Culture," *Research-Technology Management*, Vol. 52, No. 5, 2009, pp. 21–31.

New York State Energy Research & Development Authority (NYSERDA), Entrepreneur in Residence Program, n.d. [Online]. Available: http://www.nyserda.ny.gov/Energy-Innovation-and-Business-Development/Entrepreneurs-in-Residence-Program.aspx [accessed Apr. 30, 2013].

"NYSERDA Announces New Proof-of-Concept Centers at Columbia University, NYU-Poly and High Tech Rochester to Facilitate Clean-Energy Business Growth," Polytechnic Institute of New York University, Jan. 3, 2013 [Online]. Available: http://www.poly.edu/press-release/2013/01/03/nyserda-announces-new-proof-concept-centers-columbia-university-nyu-poly-an [accessed May 8, 2013].

Norman, M., "Ahead of the Curve: Mastering the Management of Transportation Research and Innovation Managers," PowerPoint presentation, Transportation Research Board of the National Academies, Washington, D.C., Fall 2012.

Ogden, T., T. Christiansen, and B. Christensen, "Large Scale Implementation of Empirically Supported Programs—Ten Years After Integrating Research, Policy, and Practice," Norwegian Center for Child Behavioral Development, Oslo, Norway, 2011.

ONR (Office of Naval Research), 2011 [Online]. Available: http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Technology-Transfer-T2/Partnership-Options/CRADA-handbook.aspx [accessed May 8, 2013].

RITT (Research and Innovation Transition Teams) Charter, National Weather Service, Silver Spring, Md. [Online]. Available: http://www.nws.noaa.gov/mdl/RITT/background/RITT_Charter.pdf [accessed Apr. 30, 2013].

Rivas, R. and D. Gobeli, "Accelerating Innovation at Hewlett-Packard," *Research-Technology Management*, Vol. 48, No. 1, 2005, pp. 32–39.

Rogers, E.M., *Diffusion of Innovations*, 5th ed., Free Press, New York, N.Y., 2003.

Rogers, E.M., "The Nature of Technology Transfer," *Science Communication*, Vol. 23, No. 3, 2002, pp. 323–341.

Rumpel, S. and J. W. Medcof, "Total Rewards: Good Fit for Tech Workers," *Research-Technology Management*, Vol. 49, No. 5, 2006, pp. 27–35.

Scardina, J., *Accomplishing NextGen Research to Implementation, Establishing NASA-FAA Research Transition Teams*, Next Generation Air Transportation System, Joint Planning and Development Office, Oct. 22, 2007 [Online]. Available: http://www.jpdo.gov/library/20071109AllHands/Research_Transition_Teams_NASA-FAA.pdf [accessed Apr. 30, 2013].

Schmitt, R.P., E.A. Beimborn, and M.J. Mullroy, *Technology Transfer Primer*, FHWA-TS-84-226, University of Wisconsin, Madison, July 1985.

Steudle, K., Second Letter Report, Committee on Implementing the Research Results of the Second Strategic Highway Research Program, Sep. 19, 2012 [Online]. http://www.trb.org/Main/Blurbs/167856.aspx [accessed Apr. 30, 2013].

Stine, D.D., "Federally Funded Innovation Inducement Prizes," Congressional Research Service, Washington, D.C., June 29, 2009 [Online]. Available: http://www.fas.org/sgp/crs/misc/R40677.pdf [accessed Apr. 30, 2013].

T2Bridge, Technology Acceleration Program [Online]. Available: http://t2bridge.com [accessed Apr. 29, 2013].

Taylor, L.K., M.D. Weist, and K. DeLoach, "Exploring the Use of the Interactive Systems Framework to Guide School Mental Health Services in Post-Disaster Contexts: Building Community Capacity for Trauma-Focused Interventions," *American Journal of Community Psychology*, 2012 [Online]. Available: http://www.springerlink.com/content/j673704073263nmt/fulltext.pdf [accessed Apr. 30, 2013].

U.S. Citizenship and Immigration Service, USCIS Entrepreneurs in Residence Initiative Summary, USCIS, May 2013 [Online]. Available: http://www.uscis.gov/USCIS/About%20Us/EIR/EntrepreneursinResidence.pdf [accessed May 8, 2013].

U.S. Department of Agriculture (USDA), "ARS, CSREES, ERS, NASS Policies and Procedures, Technology Transfer in ARS," USDA, Washington, D.C., 2000.

U.S. Department of Agriculture (USDA), *Annual Reporting on Technology Transfer, FY 2008*, USDA, Washington, D.C., 2009, 31 pp.

