TR NEWS

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The Transportation Research Board's *2005 Annual Report* is included in this issue as a special insert between pages 22 and 23.


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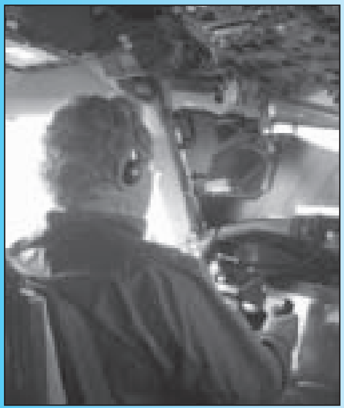

COVER: Federal Aviation Administration pilot flight-tests synthetic vision system displays on the National Aeronautics and Space Administration's (NASA's) B-757 flying laboratory, based at the federally operated Langley Research Center, Hampton , Va. (*Photo courtesy of NASA Langley Research Center/Jeff Caplan.)*

TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

TR News is produced by the Transportation Research Board Publications Office
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Jennifer J. Weeks, Photo Researcher
Juanita Green, Production Manager
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Editorial Correspondence: By mail to the Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, by telephone 202-334-2972, by fax 202-334-3495, or by e-mail jawan@nas.edu.

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ALSO IN THIS ISSUE:

COMING NEXT ISSUE

PHOTO COURTESY OF PARSONS BRINCKERHOFF

Breakdown on Manhattan's Sixth Avenue elevated railway, 1901.

Two features in the January–February 2006 *TR News* commemorate the100th anniversary of the New York City subway system—one on the role of designer and chief engineer William Barclay Parsons and the other on the system's impact on the city's growth and development. Also featured is the annual summary of findings on transportation research needs and applications, compiled by TRB Technical Activities staff from field visits to every state department of transportation and related agencies and organizations in 2005. A special insert contains the latest edition of Critical Issues in Transportation, assembled by TRB's Executive Committee.

Federal Aviation Administration Pilot Chip Adams flight-tests synthetic vision system cockpit displays on board NASA's B-757 flying laboratory based at the Langley Research Center in Hampton, Va.

PHOTO COURTESY OF NASA LANGLEY RESEARCH CENTER/JEFF CAPLAN

IDENTIFYING TRENDS in Federal Transportation Research Funding

The Complex Task of Assembling Comprehensive Data

ANN M. BRACH

In 2002, transportation accounted for 11 percent of the gross domestic product (*1*, Figure 13-2) and nearly 12 percent of household expenses (2, Table 3-12). People travel for work and for family, health, and leisure activities and depend on transportation for access to many goods and services.

New ideas, methods, and technologies have improved the quality and efficiency of transportation. Research and development (R&D) have produced more durable materials for bridges, pavements, and vehicles, as well as better fuel economy, safer vehicles, and reduced travel times.

Although the federal government is a major sponsor of transportation R&D, little information is available about the comprehensive scope and nature of the work funded at various federal agencies.

Federal Transportation Research

Many agencies sponsor transportation R&D. In addition to the U.S. Department of Transportation (DOT), the list includes the Departments of Defense (DOD), Agriculture (USDA), Commerce (DOC), Energy (DOE), and Homeland Security (DHS), as well as independent agencies such as the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Environmental Protection Agency (EPA).

Except for DOT, most agencies do not identify

The author is Senior Program Officer, TRB Studies and Information Services, and was recently appointed Deputy Director of the new Strategic Highway Research Program.

Intersection under construction at the Federal Highway Administration's Turner-Fairbank Highway Research Center, McLean, Virginia, for the testing of traffic control devices.

transportation research in their programs and budgets, which makes an estimate of their investments in this area difficult. Transportation R&D is buried in programs with goals more directly linked to the agencies' missions—for example, military preparedness, security, environmental protection, energy conservation, or support for business and agriculture.

Data Sources

The three major sources for data on federal transportation R&D are NSF, DOT, and the Research and Development in the United States (RaDiUS) database. NSF compiles data from all the federal agencies engaged in R&D, including DOT. RaDiUS obtains data from NSF and other federal agencies. Because the data are compiled and presented differently, the correlation of results from these sources is not always apparent.

◆ **NSF.** Each year, NSF collects data from federal agencies on R&D authorizations and obligations. Data are categorized in a variety of ways—for example, by budget functions such as health, defense, space, and transportation.

◆ **DOT.** R&D funding data for DOT are available from the department's Volpe National Transportation Systems Center (Volpe Center) for fiscal years 1970 to 1993 and from the department's budget office for fiscal years 1995 through 2005, leaving a gap for fiscal year 1994.

◆ **RaDiUS Database.** The RAND Corporation maintains the RaDiUS database, which includes detailed information on individual research awards, such as a description of the work, the funding mechanism, and the research performer. The data are aggregated at various levels, from project awards up to the agency or department level.

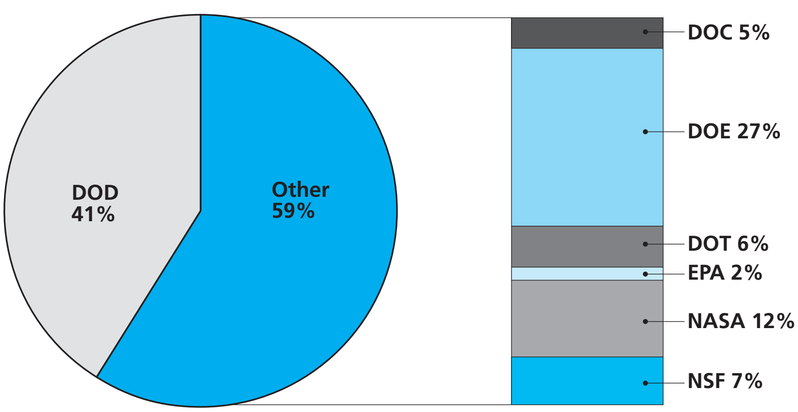

FIGURE 1 Fiscal year 1998 transportation-related R&D budget authorization for selected agencies [DOD = Department of Defense; DOC = Department of Commerce; DOE = Department of Energy; DOT = Department of Transportation; EPA = Environmental Protection Agency; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation (*3*, Figure 2-4)].

Previous Investigations

Two previous attempts to identify and characterize federal transportation research across agencies have provided a snapshot of research funding for a single year and descriptions of the types of work carried out by a department or agency.

Volpe Center Study

The first effort was by the Volpe Center, under the auspices of the White House National Science and Technology Council (NSTC) Committee on Technology, Subcommittee on Transportation Research and Development (*3*). Using RaDiUS data, as well as contacts in non-DOT agencies, the Volpe Center study estimated the investment in transportation research in several federal agencies for fiscal year 1998.

The study identified programs that carry out transportation-related research and added up the total funding for the programs to estimate transportation research funding. As a result, the estimate may have included nontransportation research that was funded from the same programs and may have omitted transportation research funded from other programs.

The Volpe Center study identified a total of $7.88 billion in transportation R&D in seven agencies: DOC, DOD, DOE, DOT, EPA, NASA, and NSF. The NSTC subcommittee, however, was interested in "enabling research," which included human performance and behavior; advanced materials and structures; computer, information, and communication systems; energy, propulsion, and environmental engineering; sensing and measurement; analysis, modeling, design, and construction tools; and social and economic policy issues (*3*, Chapter 2).

The Volpe Center study, therefore, focused on a $4.75 billion subset of transportation research addressing topics in these areas. Figure 1 shows the distribution of funding for enabling transportation research across the seven agencies.

Surprisingly, DOT accounted for only 6 percent of this federal investment in fiscal year 1998. The Volpe Center study assembled the interagency funding distribution for enabling research but did not include the remaining $3.13 billion from the total for transportation research. As a result, the study did not reveal DOT's total contribution to federally sponsored transportation research.

The Volpe Center study defined enabling research as R&D "activities with clear potential relevance to one or more transportation modes or functions, regardless of the objectives for which it is conducted or the performing agency" (3, Chapter 2). The small percentage of DOT funding may reflect the NSTC subcommittee's focus on research closer to basic, that is, with broad potential applications; DOT's research tends to be applied and mission-specific.

TRB Study

In December 2002, the Transportation Research Board (TRB) carried out the second attempt to ascertain the amount and type of federally sponsored transportation research. The effort was not intended to be an in-depth study, but a quick assessment of the federal transportation research landscape. Prepared for TRB's Executive Committee, the study was never published.

In most cases, the data in the TRB study were for fiscal year 2002 and focused on the same agencies addressed in the Volpe Center study. The exceptions were that TRB used fiscal year 1998 funding amounts from the Volpe Center report for DOC and NSF and only included U.S. Army Corps of Engineers research funding for DOD. Other sources of data for the TRB effort included agency reports and web pages, DOT budget tables, and information from contacts in the respective agencies. Table 1 summarizes the information compiled by TRB.

The TRB study also indicated that the Air Force had a total science and technology budget of nearly $1.4 billion and that the Office of Naval Research had a budget of approximately $1.7 billion, although Table 1 does not include these numbers. How much of those amounts funded what may be considered transportation research was not clear. In comparison, the NSTC report indicated that DOD spent nearly $2 billion on enabling research.

Research Funding in DOT

Figure 2 presents R&D funding for DOT. NSF data are available for 1967 through 2004. DOT data cover 1970 through 2004, except for 1994. RaDiUS contains data for 1993 through 2005.

The numbers match fairly well, because DOT is the source of the data, yet the numbers are not exactly the same. DOT and RaDiUS report what is called budget authority—the amount appropriated each year for an agency; the NSF data, however, reflect actual obligations—the amount committed by an agency each year.

The reason for discrepancies between the DOT and RaDiUS data is not clear. RaDiUS may record preliminary data before federal budgets are finalized. The differences are not large enough, however, to affect an analysis of trends. The following observations rely on data obtained directly from DOT.

Figure 2 shows an overall increase in DOT R&D funding of 360 percent from 1970 to 2003, in current dollars. Figure 3 compares the current dollar amounts for DOT data to constant 1996 dollars. On the whole, DOT research funding grew in real terms by only 1.5

TABLE 1 Approximate Federal Transportation Research Funding for Selected Agencies (in thousands of dollars)

Federal Aviation Administration	$188,200
Federal Highway Administration	$308,611
Federal Motor Carrier Safety Administration	$9,828
Federal Railroad Administration	$55,908
Federal Transit Administration	$60,050
Maritime Administration	$11,593
National Highway Traffic Safety Administration	$121,000
Office of the Secretary	$10,976
Research and Special Programs Administration	$9,860
U.S. Coast Guard	$21,273
U.S. Department of Transportation Total	$797,299
Department of Commerce (FY1998)	$250,000
Department of Energy	$305,000
Environmental Protection Agency	$29,000
NASA	$522,000
National Science Foundation (FY1998)	$300,000
U.S. Army Corps of Engineers	$430,000
Other Federal Agencies Total	$1,836,000
Total for All Agencies	$2,633,299

Fiscal year (FY) 2002 data, unless otherwise noted.
Source: Compilations from various sources by TRB staff.

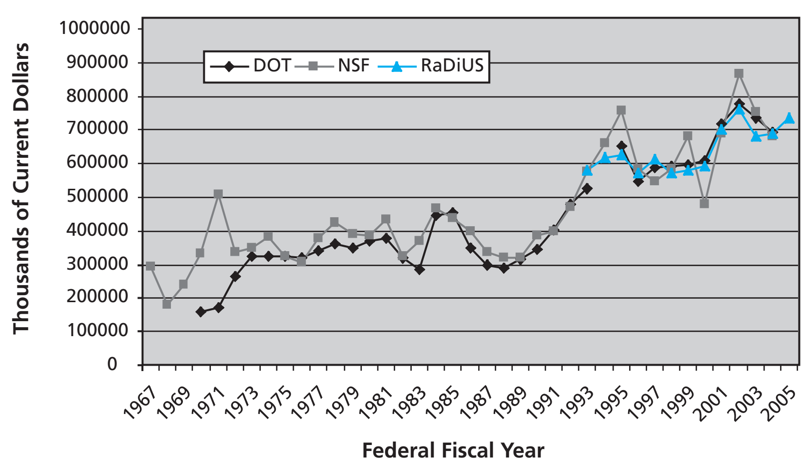

FIGURE 2 DOT R&D funding. (Data from several sources.)

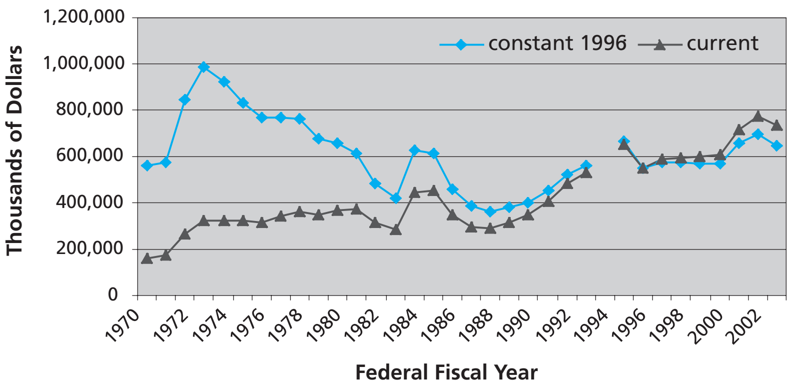

FIGURE 3 DOT R&D funding in current and constant 1996 dollars. (Data source: DOT.)

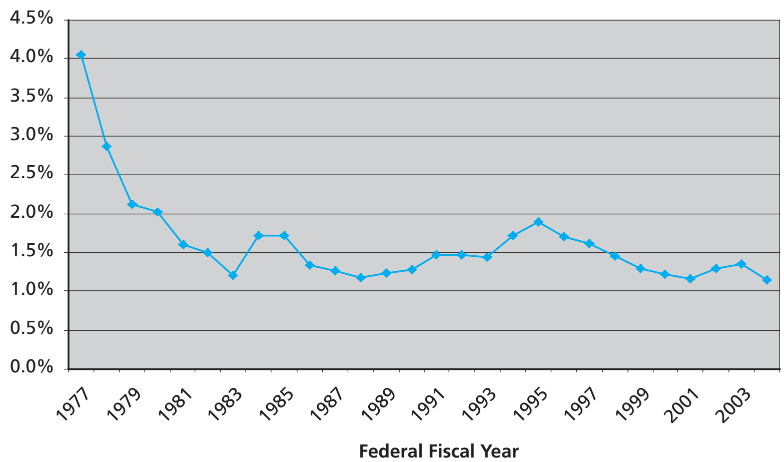

FIGURE 4 R&D as a percentage of DOT budget. (Data sources: R&D funding from DOT, except 1994, which is from RaDiUS database. Total DOT budget from Office of Management and Budget, Historical Tables, Budget of the United States Government, Fiscal Year 2006.)

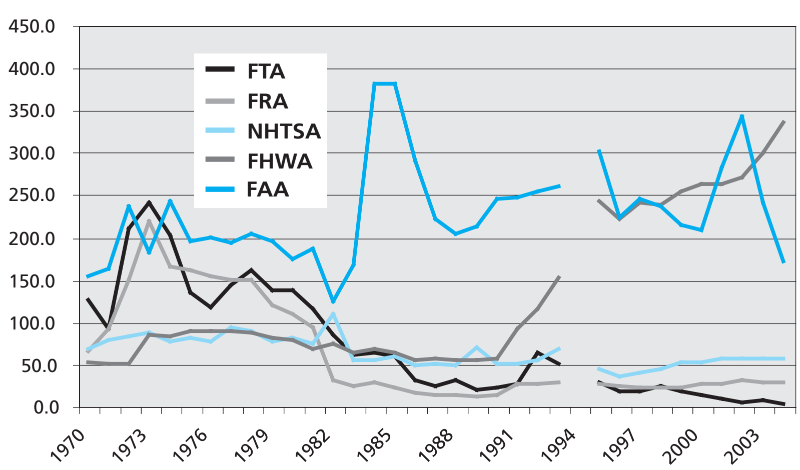

FIGURE 5 R&D funding for selected DOT modal administrations (in millions of 2000 dollars). (FTA = Federal Transit Administration; FRA = Federal Railroad Administration; NHTSA = National Highway Safety Administration; FHWA = Federal Highway Administration; FAA = Federal Aviation Administration. Data source: DOT; gross domestic product price index from White House Office of Management and Budget.)

percent. R&D funding declined from about 4 percent of DOT's total budget in 1977 to less than 1.5 percent of the total budget in 2004 (Figure 4).[1]

DOT generally funds applied, mission-oriented research in an array of areas, including infrastructure materials, design, construction, and maintenance; safety and human factors; planning and environmental sciences; economics and finance; and transportation systems management and operations.

Research supports activities such as regulation, policy making, design, and development of technical standards. Some research may be carried out in support of particular technologies, depending on the transportation mode and its industry structure—for example, whether the private or public sector owns and operates the transportation facilities.

For instance, the Federal Highway Administration (FHWA) conducts research on highway construction materials, because highways are mostly publicly owned and operated; but FHWA does not conduct research on materials for highway vehicles, which are produced by the private sector and owned by private individuals and companies. A small amount of advanced research, which supports longer-term goals instead of shorter-term mission objectives—has been carried out in areas such as nanotechnology, computational methods, and intelligent transportation systems.

DOT's R&D programs are distributed among the department's modal administrations. Figure 5 shows the distribution of R&D funds in constant dollars among five DOT agencies from 1970 through 2004. The largest programs are those of the Federal Aviation Administration (FAA) and FHWA.

FAA's funding rose significantly in the mid-1980s but did not sustain a growth trend. FHWA has seen a steady increase in funding from the early 1990s to the present. The other agencies shown—the Federal Transit Administration, the Federal Railroad Administration, and the National Highway Traffic Safety Administration—experienced decreases in R&D.

Several other agencies not shown also experienced declining R&D budgets: the Maritime Administration; the U.S. Coast Guard, now part of DHS; and the Office of the Secretary. The Research and Special Programs Administration, now the Research and Innovative Technology Administration, has had a uniformly low level of funding throughout its history. The Federal Motor Carrier Safety Administration spun off from FHWA in 2000 and has had a research budget of $3 million to $12 million (in 2000 dollars).

[1] DOT R&D funding data do not include State Planning and Research (SPR) funds distributed to state departments of transportation. A portion of SPR funds is spent on applied research to address state-specific needs and is usually matched by some state funds.

Research Funding in Other Agencies

NSF Data

NSF reports federal R&D funding according to federal budget functions, including transportation. Figure 6 shows current and constant dollar funding from 1961 through 2005 for R&D under the transportation budget function. In current dollars, the trend increases, leveling off after the mid-1990s. In constant dollars, a downward trend occurs from the early 1970s.

Detailed breakdowns of the department and agency contributions to R&D under the transportation budget function are available from 1993 through 2005. Figure 7 shows the DOT contribution separated from that of other agencies.

According to NSF data, DOT accounted for a little more than one-third of total federal transportation R&D. Almost all of the remainder is for NASA's aeronautics research. Less than 3 percent of the total is from DHS, which funded transportation research in the Transportation Security Administration and the U.S. Coast Guard; before 2003, both agencies were part of DOT.

