During the 1980s the need to encourage the development and use of new methods and technologies in highway activities was strongly highlighted in *Special Report 202: America's Highways: Accelerating the Search for Innovation* (*1*), a report that led to the establishment of the Strategic Highway Research Program. SHRP was among the first highway programs to formally recognize the values of learning about highway practices in foreign countries. For example, the five-year program facilitated ongoing arrangements for foreign highway agencies to lend staff to SHRP management, which promoted international information exchange.

The Intermodal Surface Transportation Efficiency Act of 1991 enhanced this kind of encouragement for international technology transfer. Section 6003 of ISTEA authorized the Secretary of the U.S. Department of Transportation "to engage in activities to inform the domestic highway community of technological innovations abroad," including "development, monitoring, assessment,

IMPLEMENTING TECHNOLOGY FROM ABROAD

and dissemination domestically of information about foreign highway transportation innovations that could significantly improve highway transportation in the United States...." Section 6005 established an Applied Research and Technology Program whose overall purpose is "to facilitate the identification and development of both foreign and domestic technologies, and facilitate the development of new methods for accelerating testing and evaluation of those technologies."

Organized tours had already been undertaken to explore innovative practices abroad, notably in pavement construction (*2*). Such activities, enlarged in the early 1990s, stimulated additional interest in foreign technology transfer. Indicative of this new interest was the selection of the topic for the National Cooperative Highway Research Program *Synthesis 216: Implementation of Technology from Abroad* (*3*). Some of the findings from that study are described on the following pages.

DAVID WITHEFORD

The purpose of *Synthesis 216: Implementation of Technology from Abroad* was to examine previous and current experience with identifying, introducing, and implementing foreign transportation technology and methods (FTTMs). It proceeded by compiling information, through a review of literature and surveys, on the formal and informal processes that have been used by U.S. agencies to use technologies and methodologies from abroad. It focused on experience from the highway and public transportation modes, within which it covered the issues of administration and planning, design and construction, and operations and maintenance. The synthesis sought further to identify the institutional and cultural factors that affected the ease of implementation. This was done primarily by examining a variety of case studies.

It quickly became clear that foreign techniques transferred to American practice met not only with obstacles similar to those faced by innovative domestic technologies, but additional difficulties as well. This fact was vividly highlighted in correspondence from one entrepreneur. He noted, "The chronological history in no way describes the time and effort that goes in[to] getting from one step to the next. You have to be part riverboat gambler and part inmate at Bedlam to put together a project like this."

FIGURE 1
Examples of implementation of foreign technology.

Pavement-Related

MATERIALS
Ralumac
Verglimit
Styrelf
Asphalt Stabilizer
Paveset
Accorex
Plusride
Ethyl Propylene Monomer
Etan Plasticizer

EQUIPMENT
Asphalt Cement Test Equipment
Hydromill
Accelerated Loading Facility
Australian Compaction Device
Pavement Roughness Measuring Device
Portland Cement Concrete Rapid Test
Soil Test
Dutch Cone Penetrometer

PROCESSES
Novachip
Novophalt
Drainable Base
Asphalt Recycling
Stone Matrix Asphalt
Asphalt Cement Mix
Chip Seal
Porous Mix
Thick Portland Cement Concrete Pavement

Nonpavement Technologies

MATERIALS
Hilti HVA
Silane
Sound Attenuation Walls
Bellpro Traffic Paint
EPS Foam (Soil Stabilizer)
Plastic Pipe

EQUIPMENT
Fare Handling
PASCO Road Reconnaissance
Video Information
Weigh-In-Motion
Automatic Vehicle Identification
Traffic Detector Technology
Bridge Expansion Joints
Traffic Control Hardware
Cruise Control System
Electronic Toll Collection
Moveable Barrier
Von Roll Monorail
Rail Fastener
Riflex Rail

PROCESSES
Roundabout Design
Bicycle Trail Planning and Design
Bicycle and Pedestrian Planning
Inventory Software
Traffic Control Software
Highway Capacity Model
Snow and Ice Control
Transit Service Route Methodology
Automatic Vehicle Location & Control System

SURVEY FINDINGS

Surveys were distributed to participants in overseas tours, members of state and local transportation agency staffs, and others interested in applications of new technology. The returns provided information on issues related to the identification, introduction, and implementation of FTTMs.

