Building a Foundation for Effective Technology Transfer through Integration with the Research Process

A Primer

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13. ABSTRACT (Maximum 200 words)

This primer aims to increase the effectiveness of T2 activity in transportation by describing how T2 practices can be successfully integrated into the research process to capture the potential real-world benefits of our community's research investment. This primer's agenda can be summarized as follows:

- Purpose: To help the transportation research community facilitate effective technology transfer by providing an overview of the activities that are required to transfer most kinds of research results.
- Audience: Research program directors and others at the executive level in research organizations, research project managers and their supervisors, researchers, and others in the research community.
- Scope: T2 activities centered on a particular R&D project, often defined by a single statement of work or objectives, as opposed to program-level activities that support multiple projects. The emphasis is on applied R&D, though the principles and concepts apply to basic R&D as well.

In pursuing this agenda, the primer draws heavily on three recent Transportation Research Board (TRB) publications:

- *Accelerating Implementation of Transportation Research Results*, National Cooperative Highway Research Program (NCHRP) Synthesis 461,
- *Guide to Accelerating New Technology Adoption through Directed Technology Transfer*, NCHRP Report 768, and
- *Transport Research Implementation: Application of Research Outcomes, Summary of the Second EU-U.S. Transportation Research Symposium*, TRB Conference Proceedings 51.

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1 Introduction

In the fast-changing world of research and development (R&D), it is difficult for transportation professionals to stay abreast of the most promising approaches for addressing the real-world challenges they face. Researchers often feel obliged to focus on their research field, with no time or resources to study the specific context in which their research outputs might be used. In a budgetary era where every dollar must stretch as far as possible, the lack of planning to connect research to the needs that it intends to address—technology transfer (T2)—represents a missed opportunity for more efficient leveraging of scarce resources.

Responding to this situation, this primer aims to increase the effectiveness of T2 activity in transportation by describing how T2 practices can be successfully integrated into the research process to capture the potential real-world benefits of our community's research investment. This primer's agenda can be summarized as follows:

- Purpose: To help the transportation research community facilitate effective technology transfer by providing an overview of the activities that are required to transfer most kinds of research results.
- Audience: Research program directors and others at the executive level in research organizations, research project managers and their supervisors, researchers, and others in the research community. In some situations, the "research organization" audience may be housed in the same agency as the adopter organization, as is often the case in large State DOTs.
- Scope: T2 activities centered on a particular R&D project, often defined by a single statement of work or objectives, as opposed to program-level activities that support multiple projects. The emphasis is on applied R&D, though the principles apply to basic R&D as well. Because basic R&D's outputs differ from those of applied R&D, different T2 activities will be appropriate.

In pursuing this agenda, the primer draws heavily on three recent Transportation Research Board (TRB) publications:

- *Accelerating Implementation of Transportation Research Results*, National Cooperative Highway Research Program (NCHRP) Synthesis 461 [1]
- *Guide to Accelerating New Technology Adoption through Directed Technology Transfer*, NCHRP Report 768 [2]
- *Transport Research Implementation: Application of Research Outcomes, Summary of the Second EU-U.S. Transportation Research Symposium*, TRB Conference Proceedings 51 [3].

References to the three core source documents above are provided throughout this primer to give the reader access to more detailed information and guidance on the concepts that are introduced here.

Before describing T2 activities and principles, it is important to define the terms of the discussion. (Note that these definitions are conceptually consistent with the ideas in the three source documents but are not taken verbatim from any of them.) The core terms in this primer are as follows:

- Research and Development: Any activity that aims to create or improve a technology.
- Technology: Any knowledge, process, system or other tangible or intangible thing that could be used to create benefits. Examples of technologies include a survey, a hiring process, a piece of software or "app," a traffic model, a new road construction technique or an unmanned aircraft.
- Technology Transfer (T2) Activities: All activities designed to help ensure that technologies created or improved through R&D are widely adopted for use outside or within the research-producing organization.
- Adoption: The decision to make a technology available for use in ordinary operational situations. This may or may not involve commercialization.
- Implementation Activities: Activities led by an adopter to make a technology available for ordinary operational use. These activities are generally preceded by adoption, and they often draw on research organizations for technology information and support.