RaDiUS Data

Clearly, the NSF data do not include the transportation research carried out in all the other agencies. The RaDiUS database seemed an appropriate source for the missing information. The Volpe Center study used RaDiUS data to focus on certain research areas for one fiscal year and estimated the funding from the total for the programs that were most likely to conduct the research.

An estimate of funding trends in these agencies would require data for several years in all areas of transportation research, which would include many program areas. Because the projects are not categorized as transportation research, the database would have to be searched using transportation terms, and the data aggregated from the individual projects identified. This was done for two fiscal years, 1993 and 2002.[2]

[2] Frank Brock Riggs performed the RaDiUS searches and compiled and analyzed the search results.

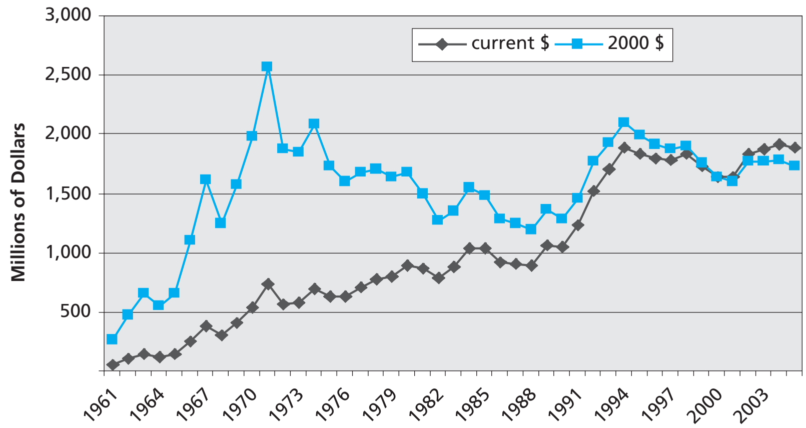

FIGURE 6 R&D by transportation budget function, in current and constant dollars. (Data source: NSF.)

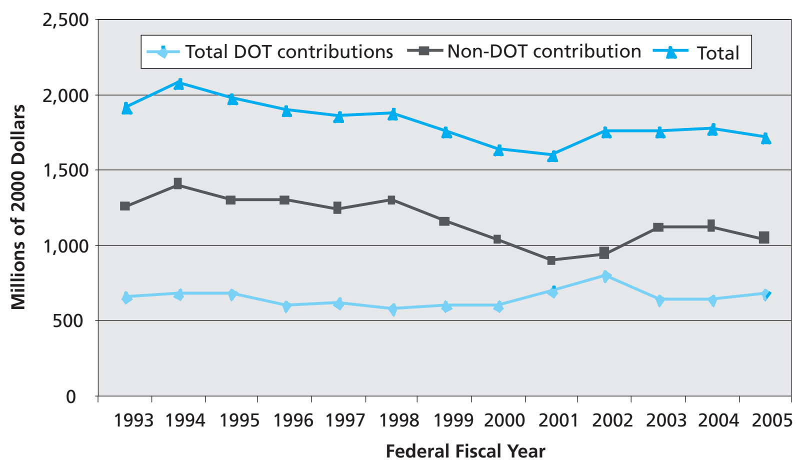

FIGURE 7 DOT and non-DOT contributions to R&D by transportation budget function, in constant dollars. (Data source: NSF.)

Assembling the Data

The project records resulting from the searches were checked individually to ensure relevance to transportation and to eliminate duplication. The database did not have consistent records for the item of greatest interest—annual funding.

Some project records had no funding information, particularly for USDA projects. Others recorded funding data in one of four ways: (*a*) total funding for an

TABLE 2 Estimated Funding of Transportation Research in Non-DOT Agencies, Fiscal Years 1993 and 2002: RaDiUS Data

	Actual Fiscal Year Funding		Average Annual Funding		Estimated Fiscal Year Funding	
	Amount (millions)	Number of Projects	Amount (millions)	Number of Projects	Amount (millions)	Percent of Projects
1993	$116	116	$17	74	$134	78%
2002	$182	354	$42	275	$223	92%

Totals do not equal sum of columns due to rounding.

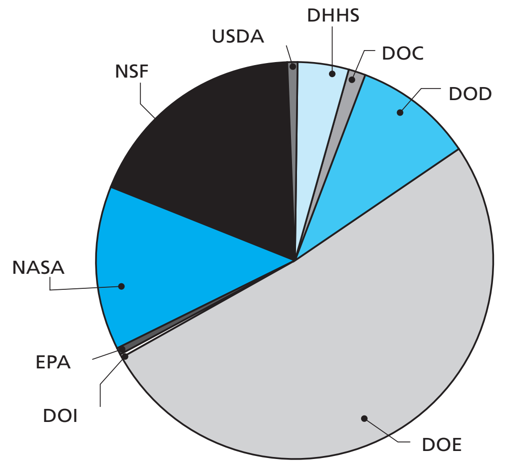

FIGURE 8 Distribution of funding for transportation research among non-DOT agencies, fiscal year 2002. (DOI = Department of the Interior; USDA = U.S. Department of Agriculture. Data source: RaDiUS database, RAND Corporation. One project from Department of Education is not included.)

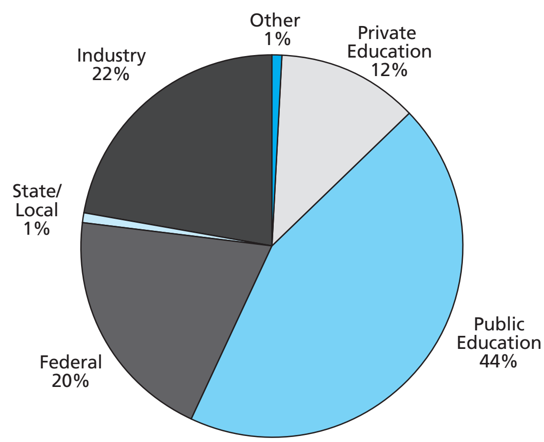

FIGURE 9 Distribution of non-DOT transportation research projects by type of research performer.

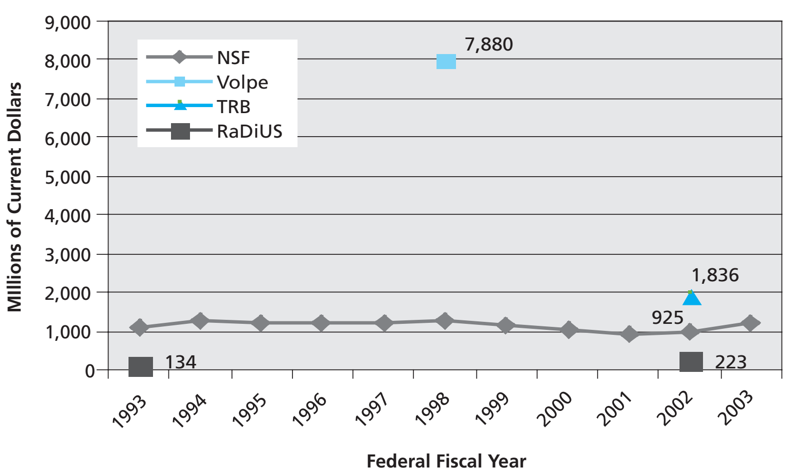

FIGURE 10 Estimates of non-DOT investment in transportation research.

entire project, often for more than one year; (*b*) average annual funding over the life of the project; (*c*) average monthly funding; or (*d*) actual funding for the fiscal year.

Projects that included funding data reported actual fiscal year funding or average annual funding, or both. If actual fiscal year funding was not available, the estimate used the figure for average annual funding. These data are presented in Table 2.

The results produce a total of $134 million in non-DOT transportation research funding in 1993, representing 78 percent of the non-DOT projects obtained from the RaDiUS search. The estimate for 2002 is $226 million, representing 92 percent of the projects identified in the 2002 search.

Comparing the Findings

Figure 8 shows the distribution of 2002 funds among federal agencies. NASA is included in this distribution and also in the NSF data for 2002, providing an opportunity for comparison. (As a new department at the time, DHS did not yet include transportation-related agencies).

The RaDiUS data indicate that NASA spent $32 million in transportation-related research in fiscal year 2002, and the NSF data indicate that NASA invested $997 million in aeronautics research that year. The search strategy used in RaDiUS was inadequate for estimating NASA's transportation research investment.

A contrasting example is found by comparing NSF data from RaDiUS with a compilation of transportation research investments prepared by NSF staff. RaDiUS indicates that NSF's 2002 investment was about $39 million, but the NSF compilation shows an investment of $75.7 million for fiscal years 2000 to 2002, or an average of about $25 million per year.[3] The difference may be that the NSF staff compilation includes research specifically focused on transportation applications, but the RaDiUS search yields basic research with broad potential applications, including transportation.

Project Awards

RaDiUS also provides information on the type of research performer, such as industry or business; private or public educational institution; federal government; private nonprofit, noneducational institution; state or local government; and other. Figure 9 gives the distribution of project awards by non-DOT agencies for 2002.

The figure shows that the majority of the awards

[3] Priscilla Nelson, NSF, provided this compilation of transportation projects.

(56 percent) were made to public and private educational institutions. Less than one-quarter went to private for-profit firms (the industry segment in Figure 9), with government agencies carrying out the remainder of the research projects.

Assessing the Approaches

Figure 10 shows the single-year estimates of non-DOT transportation research funding developed by the Volpe Center for 1998, by TRB for 2002, and by this study for 1993 and 2002. NSF data for non-DOT R&D funding under the transportation budget function are shown for comparison.

As expected, the Volpe Center's estimate according to general program areas is much higher than the others. The TRB estimate is almost twice the NSF amount for 2002, because data for more agencies were included; the TRB estimate, however, does not include all agencies' transportation R&D investments.

Despite the attempt at thoroughness, the estimates based on searches of the RaDiUS database are lower than the NSF numbers for the corresponding years. This suggests that RaDiUS searches are not a reasonable approach for developing trend data for federal transportation research funding.

Improving Accuracy

Given the importance of transportation in terms of the economy and quality of life—as well as the importance of the contributions that research makes to transportation goals—policy makers should be interested in identifying the federal government's investments in transportation research and in tracking the trends in funding. These tasks, however, are difficult to carry out with the available funding data.

The DOT and NSF data provide accurate information about transportation research investments at DOT, at two agencies of DHS—the Transportation Security Administration and the U.S. Coast Guard—and at NASA's aeronautics program. Accurate data on the funding of transportation research at other agencies, however, are difficult to assemble.

The inconsistency of the funding data in the RaDiUS database produces poor estimates. Identifying the appropriate projects to include in an analysis of transportation research depends on subjective search strategies. The more comprehensive the strategy, the more time-consuming it is to execute.

Estimates of funding levels and trends for research topic areas, therefore, warrant additional improvement. The new Research and Innovative Technology Administration of the DOT is well positioned to assume this task under its mission to coordinate and advance transportation research.

PHOTO: NASA LANGLEY RESEARCH CENTER/JEFF CAPLAN

Synthetic vision system, to give pilots a clear electronic view in fog, adverse weather, or darkness, is under development at NASA's Langley Research Center.

Acknowledgments

Several individuals and organizations provided data and advice for this study: Myron Goldstein, Norman Paulhus, and John Hopkins of the U.S. Department of Transportation; Priscilla Nelson of the National Science Foundation; the RAND Corporation, which provided access to the RaDiUS database; and the Technical Activities Division of the Transportation Research Board.

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A Transportation Professional on Capitol Hill

Observations of a Congressional Fellow

JONATHAN UPCHURCH

The author is a National Park Transportation Scholar sponsored by the National Park Foundation at Mesa Verde National Park, Colorado. From 2002 to 2004 he was a Congressional Fellow and a Professional Staff Member with the U.S. House of Representatives Transportation and Infrastructure Committee. He is a past member of the TRB Technical Activities Council.

With an interest in policy and legislation for more than two decades, I took the opportunity in 2002 to serve as a Congressional Fellow. Working in Congress reinforced my belief that transportation professionals should take a greater role in helping to create transportation policy.

For two years I worked with the U.S. House of Representatives Transportation and Infrastructure Committee—one year as a Congressional Fellow and then one year as a professional staff member. My time with the Committee coincided with much of the legislative effort in reauthorizing the Transportation Equity Act for the 21st Century (TEA-21), the federal highway and transit legislation that expired at the end of 2003.

The American Association for the Advancement of Science and 30 engineering and scientific societies sponsor Congressional Fellows to ensure that engineering and science knowledge and perspectives are a part of the decision-making process. The American Society of Civil Engineers sponsored my Congressional Fellowship.

Congressional Fellows must seek out a position

On May 15, 2003, the U.S. House of Representatives Transportation and Infrastructure Committee conducted a hearing on the reauthorization of federal highway and transit programs: (*left to right*) Congressional Staff Levon Boyagian, serving as Majority Counsel; Rep. Tom Petri, Chair of the Highways and Transit Subcommittee; Rep. Bill Lipinski, Ranking Minority Member, Highways and Transit Subcommittee; author Jonathan Upchurch, serving as Minority Counsel; and Rep. Nick Rahall.

What Is the Congressional Fellows Program?

Under the auspices of the American Association for the Advancement of Science (AAAS), approximately 30 engineering and scientific societies sponsor Congressional Fellows each year. Each Fellow spends one year working on the staff of a Member of Congress or of a congressional committee. Fellows work with congressional staff and perform the same types of tasks. Most importantly, Fellows provide scientific and technical input to policy making, decision making, and the creation of legislation.

The goals of the Congressional Fellows program are to provide a public policy learning experience, to demonstrate the value of science–government interaction, and to bring technical backgrounds and external perspectives to the congressional decision-making process.

Fellows begin the year-long assignment with a comprehensive, two-week orientation organized by AAAS. The orientation introduces Fellows to government, policy making, and the workings of Congress, through presentations by Members of Congress and high-level officials in Executive Branch agencies. The orientation includes training in the House and Senate procedures for considering and developing legislation, with significant attention to the roles of policy, process, and politics.

After orientation, Fellows seek out assignments with the staff of an individual member of Congress or of a congressional committee. Through interviews with several offices, the Fellow finds the best fit of skills and knowledge with the needs of a congressional office.

During the year on Capitol Hill, each Fellow contributes to the development of policy and legislation, providing the scientific and technical viewpoint. For additional information on the Congressional Fellows Program, visit the website, http://fellowships.aaas.org/02_Areas/02_Congressional.shtml.

on Capitol Hill that provides a good fit of their skills, knowledge, and experience with the needs of a congressional office. Interested in contributing to the TEA-21 reauthorization, I sought out committees or Member offices that would play a major role in reauthorization.

Resource and Advocate

I was offered an opportunity to serve with the staff of the House of Representatives Transportation and Infrastructure (T&I) Committee. In the House, the T&I Committee is responsible for federal highway and transit programs.

I began my work in the fall of 2002, 12 months before TEA-21 was due to expire. Although House and Senate Committees had done considerable groundwork in more than 30 hearings during 2002, reauthorization activity was beginning in earnest when I arrived. In my two years with the Committee, the House completed and passed a reauthorization bill (HR 3550) and engaged in conference negotiations with the Senate for a common bill. That effort was unsuccessful for many reasons, including the distractions of the 2004 elections.

My assignments were many and varied. My primary responsibility was the research title of the House bill, but I also contributed on many other topics. I was involved in crafting legislation, writing position papers and statements for Members to deliver on the House floor, preparing for hearings, serving as staff counsel at hearings, representing the T&I Committee, and making presentations before groups and associations about reauthorization. I served as a resource on a variety of issues and as an advocate for the importance and value of transportation research.

I was one transportation professional making a contribution to policy and legislation. All transportation professionals should take an active interest in policy and legislation and make a contribution. The greater the understanding of the process and how it works, the more effective the contribution. Following are some insights into the congressional legislative process.

Policy, Process, and Politics

Every major piece of legislation passed by Congress is influenced by policy, process, and politics. Policy represents the objectives of a federal program and the best mechanisms to achieve those objectives. Policy is debated and formed as a bill moves through the legislative process.

Process refers to the procedures and rules that are followed at all steps in the legislative development—

Past Reauthorizations of Highway and Transit Legislation

Historically, highway and transit reauthorization bills have been enacted by Congress every four to six years. The past two reauthorizations have been for six years.

Name of Legislation	Nickname	Year of Enactment	Length of Reauthorization
Surface Transportation Assistance Act	STAA	1982	4 years
Surface Transportation and Uniform Relocation Assistance Act	STURAA	1987	5 years
Intermodal Surface Transportation Efficiency Act	ISTEA	1991	6 years
Transportation Equity Act for the 21st Century	TEA-21	1998	6 years

in subcommittee, in committee, and in debate on the House floor. The House Rules Committee, for example, has a profound influence on a bill by deciding which amendments may be offered in floor debate. Another example of process is a conference committee that works to reconcile differences between the versions of bills passed by the House and the Senate.

Every Member of Congress is influenced by the needs of constituents. This is politics. A good example is how a Member's position on the issue of "donor" versus "donee" states is determined by the state's needs. Donor states pay more into the Highway Trust Fund than they receive; donee states receive more than they pay.

Recognizing that policy, process, and politics influence legislation can help a transportation professional better understand the creation of legislation and how to contribute effectively to the legislative process.

Authorizing and Appropriating

Congress must authorize every activity or program of the federal government—that is, Congress must grant permission for an activity or program to exist and for how long. Federal highway and transit legislation historically has been reauthorized every four to six years (see table, above).

Most committees in the House and Senate are authorizing committees. Many committees have a role in authorizing highway and transit programs (see sidebar, page 13), which complicates reauthorization. In contrast, appropriations committees decide annually how much money to spend on various programs.

The legislative process may seem remote and outside the technical skills of many in transportation-related professions. Yet legislation is vital to the ability of transportation professionals to serve the public and to provide a safe, rapid, comfortable, convenient, economical, and environmentally compatible transportation system.

Highway and Transit Reauthorization

Reauthorization legislation is complex, covering dozens of programs. Highways, highway safety, public transportation, motor carrier transportation and safety, research and education, planning and project delivery, transportation of hazardous materials, and financing—or generating revenues to fund the programs—are major components of a reauthorization bill.

A variety of issues is to be covered, involving many House and Senate authorizing committees. As a result, the bills passed by the House and the Senate in 2004 were 982 pages and 1,411 pages in length, respectively. The complexity of the legislation contributes to the historical experience that reauthorizations rarely are enacted on time (see sidebar, page 14).

(*Left to right:*) Rep. Eleanor Holmes Norton, Rep. James Oberstar, and Rep. Brian Baird hold a press conference, September 15, 2003, on the Rebuild America Act, introduced in the House of Representatives. Congressional staff is instrumental in drafting proposed legislation, such as the Rebuild America Act.

Dynamics of Influence

Many dynamics, often external to the transportation program, shape decision making. The state of the economy, unemployment levels, the federal budget deficit, the price of gasoline and the effect on the gas tax, the level of funding that is politically achievable, the resolution of donor–donee issues, the positions of the Office of Management and Budget and of the White House, election-year politics and re-election campaigns, and the needs of transit-intensive states versus rural states are some of the major dynamics that come into play.