Identification was defined as the step by which a potential user becomes aware of a foreign technology. Not surprisingly, publications were the most common method of identification reported, followed by conferences second and overseas travel third. Group tours appeared to be the most effective means of follow-up toward implementation. For example, the 1990 Asphalt Tour of Europe by industry leaders probably led to more applications of foreign practice in the United States than any other recent event.

Introduction was described as the step that creates hands-on understanding of what would be involved in bringing the technology into practice in the United States. In soft-side processes, such a step might be accomplished through seminars and conferences. For equipment or materials, however, this usually would require successful field demonstrations of the technology. Sponsorship by national agencies or organizations may be necessary prerequisites to such demonstrations.

Implementation experience was the major interest of the study team. The survey returns on implementation listed nearly 60 products and processes that had been put to use. Only one-third of the identified technologies were mentioned in more than one return. Most respondents listed only one technology. However, one state--in which public policy encouraged foreign investment in all types of industry--named eight foreign materials or processes that had been implemented. Unfortunately it was not always clear from the returns how many instances represented the incorporation of a foreign technology into routine practice and how many represented demonstrations only. Documentation or evaluation reports were available for approximately 50 percent of the projects.

Figure 1 lists the foreign technologies (materials, equipment, and processes) associated with pavement construction, and the wide range of other technologies named by survey respondents—from noise-attenuating walls to bicycle and pedestrian planning procedures. Pavement-related technologies accounted for nearly half of those that have been implemented. Stone matrix asphalt applications (SMA) were mentioned often.

The groups surveyed for the synthesis were

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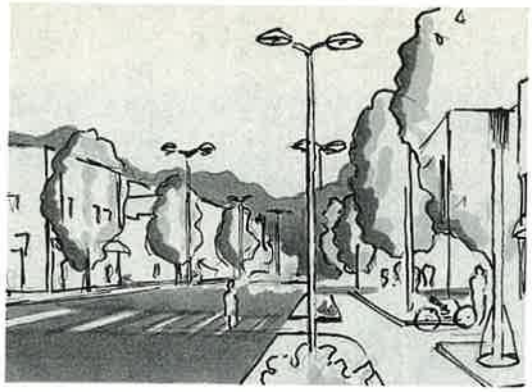

Existing Hutchinson Main Street (*left*) and future Hutchinson Main Street (*right*).
MINNESOTA DOT

asked about obstacles to smooth implementation. Many responses were one-word descriptions that were hard to classify. The groupings of administrative, technical, and political obstacles in Figure 2 are approximate at best.

Procurement difficulties were most often mentioned among administrative obstacles. Although rarely elaborated on, they included problems with the customary low-bid purchase process, restrictions on sole-source purchasing, and restrictions against specifying proprietary products. Management disinterest was listed as an obstacle only once.

The most commonly described technical obstacles were language barriers and lack of technical data. Costs were next, presumably in cases in which foreign technologies were initially more expensive than other available solutions. Other difficulties were the need to adapt to local conditions, make voltage and frequency conversions, work with metric measurements, use special materials, and develop special provisions or modified specifications. Least-mentioned were problems of equipment delivery, parts availability, and staff time required to accomplish implementation.

The only political obstacles named were "Buy America" requirements, which were cited in two transit agency responses, and several others grouped under the heading of "inertia." These included resistance from local suppliers and reluctance to change. These obstacles may be more cultural than political, but with variations they were cited several times.

Survey respondents also identified positive factors that led to successful FTTM implementation. These factors are summarized in Figure 3. Product performance is obviously essential. Support from management was listed most often among positive administrative factors.

CASE STUDIES

Nine case studies of foreign technologies were examined for the synthesis. They differed in countries of origin, types of technology, and the nature of the technology transfer process. Some were from private sources, some from public; some were privately implemented, and others were used by public agencies.