T2 and R&D activities occur through the coordinated action of multiple groups. In general, their relationships are complicated and project-specific. Also, the roles they play depend on the side they come from, either the research-producing side or the adoption/implementation side. The most important groups in the process are as follows:

- Research program directors provide financial support for the R&D and help identify R&D objectives.
- Research project managers oversee the R&D on behalf of the directors.
- Researchers conduct the R&D, developing the technology.
- Stakeholders include all of the groups identified in the present list and anyone else that may be impacted by the technology's adoption, such as standards organizations, professional associations, or senior management within the research organization. (Stakeholders are discussed in more detail throughout this document and especially in Section 3.2.)
- T2 coordinators act as brokers, managing all non-R&D activities necessary for the technology to be adopted.
- Adopters make the decision to put the technology into operational use and lead implementation activities to enact that decision.
- Users (often the general public in the case of applied R&D) are able to use the technology after the T2 Process is complete and the technology is adopted and implemented.

Adopters and users may or may not be distinct, depending on the application. If the technology is a new traffic signal design, for example, then the adopters would include managers and engineers in a city highway department that installs the new signals. Users would be the drivers that interact with the signals on a day-to-day basis. On the other hand, if the technology is a new research tool such as a data analysis software package, then the researcher who decides to use it is both the adopter and user.

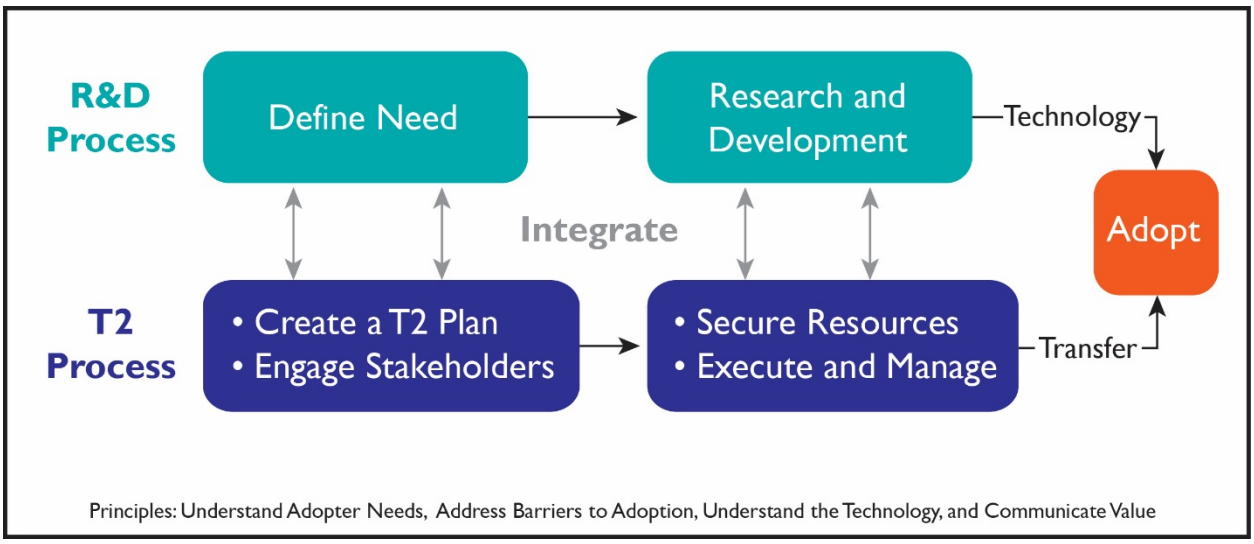


Figure 1. Integrating T2 and R&D

Figure 1 depicts two distinct but integrated processes: the R&D Process and the T2 Process. As shown, the R&D Process involves two phases.

- Define Need: A scope or statement of work is developed to establish the objectives and parameters of the R&D; any other steps to prepare to initiate the research are taken.
- Research and Development: The R&D is carried out, resulting in a new or improved technology. The R&D may be limited to what is performed by an R&D contractor according to a statement of work, or it may also include follow-on development work conducted by another organization—the research-producer, the adopter, or a third party.

The T2 Process shown in blue runs in parallel with the R&D Process. The list below is a very high-level overview of the T2 Process. The rest of this document describes it in more detail.