Who Writes Legislation?

Congressional staff write a bill and make roughly 90 percent of the decisions that affect the wording of legislation. Although Members of Congress make the major decisions and provide direction, the staff are responsible for much of the policy making and for what is included in a bill.

Staff have an influential role. Their knowledge of the programs and issues and their level of experience determine the quality of the legislation.

Only a dozen Members of Congress have engineering or science degrees. With the exception of the staff for a few committees, such as the House Science Committee, few other congressional staff have engineering or science backgrounds. This underscores the importance of having the perspectives of science and engineering available when congressional staff and Members of Congress make policy decisions.

Two of my staff colleagues together had gained a total of 37 years of experience working for the T&I Committee. Their knowledge was exceptional, as was their institutional memory of past reauthorizations. But such a wealth of experience is unusual; a staff member's experience with a topic is as likely to be short as it is to be long. But even with years of experience, a staff member cannot know all of the issues that will surface as legislation develops.

Learning About the Issues

To be well informed in drafting legislation, congressional staff must learn continually about related topics and issues. Reports prepared by the Government Accountability Office and a variety of government and nongovernment sources are key.

Staff also rely on the Congressional Research Service, an office of the Library of Congress, to research topics and to collect information. Staff attend briefings presented by interest groups. A primary source of knowledge is meeting with and listening to those who take the initiative to inform Congress—constituents, lobbyists, individuals, and representatives of interest groups, professional associations, and state and local governments. This is one of the opportunities for transportation professionals to present viewpoints.

Did You Know?

Four Senate authorizing committees have a primary role in reauthorizing highway and transit programs:

- The **Environment and Public Works Committee** is generally responsible for programs of the Federal Highway Administration.
- The **Commerce, Science, and Transportation Committee** is responsible for highway and motor carrier safety issues, which generally correspond with the programs of the National Highway Traffic Safety Administration and the Federal Motor Carrier Safety Administration.
- The **Banking, Housing, and Urban Affairs Committee** is responsible for Federal Transit Administration programs.
- The **Finance Committee** is responsible for identifying sources of revenue to fund highway and transit programs.

In the House of Representatives,

- The primary reauthorization committee is the **Transportation and Infrastructure Committee**, which has responsibility for all issues except revenues.
- The **Science Committee** contributes to transportation research issues.
- The **Ways and Means Committee** is responsible for identifying sources of revenue to fund highway and transit programs.

With 75 Members, the Transportation and Infrastructure Committee is the largest committee in the House.

Lobbying Is Not Bad

To many, a lobbyist is a well-connected, well-paid individual with too much influence on congressional legislation. Some of the professional registered lobbyists may fit this stereotype, but most of those who present their viewpoints and professional opinions to Members of Congress and congressional staff are playing an important informational role. The meetings and briefings help to educate and inform Members and staff about programs, issues, and policy proposals.

For example, a national interest group, a state department of transportation, and the transportation consulting community coordinated efforts to demonstrate the benefits of intelligent transportation systems by conducting a tour of a traffic operations center a few miles from Capitol Hill.

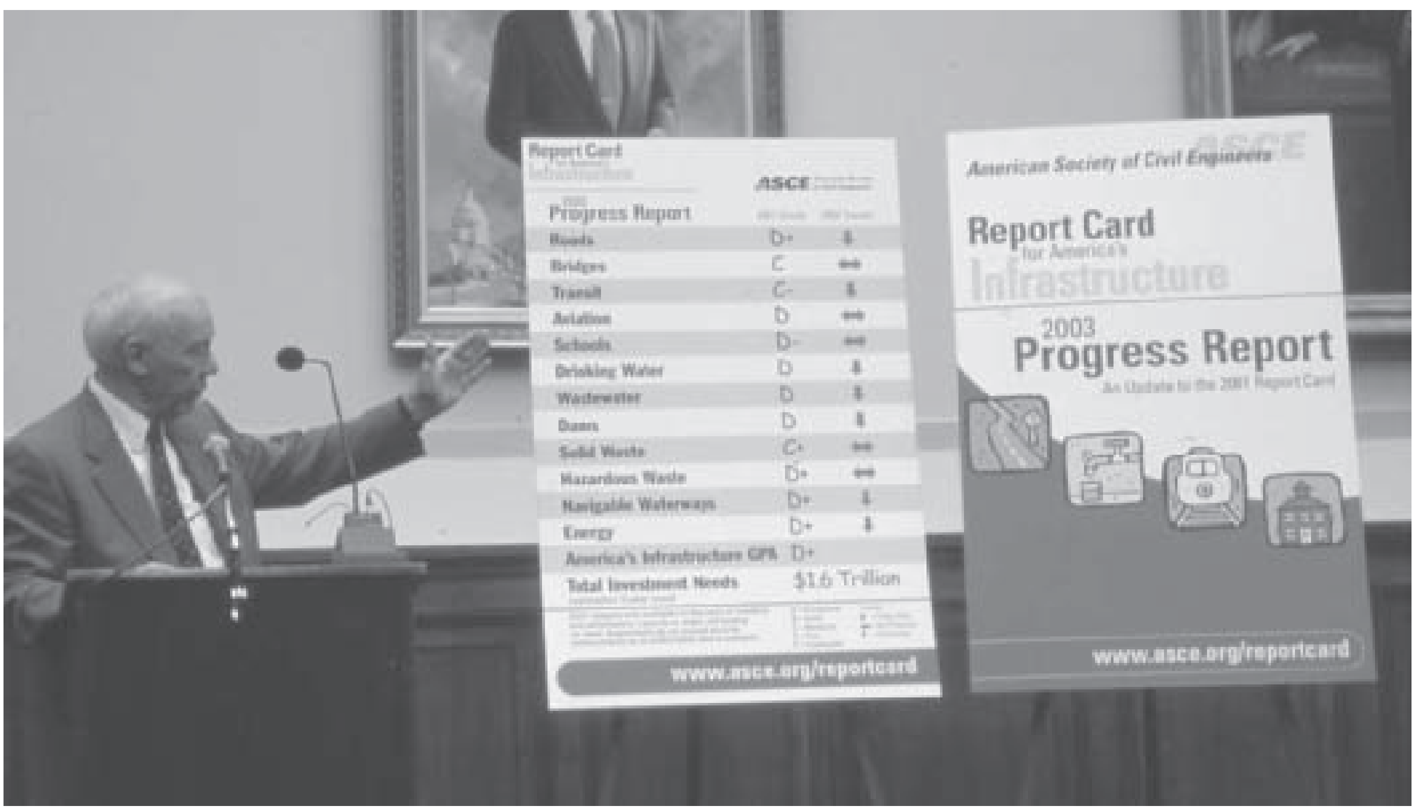
Were Past Reauthorizations Passed on Time?

	Date Previous Reauthorization Expired	Date Legislation Passed Congress	Date Legislation Signed by President	How Late?
STAA	September 30, 1982	December 23, 1982	January 6, 1983	~ 3 Months
STURAA	September 30, 1986	March 19, 1987	Vetoed by President; veto overridden by Congress, April 2, 1987	~ 6 Months
ISTEA	September 30, 1991	November 27, 1991	December 18, 1991	~ 2 Months
TEA-21	September 30, 1997	May 22, 1998	June 9, 1998	~ 8 Months
SAFETEA-LU	September 30, 2003	July 29, 2005	August 10, 2005	~ 22 Months

Presentations were made on real-time freeway management and the benefits of coordinated traffic signal systems on surface streets. The dozen congressional staff who participated came away from the event with a better understanding of transportation management and operations and why that type of program deserved funding.

Bipartisan Issue

The statement is often made that “there is no such thing as a Republican road or a Democratic bridge.” Highway and transit programs are relatively bipartisan, and the issues do not usually pit Democrats versus Republicans. More commonly, the issues revolve around geographic regions, donor versus



Rep. James Oberstar speaks at a press conference organized by the American Society of Civil Engineers, September 4, 2003, to announce the updated Report Card on America’s Infrastructure. As a Congressional Fellow and staff member, author Upchurch assisted in the preparation of speeches and remarks by members of Congress on transportation-related issues.

donee states, or whether state or local governments will have control over decisions to spend federal dollars. The T&I Committee has a reputation as one of the most bipartisan in the House.

Importance of Research

Transportation research needs champions in the legislative arena. Some Members and some staff recognize and appreciate that investments in research are investments in the future economy, efficiency, and productivity of the transportation system—they should be congratulated for their foresight.

One of the major concerns in the reauthorization debate was the great disparity between the annual transportation investment needs cited in the U.S. Department of Transportation's Conditions and Performance Report and current revenues. The common response of many players in reauthorization was that spending more and more money was a necessity.

Transportation needs are great, revenues are limited, and building and maintaining infrastructure are effective uses of revenue and resources. In the political world of two-year terms, construction often appears to have a quicker payoff and return than investments in research—with the political dividends of public visibility and improved transportation service.

An alternative response to the disparity between needs and revenues is to stretch the dollars to do more. Research is a way to do that. Research helps use available resources more effectively, reducing the imbalance between revenues and needs.

For example, if we can design and build a pavement that will last 20 years instead of 10, if we can build bridges that require less maintenance, and if we can develop a less expensive construction technique, we can accomplish more with the available revenue. These outcomes, however, are the result of investment in research but are equivalent to additional revenue.

Getting Involved

In the legislative arena, therefore, continued promotion of the benefits of investment in transportation research is necessary. Transportation professionals should be more involved in the policy-making process and in the development of legislation. Transportation professionals need to be proactive and not sit back to let others make these important decisions.

Transportation professionals are well trained in the technical aspects of their specialties. For example, transportation engineers can determine the best timing of a traffic signal to optimize traffic flow and can design the thickness of a pavement to handle 24,000 vehicles per day with 18 percent heavy trucks. But our education has not attuned us to the importance of policy and legislation.

Why should transportation professionals be interested in policy? We care that 42,000 people die each year in traffic accidents in the United States. We care that the average urban American spends 62 hours per year in congested traffic. We care that the quality of the air may trigger asthma in our children or grandchildren. These are some of the reasons that we should care about government policy and the development of legislation.

We know and understand the issues, our careers are focused on transportation, and we deal with the issues every day. We can offer to serve as resources on transportation issues for city councils, state legislatures, and Congress. All transportation professionals can play a role in policy making and legislation.

My experience as a Congressional Fellow showed that policy and legislation have a profound impact on the transportation community; the experience also showed what transportation professionals can do to serve society. Transportation professionals must be proactive in participating in the development of policy and in the creation of legislation. We have much to contribute that can lead to policy and legislation that will be more effective in improving the quality of life.

How to Keep Up-to-Date on Policy and Legislative Issues and the Actions of Congress

Several organizations regularly report on legislative activity. Following are a few of the electronic newsletters that focus on transportation legislation and policy issues:

- The American Association of State Highway and Transportation Officials publishes *AASHTO Journal Weekly Transportation Report* each Friday at http://news.transportation.org/journal.aspx.

- The American Society of Civil Engineers publishes *This Week in Washington* on most Fridays at www.asce.org/pressroom/news/grwk/index.cfm.

- The Institute of Transportation Engineers periodically publishes *Washington Weekly* at www.ite.org.

BRIDGES of the AASHO Road Test

A Unique and Historic Research Endeavor

S. J. FENVES, J. W. FISHER, AND I. M. VIEST

The authors carried out the bridge research at the AASHO Road Test and all are members of the National Academy of Engineering. Fenves is Professor Emeritus of Civil Engineering, Carnegie Mellon University, Pittsburgh, Pennsylvania, and Guest Researcher, National Institute of Standards and Technology, Gaithersburg, Maryland. Fisher is Professor Emeritus of Civil Engineering, Lehigh University, Bethlehem, Pennsylvania. Viest is President, IMV Consulting, Bethlehem, Pennsylvania.

Tests in the early 1920s and later studies showed that the service life of a highway pavement is related to the magnitude and frequency of the wheel loads, to the characteristics of the pavement and its substrate, and to the environment. Efforts to quantify these relationships led the American Association of State Highway Officials[1] (AASHO) to conduct the historic Road Test in the late 1950s.

Contributions from the 48 contiguous states, Hawaii, the District of Columbia, and the territory of Puerto Rico financed this major undertaking. The U.S. Department of Defense provided a unit of 300 to 400 soldiers to drive the test vehicles. The total cost of the project was approximately $27 million, including $12 million for research, $12 million for construction, and $3 million in contributed services.

The Highway Research Board[2] (HRB) was responsible for the project's administration and direction. Advisory committees and panels reported to the National Advisory Committee, chaired by Professor K. B. Woods, Head of the School of Civil Engineering at Purdue University. Day-to-day direction of the work was the responsibility of Project Director Walter B. McKendrick, Jr., and Chief Engineer William N. Carey, Jr.

Technical personnel reporting to Carey included research engineers in charge of the four principal branches: Alvin C. Benkelman, flexible pavements; Frank H. Scrivner, rigid pavements; Ivan M. Viest, bridges; and Paul E. Irick, data processing and analysis. Personnel included permanent staff and engineers-in-training assigned to the project by the Bureau of Public Roads[3] (BPR) for 6 months. Interested agencies and organizations also delegated consultants and observers to the Road Test.

Pouring slab for test bridge.

Adding Bridges

At the request of the AASHO Committee on Bridges and Structures, the plan to test asphaltic and concrete pavements was expanded in scope in December 1951 to include bridges. The structures were to be designed as case studies of the effect of repeated overstress on the service life of highway bridges.

The bridge research was the brainchild of three members of the HRB Bridge Committee: E. L. Erickson, Chief of the BPR Bridge Division; Glen S. Paxson, Bridge Engineer of the Oregon State Highway Commission; and Chester P. Siess, Research Associate Pro-

[1] Now the American Association of State Highway and Transportation Officials.

[2] Now the Transportation Research Board.

[3] Now the Federal Highway Administration.

fessor of Civil Engineering at the University of Illinois. At the HRB 1951 annual meeting, the committee developed the proposal for including case studies of ordinary slab-and-beam highway bridges in the AASHO Road Test.

The final plan for the Road Test included 16 short-span test bridges representing in simplified form the types of bridges commonly built on the U.S. highway system. A Subcommittee on Bridges was appointed as part of the Working Committee of the AASHO Committee on Highway Transport.

The subcommittee selected the design variables and criteria for the test bridges, which included eight bridges with steel beams, four with prestressed concrete beams, and four with reinforced concrete T-beam construction. BPR designed the bridges with steel beams; the Portland Cement Association designed the bridges with concrete beams. The subcommittee reviewed the final designs.

Construction and Adjustments

The AASHO Road Test facility was located a short distance northwest of Ottawa, Illinois, and 80 miles southwest of Chicago, on the right-of-way of the future Interstate 80. Construction of the temporary test facility started in August 1956.

The first concrete for bridge foundations was cast on October 5, 1956, and the last concrete on May 28, 1957. The erection of beams commenced in June and was completed by the end of November. Roadway slabs for bridges with steel and prestressed concrete beams were cast from August 1957 to April 1958. The superstructures for the reinforced concrete bridges were cast in August and September 1957.

Vehicles first crossed over the test bridges on August 29, 1958. Regular test traffic began on November 5, 1958, and ended on December 3, 1960.

Early in the testing, four of the steel beam bridges failed. Safety cribs then were placed for support under all bridges before the beginning of the test traffic, with enough clearance to permit unrestricted deflections under loading, as well as inspection of the underside.

Cribbing placed below test bridges.

Two of the failed bridges were replaced, increasing the total of the test bridges to 18. Regular test traffic began on the two replacement bridges on June 20, 1959. Both bridges survived the remaining period of the test traffic.

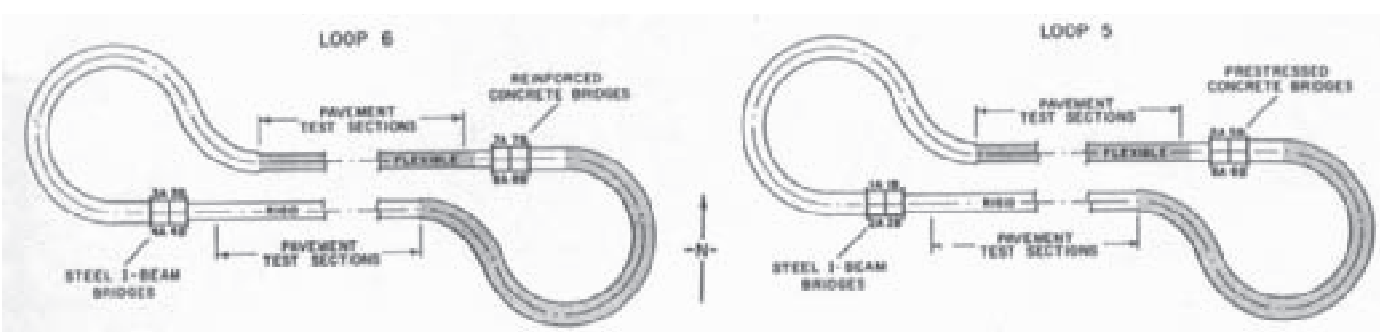
Conducting Additional Tests

Dynamic tests of the bridges were conducted from fall 1958 to October 1960, in cooperation with the University of Illinois. Bridge testing continued after the completion of the regular test traffic, first with accelerated fatigue tests and then with tests that increased the loads until the bridge's failure.

The fatigue tests added to the number of maximum stress cycles accumulated in the regular test traffic. The tests with increasing loads were conducted to determine the greatest loads that could cross a bridge, as well as the mode of failure for each bridge type. All bridge testing was completed by June 12, 1961.

The Advisory Panel on Bridges and the Special Committee on Dynamic Behavior of Test Bridges, both chaired by Paxson, guided the bridge research. Members included Erickson and and state bridge engineers W. C. Hopkins, Maryland State Roads Commission; and O. L. Kipp and A. E. LaBonte, Minnesota Department of Highways; university professors Siess and A. S. Veletsos of Illinois, B. Thürlimann of Lehigh, and J.

Locations of test bridges.



Chronology of Bridge Research at the AASHO Road Test

1951 In December, at the request of AASHO Committee on Bridges and Structures, the scope of the AASHO Road Test is expanded to include bridges.

1952 Types and number of bridges, design variables, and criteria are selected.

1953 Bureau of Public Roads designs the steel bridges; Portland Cement Association designs the concrete bridges.

1954 Cost of bridge research is estimated at $386,000, including construction.

1955 Final scope of the project is limited to slab-and-beam type bridges. Each bridge is to consist of three simple-span beams supporting a concrete slab. Bridges with steel, reinforced concrete, and prestressed concrete beams are included.

1956 National Advisory Committee for the AASHO Road Test and Advisory Panel on Bridges are established.
Construction of the test road starts in August.
First pour of concrete for bridge foundations, October 5.