Most came from Europe, and some had long records of experience there. One such technology was the New Austrian Tunneling Method (NATM). Another, SMA pavement, originated in Germany and spread throughout Europe long before it arrived in the United States. Examples from France included mechanically stabilized embankment technology, the Novachip paving system, and some of the test equipment for hot-mix asphalt (HMA). Other HMA test equipment, and the capacity analysis method, came from Germany. A bicycle and pedestrian planning process came from Finland. The Accelerated Loading Facility (ALF) and the Quickchange™ Moveable Barrier (QMB) originated in Australia (Figure 4).

FIGURE 2 Types of obstacles overcome in successful implementation cases.

ADMINISTRATIVE

Procurement (5)
Proprietary Products (2)
Travel Restrictions (2)
Sole Source
Currency Rate Fluctuation
Management Disinterest

POLITICAL

Inertia (6)
"Buy America" Requirment (2)

TECHNICAL

Language Barrier (5)
Lack of Technical Data (5)
Cost (3)
Adapting to Local Conditions (3)
Voltage/Frequency Differences (3)
Specifications (3)
Special Materials (2)
Parts Availability
Metrication
Staff Time

NOTE: Numbers in parentheses indicate frequency of mention when specific obstacle was cited more than once.

FIGURE 3 Reasons given for successful implementation.

ADMINISTRATIVE

Management Support (5)
Good Promotion
Public/Private Support
Risk/Cost Sharing
Travel Support

TECHNICAL

Superior Performance (4)
Involvement of Personnel
Close Attention to Project
Proper Analysis/Evaluation
Cost-Effectiveness
Good Manuals
Only Technology Available
Good Technical Support

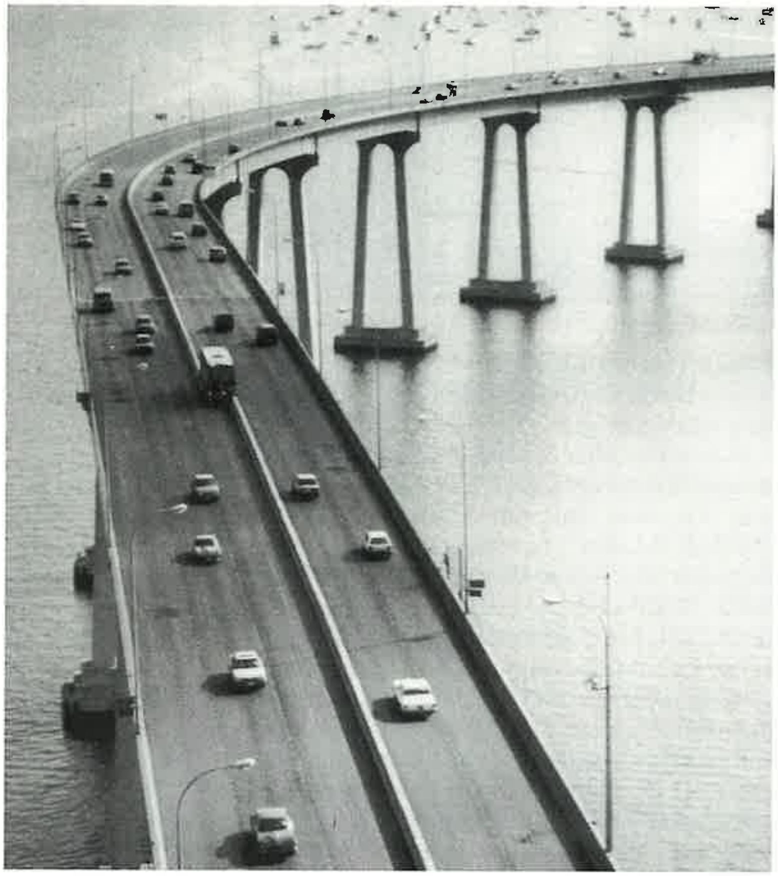

FIGURE 4 Quickchange Moveable Barrier.
BARRIER SYSTEMS, INC.

The ways in which U.S. agencies identified these technologies were as varied as their origins. Pavement-related technologies were discovered through group tours and conferences. A publication from the Organization for Economic Cooperation and Development was the source for another technology transfer discovery. A trade show was yet another. Staff exchanges between Minnesota's Department of Transportation and Finland's National Road Administration were still another mechanism. The first U.S. demonstration of NATM was encouraged by a federal agency years after the technique had been publicized in both foreign and U.S. trade journals.