U.S. Department of Defense (DoD), "Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment," DoD, Defense Procurement and Acquisition Policy, Washington, D.C., 2005 [Online]. Available: http://www.dtic.mil/dtic/tr/fulltext/u2/a484102.pdf [accessed Apr. 29, 2013].

U.S. Department of Energy (U.S. DOE), "Secretarial Policy Statement on Technology Transfer at DOE Facilities," U.S. DOE, Washington, D.C., 2011 [Online]. Available: http://energy.gov/sites/prod/files/gcprod/documents/Policy_Statement_on_TT.pdf [accessed Apr. 29, 2013].

Wallace, C.E., J.A. Anderson, and E.M. Wilson, "Transportation Technology Transfer: A Primer on the State-of-the-Practice," *Transportation Research Circular 488*, Transportation Research Board, National Research Council, Washington, D.C., May 1988.

Wandersman, A., J. Duffy, P. Flaspohler, R. Noonan, K. Lubell, L. Stillman, M. Blachman, R. Dunville, and J. Saul, "Bridging the Gap Between Prevention Research and Practice: The Interactive Systems Framework for Dissemination and Implementation," *American Journal of Community Psychology*, Vol. 41, 2008, pp. 171–181.

BIBLIOGRAPHY

Case, R., "Managing Risk in Pharmaceutical R&D," *Research-Technology Management*, Vol. 52, No. 6, 2009, pp. 54–63.

"CKO Corner, Aeronautics Research Mission Directorate's Susan Minor," NASA Ask Academy, Vol. 6, No. 1, Jan. 31, 2013 [Online]. Available: http://www.nasa.gov/offices/oce/appel/ask-academy/issues/volume6/6-1_cko_corner_minor.html [accessed May 8, 2013].

Cooper, R., *Winning at New Products, Accelerating the Process from Idea to Launch*, 3rd ed., Perseus Publishing, Cambridge, Mass., 2001.

Cui, Z., C. Loch, B. Grossman, and R. He, "Outsourcing Innovation," *Research-Technology Management*, Vol. 53, No. 2, 2010, pp. 33–42.

DARPA, *Prizes for Advanced Technology Achievements: Fiscal Year 2007 Annual Report*, Jan. 2008 [Online]. Available: http://archive.darpa.mil/grandchallenge/docs/DDRE_Prize_Report_FY07.pdf.

DARPA, "Technology Transition," DARPA, 1997 [Online]. Available: http://www.darpa.mil/WorkArea/DownloadAsset.aspx?id=2477 [accessed May 9, 2013].

"Driving Technological Surprise: DARPA's Mission in a Changing World," Defense Advanced Research Projects Agency [Online]. Available: http://www.darpa.mil/WorkArea/DownloadAsset.aspx?id=2147486475 [accessed Apr. 29, 2013].

Durlak, J.A. and E.P. DuPre, "Implementation Matters: A Review of Research on the Influence of Implementation on Program Outcomes and the Factors Affecting Implementation," *American Journal of Community Psychology*, Vol. 41, 2008, pp. 327–350.

Erhun, F., P. Concalves, and J. Hopman, "The Art of Managing New Product Transitions," *MIT Sloan Management Review*, Vol. 48, No. 3, 2007, pp. 73–80.

Federal Laboratory Consortium for Technology Transfer (FLC), "Technology for Today," FLC, Washington, D.C., 2009.

Foden, J. and H. Berends, "Technology Management at Rolls-Royce," *Research-Technology Management*, Vol. 53, No. 2, 2010, pp. 33–42.

Frantz, D. and M. Bruce, Technology Commercialization Showcase, DOE Initiatives, presentation [Online]. Available: http://www1.eere.energy.gov/commercialization/pdfs/2008_initiatives.pdf [accessed Apr. 29, 2013].

Frederich, M. and P. Andrews, "Driving Innovation into the Marketplace: IBM's First-of-a-Kind Program," *Research-Technology Management*, Vol. 51, No. 6, 2008, pp. 7–12.

Gassmann, O., E. Enkel, and H. Chesborough, "The Future of Open Innovation," *R&D Management*, Vol. 40, No. 3, 2010, pp. 213–221.

Hamblin, A., "The Imperative for Research Implementation and Delivery in Australia," Center for Resource and Environmental Studies, The Australian National University, Canberra ACT [Online]. Available: http://www.regional.org.au/au/asa/2004/symposia/6/4/1324_hamblina.htm [accessed Apr. 29, 2013].