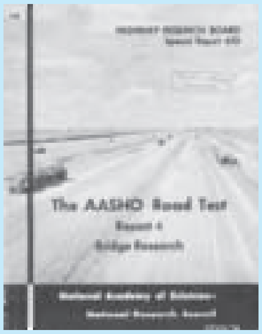
1958 University of Illinois starts cooperative investigation, Dynamic Studies of Bridges on the AASHO Road Test.
Four steel bridges designed to sustain stresses approaching the yield point fail in preliminary tests.
Controlled test traffic is inaugurated, October 15.

1959 Two of the four steel bridges that failed are replaced with two new steel bridges. Regular test traffic on the new bridges starts in June.

1960 Regular test traffic ends November 30.
Accelerated fatigue tests of bridges start in December.

1961 Bridge tests with increasing overloads start in March.
Accelerated fatigue tests are completed by end of May.
Testing of bridges is completed June 12.

1962 Bridge research results published in HRB Special Reports 61D and 71.
Conference on the AASHO Road Test convenes in St. Louis, Missouri, May 16–18.



Removing damaged steel from test bridge.

M. Biggs of Massachusetts Institute of Technology; and Road Test staff Carey and Viest.

Bridge Types

The AASHO Road Test included six test loops of two double-lane tangents with a variety of pavements. Turnarounds at each end of a tangent permitted continuous test traffic. The test bridges were one-lane, single-span structures. Groups of four bridges were placed at the beginning of the pavement test tangents on the two loops that carried the heaviest truck traffic.

All four bridges in a group were supported by a concrete substructure of two abutments and one pier on spread footings. Each superstructure consisted of three identical beams supported on steel bearings, fixed on the center pier, permitting expansion at the abutments. The 50-foot beams carried a reinforced concrete slab 6.5 inches thick and 15 feet wide. A 12-by-12-inch timber curb—two pieces spliced loosely at midspan—was bolted to the outside edge of the slab.

The steel beams varied from bridge to bridge in the size of the cross section, in the presence or absence of partial-length cover plates on the bottom flange of the I-section, and in the presence or absence of composite interaction with the slab. The cover plates were terminated according to the requirements of the stress analysis—that is, they were cut off short of the supports. In bridges with composite action, the slab was connected to the beams, eliminating differential movement along the interface of the two elements. The physical properties of the structural steel were close to the minimum specified values.

According to tension tests of coupons—or steel test strips—taken from the flanges of the delivered beams, the mean yield point varied from 34.7 to 37.9 thousand pounds per square inch (ksi) for the original bridges and was 32.5 ksi for the two replacement bridges. To preclude bonding with the slab on noncomposite bridges, the top surfaces of the steel beams were coated with a mixture of graphite and linseed oil. Channel shear connectors were welded to the top flanges of composite bridges. On the replacement bridges, a partial-length cover plate was welded on the bottom and also on the top flanges of the steel beams.

As noted, in composite bridges, differential movement does not occur along the interface of the slabs and the supporting beams. In noncomposite bridges, however, the slab deforms independently of the supporting beams and is free to slide along the top surfaces of the beams.

A commercial precaster in Springfield, Illinois, manufactured the prestressed concrete beams. All had the same cross section but with differences in prestressing steel and in the details of the end anchorages. Two bridges were posttensioned and two were pretensioned.

The beams of the posttensioned bridges were reinforced with draped parallel-wire cables. The cables were made up of ten 0.192-inch wires enclosed in a flexible steel conduit, secured by Freyssinet anchorages, and grouted. Each beam had four of these tendons in the lower-stressed bridge and six in the higher-stressed one.

The pretensioned beams were reinforced with straight 3/8-inch, 7-wire strands anchored by bond. Each beam had 16 strands in the lower-stressed and 20 in the higher-stressed bridge. All other features—such as the reinforcement of the relatively thin web connecting the two flanges of an I-section, the connection of the beams to the slab, and the slabs—were the same in all of the prestressed concrete bridges.

Loaded truck crosses test bridge. Bridge trailer that housed data recorders is at right.

The reinforced concrete bridges were constructed with monolithic T-beams. The cross section of the four bridges differed only in the details of the principal reinforcement. The stems of the T-beams were reinforced in tension with two layers of standard deformed reinforcing bars: three No. 11 bars in the bottom layer and two No. 9 bars in the upper layer. In addition, one No. 8 bar was placed in the upper layer of each stem on the lower-stressed bridges. The web reinforcement, slabs, and diaphragms were the same for all the reinforced concrete bridges.

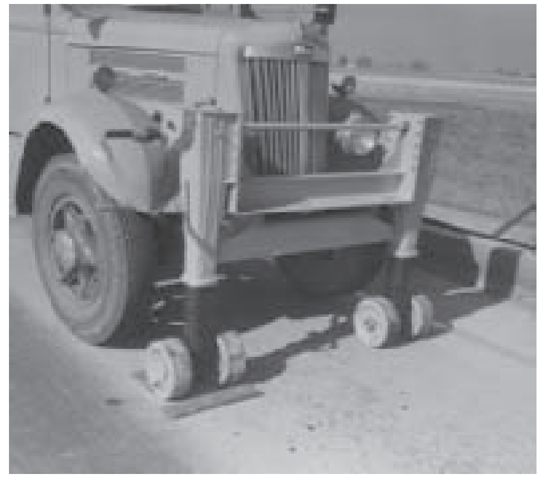
Tests with Repeated Stresses

Before the test traffic, regular test vehicles made special runs over all bridges to collect initial data on stresses and deformations. These reference tests were repeated at 6-month intervals.

Generally only small changes were observed in the stresses; nonetheless, the deflections of all bridges

Installing sensor beneath a bridge. Sensors were connected to data recording equipment in trailer.

Amplifiers and recording oscillographs in bridge trailer.



Above, left: Mechanical oscillator on a bridge. *Above, right*: Vibrating truck on bridge.

increased with time. The increase was generally 5 to 16 percent in steel bridges and 18 to 35 percent in concrete bridges. The changes in deflections indicated decreasing stiffness, probably the result of cracking in the concrete slabs and concrete beams. Progressive cracking was observed as the test vehicle trips accumulated.

Tests of steel beams with partial-length cover plates demonstrated that the section at the end of a cover plate—and by implication at other stress raisers of similar configuration—can be critical in fatigue cracking. By the end of the regular test traffic, all steel bridges with partial-length cover plates had at least one fatigue crack.

In the reinforced concrete bridges designed for high stress, two bars broke in the exterior beam after 730,000 cycles. The fractures seemed to occur suddenly. An examination of the reinforcing bars after bridge failure, however, revealed incipient cracks short distances away from the breaks. The crack growth, therefore, must have been gradual, leading to the fractures.

In the prestressed concrete bridges subjected to tensile stress lower than the modulus of rupture, some fatigue cracking of concrete was detected during the test traffic. This fatigue cracking, however, had no observable effects on the overall behavior of the test bridges, except for an increase in deflections.

The number of stress cycles for the fatigue cracking of steel beams with partial-length cover plates and for the fracture of reinforcing bars in reinforced concrete bridges was compared with laboratory fatigue data for similar specimens. The results indicated that with an estimate of the magnitude and the number of repetitions of stress, laboratory fatigue data for component elements can forecast—within reasonable limits—the service life of a bridge until fatigue failure.

Accelerating Fatigue

The AASHO Road Test bridge research demonstrated that consideration of fatigue should be integrated into the design requirements for bridges on the highway system. Furthermore, the findings suggested a simplified method for fatigue design, but systematic laboratory tests were needed to develop practical requirements. The tests were performed later at Lehigh University under the National Cooperative Highway Research Program (NCHRP).

After the conclusion of the regular test traffic in December 1960, 7 of the 13 surviving test bridges were subjected to accelerated fatigue tests. A mechanical oscillator was applied to the bridges at an amplitude that approximated the maximum stress and the range of the fluctuating stress at the critical section during the test traffic. The vibration continued until bridge failure or until 1.5 million stress cycles—comparable to the number of cycles accumulated during the test traffic, with each trip of a regular test vehicle counted as one stress cycle.

The accelerated fatigue tests were equivalent to laboratory fatigue tests and differed from the tests under regular test traffic. Most of the differences, however,

Special vehicle during test to failure with increasing loads.

could be interpreted analytically or were minor.

For the bridges that failed by fatigue, the number of stress cycles applied in the accelerated tests was small in relation to the number of vehicle trips. The effect of the differences between the two types of tests on the findings, therefore, was negligible.

Dynamic Load Tests

The dynamic amplification—or impact—of vehicle loads has been a longstanding concern in bridge design. A simple formula relates the impact factor to the length of the bridge.

Research to develop comprehensive, yet easy-to-use, impact provisions for highway bridges has a long history. The AASHO Road Test site, only a 3-hour drive from the University of Illinois at Urbana, provided the Civil Engineering Department the opportunity to extend an active program of research on bridge impact from model tests and numerical simulations to full-size vehicles running on nearly full-size bridges.

The university and HRB established a cooperative research project, with Siess and Veletsos as principal investigators. Assistant Professor Robert K. L. Wen served as the first program manager, succeeded in the fall of 1958 by Steven J. Fenves, an instructor.

Implementing Dynamic Tests

The University of Illinois team developed the tests, which were reviewed and approved by the Special Committee on Dynamic Behavior of the Test Bridges and were performed by the Bridge Research group. The group ran approximately 1,900 tests from October 1958 through October 1960 on all bridge types, using 14 types of vehicles at speeds from 10 to 50 miles per hour.

The dynamic tests explored a range of parameters for bridge vehicles—such as speed, weight, frequency, and deflection ratios—and examined influencing factors, such as initial bridge and vehicle oscillations, eccentric loading, and the effect of inoperative vehicle springs. Qualitative and quantitative evaluations and comparisons were made in two formats: time histories, with the dynamic amplification of displacement and strain plotted against the vehicle position; and spectra, with the peak responses of interest plotted against the speed parameter.

Additional characterization tests on the bridges examined static loads and loads on vehicles traveling at a crawl speed of 3 miles per hour. Characterization tests of static loading on pavements included vehicles with normal and inoperative springs. The behavior models and testing methods for bridges were well established then, but the behavior of vehicles was largely unknown.

The static loading tests established the bilinear

Load testing.

load-deflection characteristics of the vehicle leaf springs—initially the springs act as a single beam, then after overcoming the interleaf friction, each leaf deforms independently. The dynamic tests of vehicles on pavements primarily served to evaluate and calibrate the tire pressure gauges and the trailer-mounted recording mechanism developed by the Road Test instrumentation staff.

The analytical model for comparison with the experimental test results was sophisticated at the time, running on the University of Illinois' high-speed automatic computer, ILLIAC, which had 1,000 words—or 5 kilobytes—of storage.

Test Results

The dynamic tests confirmed all of the theoretical predictions about the bridges: that the bridges acted as simply supported beams; that noncomposite steel, prestressed, and reinforced concrete bridges exhibited different characteristics under load than in free vibration; and that age—that is, the number of regular load applications—reduces structural stiffness, except in composite steel bridges. Surface irregularities on the approaches and on the bridge had pronounced effects.

The major accomplishment of the dynamic tests on the AASHO Road Test bridges was the calibration of the analytical model to functioning bridges and vehicles.

AASHO Road Test Project Director Walter B. McKendrick, Jr. (*right*) joins National Academy of Sciences officials on an inspection tour of the bridge project.

Two prestressed concrete bridges after failure under increasing loads.

Other Tests and Studies

Four steel bridges, four prestressed concrete bridges, and two reinforced concrete bridges survived the tests with repeated loads and were available for tests that increased the loads until the bridge's failure. The tests studied the bridge's response to loads that approached capacity, to determine the bridge's manner of failure under moving loads, and to provide data for checking theories about ultimate strength.

In each test, the load would cross the bridge 30 times. The load then was increased for another 30 crossings. The procedure was repeated until the concrete slab was crushed, or the principal tension steel was fractured, or an already extreme permanent set—or deformation—at midspan continued to increase with each successive trip of the vehicle.

The tests with increasing loads were unique. No tests similar in scope have been performed since then on individual bridges. As Erickson observed, "[The] bridge tests in the Road Test program…have given information [about] the effect of overload on highway structures. Certainly it was demonstrated that overloading bridges sufficiently is going to wreck them."

HRB Special Report 61D, *The AASHO Road Test Report 4: Bridge Research*, describes seven additional tests and studies carried out during the project. The special post-traffic tests, for example, were carried out on pavements and bridges at the request of the Department of Defense, which was actively involved in the testing, to study the effects on bridge response of (*a*) tire pressure and tire design, (*b*) commercial construction equipment, (*c*) special suspension systems, and (*d*) military vehicles.

Other studies considered the properties of the concrete and steel in the test bridges and the development of a bond-breaking agent to allow treatment of the top flanges of the steel beams in noncomposite steel bridges. A mixture of linseed oil and graphite was found effective for preventing a bond.

The materials tests investigated the outdoor creep and shrinkage of concrete in prestressed concrete

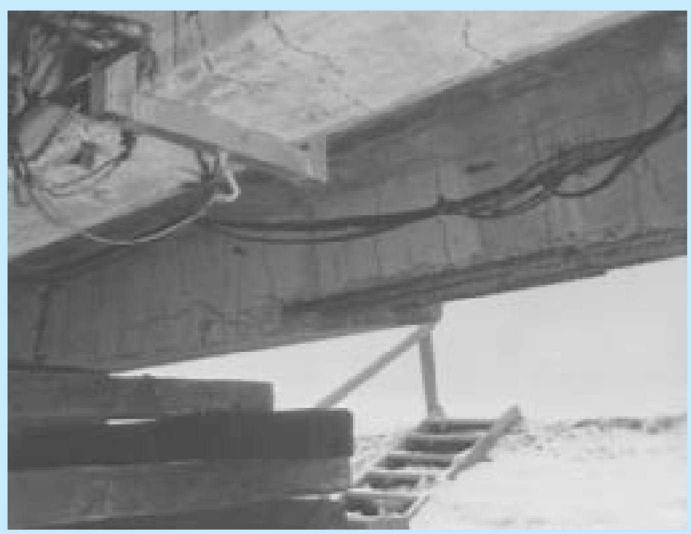
When Does a Bridge Fail from Fatigue?

The Road Test's composite steel beam bridge was designed to sustain the stress of 35,000 pounds per square inch at the ends of the partial-length cover plates that were welded to the bottom flanges of the rolled steel sections. The bridge sustained all 558,400 trips of the assigned test vehicles.

By the end of the test traffic, fatigue cracks were visible at five locations. Three were confined to the areas around the toe of the welds connecting the cover plates. One extended from the weld to the near edge of the flange and another extended the full depth of the bottom flange from the edge to the web.

Additional applications of critical stress with a mechanical oscillator caused further growth in the cracks. One crack extended slowly toward the web. At 25,800 oscillator cycles, the crack reached about 6 inches into the web; a complete fracture of the steel section occurred after 47,500 oscillator cycles—that is, a total of 605,900 cycles of critical stress.

Two reinforced concrete bridges designed for a tensile stress of 40,000 pounds per square inch also were subjected to additional critical stresses with an oscillator. The tests proceeded smoothly for more than 170,000 post-traffic cycles. The response of the strain gages at midspan of one of the bridges became erratic at 172,600 cycles. An inspection after 174,000 cycles revealed two fractured reinforcing bars.



Fatigue failure of reinforcing bars in a reinforced concrete bridge.

In the other bridge, the bar fracture was signaled by a loud noise at 172,200 post-traffic cycles. One reinforced concrete bridge sustained a total of 730,100 and the other 728,300 critical stress cycles.

beams; relaxation and fatigue tests of the prestressing steel; fatigue tests of the reinforcing bars in the stems of the reinforced concrete bridges; and determination of the residual stresses and fatigue strength of structural steel in the rolled sections of the steel bridges.

The results of the creep and shrinkage tests of concrete cylinders, made from the same mix and at the same time as the prestressed concrete beams, were not published.

Follow-Up

The development of fatigue cracks at the ends of partial-length cover plates on steel test bridges demonstrated the need for comprehensive experimental studies. At that time, only approximate design relationships were available, relying on limited laboratory tests of small-scale samples. NCHRP initiated comprehensive research to provide data for the design of welded bridges. A series of research projects was carried out at Lehigh University starting in 1967.

Additional studies followed in the 1970s, when fatigue cracking was discovered in bridges on the highway system. Some of the cracking in beams with partial-length cover plates occurred in bridges with as little as 13 years of service. Furthermore, fatigue cracks were discovered frequently at the ends of web stiffeners, when stopped short of the beam flange.

The new studies included variable-cycle loading, full-scale bridge attachments, detection and repair of fatigue cracks, and an examination of large-scale experiments carried out worldwide in the 1970s and 1980s. NCHRP published these studies in nine reports—seven on the tests carried out at Lehigh University and two on tests at United States Steel Corporation. A new set of design requirements appeared in the 1986 American Association of State Highway and Transportation Officials (AASHTO) specifications.

Research on bridge dynamics has continued at the University of Illinois, at the Federal Highway Administration's Turner-Fairbank Highway Research Center, and elsewhere. The analytical bridge model for the Road Test bridges has been extended to continuous bridges and to two-dimensional modeling. Two-dimensional modeling has allowed the consideration of bridge skew, lateral stiffness distribution, superelevation, the effect of centrifugal forces, and many other parameters.

Dynamic tests are performed sporadically as a part of other full-scale bridge tests, but no program has matched the scale and comprehensiveness of the AASHO Road Test. With the veracity and reliability of analytical models today, if the bridge behavior can be verified by static and low-speed crawl tests, the full dynamic behavior predicted by the analytical models is accepted, at least for conventional dynamic effects on linearly elastic bridges.

AASHO Road Test Bridge Engineering Researchers

At the Road Test Site
Ivan M. Viest, Bridge Research Engineer
John W. Fisher, Assistant Bridge Research Engineer
Charles F. Galambos, Bureau of Public Roads (BPR) Bridge Engineer
James H. Hatton, BPR Assistant Regional Bridge Engineer

Resident Staff Consultants and Observers
Bert E. Colley, Portland Cement Association
Samuel M. King, American Trucking Associations
R. Ian Kingham, Canadian Good Roads Association

BPR Trainees
David C. Briggs, Vernon Buchele, Jerry L. Budwig, Lloyd R. Cayes, Gordon C. Hoxie, Kenneth D. Jaeger, Gerald N. Lind, Norman W. Loeffler, William T. Medley, Gordon W. Million, Norman C. Mueller, Donald J. Philbrick, Richard A. Richter, John W. Schmidt, Robert E. Stanford

At the University of Illinois
Chester P. Siess, Professor of Civil Engineering
Anestis S. Veletsos, Professor of Civil Engineering
Robert K. L. Wen, Assistant Professor of Civil Engineering
Steven J. Fenves, Instructor in Civil Engineering
Tseng Huang, Assistant Professor of Civil Engineering

Research Assistants in Civil Engineering
Elton G. Endebrock, Norris L. Hickerson, Alfred Korn, Walter P. Moore, Richard L. Rolf

A Unique Experiment

The bridge experiment at the AASHO Road Test provided insights into the behavior of highway bridges under the stresses caused by

- Large volumes of truck traffic,
- Moving loads, and
- Extreme overloads.