- Create a T2 Plan: A rough conceptual outline of needed T2 activities is developed, including aspects such as which stakeholders must be engaged. The T2 plan evolves and solidifies as stakeholders are engaged and other aspects of the preliminary plan are implemented.
- Engage Stakeholders: Stakeholders are engaged in a dialogue about what the technology must do to be successful and what role they can play in facilitating that success.
- Secure Resources: Funds and other resources and tools are identified to support and accelerate T2 activities.
- Execute and Manage: The range of activities outlined in the T2 plan are conducted and adjusted as necessary.

Unless otherwise noted, T2 activities described below should be coordinated by a formally designated T2 coordinator who draws on experts and other resources to enable and manage the T2 Process on behalf of the research organization. An effective T2 coordinator must have the following skills and qualities:

- Clear understanding of the practical issues that affect the decision to adopt a technology
- An appreciation of the R&D
- Communication skills, and in particular, familiarity with the best approaches for engaging stakeholders and building support for a technology
- Accountability for results.

T2 activities are often left to research project managers or researchers, limiting the likelihood of successful technology transfer. Recognizing the T2 coordinator role as distinct is essential to T2 success, although the role need not be filled by dedicated staff. For smaller organizations, T2 coordination may be only a (defined) part of the staff member's overall responsibilities.

Example: Coordinating T2

Like many larger State DOTs, the Virginia Department of Transportation (VDOT) funds research to meet its own operational needs and then adopts successful research results: it is both a research agency and an adopter agency. To help manage the entire process, VDOT has a full-time staffer with the job title Implementation Coordinator (IC) who handles roughly 50 R&D projects at a time. The IC works as a T2 coordinator driving the technology toward adoption on behalf of VDOT's research arm and also coordinates implementation on behalf of VDOT's adopter arm. The IC's work begins with participating in the committees that define research objectives. Once the R&D is underway, conducted by either VDOT research scientists or contractors, the IC helps in research project progress reviews. After the R&D is completed, the IC develops and executes an implementation plan with the assistance of other staff. An important aspect of the IC's work is that he **coordinates contributions from many different people in different positions to enable the T2 Process**: executive management for T2 funding and overall support and direction, research scientists for their insight into the details of the R&D, and transportation practitioners—design engineers, operations engineers, equipment managers, and others—who understand the problems to be solved [4, 5].

Section 2 describes T2 activities that T2 coordinators should arrange and manage in terms of the principles with which the activities are aligned. Section 3 describes T2 activities in terms of the steps that must be taken.

2 Principles

T2 should be integrated with each phase of the R&D Process for a given R&D project. In each phase, effective T2 aims to accomplish four critical objectives:

- Understand potential adopters' needs
- Understand how the technology being developed could meet those needs
- Address potential barriers to adoption
- Communicate the value of adopting the technology in question.

Using these objectives as guiding principles, T2 coordinators act as brokers, identifying and engaging the various stakeholder groups and facilitating a transactional dialogue between them to ensure technology adoption. The rest of this section discusses the four principles and describes how to integrate each one with the R&D Process before, during, and after an R&D project.

2.1 Understand Adopter Needs

For anyone conducting T2 activities, the primary guiding principle is to understand what a potential adopter needs. There are two aspects to this understanding: Functional Needs and Process Needs. Functional Needs are at the core of what the technology must do to solve a given problem. For example, a new traffic signal design must manage intersection traffic more safely and/or smoothly than older designs. Process Needs have to do with other issues and factors that will likely shape an adopter's decision-making process. Process Needs generally encompass institutional policies, regulations, market considerations, legal requirements, and other constraints. Continuing the example, a new traffic signal specification would be risky to adopt from a legal liability perspective, no matter how safe it is, unless it is included in the Manual of Uniform Traffic Control Devices (MUTCD). Having the signal specification included in the MUTCD is a Process Need that must be addressed to enable adoption.

In general, the two types of needs are handled differently. Functional Needs must be directly addressed by the R&D; some Process Needs can be addressed through R&D while others cannot. The Process Needs that cannot be incorporated into R&D can be considered "barriers" to adoption that must be handled by some non-R&D means. For example, liability risks associated with a new transportation technology may need to be managed through the development of legal opinions or new insurance options. Functionality can be tested during R&D; barriers to adoption cannot.