Hughes, M.E., H.V. Howlieson, G. Walejko,, N. Gupta, S. Jonas, A.T. Brenner, D. Holmes, E. Shyu, and S. Shipp, "Technology Transfer and Commercialization Landscape of the Federal Laboratories," Science and Technology Policy Institute, Washington, D.C., 2011, pp. 163.

Kapp, K., H. Ford-Latham, and W. Latham, *Integrated Learning for ERP Success, A Learning Requirements Planning Approach*, CRC Press, Boca Raton, Fla., 2001.

Lawson, C. and R. Whiteley, "Industrial Research Institute's 10th Annual R&D Leaderboard," *Research-Technology Management*, Vol. 51, No. 6, 2008, pp. 13–17.

Lilford, R., S. Pauker, D. Braunholtz, and J. Chard, "Getting Research Findings into Practice: Decision Analysis and the Implementation of Research Findings," adapted from *Getting Research Findings into Practice*, BMJ Books/International Medical Journals [Online]. Available: http://www.bmj.com/cgi/content/full/317/7155/405 [accessed Apr. 29, 2013].

Loppinen, S., J. Lammasniemi, and P. Kalliokoski, "Practical Application of a Parallel Research—Business Innovation Process to Accelerate the Deployment of Research Results," R&D Management, Vol. 40, No. 1, 2010, pp. 101–106.

Mittal, A., "Observations on the Small Business Innovation Research Program," Report GAO-05-861T, General Accounting Office Testimony Before the Subcommittee on Environment, Technology, and Standards, Committee on Science, House of Representatives, Washington, D.C., June 28, 2005, 7 pp.

NASA, Technology Readiness Levels [Online]. Available: http://esto.nasa.gov/files/TRL_definitions.pdf [accessed Apr. 30, 2013].

National Center for Technology Innovation and Center for Implementing Technology in Education, "The Assistive Technology Planner: From Research to Implementation," [Online]. Available: http://www.ldonline.org/article/12375 [accessed Apr. 29, 2013].

National Institute of Standards and Technology, *Federal Laboratory Technology Transfer, Fiscal Year 2010, Summary Report to the President and the Congress*, U.S. Department of Commerce, Washington, D.C., 2012 [Online]. Available: http://www.nist.gov/tpo/publications/upload/Fed-Lab-TT_FINAL.pdf [accessed Apr. 29, 2013].

National Materials Advisory Board and Board on Manufacturing and Engineering Design, *Accelerating Technology Transition: Bridging the Valley of Death for Materials and Processes in Defense Systems*, National Academy Press, Washington, D.C., 2004.

Nunes, S., "IBM Research: Ultimate Source for New Business," *Research-Technology Management*, Vol. 47, No. 2, 2004, pp. 20–23.

O'Connor, G., R. Hendricks, and M. Rice, "Assessing Transition Readiness for Radical Innovation," *Research-Technology Management*, Vol. 45, No. 6, 2002, pp. 50–56.

Oxman, J., "The Hidden Leverage of Human Capital," *MIT Sloan Management Review*, Vol. 43, No. 3, 2002, pp. 79–84.

Peterson, J.C., E.M. Rogers, L. Cunningham-Sabo, and S.M. Davis, "A Framework for Research Utilization Applied to Seven Case Studies," *American Journal of Preventive Medicine*, Vol. 33, No. 1, Supplement, July 2007, pp. S21–S34 [Online]. Available: http://hsc.unm.edu/som/prc/_pdfs/S21FrameworkResearchUtilAppliedeven%20Case%20studies.pdf [accessed Apr. 30, 2013].

Surry, D., and D. Ely, "Adoption, Diffusion, Implementation, and Institutionalization of Educational Technology," University of Southern Alabama, Mobile, 8 pp. [Online]. Available: http://www.southalabama.edu/coe/bset/surry/papers/adoption/chap.htm [accessed Apr. 29, 2013].

Smith, P. and D. Reinersten, *Developing Products in Half the Time, New Rules, New Tools*, 2nd Ed., John Wiley & Sons, New York, N.Y., 1998.

Stalk, G., Jr., and T. Hunt, *Competing Against Time*, Free Press, New York, N.Y., 1990.

State Science and Technology Institute, "A Resource Guide for Technology-based Economic Development: Positioning Universities as Drivers, Fostering Entrepreneurship, Increasing Access to Capital," Economic Development Administration, U.S. Department of Commerce, Washington, D.C., 2006.

Stevens, G. and K. Swogger, "Creating a Winning R&D Culture—I and II," *Research-Technology Management*, Vol. 52, Nos. 1 and 2, 2009, pp. 35–50 and 22–28.