Extensive fatigue tests conducted after the completion of the Road Test studies have resulted in simple, but comprehensive, design requirements that should ensure the satisfactory long-term performance of welded steel bridges.

Because details of bridge dynamic behavior now can be ascertained by static and low-speed crawl tests combined with predictions from analytical models for all but the most unusual bridges, another experimental program of the scale and comprehensiveness of the dynamic load tests at the AASHO Road Test is unlikely. The bridge experiment at the AASHO Road Test nearly 50 years ago remains unique.

Starting Students on the Transportation and Civil Engineering Track

AASHTO's TRAC Program Leads by Example

SHARON J. TILLMAN

The author is editor of the quarterly newsletter TRAC Record *and marketing consultant to TRAC, a program of the American Association of State Highway and Transportation Officials, Washington, D.C.*

The American Association of State Highway and Transportation Officials (AASHTO) created the nonprofit TRAC Program—which stands for transportation and civil engineering—to improve the quality and the diversity of the professional transportation workforce.[1] The hands-on education outreach is designed for use in science, math, technology, and social science classes.

TRAC engages students in solving real-world problems, sends volunteer mentors into classrooms, and supplies teachers with the needed materials, while connecting students in kindergarten through 12th grade to the work world of transportation professionals and civil engineers. The program aims to inspire students to consider careers in these fields.

Raising Awareness

Someone once asked a group of businesspeople, "Who is the greatest basketball player of our time?" Some answered Michael Jordan, others said Julius Erving or Larry Bird.

"Wrong," was the reply. "The greatest player could be the one kid who was never told he or she could play."

Similarly, the person who designs the world's first magnetic levitation transit system or creates a life-saving intelligent transportation system could be sitting in a classroom anywhere in the country or in the world. But without an awareness of transportation as a career opportunity, that potential may never be realized.

"Getting the students excited about the field of transportation is our ultimate goal," says TRAC Manager Tate Jackson. Mentoring students—especially women and minorities—is the principle that drives the program. Now in its 11th year, TRAC was one of the first transportation outreach programs in the United States.

A student from Manor High School, near Austin, Texas, watches as a volunteer from Texas DOT prepares to load test a spaghetti bridge during the school's annual Spaghetti Bridge Competition.

[1] TRAC is a trademark of AASHTO.

Guiding Principles

Four basic principles guide TRAC:

◆ The professional and technical ranks of transportation and civil engineering have been in a steady decline—young people must be encouraged to pursue careers in transportation.

◆ National leadership from within the transportation profession is needed to develop interest about the field among a diverse population of precollege students, who are the transportation students and professionals of tomorrow.

◆ Mentoring brings out a student's potential and presents career options not previously considered.

◆ With the right tools, teachers and volunteers can reach students with greater ease and greater effectiveness.

Math teacher Randy Wormald (*left*) of Belmont High School, Belmont, New Hampshire, reviews a map with students during a TRAC activity.

"This program is contributing to workforce development, and it enables state departments of transportation to contribute to the communities they serve," notes John Horsley, Executive Director of AASHTO. "TRAC is a win–win achievement, bringing us closer to the public and the public closer to us."

Horsley points out that TRAC builds on the federal Garrett A. Morgan Transportation and Technology Futures Program, which shares the goal of "attracting new talent to the transportation industry."

No national statistics are available on the makeup of the transportation labor force, but statistics on civil engineering provide a good indicator. According to the Bureau of Labor Statistics, of the 293,000 civil engineers in the nation in 2004, 11.7 percent were women, 7.7 percent were African Americans, and 4.6 percent were Hispanics. In comparison, the national labor pool of 139,252,000 employed persons for the same year included 46.5 percent women, 10.7 percent African Americans, and 12.0 percent Hispanics.[2]

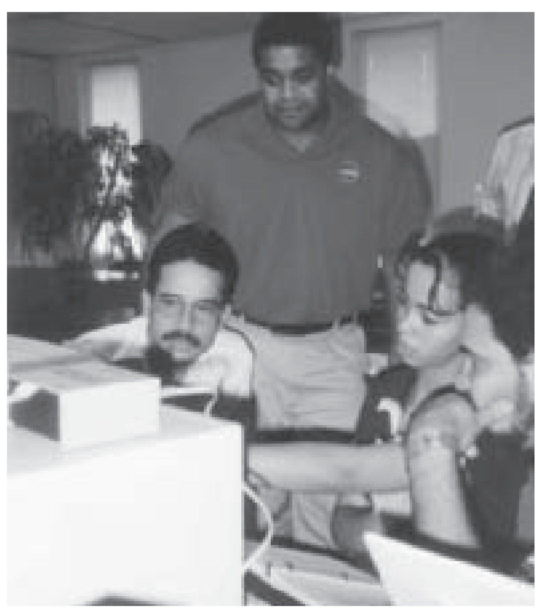
Professionals Band Together

In the late 1980s, AASHTO charged a committee to develop a guide for recruiting civil engineering students. The target audience was college juniors and seniors.

The effort was addressing the shortage of civil engineers, but the underlying problem was that not enough young people were aware of civil engineering in the first place. After developing the guide, the task force recommended that AASHTO launch an initiative to attract young people to transportation and civil engineering careers—an initiative that would connect to high school and middle school students and convey excitement about the profession.

A task force developed an interactive approach to recapture the enthusiasm that most children have when they build things—like sand castles and block towers. What emerged was an on-the-job experience that took advantage of the emerging personal computer, incorporated hands-on learning, and included realistic planning and design problems based on transportation and civil engineering concepts. The task force theorized that if the engineering problems incorporated practical applications of what students were learning in math and science, teachers would be interested in bringing the program into the classroom.

Working with these recommendations, AASHTO, the Federal Highway Administration (FHWA), and the National Cooperative Highway Research Program



TRAC National Manager Tate Jackson (*center*) trains volunteer engineers on the TRAC activities in Puerto Rico.

[2] Bureau of Labor Statistics. Household Data, 2004. www.bls.gov.

Photograph: Kirk Frankfurth

TRAC's Highway Safety module emphasizes teamwork, as students work together to choose the best solution to a traffic problem.

(NCHRP) launched TRAC in January 1991. Members of AASHTO, FHWA, various professional societies, and other industry and minority organizations provided financial support and participated on the program's joint steering committee.

The AASHTO Special Committee on TRAC, comprising state department of transportation (DOT) officials and AASHTO and FHWA employees, acts as an oversight board, making policy decisions and guiding the program (see sidebar, page 29). AASHTO administers the TRAC Program, which benefits in several ways:

- **Resources—**Through AASHTO, TRAC has access to information currently used in the field and can present real situations to students, accurately portraying the work of the transportation profession.
- **Organization—**The TRAC national management staff is located at AASHTO's Washington, D.C., headquarters, streamlining the program's business operations and strengthening management.
- **Networking—**As the voice of the state DOTs, AASHTO is well connected with members of the industry on many levels. TRAC has access to these contacts to raise awareness, gain funding, and recruit volunteers.

At the State Level

TRAC reaches its target audience of students through state DOTs. After joining the program and paying the annual membership fee of $12,750, a state DOT establishes a regional center to administer the program.

TRAC national headquarters provides guidance, marketing materials and services, training for volunteers and teachers, curricula, and other services. Each regional center is responsible for placing the program in schools, recruiting mentor teams, and maintaining and updating the TRAC Pacs, or education toolkits.

Most DOTs work closely with other government agencies, universities, nonprofit organizations, and private industry to implement TRAC. The Connecticut TRAC Program, for example, is a partnership of the Connecticut Pre-Engineering Program (CPEP)[3] and Connecticut DOT.

"[When TRAC was first implemented,] we had the curricula and the volunteers—all we needed were schools to complete the circle," notes program comanager Ralph Phillips, Jr., Transportation Supervising Engineer for Connecticut DOT. "CPEP brought the schools and students to TRAC."

CPEP and TRAC have similar core values and missions. CPEP works with underrepresented groups to raise awareness of math, science, and engineering, and TRAC brings the work world of engineering to students.

"TRAC increases our ability to serve our mission," says CPEP's Glenn Cassis.

In the Classroom

The TRAC Program is at work in 18 states,[4] with associate programs in Puerto Rico, Tanzania, and South Africa. Mississippi is an example of a state success.

In 2003, TRAC Mississippi received $1 million from the state's Transportation Commission to launch the program statewide. Mississippi became the first state to make TRAC part of the required curriculum. Seventh grade students in 187 public schools use TRAC in Career Discovery classes.

Although the TRAC Program is well established at the middle and high school levels, volunteers attend career days and similar activities at the elementary school level. Currently in development, TRAC K–4 is a series of lesson plans written by and for elementary school teachers. The kindergarten and first grade curriculum focuses on civil engineers as community helpers, then in the second through fourth grades the focus is on civil structures—such as roads, bridges, and dams—as well as on basic problem solving.

At the core of the program is the TRAC Pac toolkit, which contains the equipment, software, program guides, and materials for classroom activities. The most recent edition, TRAC Pac 2, consists of eight education modules, each comprising various activities, experiments, demonstrations, and projects with a link to transportation.

The sponsoring state DOTs supply the modules to the schools, which can choose the units that best serve the students. Each module meets the National

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[3] www.cpep.org.

[4] Connecticut, Georgia, Illinois, Kansas, Maryland, Michigan, Mississippi, Missouri, Nevada, New Hampshire, New York, North Dakota, Rhode Island, Texas, Vermont, Wisconsin, Wyoming, and Washington, D.C.

Photograph: Kirk Frankfurth

Photograph: Kirk Frankfurth

Students at Leonardtown High School in Maryland (*photo, left*) design and test magnetic levitation cars for speed and distance and (*photo, right*) study particle sedimentation rates during an activity from the Highway Development and the Environment module.

Standards of Learning for Science Education, Technology, Technological Literacy, Mathematics, and Social Studies.

Students as Investigators

All TRAC activities are hands-on and allow each student to work at his or her own pace. The students are given inspiration, guidance, and the proper tools; sometimes students must work in teams as transportation professionals and engineers often do.

Students can build a working magnetic levitation train, measure the impacts of collisions, or build an entire electronic city and help it grow. Students of all ages seek out and absorb information, formulate new ways of solving problems, and learn that working in the transportation field is fun, exciting, stimulating, challenging, and doable.

Randy Wormald, a mathematics teacher and curriculum coordinator for Grades 9 through 12 at Belmont High School, Belmont, New Hampshire, has been using the TRAC Program since 2002 and has developed TRAC into one of the school's most sought-after classes.

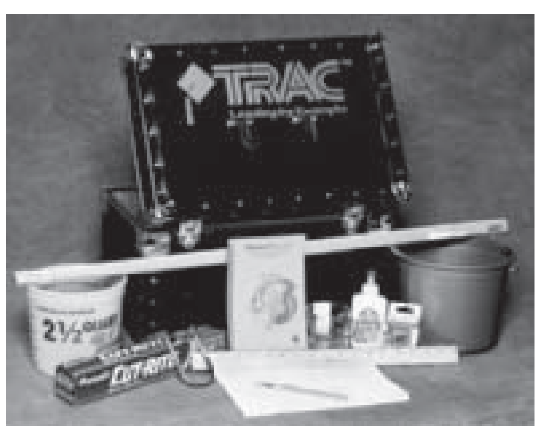
"Having taught math and computer education in New Hampshire, the Virgin Islands, and Taiwan, I've seen that all kids share the same qualities—they want to learn, and the same things get them hooked," he observes. "An element of competition, either internal or external, plus hands-on learning and excitement, are keys to success when teaching children of any age. TRAC is one of the rare programs that embodies all of these qualities—and it provides a career component as a bonus."

Teachers as Facilitators

The teacher acts as a facilitator as students explore the lessons presented in the TRAC modules. The teacher's knowledge becomes a resource as the students investigate ways to approach the problems. Although the TRAC curriculum is self-contained, including lessons and activities, participation does not require the teacher to set aside a subject's lesson plan. Instead, teachers can use TRAC to illustrate and broaden concepts addressed in their curricula.

Tupelo Middle School Principal Linda Clifton was an advocate for Mississippi's statewide implementation of TRAC. She has noted a positive effect on standardized test scores since TRAC's 1998 debut at her school.

"TRAC has caused my students' scores on the measurement portion of the National Achievement test to increase," Clifton reports. "Because students are encouraged to apply math and science skills and to see the relevance to everyday applications, they are doing



Photograph: Kirk Frankfurth

Components of the TRAC Pac 2 Bridge Builder module.

Student tests a magnetic levitation car.

better on assessment tests—they score 'well above average' in language and math, and within the state, Tupelo Middle has a Level 5 rating, the highest a school can receive."

Engineers as Guides

The engineers and transportation professionals who volunteer for the TRAC Program serve as role models, mentors, and guides to the students. In many instances, this may be the first engineer the students have ever met.

Through presentations, experiences, and professional expertise, the volunteers provide a real-world link to the TRAC curriculum, supplementing the teachers' lessons. The volunteers visit the classrooms, sponsor field trips to job sites, present activities at DOT career days, and host TRAC competitions. To be successful, however, a state's volunteer program needs support from the highest levels of management.

Henry Hungerbeeler, retired director of Missouri DOT, was an early TRAC supporter. "Top DOT management support of TRAC is key to the success of the program, regardless of the state," he maintains. "When management allows for staff to participate in volunteer efforts such as TRAC, the volunteers give more, and the students get a great education and a positive view of engineering and transportation careers."

TRAC Pac 2 Modules

TRAC Pac 2 is the curriculum for students in Grades 5 through 12. Most units serve a class of 25 students and include a teacher guide, volunteer tips, and a QuickTime™ movie of each activity, reducing the need for training.[5]

Teachers can request only the modules that are relevant to their lesson plans. All of the activities in the modules are easily adapted to different grade levels, adding to the economy and efficiency of the materials.

◆ **Bridge Design.** With the Bridge Design module, students practice the math and science concepts that a structural engineer uses to create a bridge. The concepts are presented individually, culminating in the construction of the students' own creations, applying algebra, geometry, and physics skills.

◆ **City Planning.** The realistic computer software package SimCity® 4000[6] introduces students to urban design, problem solving, critical thinking, and group decision making through transportation planning and zoning activities. Students work to improve citizens' quality of life through city redevelopment, zoning, and new development, while

[5] QuickTime is a trademark of Apple Computer.

[6] Copyright 1999, Electronic Arts, Inc. All rights reserved.

Research Keeps TRAC on the Right Track

CRAWFORD JENCKS

Managed by the Transportation Research Board and sponsored by the American Association of State Highway and Transportation Officials (AASHTO), the National Cooperative Highway Research Program (NCHRP) has been involved from the beginning in the AASHTO TRAC (Transportation and Civil Engineering) Program. The program was designed to interest students, especially minorities and women, in the transportation profession and civil engineering.

NCHRP research projects have helped assess the problem, have produced the initial content of the program, have provided evaluations and guidance, and most recently have updated the modules and activities:

◆ NCHRP Project 20-7, Task 41: AASHTO Guide for Recruitment and Retention of Transportation Professionals (1990), created the guide and developed pilot program material for the then-evolving AASHTO TRAC program.

◆ NCHRP Project 20-24(03), Expanding the Civil Engineering Pool (1994), produced NCHRP Report 347, *Civil Engineering Careers: Awareness, Retention, and Curriculum,* and NCHRP Report 347, Part II, *A User's Guide for Awareness, Retention, and Curriculum Programs*. Both provided resource material to TRAC.

◆ NCHRP Project 20-24(03)A, Civil Engineering Careers in Transportation: Outreach Program (1993), supported AASHTO's development of prototype material for TRAC. A summary was published as NCHRP Research Results Digest 196, *Revised, Unique, Hands-On Educational Program for High School Mathematics and Science Classes.*

◆ NCHRP Project 20-07, Task 90: TRAC—The Next Generation (1997), defined concepts for the next generation of hands-on equipment and activities, called TRAC Pac 2.

◆ NCHRP Project 20-52, TRAC Pac 2: A Hands-On Educational Program (2002), produced the modules and activities for TRAC Pac 2 that were delivered to AASHTO for integration into the TRAC program.

◆ Project 20-52(01), Implementing TRAC Pac 2: A Hands-On Educational Program (2005), developed a set of marketing, promotional, and motivational tools to optimize the acceptance and implementation of the TRAC Pac 2 program.

The author is Manager, National Cooperative Highway Research Program, TRB, Washington, D.C.

meeting the challenges of cost, time, and natural disasters.

◆ **Highway Development and the Environment.** Students learn about erosion, sedimentation, and filtration from the perspective of a highway engineer. Assuming the role of an environmental specialist, students examine the environmental issues involved with highway planning. This module brings together the sciences and social studies.

◆ **Highway Safety.** Students learn about the physics of momentum and impulse in relation to traffic accidents, including the effect of a collision with a fixed object and the impact of a vehicle hitting a crash barrier. In addition, the module covers traffic engineering concepts such as congestion, traffic volume, and sight distance in relation to safe speed.

◆ **Magnetic Levitation.** Students put magnetic levitation cars through their paces while learning about Newton's first and second laws of motion—concepts that civil engineers rely on when designing new roadways or developing intelligent transportation systems (ITS).

◆ **Motion and the Transportation Engineer.** Through transportation engineering methods, students learn the principles of motion, energy, and Newton's laws of motion, as well as skills for scientific inquiry. Divided into two sections, covering momentum and impulse, the module includes lecture demonstrations and hands-on laboratory activities with the latest data collection hardware and software.

◆ **Roadway Design and Construction**. Through activities, students learn about data visualization, the law of sines, the societal impact of transportation systems, and computer algorithms. The topics showcase the range of professional disciplines involved as a road project proceeds from design to construction. Students apply classroom theory to transportation issues that affect their lives daily.

◆ **Traffic Technology**. Concepts that serve as the building blocks for physics, electrical theory, and computer programming—including basic linear motion, basic circuits, and Boolean logic—are presented. Traffic Technology introduces students to the fundamentals of highway safety and traffic signal design. Reaction time, braking distance, computer programming and spreadsheets, and ITS technology are also covered.

Beyond the Classroom

Expanding beyond the classroom walls and the traditional school year, TRAC and AASHTO sponsor an annual Design–Build Competition, now in its third year. The competition requires solving a transportation problem from one of the eight modules, within specific parameters.

Who's Who at TRAC

TRAC Steering Committee

Normetha Goodrum, Deputy Administrator, Maryland State Highway Administrator, *Region 1 Representative*

Harry Lee James, Deputy Executive Director and Chief Engineer, Mississippi Department of Transportation, *Region 2 Representative*

Pete Rahn, Director, Missouri Department of Transportation, *Region 3 Representative*

Roberta Tisdale, Personnel Director, Michigan Department of Transportation, *Region 3 Representative*

Grant Levi, Deputy Director for Engineering, North Dakota Department of Transportation, *Region 4 Representative*

Hannah Whitney, Assistant Executive Director, AASHTO, *Secretary*

TRAC Staff

Tate Jackson, National TRAC Manager, 202-624-5814, tjackson@aashto.org

Sheri Johnson, National TRAC Coordinator, 202-624-5403, sherij@aashto.org

444 North Capitol Street, Suite 249, Washington, DC 20001
Fax: 202-624-7788
www.trac.net

The competition is open to TRAC students in Grades 9 through 11. Finalists present their projects at the AASHTO annual spring meeting and are judged by the Standing Committee on Highways, which consists of chief engineers and administrators from across the United States. This year students are solving a Runaway Truck Ramp problem based on the module, Motion and the Transportation Engineer.