Technologies were introduced to the United States in various ways. The Federal Highway Administration acquired the plans and documentation for the patented ALF, funded the purchase of the asphalt test equipment, and initiated the first SMA demonstrations and open houses. Novachip came to the United States when the French owners arranged with U.S. contractors to demonstrate their process with equipment and crews brought over from France. The Reinforced Earth Company was set up in the United States to market the products of the French parent organization. A private U.S. company obtained QMB through a license agreement and modified it for U.S. application, and the capacity analysis method was introduced through a research project established to update the *Highway Capacity Manual* (*4*).

Different implementation methods were used for these FTTMs. In the simplest case, the unsignalized intersection capacity procedure was adopted by TRB's Committee on Highway Capacity and Quality of Service and published for use. Minnesota DOT, with support from a Finnish exchange staff and consultants, worked cooperatively with a local community to implement the pedestrian and bicycle plans. The moveable barrier system and ALF were constructed in the United States for private-sector sales and FHWA research, respectively. The French and German asphalt test equipment was purchased and put to regular use in material laboratories at Colorado DOT and FHWA's Turner-Fairbank Highway Research Center. Novachip has had applications in several states, paid for by county construction dollars in one case and by state research or other funds elsewhere. Reinforced Earth Company products have been installed through construction contracts in numerous projects. NATM was implemented in Pittsburgh under federal sponsorship and later in Washington, D.C., as a result of value engineering change proposals submitted by a foreign contractor.

Obstacles had to be overcome in most situations before these foreign technologies could be implemented. Though not necessarily typical, the case of the moveable barrier illustrates some of the problems.

QUICKCHANGE™ MOVEABLE BARRIER

DESCRIPTION

QMB is a two-part system consisting of safety-shaped concrete barrier segments linked to form a continuous wall and a transfer vehicle that lifts and moves the segments laterally. The conveyor operates on the roadway at speeds up to 8 kilometers per hour (5 miles per hour) with a two-person crew and can shift 0.6 kilometers (1 mile) of barrier in less than 20 minutes. The system can serve as a moveable median barrier for permanent lane-reversal or high-occupancy vehicle applications, and as a traffic control and worker protection device for work zones at highway construction sites, as shown in Figure 4.

IDENTIFICATION

In 1981 the Australian government contracted with Quicksteel Engineering, Ltd., to design and furnish a curb-height median to control traffic on the Sydney Harbor Bridge. The patented system that was developed was seen at the American Traffic Safety Services Association trade show by the current president of Barrier Systems Incorporated (BSI), an American company that was subsequently formed to promote a modified barrier for the U.S. market.

Initial contacts between the companies in 1982 led to a licensing agreement between the Australian manufacturer and BSI. Redesign of the curb into a safety-shaped barrier was conducted jointly by BSI and the Australian manufacturer during the next two years. The new barrier was designed to meet U.S. standards, based on concurrent consultations with various U.S. state and federal agencies. The first crash testing of the modified barrier and tests of the transfer vehicle were performed in Australia.

INTRODUCTION OF TECHNOLOGY

The tested designs were used in 1985 to build the first U.S. prototype. Crash testing of the prototype at the California Department of Transportation led to further modifications. By 1986 BSI had built its own test track and conducted crash tests, including a consultant-managed test series for the final design. After submitting the test findings to FHWA, BSI received approval of the barrier as an experimental feature. Sales efforts then began, formal testing at the Caltrans test track was completed, and in 1987 the first orders for the QMB system were received. BSI now held patents of its own on the design modifications for the QMB, whose research and development expenditures had well exceeded $1 million.

IMPLEMENTATION

The barrier system and its transporter can now be purchased or leased from BSI. By late 1993 more than 113 kilometers (70 miles) of the barrier system were operating in 20 applications across the United States. Seventeen states have used the system; Montreal, Canada, and Auckland, New Zealand, have also implemented it. In 1992 QMB was cited by *Construction Equipment* magazine as one of the 100 most significant new products for highway construction and related industries.