Understanding adopter needs—both Functional Needs and Process Needs—and using that understanding to help make R&D relevant and adoptable involve a range of activities throughout the R&D Process. Table 1 lists activities that may be appropriate in different phases, depending on the specific R&D project. Involving potential adopters and other stakeholders early is **very important**. That said, when the R&D project is more exploratory, with less clearly defined applications, it may not be necessary to involve potential adopters.

Table 1. Understanding Adopter Needs

Timing	T2 Activity
Before R&D	• Identify and meet with members of the adopter community, especially potential early adopters and those who are facing unique challenges that the researchers will want to understand. • Gather information on the adoption decision context while developing a R&D project plan. • Involve potential adopters in proposal evaluations.
During R&D	• Involve adopters in project reviews or R&D advisory committees to help guide the R&D's evolution [2:15]*. • Involve users in field testing, beta testing, etc., to get their input on technology development.
After R&D	• Use insights from adopters to design communication strategies for adopter community engagement.

Example: Understanding Adopter Needs

The European research effort INNOTRACK focused on decreasing railroad track-related lifecycle costs and streamlining the adoption of innovative solutions across Europe. Major rail sector stakeholders (eight European countries, more than 12 industrial partners and nine research institutions) set out to address the increasing demands on the railway in the areas of speed and axle loads; availability and reliability; and environmental and safety requirements. The project produced more than 140 reports—including analyses, processes, methods, technical standards—and other applicable innovations. One advanced track form, the Embedded Rail System, has been developed by INNOTRACK to reduce life-cycle track cost by engineering out variability through design and installation techniques. It features high productivity construction with 30% reduced construction time, reduced construction cost, reduced maintenance, and the elimination of several failure modes. This technology also facilitates automated inspection (including ultrasonic) and allows for fully automated video/geometry inspection by design. **Stakeholders participated in all phases of the project from defining the problem, conducting the research, to evaluating the answers,** which contributed to INNOTRACK's successful adoption [3:103, 6, 7]**.**

2.2 Understand the Technology

T2 activities must be customized for the technology. Because different technologies are useful to different adopters and face different barriers to adoption, fully understanding the technology is fundamental to effective T2. How does the technology perform and under what conditions? What does it require as inputs? What are its policy implications or requirements? Table 2 describes activities that will generally be useful in applying this principle. The details of appropriate T2 activities depend on the specifics of the R&D project in question.

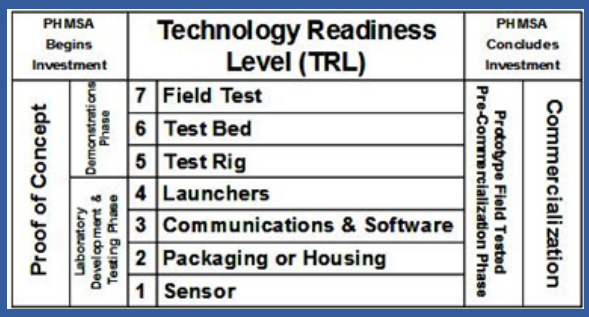
* The referencing system used here is formatted as follows: [*ref1_pub_#*:*page_#*, *ref2_pub_#*:*page_#*]. Page numbers are omitted when they are not needed.

Table 2. Understanding the Technology

Timing	T2 Activity
Before R&D	• Define clear R&D objectives and metrics for the technology being developed [3:58]. Objectives and metrics for basic and exploratory research will likely differ from those for applied research.
During R&D	• Throughout R&D, and especially as contracted R&D draws to a close, monitor the technology's performance and its practicality and feasibility in terms of system integration and compatibility [1:26], privacy, intellectual property rights, economic considerations, and standards [2:16]. This will allow initial work on identifying barriers to adoption, planning communications, and planning follow-on technology development. For example, if data requirements for an analytical technique exceed data availability at potential adopter agencies, further development may be necessary to create a less data-intensive approach. • Watch for ancillary technologies that result from the R&D, such as databases and research tools. Even though they may not have been specified in the project objectives, they may have value to others, and may warrant formal evaluations and T2 plans.
After R&D	• With the technology completed, conduct a more thorough version of the evaluation described under "During R&D" above. • Use evaluation results to enable 1) effective communication about its value and 2) action on barriers to adoption.