The FHWA Office of Civil Rights has requested that TRAC Programs take on an expanded role at the national Summer Transportation Institutes (STI), held on college campuses around the country to introduce middle and high school students to careers in transportation. Pending funding, the TRAC national office would assist states in the start-up of STIs and would provide on-site personnel and training.

As TRAC moves forward and continues to touch students, teachers, and volunteers around the world, the goals remain.

"Developing technical, engineering, and science talent remains critical for the future of transportation and civil engineering," says Jack Basso, AASHTO's Director of Management and Business Development. "To ensure the TRAC Program's continued success, we must develop a system to gain empirical data on graduation rates and enrollment figures. Additional resources and funding also are critical—we will be able to extend TRAC's outreach through grants and fundraising and by developing partnerships."

POINT OF VIEW

A Brief History of Highway Quality Assurance

RICHARD M. WEED

The author, who retired from the New Jersey Department of Transportation in 2002, is a full-time consultant based in Trenton. He is an Emeritus Member of the TRB Management of Quality Assurance Committee.

One of the nation's most valuable assets is the network of roads and bridges linking suppliers of goods and services with customers. The nation's well-being depends on the highway system's condition, which in turn relates to the quality of construction.

Highway quality assurance has evolved over approximately four decades and encompasses all the programs and procedures for controlling and accepting construction quality. For the most part, the procedures in use today are fair and effective, but that was not always the case. As a former statistical engineer with the New Jersey Department of Transportation (DOT), I spent most of my career in quality assurance; following are some of the more important lessons learned.

Real-World Variability

The first of these lessons occurred while I was studying for a civil engineering degree. The lesson was taught not by one of my professors, but by a highway inspector who had few academic credentials. I was working in the summers on highway construction for New Jersey DOT when one of the inspectors had an interesting idea: "Let's send two identical samples to the department laboratory to see if they come out the same."

We carefully prepared two samples as nearly alike as possible and sent them to the laboratory. I do not recall the exact results, but they differed considerably more than we had expected. That was my first exposure to the real world of variability, and I sensed that this must be an important aspect of engineering.

NOTE: *Point of View presents opinions of contributing authors on transportation issues. The views expressed are not necessarily those of TRB or* TR News. *Readers are encouraged to comment in a letter to the editor on the issues and opinions presented.*

Today we understand that there are several possible explanations for differences between tests of identical samples. Maybe the samples were not as identical as we thought; maybe the samples were handled differently during transportation; or maybe the samples were tested by different operators, or on different testing equipment, or on different days.

But despite the potential sources of variability, samples of this type are used routinely to make important decisions about the acceptability of the construction items they represent. If this ever-present variability causes substandard work to be erroneously accepted, performance problems will arise that are likely to prove both costly and inconvenient. If satisfactory work is mistakenly rejected, completion of the project is delayed, the contractor is treated unfairly, and the result may be increases in future bid prices. Obviously, we need to minimize both types of mistakes.

Road Test Results

At roughly the same time I became acquainted with the realities of variability, the highway profession was learning a similar lesson from the American Association of State Highway Officials (AASHO) Road Test. This elaborate experiment alerted everyone that highway construction was far more variable than anyone had realized and, in some cases, was of lesser quality than anyone had recognized.

The reports from the AASHO Road Test used statistical measures to describe construction quality, and a few engineers saw that these same measures might offer a better way to specify what was desired than did the materials-and-methods specifications then in use. Not only would a statistical approach afford greater freedom to the construction industry to use its considerable skills and innovative abilities to achieve the desired results, but the approach also would provide a valid, quantitative way for highway agencies to judge the acceptability of the finished product.

The approach also would offer legal advantages, because in some cases, courts of law had not allowed highway agencies to reject defective work over which the agencies had exercised primary control via materials-and-methods specifications. Another advantage would be the creation of valid databases that eventually could improve understanding of the relationships between construction quality and ultimate performance.

This new approach of basing construction specifications on statistical concepts clearly was a win-win situation for all concerned. As engineers gained familiarity with statistical techniques, the use became more frequent and more effective. Growing pains were inevitable, but these early efforts turned out well enough that within a few years many other highway agencies had followed suit.

Analyzing the Risks

One of the most significant realizations from this early work was that the analysis of operating characteristic (OC) curves and of expected payment (EP) curves was an indispensable part of statistical quality assurance. Only through the study of these curves can two critical risks be known and controlled at suitably low levels: the highway agency's risk of accepting defective work, and the contractor's risk of having good work penalized or rejected.

This offers both technical and diplomatic advantages. The correction of faulty specifications in the office before reaching the field greatly increases the likelihood of making good acceptance decisions. Assuring that statistical specifications perform correctly and fairly greatly improves the working relationship between the highway agency and the construction industry.

Statistical Quality Measures

The first specifications of this type applied simple statistical measures, often the mean—or average—of the test values. As more construction data became available for analysis, engineers realized that the mean by itself was not always an adequate predictor of performance. Two lots of material having the same mean might have markedly different levels of variability and, consequently, substantial differences in the amounts of substandard material and in the expected levels of performance.

The next step was to look for statistical quality measures that would take variability into account. The moving average was out—it was as insensitive as the mean was to variability. In addition, the moving average was influenced by adjoining lots of material, making any type of risk analysis extremely difficult.

A few agencies tried average absolute deviation, which has never been studied thoroughly as a formal statistical measure and is not well suited for single-sided specifications for which a unique target value

cannot be defined. The conformal index also was proposed, but the drawbacks are essentially the same as those of the average absolute deviation.

This left as the logical choices percent defective (PD) and percent within limits (PWL)—which are different representations of the same thing. PD/PWL is a standard statistical measure, extensively studied, known to be an unbiased estimator, capable of handling single-sided and double-sided applications, and with published tables for use. For these reasons, PD/PWL continues to have the strongest intuitive appeal to most writers on statistical quality assurance.

Bonus Provisions

Another key milestone in the development of highway acceptance procedures was the advent of bonus provisions. The earliest statistical specifications either paid full price or assessed some degree of pay reduction, depending on the deficiency in quality. Highway engineers eventually realized that if withholding payment for substandard work made sense, offering some degree of monetary incentive for superior work also made sense. The idea was to encourage and compensate contractors whose attention to quality control produced work that substantially exceeded the specified levels of quality and, as a result, could be expected to provide above-average performance.

Several arguments support an incentive approach. Once OC/EP curve analyses became more common practice, some degree of bonus provision was recognized as necessary for the long-term average pay factor to be 100 percent for work exactly at the level defined as acceptable. The natural variability of statistical measures often produces quality estimates that are either too low or too high. Bonus provisions allow the resulting underpayments or overpayments to balance in a way that turns out to be fair and equitable.

Other benefits of bonus provisions include motivation for higher quality work, improved relations with the construction industry, and the likelihood that better contractors more often will be the successful bidders—because contractors more assured of receiving bonus payments can afford to bid lower. Because of these benefits, a substantial majority of highway agencies now use bonus provisions in one form or another.

Performance-Related Specifications

A goal in highway specification writing is to relate basic engineering properties—for example, the resilient modulus of pavement—directly to performance, so that specifications only state appropriate levels of appropriate properties. That goal remains elusive, however, and efforts have focused on developing performance-related specifications (PRS) based on mathematical models linking quality characteristics—such as air voids in asphalt concrete or the compressive strength of portland cement concrete—or statistical quality measures, such as PD or PWL, to performance and longevity. Typically, these specifications include pay schedules developed through life-cycle cost analysis.

PRS developmental efforts have produced a dichotomy of approaches. On the one hand, highly complex national studies have produced sophisticated computer programs like HMASPEC and PCCSPEC, based on mechanistic design principles, life-cycle cost analyses, and various decision-making processes. On the other hand, a few state transportation agencies, including New Jersey DOT, are engaged in grassroots efforts to use their own data to create simplified mathematical models with the same underlying scientific principles.

The methods developed by the national studies offer the potential for greater precision and accuracy, but at the expense of considerably greater data requirements and complexity. The grassroots models are more empirical, but their simplicity and ease of being tailored to local conditions make them attractive from a practical standpoint. States that would like to convert statistical specifications to actual PRS will have to decide which of the two profoundly different approaches to take. The optimal approach may lie somewhere between these two extremes.

Simple but Scientific

Much has been accomplished in the field of highway quality assurance, but much remains to be done. A slight variation of the KISS rule has served New Jersey DOT well: Keep It Simple but Scientific. The guidance may be useful to other agencies as they continue to advance the state of the art of PRS.

In other words, start with the simplest approach that makes scientific sense, and switch to something more complex only if there is evidence or data showing that the simple method is not working. As a statistical practitioner always concerned about the accumulation of error in any complex system, I advocate this practical approach for designing any engineering process.

Rapid Location of Road Construction Materials in Flat, Featureless Terrain

DAVID JONES

The author is a Technical Specialist at the Council for Scientific and Industrial Research, Pretoria, South Africa. He served as loan staff to the Transportation Research Board in Washington, D.C., in 2004, and currently is on assignment at the University of California Pavement Research Center in Davis.

In many areas of southern Africa, flat, featureless terrain makes the location of road construction materials difficult. Thick covers of sand add complications in the arid and semi-arid areas of the west and in the coastal plains of the east.

As part of a larger study, various methods were investigated to locate road construction materials. These included traditional techniques with maps, aerial photographs, and satellite images, as well as some innovative techniques, such as looking for geobotanical indicators.

Problem

Traditional methods of material location entail a desktop study of the road alignment on geological and topographical maps, plus aerial photographs and even satellite images, to identify potential sources. A field survey follows.

In many developing countries, aerial photographs and satellite images are not available. Moreover, geological and topographical maps are of little use in flat, featureless terrain with a deep sand cover.

Sparse population and the lack of infrastructure imply few records of gravel sources. Many contractors therefore resort to field studies, which can consume months of often-fruitless investigation, leaving scars on previously unspoiled landscapes.

Solution

The presence of many plant species and even the nature of their growth often depend on the mineralogical and physical properties of the soil. In the past, plant indicators have been used to locate various minerals and metal ores; however, data and documentation on the use of these indicators to locate construction materials are minimal.

Many road builders of the preceding generation placed great importance on interpreting the natural vegetation when pegging alignments and locating materials. Much of this knowledge, however, has been lost as these field-trained staff have retired.

Literature Study

The literature on the topic is limited to locating calcareous materials such as limestone and caliche in Africa by identifying plant species with a high tolerance for calcium, like *Catophractes* and *Grewia*. However, an investigation of the vegetation around a variety of known material sources in various geological regions revealed that the presence of certain species was restricted to the immediate area of the source and not beyond; for example, *Stoebe* species was found near laterite.

Location of similar growth patterns elsewhere in the landscape sometimes indicated similar materials. The study also revealed that morphological differences in certain species—such as stunted growth in *Acacia* species and *Colophospermum* species—often indicated changes in material or in other relevant factors, such as perched water tables, impeded drainage, or areas with high clay content.


PHOTO: EDWARD BRISSE, SOUTH AFRICA

Catophractes alexandri or trumpet thorn can indicate caliche deposits.

Ultralight aircraft used for aerial survey.

Application

Economic developments in southern Africa and plans for growth dictated the need for a corridor linking the port of Maputo in Mozambique on the east coast of Africa with Walvis Bay, a port on the west coast of Namibia. The 2750-kilometer-long corridor would cross four countries.

Most of the western sections of the road traversed sparsely populated, arid areas with only a basic infrastructure of vehicle tracks. The area is flat, featureless, and covered with thick layers of mostly wind-blown sand. The vegetation is predominantly scrub savannah, and the only road construction materials are the sand and isolated deposits of caliche and arkose.

Without suitable aerial photographs, the contractor for one of the Botswana sections of the road resorted to a ground study. The lack of roads in the area and the presence of thick scrub savannah vegetation hampered the investigation, and an alternative was sought to prevent further costly delays.

A repeat ground study to locate potential botanical indicators was considered inappropriate because of the nature of the terrain and the lack of infrastructure. The alternative of acquiring aerial photographs also was rejected because of the costs and the time requirements.

An aerial survey to search for botanical indicators therefore was proposed. An ultralight aircraft (see photo, this page) was selected because the plane is slow, highly maneuverable, and inexpensive to operate in comparison with a helicopter; a fixed-wing aircraft generally is too fast for this kind of visual survey.

The following procedure was used:

- The aircraft was flown approximately 200 m above the ground along the proposed alignment.
- The area to the left and right of the route alignment would be searched for any abnormalities in (*a*) the microtopography, such as pan rims; (*b*) the vegetation, such as a distinct change of species, a dense thicket of one or two species, or a change in plant morphology; or (*c*) the soil color. The key plants

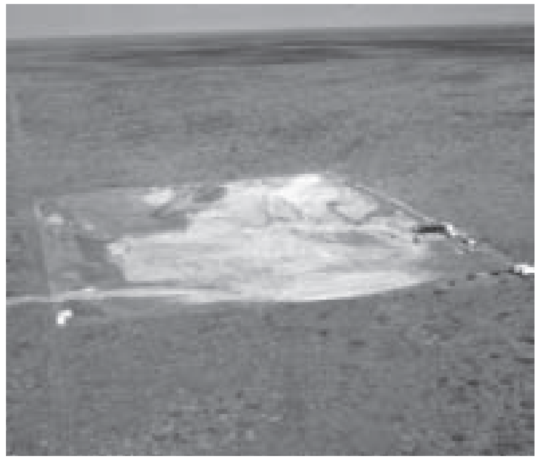
North Dakota Vegetation Yields Clues to Construction Materials

In the United States, although particular plant species have been associated with the presence of certain materials, the information seldom is used to locate aggregate sources. An exception is North Dakota, which lacks surface and near-surface rock exposures—the state department of transportation (DOT) relies on vegetation indicators to locate aggregate for road construction.

North Dakota DOT employees look for plants such as big sand grass, pigeon grass, and crested wheatgrass to locate gravel pits. According to DOT observations, woody shrubs, such as buck brush and sage, do not thrive well in gravely areas, and at midsummer the well-drained areas typically burn or thin out—another indicator. Because North Dakota is an agricultural state, crops also have provided clues to subsurface conditions.

In southwestern Oregon, unique vegetation is associated with ultramafic and serpentine rocks in the Klamath Mountains. The Oregon white oak is known to indicate well-draining material such as sand and gravel in the Puget Lowlands of Washington State. The pink prairie cone flower grows near limestone in southeast Kansas. These associations, however, have not been used to locate potential materials for road construction.

The technique developed by South Africa and Botswana, described by David Jones in the accompanying Research Pays Off article, offers a successful model for reconnaissance work to develop new sources of road construction materials, applicable in the United States and other countries.



(*Left*) Caliche deposit covered by Catophractes species and (*right*) working quarry started in same area.

proved to be *Catophractes alexandri* or trumpet thorn, *Grewia flava* or brandybush, and *Pecheulloeschea leubnitziae*.

◆ When a plant site was observed, the pilot flew the aircraft to the area for a closer inspection from the air. If any of the indicator plants were noted, the Geographic Positioning System coordinates were recorded and a subjective rating was given to facilitate and prioritize later site visits.

◆ After inspection, the ultralight aircraft was flown back to the route along the alignment until a new potential site was discerned.

With this procedure, a 60-kilometer section of the route was traversed in approximately 3 hours. A total of 14 potential sources of material were identified in the area already surveyed unsuccessfully in the earlier ground study.

Five of the sites, selected at appropriate points along the route to minimize haul distances, were visited in the following two days with a backhoe loader. All of the sites contained caliche of varying quality and quantity, 1.0 to 2.0 m below the surface, which is common in the terrain, and is included in contract pricing practice. Tests on samples removed during this expedition showed that sufficient material could be excavated to meet the required standards for the various layers and the surface treatment.

Benefit

A 3-hour ultralight aircraft flight using botanical indicators to identify potential sources of materials, followed by a 2-day site inspection, located sufficient material to build a 60-kilometer section of road. A 2-month field survey in the same area using traditional techniques had failed to locate the sources.

The costs for the pilot, the materials specialist, the aircraft, and the field allowances amounted to approximately $2,000. In comparison, the costs for a geologist, an assistant, and vehicle and field allowances for the traditional survey totaled more than $8,000. The time and cost savings with the ultralight aircraft survey are evident.

Although finding suitable road construction materials is never a guarantee in any survey, the prescribed technique enhanced the ability of the prospector to find suitable material or to know beyond reasonable doubt that suitable materials were not present. The technique has been used successfully to locate materials—or to confirm that none were available—in several projects for which traditional methods were unsuccessful or inconclusive.

South Africa and Botswana have developed guideline documentation on the use of botanical indicators in material location. Although these studies were undertaken in southern Africa, the procedure is applicable to any area with similar conditions—such as the southwestern United States, the Australian interior, or the Middle East.

For further information, contact David Jones, Technical Specialist, CSIR, P.O. Box 395, Pretoria 0001, South Africa; telephone 2712-841-3831, e-mail djones@csir.co.za.

EDITOR'S NOTE: Appreciation is expressed to G. P. Jayaprakash, Transportation Research Board, for his efforts in developing this article.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-2952, e-mail gjayaprakash@ nas.edu).

Christina S. Casgar

U.S. Department of Transportation

In January 2004, Christina Casgar joined the Office of the Secretary of Transportation in the U.S. Department of Transportation's (DOT) newly created Office of Freight and Logistics, formerly the Office of Intermodalism. The Office of Freight and Logistics is developing an integrated freight policy for U.S. DOT and serves as a conduit to shippers, carriers, and terminal operators.

Casgar's background includes management of freight research projects, development of public information sessions, and business analysis of the structural reorganization and policy changes in marine and intermodal freight transportation. Her 15 years in Washington, D.C., have focused on federal, state, and local policy analysis in transportation.

Casgar's previous experience at an operating port authority, combined with years of advocacy for greater focus on freight system challenges, brought her to what she calls "the ideal career spot" at U.S. DOT.

"Bringing together intermodal players for common benefits … is critical—the more we can educate leaders on freight challenges, the better we can keep the nation's economy humming."

"Secretary Mineta has stated that port and freight capacity issues are on his top-10 list for his second term," says Casgar. "Being part of the Secretary's freight policy team right now is the right spot at the right time for me."

Casgar and a small leadership team representing maritime, rail, and trucking components of the U.S. DOT are drafting freight policy. U.S. DOT has engaged and funded the Transportation Research Board's (TRB) Freight Transportation Industry Roundtable to serve as a bridge between U.S. DOT and a cross-section of industry leaders who provide U.S. DOT leaders with insights into industry operations and perspectives.