WEBSITES

The Center for Health Dissemination and Implementation Research [Online]. Available: http://research-practice.org.

DARPA Robotics Challenge [Online]. Available: http://theroboticschallenge.org/aboutprogram.aspx.

Federal Laboratory Consortium; Intermediaries' Role in Technology Transfer and Commercialization of Federal Intellectual Property [Online]. Available: http://www.flcmidatlantic.org/intermediaries.html.

Global Implementation Conference [Online]. Available: http://www.implementationconference.org/.

Industrial Research Institute (IRI) [Online]. Available: http://www.iriinc.org/.

NASA Technology Commercialization Center [Online]. Available: http://www.teccenter.org/.

National Cooperative Highway Research Program, Project 20-93, Development of a Guide for Transportation Technology Transfer, Literature Review [Online]. Available: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3185.

National Implementation Research Network (NIRN) [Online]. Available: http://nirn.fpg.unc.edu/.

National Technology Transfer Center [Online]. Available: http://www.nttc.edu/.

National Weather Service Research and Innovation Transition Team (RITT) [Online]. Available: http://www.nws.noaa.gov/mdl/RITT/index.php.

State Science and Technology Institute [Online]. Available: http://www.ssti.org/Awards/2009.shtml.

U.S. General Services Administration [Online]. Available: http://challenge.gov. An online challenge platform administered by the U.S. General Services Administration in partnership with ChallengePost that empowers the U.S. government and the public to bring the best ideas and top talent to bear on our nation's most pressing challenges. This platform is the latest milestone in the administration's commitment to use prizes and challenges to promote innovation.

APPENDIX A

Interview Protocols

Tier 1 (Screening) Interview

Introduction:

- Project description: The study is being conducted to learn from organizations outside transportation that have developed techniques for bridging the gap between research and implementation and bringing research to market quickly. Ongoing sponsored research in the highway community could benefit from understanding and incorporating similar fast-tracking processes for high-payoff research.
- Synthesis project: State of practice report, to be used to provide insight for research program management within the highway transportation community; primarily for use by public-sector entities.
- Consultant: Barbara T. Harder, principal, B. T. Harder, Inc., Philadelphia, PA.
- Sponsors: AASHTO member departments (in particular research units), in partnership with FHWA, and administered by the Transportation Research Board of the National Academies.
- Explain purpose of the call: To determine who would be the most appropriate person to discuss the organization's implementation experiences and discuss best practice examples—if the person is the one who would supply the detailed information sought, then follow the line of questioning for the Tier 2 (Detailed) Interview.
- Restate that the work is a synthesis, and that the interviewee will not be quoted; ask for permission to include the person's name and contact information in the list of interviewees that will be included in the final report.

Seek information:

- Check that the person is an appropriate first contact. Ask if the person can provide general information about the organization's research activities and results implementation processes. If not, find out who is the right first contact.
- Ask for general descriptions of the type of program, type of research, staffing, location, facilities, and extent of implementation activities and any other descriptive information about the program.
- Ask for the size of the budget for research and for implementation, if available.
- Ask if there are any barriers to include material from an interview in the synthesis.
- Get detailed contact information for person(s) most clearly responsible for management of implementation.
- Determine if there are any specific issues or items that should be pursued.
- Get an initial grasp of the types of documentation and publications, websites, and other general information that might be available.
- At conclusion of interview, express thanks: confirm the person's contact information, and that the person will not be quoted, but name and contact information will be included in the synthesis report; provide B. T. Harder, Inc., contact information (phone number, e-mail address) should the interviewee have any follow-up questions or observations.
- Send a thank you e-mail.

Tier 2 (Detailed) Interview

An e-mail was sent to the majority of tier 2 interviewees prior to conducting the interviews. This introductory e-mail established the scope and purpose of the interview, listed a few questions regarding the information sought during the time on the telephone, and confirmed the date and time for the interview. Several interviewees were available at the time of calling to schedule the interview, and e-mail correspondence was not necessary.

Introduction: (Review introductory material to the extent it is needed—much of the information was included in the e-mail sent to the tier 2 interviewees.)

- Project description: The study is being conducted to learn from organizations outside transportation that have developed techniques for bridging the gap between research and implementation and bringing research to market quickly. Ongoing sponsored research in the highway community could benefit from understanding and incorporating similar fast-tracking processes for high-payoff research.
- Synthesis project: State of practice report, to be used to provide insight for management of research programs within the highway transportation community; primarily for use by public-sector entities.