Example: Understanding the Technology

The Pipeline and Hazardous Materials Safety Administration (PHMSA) uses customized Technology Readiness Levels (TRLs) as a tool to manage its research portfolio. The TRL scale is a tool for assessing the maturity of a technology: How ready is a technology to fulfill its mission? A project receives a score ranging from 1 to 9, where higher numbers indicate greater technological maturity. PHMSA's implementation of the TRL scale is depicted here; note that PHMSA focuses on technologies up through TRL 7. **PHMSA primarily uses its TRL scale to help inform management decisions about developing and transitioning technologies and then demonstrating them in the field under real operating conditions.** Because the TRL scale does not address barriers to adoption including economics or regulatory acceptance, PHMSA uses it as one factor among many in its decision making [8].



2.3 Address Barriers to Adoption

As mentioned above, there may be issues not directly related to the capability of the technology that will affect whether it can be adopted. What non-technical issues would someone have to confront before choosing to adopt the technology? In general, these Process Needs have to do with the

implications of the technology in terms of policy, laws, markets, and society. The issues are typically *identified* in the course of understanding the need and the technology. This principle refers to the set of activities that *address* such barriers. Table 3 outlines general opportunities for applying the principle at different phases in the R&D Process. Specifics will depend on the details of the technology.

Table 3. Addressing Barriers to Adoption

Timing	T2 Activity
Before R&D	• Identify likely barriers to adoption and assess options for mitigation.
During R&D	• Take initial steps to mitigate barriers to adoption that arise or are confirmed as the technology evolves.
After R&D	• With a clear understanding of the technology to be adopted, address barriers to adoption, customizing the approach to particular adopters as necessary (e.g. licensing agreements to manage particular IP concerns that may depend on the adopter agency).

Example: Addressing Barriers to Adoption

Protected-permitted left-turn (PPLT) signal phasing at traffic signals has existed for many years in the U.S., but the lack of a standard display created driver confusion. Research to develop a uniform display for the PPLT that could be easily understood and would enhance safety culminated in the development, testing and recommendation of a new flashing yellow arrow (FYA) display. Adoption of this innovation was impeded largely by hesitancy on the part of potential adopters (inherently risk-averse traffic engineers) and was delayed by the six year process of approval for including the FYA display in the Manual on Uniform Traffic Control Devices (MUTCD). The concerns of the traffic engineers were addressed both through continued R&D with positive results and through collaboration with legal practitioners such as the TRB Standing Committee on Tort Liability and Risk Management to ensure risks were managed and minimized. Leadership from the FHWA was required in order to complete the approval process needed before the FYA could be included in the MUTCD. These steps removed the barriers to adoption and cleared the way for successful deployment [3:121].

2.4 Communicate Value

The need to communicate the value of the technology is the final guiding principle. It is about "closing the deal," and it is *fully* possible only when armed with an understanding of the need and the technology designed to meet it. Despite its position at the end of the principles list, though, communicating about the technology needs to happen *throughout* the R&D project, not only at the end. See Table 4 for a sample of possible communication activities appropriate for each phase of the R&D Process. In each phase, it is important to communicate via multiple channels. T2 must engage a broad range of stakeholders, and no single communication approach will reach them all [2:45, 3:91, 3:134].

