Seeking Ways To Accelerate the Implementation of Innovation in Highway Transportation

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Research, and the innovation it seeks, is usually a search for lower cost, higher quality, or improved performance. Invention can lead to innovation, but innovation only occurs when ideas are used. In other words, innovation requires implementation and successful implementation is linked to the satisfaction of a need or a solution to a problem.

In the traditional view, a small, initial group of innovators uses a new technology. At some point demand takes off and an increasing number of innovators adopts the technology. In time, demand for the new technology tapers off or another technology becomes available and it begins to be adopted. (This process is characterized by an S-curve; see Figure 1.)

Private sector consumers of technology are driven by strong economic incentives to create new products; the public sector's motivation to innovate is usually more complicated. It can stem from regulations requiring specific technologies that might be new or innovative for the local agency (for example, nonattainment areas will have to institute vehicle emissions inspection and maintenance programs using advanced testing equipment to meet air quality regulations) or requiring results that force the local agency to choose from among a set of alternative innovative solutions (for example, siting a landfill often requires such a thorough assessment of available land parcels that a geographic information system becomes necessary to account for all factors involved). Financial incentives can encourage the choice of a new technology, or an aggressive technical assistance program can stimulate local agencies to make changes that encompass new technology by pointing out potential cost and staff economies. Demands for greater accountability of public spending often lead to innovation in management systems.

Generally, public agencies face many barriers to innovation and do not innovate quickly. This stems from several reasons, including limited knowledge about new technology and innovation, lack of funds for start-up of new programs, and lack of in-house technical expertise to assist in introducing innovation. Economics is a factor because, unlike their private counterparts, public managers cannot look to the profitability of competitors as an indication of successful innovation, and they are not punished in the marketplace for failing to adopt the most efficient technologies, as pointed out by Bruce Jacobs and David Leo Weimer at the University of Rochester (*1*).

Looking Closely at Barriers to Innovation

Accelerating the implementation of research results is a major topic of interest for the Research and Technology Coordinating Committee (see sidebar). Although acknowledging that the Federal Highway Administration has a well-established and extensive technology program, committee members noted that adoption of innovation at the state and local levels is slow and uneven. There are many new technologies that could help highway officials address both condition and capacity problems, do their jobs more productively, and make their systems operate more efficiently, but some technologies are slow to be implemented and opportunities to apply and use new and innovative techniques are often missed.

The Strategic Highway Research Program recently addressed this issue in developing the implementation plan for its research products. Because a primary aim of SHRP was research results that could close specific technological gaps that have impeded the effective advancement of the highway program, SHRP has focused on implementing the products it developed. SHRP staff examined the path to implementation to better understand how to overcome the barriers to getting its products into use. They found six gaps, or barriers, that appear repeatedly. These include staff training needs; limited internal investment; additional demonstration, field tests and validation; existing procurement processes; prerequisite state management actions; delays associated with adopting new standards, codes, and practices; and other more specific problems (see Table 1). Studies such as

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SHRP's are useful because they provide a general picture of the barriers involved in implementing new technology.

Case Study Analyses of Successful Innovation

In support of the Research and Technology Coordinating Committee (RTCC), Transportation Research Board staff studied some specific examples of new technology implementation in search of the characteristics and circumstances that help achieve success. The staff studied five innovations or new technologies and identified for each who was involved and who did what; the advantages of the innovation; what made the innovation possible; the major barriers encountered in implementation; and the outlook for widespread use. The technologies are summarized briefly in Table 2. These case studies, although limited in number, yielded some strong impressions about successful implementation. They show that success is possible and point to characteristics and circumstances that helped achieve success. Working on this basis, it may be possible to support and improve existing efforts, such as FHWA's technology transfer activities, to implement innovation in the highway field. Major characteristics and impressions include the following.