- Consultant: Barbara T. Harder, principal, B. T. Harder, Inc., Philadelphia, PA.
- Sponsors: AASHTO member departments (in particular research units), in partnership with FHWA, and administered by the Transportation Research Board of the National Academies.
- Explain purpose of the call: To seek information regarding the organizations' strategies and methods to ensure research results are applied/used in operational practice; and to identify processes that may be applicable to highway transportation practice that would cause acceleration in implementation of research results/innovations.
- Restate that the work is a synthesis, and that the interviewee will not be quoted. Ask for permission to include the person's name and contact information in the list of interviewees that will be included in the final report.

Seek information:

- Confirm that the person is the correct person to interview—confirm the person is involved with implementation of research results and can provide experience examples.
- Clarify terminology; interviewee may use different terms than "implementation."
- Identify the person's expertise, experience, and responsibilities.
- Get detailed contact information.
- Get program overview and determine the extent of implementation activities; where are the research results implemented—what are the user organizations.
- Seek to understand the organizational environment and culture in which implementation of research results are being performed.
- Ask for the top factors that positively influence the timing of implementation activities.
- Ask for the top three factors that negatively influence the timing of implementation activities (if there are more, people will give them).
- Ask what facilitates or eases the implementation process so that the process has fewer hurdles and barriers and moves more quickly.
- Seek information about what types of talent and expertise are available to perform implementation work.
- Ask for a description of a successful implementation experience and how the success factors affected the process.
- Ask for recommendations of any unique programs or processes that may be applicable to transportation.
- What documentation is there that describes the implementation processes and examples (get websites or report locations).
- At conclusion of interview, express thanks: confirm the person's contact information, and that the person will not be quoted, but that name and contact information will be included in the synthesis report; provide B. T. Harder, Inc., contact information (phone number, e-mail address) should the interviewee have any follow-up questions or observations.
- Send a thank you e-mail.

APPENDIX B

Interviewees

Grace Brill, Market Intelligence Solutions, LLC, Principal, 984 Don Manuel Street, Santa Fe, NM 87505; commercialization and marketing consulting with DOE laboratories

Dr. Lou Christodoulou, Director, Defense Sciences Office, DARPA Defense Sciences Office 3701 North Fairfax Drive, Arlington, VA 22203 (position at the time of interview)

Gary K. Jones, Washington DC Representative, Federal Laboratory Consortium for Technology Transfer, 1001 Connecticut Avenue, N.W., Suite 735, Washington DC 20036; 202-296-7201; gkjones@federallabs.org, www.federallabs.org

David Kuehn, Team Leader, Office of Corporate Research, Technology, and Innovation Management: Exploratory Advanced Research, Federal Highway Administration, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, VA 22101; 202-493-3414; david.kuehn@dot.gov

Andrew Morrow, Technology Marketing Manager, Software and Digital Assets, Office for Technology Commercialization, University of Minnesota, 1000 Westgate Drive, St. Paul, MN 55114; 612-626-7283; amorrow@umn.edu

Dr. Michael Muthig, Project Manager, Concurrent Technologies Corporation, 1233 Washington Street, Suite 1000, Columbia, SC 29201; T2Bridge, authorized U.S. Department of Defense Partnership Intermediary, Air Force Research Laboratory (position at time of interview)

Dr. Jonathan Porter, Chief Scientist, Federal Highway Administration, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, VA 22101; 202-493-3038; jonathan.porter@dot.gov; previously with the Office of the Secretary of Defense, Defense Research and Engineering; 505-989-1599

Joseph D. Tario, P.E., Senior Project Manager, NYS Energy Research & Development Authority, Transportation and Power Systems Research, 17 Columbia Circle, Albany, NY 12203; 518-862-1090 extension 3215; http://www.nyserda.org jdt@nyserda.ny.gov

Dr. Louis Tijerina, Senior Technical Specialist, Research and Advanced Engineering Laboratory, Ford Motor Company, 2101 Village Road, Dearborn, MI 48128; 313-317-9231; LTijeri1@ford.com

Dr. Roger D. van Zee, Leader, Nanoscale and Optical Metrology Group, Chemical Science and Technology Laboratory, NIST, 100 Bureau Drive, M/S 8360, Gaithersburg, MD 20899

Jeffrey J. Walaszek, Team Leader, Office of Technology Transfer and Outreach, U.S. Army Engineer Research and Development Center, Topographic Engineering Center; 703-428-6724; jeffrey.j.walaszek@usace.army.mil — more detailed discussion to follow

Abbreviations used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
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
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
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

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