Table 4. Communicating Value

Timing	T2 Activity
Before R&D	• After ensuring that the R&D will be relevant by listening to stakeholders and defining the technology objectives appropriately (see Sections 2.1 and 2.2), build support for the R&D among stakeholders who influence funding and staffing decisions. • Identify "champions," who have a particular sense of ownership in the R&D and the influence necessary to help it be successfully adopted and implemented.
During R&D	• Publish research alerts for adopters and report on progress regularly to key stakeholders, including upper management and technical leaders who will ultimately be responsible for overseeing implementation[2:45]. • Once the technology has passed all testing and is confirmed to operate effectively in real-world circumstances, conduct pilot demonstrations to show potential adopters that the technology works [2:57, 3:133].
After R&D	• Conduct showcases to demonstrate the technology's practical and economic merit to upper management and technical staff at adopter agencies, reducing the political, professional, and financial risks they face in implementing the technology [2:57, 3:133]. • Involve early adopters of the technology in peer exchanges to provide potential adopters more easily trusted third-party evidence of the technology's value. • Provide implementation guidance and training to help adopters understand how to get value from the technology, which increases their confidence in it [1:33, 2:65, 3:133]. • Track progress on implementation, collecting quantitative and qualitative information about benefits gained by users (if possible, measure before and after outcomes); communicate the results to inform other users, encourage new users, and demonstrate to T2 funders that their support is showing results.

Example: Communicating Value

The Tennessee Department of Transportation (TDOT) had interest in the Strategic Highway Research Program 2 (SHRP2) R21 project, *Composite Pavement Systems*, which focused on the design and construction of sustainable, renewable roadway surfaces. TDOT applied for assistance through the SHRP2 Implementation Assistance Program (IAP). The IAP is designed to foster sharing of experience and lessons learned between highway agencies regarding the implementation of SHRP2 products. The IAP provides funding and some implementation support and, in return, agencies such as TDOT agree to have staff participate in webinars, expert panels, or other forums where they can share their experience including the challenges, successes, and lessons learned in implementing a SHRP2 product. In this case, few roads are currently designed to utilize composite pavements because reliable guidance for designing and using these materials has been lacking. Because of SHRP2's requirement that agencies participate in efforts to communicate the value of the projects it funds, other agencies will no longer need to develop construction specifications and quality management guidelines on their own, but instead, can consider using these guidelines. **These training tools and case studies include relevant design and construction issues, and are essential to widespread adoption and use of composite pavements.** With the new guidance, models, techniques, and specifications, State and local transportation departments and other organizations can have confidence that the new composite pavement systems they install and maintain will be long lasting and have predictably low life cycle costs [9].

3 Process

The previous section emphasized understanding T2 as a *distinctive* set of activities related to brokering a transaction. In contrast, this section emphasizes that T2 activities are *similar* to other activities that can be managed with standard project management methods. Although informed and guided by the T2 principles in Section 2, the process for T2 is familiar to any project manager: make a plan, engage stakeholders, marshal other resources, execute the plan and manage the process. The following sections describe the steps and issues that the T2 coordinator should consider.

3.1 Create a T2 Plan

A T2 plan outlines the people and organizations involved in the T2 Process and the roles they play, the activities they undertake, and the desired outcomes. It describes how the principles identified above will be applied to help assure that a particular technology will be adopted. T2 plans will vary in scale and scope depending on the specific technology and other factors. They may encompass plans for certain parts of the T2 Process, such as a stakeholder engagement plan. The T2 plan may specify target market penetration rates and a comprehensive menu of approaches to reach that target, or it may be more limited [10].

Creating a T2 plan outline is the first step in the T2 Process, but the T2 plan is a living document, evolving and becoming more concrete as stakeholders are engaged and as the R&D progresses. Completing the initial plan is critically important for securing the resources to implement it. It also provides a framework for assessing T2 progress.

Putting a T2 plan together involves these steps:

1. Identify and clearly articulate the reasons for and benefits of the technology.
2. Assess the market for the technology. Who will adopt it and why?
3. Consider the barriers to adoption. Even if the technology performs the function that the adopter needs, other issues may prevent the adopter from employing it. What are those issues? How can they be managed?
4. Map out the stakeholders. Who will be affected if the technology is adopted? How could they influence the adoption process? Who might be effective partners in implementation?
5. Design a sequence of T2 activities that will engage stakeholders, mitigate barriers to adoption, and convince adopters of the technology's value.