1. *Implementing innovation always involves a considerable amount of hard work.* Implementors and users must become knowledgeable about the innovation, its capabilities, and its limitations. Preliminary trials or tests must be made and adaptations often made to fit the innovation into the local environment. Full-scale tests are

TABLE 1 Barriers to Product Implementation Identified by SHRP

BARRIER	COMMENTS
Staff training needs	More than half the SHRP products will require special staff training initially; this is a large unmet need.
Limited internal investment	Many products require state investment in new laboratory equipment, field equipment, testing devices or other facilities.
Demonstration, field tests, and validation	Some states will require additional testing and validation at local sites, using in-state personnel, and/or using indigenous materials; such tests will provide some training benefit.
Procurement procedures	Although SHRP specification products are intended to yield higher quality or longer-lived constructed facilities, they could result in higher initial costs; constraints may exist that limit such options.
Prerequisite state management actions	Several SHRP products require states to have information and management systems in place before they can be implemented.
Delays in adopting standards and codes	Many of the key SHRP products are standards, specifications, or test methods to support specifications. Because the decision to adopt standards or specifications rests with each individual state, the adoption process will be "business as usual" unless AASHTO, ASTM, and other standards-setting groups accept the standards and use their influence to accelerate the process in the states.
Other barriers	There are product-specific barriers that call for tailor-made solutions. Their significance could be far greater that any of the common barriers already mentioned. For example, a new binder specification requires the cooperation of the asphalt supply industry as well as state-mandated changes.

TABLE 2 Technologies or Innovations Examined by RTCC

TECHNOLOGY	DESCRIPTION
CON/SPAN culvert design	This innovative culvert design for highway bridges was developed by an engineering firm based on FHWA and other research. The design approach is an alternative to small bridges, can be precast off-site, and can have lower life cycle costs than conventional bridge designs. The firm initiated a successful process of public sector acceptance of its "non-standard" design, but acceptance is on a state-by-state basis.
Bridge deck assessment	This effort featured a cooperative R&D program involving the end users in the planning and direction of the R&D. Radar and infrared thermography, not previously used on asphalt-overlaid bridge decks and not generally accepted by the highway community, were tested and compared with traditional methods in five states. The results showed a particular form of deterioration in New England bridge decks not detected by traditional methods.
Geographic information systems	Geographic information systems (GIS) offer many public works agencies a powerful management tool by tying spatial and nonspatial data together in a system capable of analyzing, displaying, and retrieving the data. They can have wide-ranging effects on organizational structures and, because they are still evolving at a rapid pace, their full potential is not completely understood.
Earth reinforcement systems	These systems consist of adding a reinforcing material to a compacted soil fill to improve the stability of the soil mass. They are a cost-effective alternative to some traditional retaining wall designs; however, not all aspects are completely understood so, although many successful systems have been put in place, general acceptance of this approach is limited.
Pile driving analyzer	The combination of the pile driving analyzer, an electronic device for monitoring pile driving operations, with the wave-equation replaces an empirical approach that was nearly 75 years old. The combination provides an improved means for managing pile driving operations and verifying bearing capacity; it can improve pile design and lower costs.

needed to ensure that existing operations will continue to operate smoothly. Finally, support personnel must be trained to use the procedures, equipment, and facilities involved. Much of this work often must be undertaken by individuals who have day-to-day responsibilities that fill all available time.

2. *Once the research and development are complete, successful innovation usually involves a champion who will not quit on the concept*; sometimes there is more than one champion. Never is there no champion.

3. *Successful innovations usually address an immediate or long-standing need (or a portion of it)*; the problem must be perceived as important (to provide the incentive for change) or the payoff of the innovation must be substantial.

4. *Institutional barriers (those that involve people and procedures) are probably the most difficult and time-consuming to overcome.* The procurement process; standards, codes, and practices; organizational inertia; institutional arrangements; and so on, are all well established and have an important role in ensuring accountability and protecting the public investment. However, they can stand in the way of innovation, even when a quick change could be beneficial.

5. *Successful innovation requires changing familiar individual patterns of behavior and gaining the confidence of those who are being asked to implement the changes.* The familiar makes people comfortable; change makes people uncomfortable, especially when it involves people's perceptions of their skills, jobs, and opportunities. Consequently, people often resist change.