Casgar earned a master's degree in maritime policy from the University of Delaware, Newark, and began her career at the Port of Wilmington, Delaware. She started as marketing coordinator, representing the port with customers, the press, and city council—then the port's board of directors. Two years later, she became the port's European representative, opening an office and developing a customer base in Europe. This allowed Casgar to work with cargo development at its source.

In Europe she developed accounts for the port with steel producers, automobile manufacturers, wood and paper producers, and food and flower exporters. In her last 4 years at the Port of Wilmington, Casgar worked as director of port relations, monitoring and further developing the port's major accounts in containerized fruit and vegetables.

"I was able to see first-hand how containerization revolutionized shipping and the port industry," she recalls.

In 1991, soon after the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA), Casgar left the port to join TRB as Marine Transportation Specialist (Marine and Intermodal Freight) in the Technical Activities Division. The responsibilities presented her with the opportunity to work on the freight challenges outlined in the new legislation.

While at TRB, Casgar worked with key transportation research professionals and conducted research on issues confronting U.S. public port authorities, including staff work for the TRB–National Research Council Study on Landside Access to U.S. Ports. Casgar also attracted major new sponsors for TRB's maritime activities and broadened the financial and technical constituency for marine and intermodal transportation research.

TRB committees that Casgar has staffed or served as a volunteer include Inland Water Transportation, International Trade and Transportation, Ferry Transportation, National Transportation Data Requirements and Programs, the Innovations in Freight Transportation Modeling Task Force, and Intermodal Terminal Design and Operations. Currently she serves as chair of the Freight Systems Group and is a member of the Technical Activities Council.

Casgar thrives on positions that require building connections to private-sector freight operations to solve public policy problems. Before moving to U.S. DOT, she spent several years as the Executive Director of the Foundation for Intermodal Research and Education (FIRE), a nonprofit public education foundation under the Intermodal Association of North America. That position gave Casgar the opportunity to serve the intermodal freight community by developing and distributing accurate and informative materials about intermodal transportation.

"Bringing together intermodal players for common benefits can be a steep pull at times, but the need is critical—the more we can educate leaders on freight challenges, the better we can keep the nation's economy humming," Casgar observes. "As the U.S. changes from a domestically driven economy to a more internationally driven economy, this education about bottlenecks in the global supply chain becomes ever more critical."

Robert C. Johns

Center for Transportation Studies, University of Minnesota

As director of the Center for Transportation Studies (CTS) at the University of Minnesota, Minneapolis (UMN), Robert Johns strives for his center to be a catalyst for transportation innovation through university research , education, and outreach. He directs a staff of 24 and works with university faculty in disciplines ranging from engineering and technology to economics, geography, planning, psychology, political science, supply chain management, architecture, and landscape architecture.

Johns currently leads an interdisciplinary research and outreach program, Access to Destinations, which seeks to develop accessibility measures for various locations in the Minneapolis–St. Paul, or Twin Cities, area. The results will help explain changes in land use and transportation over the past decade, especially regarding the rapid increase in traffic congestion. The information will also be used to analyze alternative land use strategies and modal investments in the future.

"I … work in a field and an environment that has allowed me to continue to be a student, to pursue learning and to facilitate creative innovations—an essential strategy … in the field of transportation as we address our future challenges."

"Our center is an interface between academic expertise and transportation practice," Johns explains. "Innovative initiatives result when we succeed at bringing our faculty together with professionals to address our most vexing transportation problems."

Involved in the Transportation Research Board for more than 20 years, Johns has served on many committees including Transportation Data and Information Systems, Public Involvement in Transportation, Strategic Management, Management and Productivity, and Performance Measurement; and he chaired the Strategic Management Committee, and the Management and Leadership Section. He currently chairs the Policy and Organization Group, which provides leadership and support to 30 committees, and is a member of the Technical Activities Council.

Johns took an unusual path to his position of leadership. His background comprises experience in research, marketing, technology, business, and liberal arts. He earned a bachelor of science degree in engineering operations, a master's degree in business administration, and a second master's in English with an emphasis on American literature. He pursued the English degree to satisfy his interest in liberal arts, but has found that the knowledge he gained has proved useful in his research, management, marketing, and facilitation roles.

"Studying literature gave me insight into characters and cultures, helping me understand, for example, the cultures and perspectives of people in different sectors—public, private, and academic—and helping me facilitate communication among people who have difficulty seeing other points of view."

After college, Johns worked various positions—as a systems analyst at the University of Iowa Hospital; market manager for the Atchison, Topeka, and Santa Fe Railway Company in Chicago; manager of methods and data systems at the Minnesota Department of Transportation; and director of the Regional Data Center at the Metropolitan Council of the Twin Cities Area. He began an 18-year career at the University of Minnesota in 1988 as a Coordinator for Research in CTS, helping founding director Richard Braun establish research funding processes, technology transfer mechanisms, and a large participatory structure involving public, private, and academic sector leaders.

Working under CTS director and Professor Gerard McCullough, Johns led a major interdisciplinary research and outreach program—the Transportation and Regional Growth Study—which continues to be used by Minnesota decision makers in understanding the dynamics of traffic congestion and suburban growth.

In 2001, Johns was appointed CTS director. He created a CTS scholars program, bringing together 40 faculty and researchers from more than 25 disciplines at UMN to work more closely with CTS staff in identifying research opportunities and strengthening transportation education. Johns also helped establish the Graduate Certificate Program in Transportation Studies. With the help of his staff and researchers, the annual funding to UMN for transportation research, education, and outreach has increased to $16 million.

Johns has strong views on where transportation research is heading. He believes that transportation is entering an era of change and innovation, driven by challenges that demand attention, and that increased research funding is needed. According to Johns, the future will focus on more integration of transportation in urban design, new vehicle navigation and communications technologies, the use of new fuels, innovative pricing and financing schemes, greater focus on environmental and energy impacts, and increased attention to safety, freight, and new modal strategies.

"I have been fortunate to work in a field and an environment that has allowed me to continue to be a student," Johns says, "to pursue learning, and to facilitate creative innovations—an essential strategy for all of us in the field of transportation as we address our future challenges."

Preparing for New Strategic Highway Research Program

Neil Hawks was appointed Interim Director and Ann Brach Deputy Director of the newly authorized Strategic Highway Research Program II (SHRP II). Both members of TRB's staff, Hawks and Brach have started preliminary work for the new program's launch.

"Although SHRP II is not yet officially under way, and funds will not start flowing for some months, there is an immediate need to get an oversight committee organized and start addressing a variety of challenging organizational and scoping issues," notes TRB Executive Director Robert E. Skinner, Jr. "Neil and Ann are well prepared to handle this start-up phase."

Hawks, TRB Director of Special Programs, has more than 35 years of transportation experience—23 with TRB—and served in senior management with the original SHRP. Brach, Senior Program Officer in the Division of Studies and Information Services, has been the principal organizer of all SHRP II planning activities for the past 5 years, and has served as Chief of Research and Technology for the Maryland State Highway Administration and as a Research and Technology Program Manager for the Federal Highway Administration.

TRB Annual Meeting: Spotlights and Highlights

"Transportation 2025: Getting There from Here" is the main spotlight theme of TRB's 85th Annual Meeting, January 22–26, 2006, in Washington, D.C., with additional spotlights on sessions covering "The Interstate Highway System's 50th Anniversary: What Have We Learned?" and "SAFETEA-LU: What It Means for Research and the Transportation Community." More than 9,000 transportation professionals are expected for the informational sessions, presentations, and workshops covering all modes of transportation and a range of topics, including critical issues in congestion, financing, security, safety, the environment, and institutional systems; trends in technology and the economy; and public expectations for accountability and performance.

Ralph J. Cicerone, the new president of the National Academy of Sciences, will be the featured speaker at the Chairman's Luncheon, a premiere event, Wednesday, January 25, at the Omni Shoreham Hotel in Washington, D.C. Former Chancellor of the University of California, Irvine, Cicerone is an atmospheric scientist with expertise in atmospheric chemistry and climate change.

Abba Lichtenstein, recipient of the 2006 Thomas B. Deen Distinguished Lectureship award, will speak on "The Preservation of Historic Transportation Facilities," on January 23, at the Marriott Wardman Park Hotel. Lichtenstein is the founder and former president of the original Lichtenstein Consulting Firm, and a prominent expert on historic bridges.


Lichtenstein

The Deen Distinguished Lectureship acknowledges the career contributions and achievements of an individual in areas covered by TRB's Technical Activities Division. Honorees present summaries of their technical areas, covering the evolution, status, and prospects for the future.

For more information, go to www.TRB.org/meetings.

Nobel Laureate Has TRB, Academy Connections


Schelling

Thomas C. Schelling, a member of both the National Academy of Sciences and the Institute of Medicine, has received the 2005 Nobel Memorial Prize in Economics for his work in game theory analysis, with Robert J. Aumann of Hebrew University in Jerusalem. Schelling has served on many National Academies Committees, including the Committee for a Study on Transportation and a Sustainable Environment, which produced TRB Special Report 251, *Toward a Sustainable Future: Addressing the Long-Term Effects of Motor Vehicle Transportation on Climate and Ecology* in 1997.

Distinguished University Professor Emeritus at the University of Maryland Department of Economics and School of Public Policy, Schelling has published highly influential works in a number of areas including nuclear proliferation and arms control, terrorism, organized crime, energy and environmental policy, climate change, and racial segregation. Schelling taught at Harvard for 31 years before joining the faculty at the University of Maryland in 1990.

In 1993, the National Academies honored him with the Award for Behavioral Research Relevant to the Prevention of Nuclear War, for his pioneering work in the logic of military strategy, nuclear war, and arms races.

Schelling describes game theory as "the study of how people interact when each person's behavior depends on, or is influenced by, the behavior of others." For example, he says, "drivers in traffic start honking their horns…because someone else honked their horn first. Hearing your car horn, I honk mine, thus encouraging you to honk more insistently. People respond to an environment of people's responses."

FOCUS ON ISSUES—The Research and Technology Coordinating Committee (RTCC) met November 1–2, in Washington, D.C., to discuss issues related to the direction and management structure of the Federal Highway Administration's (FHWA's) recently authorized $14 million advanced research program. Former RTCC member Irwin Feller of Pennsylvania State University, University Park, moderated the discussion. With support from FHWA, the RTCC provides continuing guidance on the nation's highway research program. (*Left to right:*) Participating in the discussions were Dennis Judycki, Associate Administrator for Research and Technology, FHWA; Richard Capka, Acting Administrator, FHWA; Al Teich, Director, Science and Policy Programs, American Association for the Advancement of Science; Gary Henderson, Director, Office of Infrastructure Research and Development, FHWA; and Tommy Beattie, Director, Office of Pavement Technology, FHWA.

SETTING PRIORITIES FOR SAFE OPERATIONS—The Committee on Research Priorities and Coordination in Highway Infrastructure and Operations Safety considered priority areas, priority setting, and coordination of research on highway infrastructure and operations safety at a meeting, September 12–13, in Washington D.C. Participants included (*left to right:*) Timothy Neuman, CH2M Hill; Leanna Depue, Central Missouri State University, Missouri Safety Center; Dan S. Turner, University Transportation Center for Alabama; Forrest Council, University of North Carolina, Chapel Hill, Highway Safety Research Center; (*and in photo at right, left to right:*) Chris Lawson, Office of Safety, Federal Highway Administration; Alison Smiley, Human Factors North, Inc.; Ann Dellinger, Centers for Disease Control and Prevention; and Ezra Hauer, University of Toronto.

COOPERATIVE RESEARCH PROGRAMS NEWS

Measuring Tire–Pavement Noise at the Source

Tire–pavement noise has become an important consideration for highway agencies as the public demands highway traffic noise reduction. Although sound walls moderate highway noise, improved pavement structures and surfaces may provide less expensive alternatives for noise mitigation.

Widely accepted procedures to measure tire-pavement noise under in-service conditions are not available. Research is necessary to develop and evaluate procedures measuring noise levels applicable to light and heavy vehicles, and on all paved surfaces.

Illingworth & Rodkin, Inc. of Petaluma, California, has received a $250,000, 24-month contract [National Cooperative Highway Research Program (NCHRP) Project 1-44, FY 2005] to develop procedures for measuring tire–pavement noise. Testing in-service pavements will demonstrate the value of these procedures for various pavement types, noise levels, and light and heavy vehicles.

The goal is to supply highway agencies with appropriate means for measuring and rating tire–pavement noise levels on pavements, evaluating new pavements that offer noise-diminishing features, and identifying design and construction features associated with different noise levels. This information will help agencies identify methods for reducing noise impacts on nearby communities.

For further information, contact Amir N. Hanna, TRB, 202-334-1892, ahanna@nas.edu.

National Database System for Highway Bridge Maintenance

Highway agencies perform a variety of maintenance procedures to preserve highway bridges. Although some of these procedures may be similar from agency to agency, most of the applications methods, rates, bases of measurement, costs, performance, and other related factors differ. No widely accepted system uniformly records data related to maintenance actions.

Research is needed to review relevant information; recommend uniform definitions of data associated with maintenance actions; and develop a database system for collection, storage, and retrieval of related data.

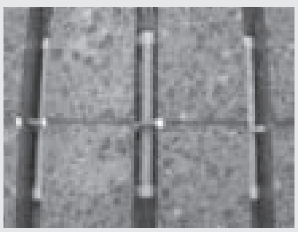
(continued on next page)

The University of Colorado at Boulder has been awarded a $348,846, 21-month contract (NCHRP Project 14-15, FY 2005) to develop a national database system of bridge-maintenance actions, materials, methods, and effectiveness; and to recommend uniform definitions of related data. The database system will be prepared in a format suitable for consideration and adoption by the American Association of State Highway and Transportation Officials.

Adaptability for web-based applications will be pursued in a follow-up effort. Uniform definitions and a national database system will enable sharing of bridge maintenance data, which will help highway agencies make appropriate adjustments to improve performance and reduce the cost of bridge maintenance operations.

For further information, contact Amir N. Hanna, TRB, 202-334-1892, ahanna@nas.edu.

Evaluating Dowel Alignment in Concrete Pavements



Dowels used in jointed portland cement concrete pavements provide load transfer, reduce faulting, and improve performance. The dowels are positioned manually before concrete placement or automatically by dowel bar inserters during construction. Inspection of pavements in several states has revealed that misalignment of dowels can occur with both methods of placement; however, slab cracking and other forms of distress may not always occur as a result of the misalignment.

Research to determine the extent of dowel misalignment in pavement construction and the effect on performance is limited. More extensive research is necessary therefore to address the issues associated with dowel alignment, identify approaches for estimating the short- and long-term effects of different levels and types of misalignment on performance, and develop guidelines for use in performance-related specifications.

The University of Minnesota has been awarded a $499,983, 27-month contract (NCHRP Project 10-69, FY 2005) to study the effects of all forms and combinations of dowel misalignment—for example, vertical and lateral skew and displacement—on performance, and to develop guidelines for dowel alignment in concrete pavements. The research findings will improve the design and analysis of concrete pavements and provide appropriate measures for use in performance-related specifications.

For further information, contact Amir N. Hanna, TRB, 202-334-1892, ahanna@nas.edu.

Crash Energy Management for Light Rail Vehicles

Questions about using the longitudinal static strength or buff strength of light rail vehicles (LRV) to control vehicle crush and to protect passengers in a collision remain unanswered. This has prevented a consensus on a structural safety standard for LRVs.

A crash energy management (CEM) design may provide added protection to passengers in roadway vehicles that collide with LRVs by reducing the frequency and severity of roadway vehicle passenger injuries. Accident statistics for U.S. LRV operations indicate that collisions with roadway vehicles constitute a significant proportion of all injuries and fatalities associated with LRV operation.

LOOKING TO TRANSIT'S FUTURE—The TCRP Oversight and Project Selection (TOPS) Committee approved new research projects for fiscal year 2006 at a meeting on October 27, 2005. Projects include safety improvements for interactions between light rail, pedestrians, and vehicles; the impact of 511 traveler information services on transit call-center operations; practical measures to increase transit industry advertising revenues; the design and operation of bus-only shoulder lanes on heavily congested sections of highways; and more. Assisting in the selection of projects for funding were (*left to right:*) Lou Sanders, American Public Transportation Association; Marc Hall, Conference of Minority Transportation Officials; Paul Larrousse, Director, National Transit Institute; and Jeanne Krieg, CEO, Eastern Contra Costa Transit Authority.

Research is needed to establish crush performance requirements that could serve as the principal part of an American Society of Mechanical Engineers (ASME) structural safety standard specifying levels of crush force and force-displacement relationships based on engineering analyses and simulations of various accident scenarios. These requirements would take into account variations in the operating environment, train consist configuration, occupant-compartment protection, and variations in current and anticipated vehicle designs.

In addition to crush performance requirements based on LRV-to-LRV collisions, this research will assess the effectiveness and practicality of using LRV CEM structural design approaches to mitigate roadway-vehicle passenger injuries from LRV collisions.

Applied Research Associates, Inc. has been awarded a $299,990, 16-month contract (Transit Cooperative Research Program Project C-17, FY 05) to provide technical assistance to enable the ASME committee to determine reasonable performance requirements for dynamic crush behavior for LRV-to-LRV collisions based on a CEM approach that minimizes the probability of injury and fatality for a range of LRV designs under various high-risk collision scenarios. As a secondary objective, the committee seeks information and guidance on the technical feasibility and practicality of CEM zones to mitigate damage and human injury in roadway vehicles during LRV–roadway vehicle collisions. This research will support the current ASME effort to develop a structural safety standard for LRVs.

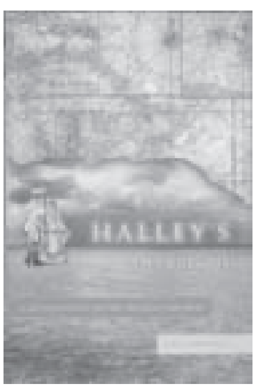
For further information, contact Chris Jenks, TRB, 202-334-1892, cjenks@nas.edu.

Sea Basing: Ensuring Joint Force Access from the Sea
National Research Council, Washington, D.C., 2005; 87 pp; $25.25; 0-309-09517-4.

United States military forces that are sent to world trouble spots will no longer establish beachheads, iron mountains, or huge headquarters operations. Instead, these facilities and functions will move from land to a sea base at least 25 miles offshore—a concept called sea basing. The Defense Science Board (DSB) recently concluded that sea basing will be a critical joint military capability in the future and called for further development of the concept. The U.S. Navy therefore requested that the National Research Council organize a workshop to assess the science and technology capabilities, both inside and outside of the Navy, for the implementation of sea basing and to identify research and development to support the strategy.

This report, compiled from discussions and presentations at the workshop, includes an examination of sea basing operational concepts; the ship and aircraft technology available to make sea basing work; and issues involved in creating a sea base as a joint system.

Halley's Quest: A Selfless Genius and His Troubled Paramore
Julie Wakefield. Joseph Henry Press, Washington, D.C., 2005; 261 pp; $27.95; 0-309-09594-8.