INSIGHTS FROM THE CASE STUDIES

The nine case studies revealed implementation procedures of considerable diversity. Some successes originated from the foreign private sector, some from the public. Some have been transferred into the United States through the private sector, whereas others have gone through the public sector. The case studies suggest that foreign technologies generally were implemented because top-level management aided in overcoming the obstacles to success at a key point.

The technologies implemented by the private sector typically met with difficulties and delays. These were overcome by persistence in the moveable barrier case, and evidently through aggressive marketing in the cases of Novachip and The Reinforced Earth Company. In all these cases, only the expectation of an ultimately profitable outcome could have sustained the preliminary efforts necessary to introduce the products.

National public agencies like FHWA or the Federal Transit Administration, with legislative mandates and significant funding for research and development, are perhaps best positioned to overcome most of the likely obstacles. They are better able than public agencies at state and local levels to expedite implementation through demonstrations, as in the cases of SMA, soil-nailing, or the Pittsburgh NATM tunnel project.

At the state level, where interest in FTTM seems highly variable from state to state, other influences may drive the international technology transfer mechanism. In the case of Minnesota DOT's transfer of planning and other technologies from Scandinavian countries, cultural ties in addition to shared experience appear to have facilitated the exchanges. In addition, Minnesota DOT has built-in departmental activities that facilitate the acceptance of innovation. Colorado's partnership with FHWA in demonstrating the HMA test equipment probably resulted because a Colorado DOT staff member participating in the Asphalt Tour witnessed its values firsthand.

OUTLOOK FOR FOREIGN TECHNOLOGIES

Several changes in the conditions surrounding technology transfer in the United States suggest that the opportunities are improving for implementation of foreign technology. First, national policy and economic pressures may create an environment favoring innovation regardless of its source. Second, ISTEA funds and other public resources are being dedicated to increasing awareness of foreign practices through tours, CD-ROM packaging of international data bases, and other means. Third, innovation is also being fostered in the private sector, by organizations like the Civil Engineering Research Foundation, for example, which has launched the Highway Innovative Technology Evaluation Center (HITEC). As one HITEC brochure claims, "By providing impartial evaluations of technologies where no standards exist, HITEC hopes to enhance the incentives for private industry to invest in highway oriented research and development, and for state and local governments to implement more quickly innovative products in the highway system."

Accelerated Loading Facility at Turner-Fairbank Highway Research Center.
FHWA

CONCLUSIONS

Like the rising tide that lifts all boats, the improving climate for acceptance of innovations helps foreign as well as domestic new technologies. There can be little doubt, however, that those implementing foreign technology encounter more obstacles than those putting domestic innovations into practice. As the moveable barrier case shows, implementing foreign technology can be a little like show business: the apparent overnight success is usually more truly the culmination of years of hidden struggle and hard work.

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Checklist for Transfer of Overseas Technology

Case studies and survey returns identified major issues affecting the implementation of foreign technologies. The resulting insights led the study team to develop a list of questions that should be asked by anyone contemplating the application of a foreign technology. The relevance of particular questions will vary according to local circumstances and will depend on whether the technology is in the realm of materials, equipment, or processes. The following checklist is suggested when the incorporation of foreign technologies in public programs is being considered:

1. Do legal difficulties or regulatory prohibitions in contracting procedures preclude implementation? For example, is a low-bid award process the only possible procedure? Are there restrictions against use of proprietary products? Can sole source purchases be made? Is life-cycle costing acceptable?
2. Does top management support the introduction of new technologies? If resistance to change on the part of industry or other local groups is evident, can it be overcome?
3. Can special provisions and specifications (such as performance specifications) be prepared so that the technology can be appropriately selected?
4. Do demonstrations, locally or elsewhere, show conclusively that the technology performs acceptably?
5. Is the necessary documentation (specifications, training materials, and so on) adequately translated into English language and measurements so that implementation is facilitated?
6. Must personnel skills be developed or other expertise be made available before implementation can occur?
7. Are appropriate materials or equipment available locally to support implementation?
8. Is the technology supplier capable of providing ongoing support as needed in technical data, training, equipment maintenance, and parts availability?

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