Example: Creating a T2 Plan

Every Day Counts (EDC) is an FHWA-initiated, State-based model to identify and deploy proven yet underutilized technologies, cases where the R&D has been completed but adoption has not been achieved. EDC operates on a two-year cycle. Every two years, FHWA issues a call for proven, deployment-ready technologies. After a selection process, transportation leaders from across the country gather at regional summits to discuss challenges to adoption of each of the selected technologies. On a technology-by-technology basis, FHWA innovation deployment teams provide technical assistance to partners, developing and executing multi-faceted implementation plans. Activities in the plans include technology evaluations, case studies, informational articles, implementation workshops, and published implementation guides. FHWA staff also monitor and report on nationwide use of each EDC technology. Through three cycles of EDC, a total of 32 technologies—innovations and enhanced business processes—have been promoted. Every State transportation agency has used eight or more of the EDC technologies, and some have adopted over 20. **FHWA's success results from its comprehensive approach to implementation planning and its strong commitment to execution** [11].

3.2 Engage Stakeholders

Engaging stakeholders is essential throughout the R&D Process. A broad range of people stand to benefit from the advancement of the R&D and the adoption of the resulting technology. Partnering with them helps bring new resources into the process and also clarifies objectives and challenges.

The best way to engage different T2 stakeholders depends on the specifics of the technology and the sponsoring and adopter organizations. Table 5 summarizes the core stakeholders in a T2 Process, the people who are *most* important for a T2 coordinator to engage. For brevity's sake, some T2 stakeholders are not listed here, such as the people and organizations that influence the stakeholders in the table—the stakeholders' stakeholders.

Table 5. T2 Process Core Stakeholders

Core Stakeholder	Stakeholder Contribution to the T2 Process
Adopters (management and staff)	• Help clarify the problem that the technology must solve. • Help identify decision process/policy issues that could be barriers to adoption. • Help vet and refine strategies for communicating with the adopter community.
Early adopters	• Participate in technology demonstrations. • As a trusted 3rd party, vouch for the technology to other potential adopters.
Research directors and other upper management	• Provide resources for T2. • Advocate for the technology.
Technical experts (such as the researcher's peers)	• Provide guidance to T2 team (research director, research project manager, T2 coordinators, et al.) and/or other stakeholders.

A "champion" for the technology is a special kind of stakeholder. Champions have a sense of ownership in the technology, and are personally vested in its successful adoption. Champions often emerge from the ranks of management, on both the research-producing and the adopter side. They are most effective when they are influential within an organization and/or industry and can help secure resources or other people's support. Champions are extremely valuable for effective T2 [1, 2, 3].

Example: Engaging Stakeholders

In the 1990s, the Federal Aviation Administration (FAA) collaborated with multiple stakeholders to study how Runway Safety Area (RSA) requirements might be met at runways without sufficient area for full compliance. This collaboration resulted in a technique called an Engineered Material Arresting System (EMAS) that used crushable concrete placed at the end of runways to safely stop overrunning aircraft. The FAA had the job of transferring this technology to airport user organizations and brought stakeholder organizations on board early in the implementation of the new technology to ensure that the technical needs of the airports would be satisfied. The Port Authority of New York and New Jersey loaned one of its senior engineers to the FAA to provide customized input to facilitate the transfer of the technology. This valuable input included identifying implementation issues that were critical to the ultimate success and usability of the technology by airports. Currently, EMAS is installed at 99 runway ends at 60 airports in the US, and more are planned. There have been nine incidents where EMAS has safely stopped overrunning aircraft with a total of 243 crew and passengers aboard [2:47, 12, 13].

3.3 Secure Resources

Like any other activity, T2 requires resources, and that includes people, tools, and the funds needed to engage them. Funds to support T2 can come from the funder of the R&D, the adopter—especially when the adopter group and the R&D group reside within the same organization—and/or a third party organization with a stake in the technology's adoption. The particular source(s) depend on the details of the technology and the organizations involved. The critical point here is that, regardless of the source, T2 activities do require funding. The following actions should be considered for inclusion in any strategy to secure that funding.

- Use the T2 plan to explain the steps in the process and describe their value.
- To make the most of ongoing and planned T2 activities, identify complementary R&D projects within the R&D-producing organization (which may also be the R&D-adopting organization) that could support or leverage T2 for the R&D project at hand.
- To ensure and demonstrate that T2 funds will be used wisely, identify and plan to use existing T2 infrastructure, resources, and tools—internal experts and practices (such as newsletters and other information outlets) and external offices and organizations involved in T2.
- Work with the technology's stakeholders and look broadly to find organizations that would benefit from the technology's adoption and may be willing to support it.