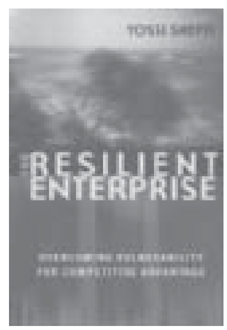


Edmond Halley predicted the appearance of a comet that would bear his name; however, his greatest achievement may have been discovering accurate navigation techniques for sea vessels. *Halley's Quest* captures the science and spirit behind a trilogy of sea voyages on Halley's 52-foot ship *Paramore*, as he charted the earth's magnetic fields, determining the difference between true and magnetic north. The author portrays the struggle that Halley endured to change the course of science by producing charts that described more accurate ways to navigate and document new geophysical phenomena ranging from ocean patterns to the motion of Jupiter's moons.

Global Competition in Transportation Markets: Analysis and Policy Making
Edited by Adib Kanafani and Katsuhiko Kuroda. Elsevier Ltd., United Kingdom, 2005; 391 pp; $94.95; 0-7623-1204-1.

This book consists of the proceedings of an international symposium held at Kobe University, Japan, that brought together some of the world's leading researchers in transportation planning and policy. The papers present state-of-the-art research on competition, regulation, and system structure in air and maritime transportation and serve as a resource in transportation systems management. The book also could serve as a text for an advanced graduate course in transportation, economics, or public policy related to maritime freight.

The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage
Yossi Sheffi. The MIT Press, Cambridge, Massachusetts, 2005; 338 pp; $29.95; 0-262-19537-2.



Yossi Sheffi examines ways that companies can build flexibility throughout their supply chains, by following proven design principles and by developing the right culture—balancing security, redundancy, and short-term profits. Investments in resilience and flexibility reduce risk and create a competitive advantage in the marketplace, he maintains, and he demonstrates how to turn resilience investments into a competitive advantage.

The book has five parts: part one introduces the notions of vulnerability and resilience, focusing on the causes and nature of disruptions; part two describes supply chain management and the challenges associated with managing multiparticipant supply chains; part three examines basic vulnerability-reduction measures—security, fast detection, and redundancy; and parts four and five summarize the main lessons of the book, including organizational recommendations and action items.

The books in this section are not TRB publications. To order, contact the publisher listed.

TRB PUBLICATIONS

Research on Women's Issues in Transportation, Volume 2: Technical Papers
Conference Proceedings 35, Volume 2
This volume contains peer-reviewed breakout and poster papers and several abstracts of papers presented at the conference on Women's Issues in Transportation, in Chicago, Illinois, November 18–20, 2004. The conference was designed to identify and explore additional research and data needed to inform transportation policy decisions that address women's mobility, safety, and security needs and to encourage initiatives by young researchers. Volume one, which will be released in 2006, will include the conference summary and four peer-reviewed survey papers.

2005; 210 pp; TRB Affiliates, $42.75; nonaffiliates, $57. Subscriber categories: planning and administration (IA); safety and human performance (IVB).

Pavement Design and Accelerated Testing 2004
Transportation Research Record 1896
A mechanistic–empirical model to predict transverse joint faulting, a multilayer boundary-element method for evaluating top-down cracking in hot-mix asphalt pavements, and one-way and two-way directional heavy-vehicle simulator loading are examined in this four-part volume on education tools, rigid pavements, flexible pavements, and accelerated pavement testing. The K. B. Woods Award winning design and construction of transportation facilities paper, "Computer-Based Multimedia Pavement Training Tool for Self-Directed Learning," by Stephen Muench and Joe Mahoney of the University of Washington, also appears in this volume.

2004; 214 pp; TRB affiliates, $42; nonaffiliates, $56. Subscriber category: pavement design, management, and performance (IIB).

Statistical Methods and Safety Data Analysis and Evaluation
Transportation Research Record 1897
This volume presents research on the development of accident prediction models for rural highway intersections; the use of logistic regression to predict the severity of median-related crashes in Pennsylvania; the marginal impacts of design, traffic, weather, and related interactions on roadside crashes; and the evaluation and validation of an automated in-vehicle data collection system for developing roadway alignments. The D. Grant Mickle Award winning paper on operation, safety, and maintenance of transportation facilities, "Safety Effects of Narrow Lanes and Shoulder-Use Lanes to Increase Capacity of Urban Freeways," by Karin Bauer, Douglas Harwood, and Karen Richard of Midwest Research Institute, and Warren Hughes of BMI-SG, is also included in this volume.

2004; 210 pp; TRB affiliates, $40.50; nonaffiliates, $54. Subscriber category: safety and human performance (IVB).

Travel Demand and Land Use 2004
Transportation Research Record 1898
The authors examine the decision processes for activity-travel scheduling and rescheduling; the personal time–space prism vertex locations in developing countries; the impact of intrahousehold interactions on individual daily activity-travel patterns; the dynamics of on-street parking in large centralized cities; and transportation needs, location choice, and perceived accessibility for businesses.

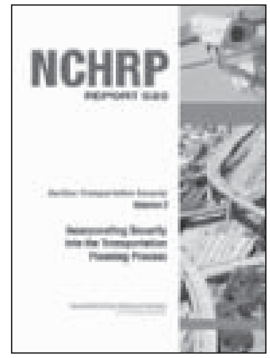
2004; 210 pp; TRB affiliates, $40.50; nonaffiliates, $54. Subscriber category: planning and administration (IA).

Driver and Vehicle Simulation, Human Performance, and Information Systems for Highways; Railroad Safety; and Visualization in Transportation
Transportation Research Record 1899
This volume presents research on the use of intelligent transportation system data for determining driver deceleration and acceleration behavior, motorist response to arterial variable message signs, the effects of vehicle height on drivers' speed perceptions, and the effects of passenger and cellular phone conversations on driver distraction. The organizational competence of the U.K. rail industry in strategic safety management and the current practice and future directions of visualization in transportation also are examined.

2004; 187 pp; TRB affiliates, $39; nonaffiliates, $52. Subscriber category: safety and human performance (IVB).

Construction 2004
Transportation Research Record 1900
This four-part final volume of the 2004 Record series covers topics in portland cement concrete pavements, bituminous pavements, quality assurance, and construction management. Analysis includes multivariate models for evaluating segregation in hot-mix asphalt pavements, the effect of material transfer devices on flexible pavement smoothness, the process for selecting innovative quality assurance practices for materials, context-sensitive construction solutions, and innovative strategies on the Dallas High Five project.

2004; 148 pp; TRB affiliates, $37.50; nonaffiliates, $50. Subscriber category: materials and construction (IIIB).



Surface Transportation Security—Incorporating Security into the Transportation Planning Process
NCHRP Report 525, Volume 3

The NCHRP Report 525 series assembles information pertaining to security problems and closely related issues into single, concise volumes. These volumes focus on the concerns that transportation agencies are addressing when developing programs in response to the terrorist attacks of September 11, 2001, and the anthrax attacks that followed. Volume 3 presents a broad assessment of the status, constraints, opportunities, and strategies for incorporating security into transportation planning at the state and metropolitan levels and for including security-related projects in state and metropolitan priority programming decisions.

2005; 58 pp; TRB affiliates: $15; TRB nonaffiliates: $20. Subscriber categories: planning and administration (IA); safety and human performance (IVB); public transit (VI); security (X).

Surface Transportation Security—A Self-Study Course on Terrorism-Related Risk Management of Highway Infrastructure
NCHRP Report 525, Volume 4

This volume provides a general background in terrorism-related risk management for highway infrastructure and will assist bridge and structure engineers and managers in identifying critical highway assets and their potential vulnerabilities, developing possible countermeasures to prevent or ameliorate threats to such assets, and determining the capital and operating costs of such countermeasures.

CD-ROM; 2005; TRB affiliates: $26.25; TRB nonaffiliates: $35. Subscriber categories: planning and administration (IA); bridges, other structures, and hydraulics and hydrology (IIC); public transit (VI).

Surface Transportation Security—Guidance for Transportation Agencies on Managing Sensitive Information
NCHRP Report 525, Volume 5

This report examines ways to identify sensitive information that must be protected and to control sensitive information responsibly—the foundation for any transportation agency's policy. Chapters cover establishing a sensitive information management policy, identifying sensitive information, and controlling access.

2005; 55 pp; TRB affiliates: $15.75; TRB nonaffiliates: $21. Subscriber categories: planning and administration (IA); transportation law (IC); safety and human performance (IVB); aviation(V); public transit (VI); rail (VII); freight transportation (VIII); marine transportation (IX); security (X).

Surface Transportation Security—Guide for Emergency Transportation Operations
NCHRP Report 525, Volume 6

This sixth volume of NCHRP Report 525 supports the development of a formal program for the improved management of traffic incidents, natural disasters, security events, and other emergencies on the highway system. A coordinated, performance-oriented, all-hazard approach called emergency transportation operations (ETO) is outlined. The volume focuses on an enhanced role for state departments of transportation with the public safety community. Supplementing this volume is NCHRP Web-Only Document 73, a resources guide and bibliography on ETO.

2005; 56 pp; TRB affiliates: $15.75; TRB nonaffiliates: $21. Subscriber category: planning and administration (IA); maintenance (IIIC); operations and safety (IV); security (X).

Recommended Guidelines for Curb and Curb-Barrier Installations
NCHRP Report 537

AASHTO highway design policy discourages the use of curbs on high-speed roadways, but curbs are often required because of restricted right-of-way, drainage considerations, access control, and other functions. This report presents recommendations for combinations of curb and strongpost guardrails, curb height, and lateral offset between the curb and guardrail for operating speeds greater than 60 kilometers per hour (40 miles per hour).

2005; 97 pp; TRB affiliates: $16.50; TRB nonaffiliates: $22. Subscriber categories: highway and facility design (IIA); safety and human performance (IVB).

Traffic Data Collection, Analysis, and Forecasting for Mechanistic Pavement Design
NCHRP Report 538

Guidelines are presented for collecting traffic data for pavement design. Also described are the actions required at the state and national levels to implement TrafLoad, a software package for analyzing traffic data and for producing the traffic data inputs required for the AASHTO pavement design software. TrafLoad and related user and procedures manuals are available online.

2005; 114 pp; TRB affiliates: $16.50; TRB nonaffiliates: $22. Subscriber category: planning and administration (IA); pavement design, management, and performance (IIB).

To order the TRB titles described in Bookshelf, visit the TRB online Bookstore, www.TRB.org/bookstore/, or contact the Business Office at 202-334-3213.

CALENDAR

TRB Meetings 2006

January

22–26 TRB 85th Annual Meeting
Washington, D.C.
Linda Karson

March

26–27 Safety Data Analysis Tools Workshop
(by invitation)
Washington, D.C.
Richard Pain

28–30 Transportation and Economic Development 2006*
Little Rock, Arkansas

April

9–11 10th National Light Rail Transit Conference: Light Rail—A World of Applications and Opportunities*
St. Louis, Missouri
Peter Shaw

19–21 Visualization in the Changing Transportation World
Denver, Colorado
Richard Pain

26–28 8th Annual National Harbor Safety Committee Conference*
Washington, D.C.
Joedy Cambridge

May

TBD Environmental Geospatial Information for Transportation: A Multidisciplinary Examination of Noteworthy Practices
(by invitation)
Thomas Palmerlee

June

4–7 North American Travel Monitoring Exposition and Conference
Minneapolis, Minnesota
Thomas Palmerlee

4–7 1st International Symposium on Freeway Operations*
(by invitation)
Athens, Greece
Richard Cunard

July

9–11 Joint Summer Meeting
San Diego, California
Mark Norman

16–19 3rd International Conference on Bridge Maintenance, Safety, and Management*
Porto, Portugal

16–20 11th AASHTO–TRB Maintenance Management Conference*
Charleston, South Carolina

23–26 45th Annual Workshop on Transportation Law
Chicago, Illinois
James McDaniel

25–29 5th International Symposium on Highway Capacity*
Yokohama, Japan
Richard Cunard

30–Aug 3 2nd International Symposium on Transportation Technology Transfer*
St. Petersburg, Florida
Kimberly Fisher

August

TBD 7th National Access Management
Park City, Utah
Kimberly Fisher

2–4 3rd Bus Rapid Transit Conference
Toronto, Ontario, Canada
Peter Shaw

6–9 1st International Conference on Fatigue and Fracture in the Infrastructure: Bridges and Structures of the 21st Century*
Philadelphia, Pennsylvania
Stephen Maher

23–26 7th International Conference on Short and Medium Span Bridges*
Montreal, Quebec, Canada
Stephen Maher

September

TBD 10th National Conference on Transportation Planning for Small and Medium-Sized Communities: Tools of the Trade
Nashville, Tennessee
Kimberly Fisher

October

TBD Freight Demand Modeling: Improving Analysis and Forecasting Tools for Public-Sector Decision Making
Elaine King

2–5 Plastic Pipes XIII Conference*
Washington, D.C.

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar. To reach the TRB staff contacts, telephone 202-334-2934, fax 202-334-2003, or e-mail lkarson@nas.edu. Meetings listed without a TRB staff contact have direct links from the TRB calendar web page.

*TRB is cosponsor of the meeting.

INFORMATION FOR CONTRIBUTORS TO

TR NEWS

TR News welcomes the submission of manuscripts for possible publication in the categories listed below. All manuscripts submitted are subject to review by the Editorial Board and other reviewers to determine suitability for *TR News*; authors will be advised of acceptance of articles with or without revision. All manuscripts accepted for publication are subject to editing for conciseness and appropriate language and style. Authors receive a copy of the edited manuscript for review. Original artwork is returned only on request.

FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 to 4,000 words (12 to 16 double-spaced, typed pages). Authors should also provide appropriate and professionally drawn line drawings, charts, or tables, and glossy, black-and-white, high-quality photographs with corresponding captions. Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may help readers better understand the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographic or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information is used. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing. Readers are also invited to submit comments on published points of view.

CALENDAR covers (*a*) TRB-sponsored conferences, workshops, and symposia, and (*b*) functions sponsored by other agencies of interest to readers. Notices of meetings should be submitted at least 4 to 6 months before the event.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

LETTERS provide readers with the opportunity to comment on the information and views expressed in published articles, TRB activities, or transportation matters in general. All letters must be signed and contain constructive comments. Letters may be edited for style and space considerations.

SUBMISSION REQUIREMENTS Manuscripts submitted for possible publication in *TR News* and any correspondence on editorial matters should be sent to the Director, Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, telephone 202-334-2972, or e-mail jawan@nas.edu.

- All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word 6.0 or WordPerfect 6.1 or higher versions, on a diskette or as an e-mail attachment.
- Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi or greater. A caption should be supplied for each graphic element.
- Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

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Getting There from Here

Celebrations of the 50th Anniversary of the Interstate Highway System will pay tribute to the vision and dedication that created the system and will recognize the commitment necessary to preserve and manage all of the components of the U.S. transportation network. Lessons from the past and from current research programs—together with new technology and the new opportunities created by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—provide a solid foundation for that task. The Transportation Research Board (TRB) has assembled and published a bookshelf of resources and guides for transportation professionals, decision makers, and members of the general public, promoting innovation and progress in transportation through research.

Related TRB publications include the following:

Highway Capacity Manual 2000

- U.S. customary print version (HCM2KE), 1,134 pages, binder, 2000, ISBN 0-309-06746-4, $110.00
- U.S. customary print version with CD-ROM (HCM2EC), ISBN 0-309-06746-4, $155.00
- Metric print version (HCM2KM), 1,134 pages, binder, 2000, ISBN 0-309-06681-6, $110.00
- Metric print version with CD-ROM (HCM2MC), 1,134 pages, binder, 2000, ISBN 0-309-06681-6, $155.00
- CD-ROM—2-disk set with both U.S. customary and metric versions (HCM2KC), 2000, $100.00

The Workforce Challenge: Recruiting, Training, and Retaining Qualified Workers for Transportation and Transit Agencies
Special Report 275 (SR275), 186 pages, 6 x 9 paperback, 2003, ISBN 0-309-08563-2, $23.00

Transportation Finance: Meeting the Funding Challenge Today, Shaping Policies for Tomorrow
TRB Conference Proceedings 33 (CP033), 97 pages, 8.5 x 11 paperback, 2005, ISBN 0-309-09499-2, $37.00

Analytical Tools for Asset Management
NCHRP Report 545 (NR545), 61 pages, 8.5 x 11 paperback, 2005, ISBN 0-309-08832-1, $32.00

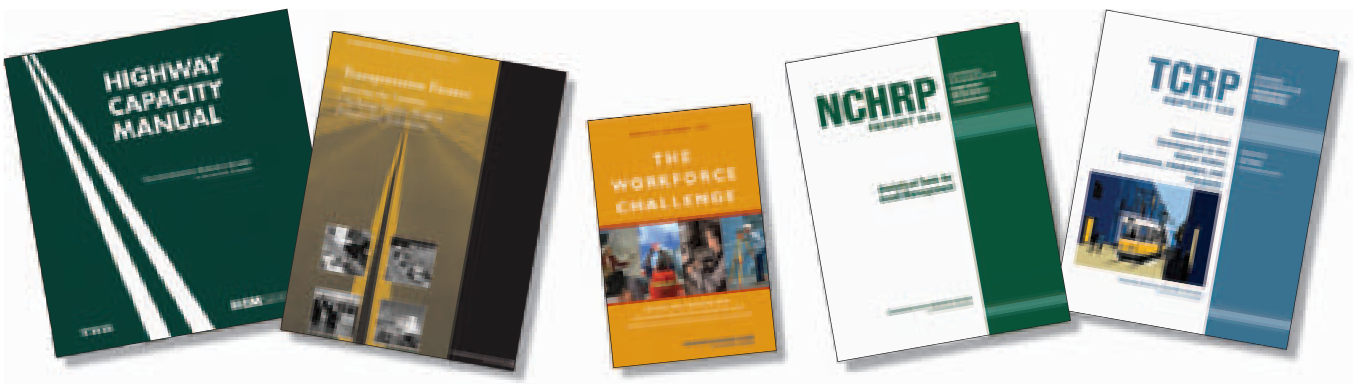
Optimal Timing of Pavement Preventive Maintenance Treatment Applications
NCHRP Report 523 (NR523), 76 pages, 8.5 x 11 paperback, 2004, ISBN 0-309-08811-9, $21.00

Guide for Customer-Driven Benchmarking of Maintenance Activities
NCHRP Report 511 (NR511), 271 pages, 8.5 x 11 paperback, 2004, ISBN 0-309-08786-4, $30.00

Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects
TCRP Report 102 (TC102), 524 pages, 8.5 x 11 paperback, 2004, ISBN 0-309-08795-3, $45.00

Freight Capacity for the 21st Century
Special Report 271 (SR271), 155 pages, 6 x 9 paperback, 2003, ISBN 0-309-07746-X, $23.00

Emerging New Paradigms: A Guide to Fundamental Change in Local Public Transportation Organizations
TCRP Report 97 (TC97), 105 pages, 8.5 x 11 paperback, 2003, ISBN 0-309-08774-0, $22.00



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