6. *Few innovations are simple one-to-one replacements for existing technologies or procedures or equipment*; they are more likely to affect a system in many different ways. This can make them hard to evaluate and to implement.

7. *Organizing for innovation so that end-users are involved in R&D project planning and evaluation helps accelerate the development and implementation of innovation.* The people who must use new technology are often best informed about the conditions and limitations of its operating environment. Thus, their outlook and opinions could be useful; getting and keeping them involved from the start can help avoid many potential acceptance and implementation problems.

8. *Innovation can be encouraged in a number of ways; there is no way to guarantee it.*

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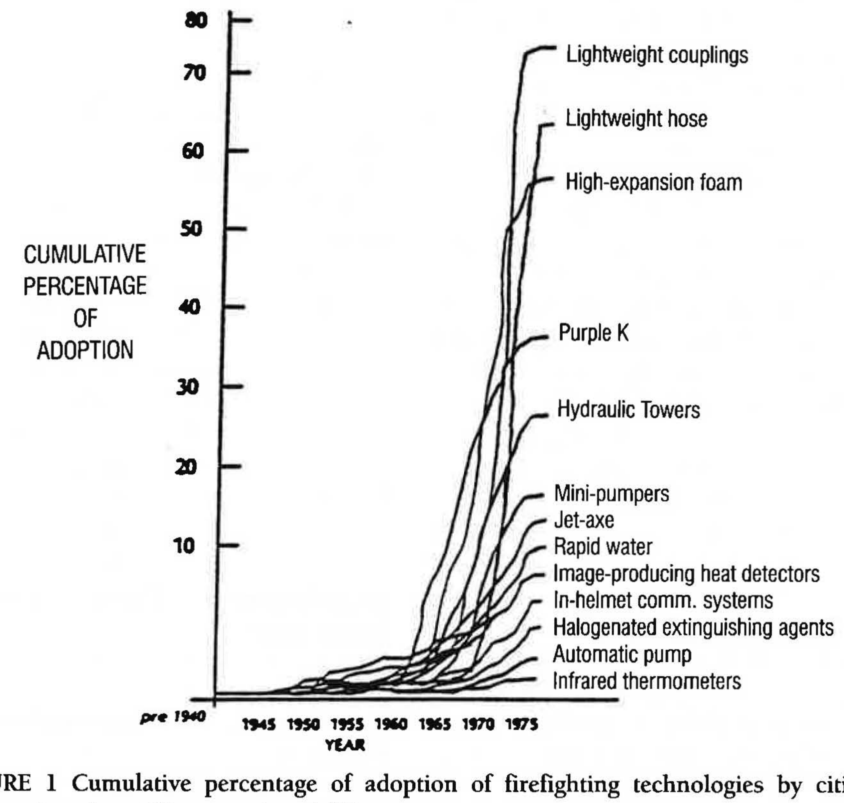

FIGURE 1 Cumulative percentage of adoption of firefighting technologies by cities (percent based on 551 respondents) (2).

This article is based on material originally prepared for the Research and Technology Coordinating Committee (RTCC), which was organized by TRB in 1991 to provide the Federal Highway Administration (FHWA) with an ongoing and independent assessment of its research, development, and technology efforts. It is composed of top-level administrators, researchers, and practitioners from state, academic, and private sectors who are addressing a range of issues, including economic, safety, energy, and environmental concerns, and will consider the views of research bodies, highway users, suppliers, contractors, and others.

The impetus for the committee stems from a series of discussions among the various components of the highway industry, including FHWA and the American Association of State Highway and Transportation Officials (AASHTO), that yielded a consensus that the nation's highway R&D efforts could benefit from such an assessment of its R&D program and additional research opportunities through periodic independent reviews. FHWA's R&D program, which the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) expanded considerably, now involves exploring the potential for "intelligent" highways and motor vehicles; continuing major research programs such as the Strategic Highway Research Program's (SHRP's) pavement performance test; and seeking greater private-sector involvement in research than in the past.