Example: Securing Resources

In 2004, the Michigan DOT (MDOT) kicked off its Local Safety Initiative to assist local agencies in Michigan to reduce crashes in their communities. MDOT's goal was to transfer knowledge and resources to local agencies to build their technical capabilities and ultimately to reduce the number and severity of road crashes. Useful resources for T2 are more than financial. MDOT's creative approach was to provide resources in the form of direct engineering support, training, and several safety software tools. MDOT continues to builds partnerships with local agencies by teaching their staff how to access and analyze crash data, conduct field reviews, and determine appropriate countermeasures. MDOT also directs local agencies toward funding sources. By providing these resources as part of the transfer of safety technologies, MDOT is making progress towards reducing crashes on Michigan's roads [2:52].

3.4 Execute the Plan and Manage the Process

Executing the T2 plan involves taking the steps outlined throughout this document. Managing the T2 Process involves evaluating progress and taking corrective action when necessary, which requires defining metrics that matter for a specific project's technology. That is often challenging in T2. The difficulty may arise from the large and diverse set of stakeholders, from uncertainty about who will be the ultimate adopters of a technology or from the challenge of identifying the "tipping point"—the information or event that is the last or most influential piece leading to adoption. For example, defining market penetration as a metric for measuring success can be challenging. Not all agencies may have a need for a particular technology, and those that need it may not have the same level of need. It may be that deep and thorough adoption by one agency would be better in terms of producing on-the-ground benefits than having five agencies adopt at a more superficial level. Regardless of the challenges, attempting to evaluate progress and use the metrics to guide the process is critical to maintain focus on making an impact.

Example: Managing the Process

Infosys began as a small, successful, software company. Leaders at Infosys saw great potential in providing business services beyond software. The organization took a risk and developed Infosys Consulting, a more comprehensive approach to helping organizations solve their problems. The result was increased revenue, awards for innovation, and recognition as an innovator in the industry. Rather than applying the metrics used in their original business, Infosys leaders sought to develop adaptive metrics aimed at assessing trends and providing useful feedback to managers. Decision makers realized that novel and unique metrics were a necessary part of the development process. They did not just apply commonly used metrics from their original software business. **A keystone to their success in innovation was developing unique metrics and scorecards for their new approach to consulting.** Their metrics were fluid enough to move with changes, yet explicit enough to provide the information necessary to make additional requisite adjustments [2:80].

4 Summary and Next Steps

This primer provides a high-level overview of activities that are needed to maximize the likelihood that technologies developed through R&D are adopted. Stripping away the examples and descriptions, the main point of the primer is this: T2 coordinators must understand adopters' needs and use that understanding to help guide and package the technologies produced by R&D to meet those needs. Understanding the adopters' needs means understanding both their Functional Needs—what must a technology do—and their Process Needs—what is the context in which the adoption decision takes place, and what must be done to allow adoption. Adopters' needs should drive the entire T2 Process. That includes informing the R&D objectives, approaches for addressing Process Needs, and stakeholder engagement plans.

Beyond the focus-on-the-adopter theme, the primer also includes suggestions about how to proceed with T2. The most fundamental among them are as follows:

- Recognize that T2 and R&D are distinct, though absolutely complementary. There must be a T2 Process running in parallel with every R&D project, and the T2 Process can be managed much like any other project: make a plan, resource it, and then execute the plan and manage the process.
- Designate a T2 coordinator for every R&D project—someone with the explicit responsibility of facilitating the T2 Process, the time to dedicate to it, and the appropriate training and resources.
- Adapt the guidance in this primer to the details of the given R&D project. Whereas the T2 principles and process described here apply universally, the details of the technology, the organization managing the research, the adopter organization, and the adoption context will determine particular T2 practices.

The next step in using this primer depends on the reader's current relationship with the T2 Process. For anyone who has already been involved with T2, the next step would be to re-assess past and current T2 practices to identify potential areas of improvement. For those new to T2, the next step would be to work toward creating your first T2 plan by choosing a promising R&D project and proceeding through the steps outlined here. In either case, it would help to consult the documents referenced in this primer and contact the U.S. DOT Technology Transfer Program Manager at TechTransfer@dot.gov with any questions.

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